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Review Article

Factors Influencing the Adoption of Cocoa Agroforestry Systems in Mitigating Climate Change in Ghana: The Case of Sefwi Wiawso in Western Region

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Introduction

Climate change is having great impact on agricultural productivity worldwide. Agriculture is strongly influenced by weather and climate [1,2]. Climate change and variability adversely affect environmental resources such as soil and water upon which agricultural production depends, which poses a serious threat to sustainable agricultural production [2]. In Ghana climate variability and change is expected to have an adversely effect on the agriculture sector. According to the NIC, (2009) by 2030 temperature are projected to rise by 0.5 °C. This situation would result in fewer rainy days and more extreme weather conditions like prolonged droughts. The impacts of a changing climate will have direct and indirect effects on global and domestic food systems [3,4]. Rioux [5] reported that climate change has affected yields in food crop production in many Africa countries. If the issues of climate change and variability are not addressed incomes and food security of rural households in Ghana would be undermined because there would be increased incidence of diseases and pest as well as prolonged variable rainfall patterns.

Cocoa production employs over 15 million people worldwide with over 10.5 million workers in West Africa [6]. Cocoa, in addition to cereals and other root and tuber crops contribute largely to food security in Ghana. In Ghana cocoa production is an essential component of rural livelihoods and its cultivation is considered a 'way of life' in many production communities [7]. The cocoa sub sector cocoa employs about 800,000 farm families spread across the cocoa growing regions of Ghana and generating about $2 billion in foreign exchange annually [8,9]. The expansion of cocoa production is replacing substantial areas of primary forest. It's of no surprise that the total area under cocoa cultivation increased by 50,000 hectares between 2012 and 2013 and there is no indication that the rate is slowing down. According to Anim Kwapong et al. [10] the government of Ghana recognizes that climate change is already negatively affecting Ghana's cocoa sector in myriad ways and that, it is likely to continue hampering Ghana's environmental and socio-economic prospects in the coming decades. Cocoa agroforestry system has been identified as is an important strategy that can ameliorate climate change [11]. This system can play a dual role of mitigation and adaptation, which makes it one of the best responses to climate change. It is noted that agroforestry has multi-functional purposes which makes it one of the most promising strategies for climate change adaptation [11,12]. The use of trees and shrubs in agricultural systems help to tackle the triple challenge of securing food security, mitigation and reducing the vulnerability and increasing the adaptability of agricultural systems to climate change [13,14]. With this view, serious attention must be given to cocoa agroforestry which is capable of reducing temperatures and enhancing the growing of cocoa thus sustaining livelihood of many households in this climate changing pattern. According to previous studies [11,13,15] agroforestry as an adaptation strategy could sustain agricultural production and enhance farmers' ability to improve livelihoods and will minimize the impacts of climate change which include drought, variable rainfall and extreme temperatures. Agroforestry as a forest-based system plays a significant role in conserving existing carbons, thereby limiting carbon emissions and also absorbing carbons that are released into the atmosphere [16]. Nair [17] also indicated that agroforestry has received international attention as an effective strategy for carbon sequestration and greenhouse mitigation. Cocoa agroforestry can increase farmers' resilience and position them strategically to adapt to the impacts of a changing climate. This system of cocoa production can be very useful because it generates quite substantial benefits on arable lands in diverse ways; trees in agricultural fields improve soil fertility through control of erosion, improve nitrogen content of the soil and increase organic matter of the soil [18,19]. Agroforestry can also transform degraded lands into productive agricultural lands and improves productive capacities of soils [18]. Although agroforestry is not new in Ghana, it is quite optimistic that effective adoption to climate change will contribute towards the achievement of sustainable development and to a large extent, the attainment of the Sustainable Development Goals (SDGs). Despite the immeasurable benefits of cocoa agroforestry system, adoption is not widespread and for that matter success stories are found in isolated cocoa farming areas among few adapters of cocoa agroforestry system initiatives. Aidoo and Fromm [20] report that although cocoa farmers are aware about sustainability issues, they

hardly adopt sustainable production practices. It is quite not always the case that policies are implemented as they were intended and so the need to assess farmers' perspectives on cocoa agroforestry adoption and implementation especially when climate change has become a serious constraint to cocoa production in Ghana. Traditional coping mechanisms to the impact of climate change in the Western Region of Ghana include mixed cropping, non-farm activities and traditional agroforestry practices by some individual cocoa farmers. However, non-shade cocoa production systems, bush burning, slash and burn farming methods expose the cocoa communities to further impacts of climate change. This calls for swift attention from all, especially cocoa farmers in the study communities to tackle the problem. Despite the economic, environmental and sustainable cocoa production potential via agroforestry systems, farmers have not adopted cocoa agroforestry practices entirely especially in Sefwi Wiawso District. Understanding cocoa farmers decision making processes in ensuring sustainable food supply and cocoa yield in cocoa agroforestry system is critical. Research frontiers in cocoa agroforestry systems need to be identified and better understand barriers to adoption and the development of strategies to support cocoa agroforestry that enhance food security in climate changing conditions. The objectives of this study are therefore to empirically assess the factors that affect farmers' decision to adopt cocoa agroforestry systems and determine cocoa farmers' perception on cocoa agroforestry as an adaptation strategy to climate change.

Methodology

The study was conducted at Sefwi Wiawso in the Western and region of Ghana. The district lies within latitudes 6° 00"and 6° 30 North and Longitudes 2° 15"' and 2° 45 West. The District covers an area of about 2,634 square kilometers. The detailed hydrometeorological characteristics of the study area are provided in Table 1.

A stratified random sampling technique was employed in the selection of the 300 cocoa farmers interviewed for the study. In the first stage, Western Region was purposively selected due to the fact that apart from being one of the highest cocoa producing regions in Ghana, it is one of the regions which has experienced significant impact as a result of climate change. In the second stage, Sefwi Wiawso was randomly selected. In the third stage, five communities were randomly selected. In the final stage 60 cocoa farmers were randomly selected from each village. Primary data were employed in the study. The primary data consisted of qualitative data and household survey interviews. Specifically, the primary data were collected through focus group discussions (FGD), stakeholder interviews, and field observations. The household survey interviews employed both open-ended and close ended survey instruments.

Table 1: Hydrometeorological characteristics of the study area.

Characteristics	Levels
Mean temperature	Maximum: 33°C Minimum: 26°C
Climate	Tropical rainforest
Average humidity	Dry season: 50-75% Rainy season: 85-90%
Average rainfall	1500-1800 mm
Topography	Undulating
Soil condition	Loamy
Average elevation	206 m

To examine the factors that influence a household's decision to participate in agroforestry a logistic regression model was employed.

The model was specified as:

$$Z_i = Log\left\{P_i/(1-P_i)\right\} = \alpha + \beta_1 X_1 + \beta_2 X_2 + \ldots\ldots + \beta_k X_k + u$$

Where: $i = 1, 2, 3\ldots\ldots\ldots, k$ are the observations, α = constant. β = the regression parameter to be estimated. βX = linear combination of independent variables. Z_i = the log odds of choice for the ith observation. P_i = the probability of observing a specific outcome of the dependent variable (adoption). X_n = the nth explanatory observation. u = the error term.

Results and Discussion

The gender composition of the cocoa farmers among revealed that 81.5 percent of the respondent are males with 19.5 percent been females. This indicates that cocoa production is a male dominated occupation in the study area. In Ghana cocoa production is considered a male job but this is not the situation at the study sites because both women and men play a critical role in the production cycle. Within the last 30 years, cocoa farmers observed some impacts of climate change in the study communities, information gather from the cocoa farmers showed that there has been varying pattern in rainfall and sunshine. With regards to drought, overwhelming 98 percent of cocoa farmers reported the occurrence of drought in the study area and linked it to climate change. The pattern of rainfall distribution has changed as reported from the study. The study reported high level of windstorm, high incidence of flooding and frequent occurrences of pests and disease on their cocoa farms in recent time. These are attributed to climate change. Frequent felling of trees, non-shade cocoa production systems, wood harvesting for charcoal and firewood and bush burning among others were mention as some course of changing climate in the farming communities. About two thirds of the farmers reported unplanned trees harvesting as a major cause for variable rainfall thus climate change. This suggest that majority of farmers are aware of some of the causes of climate change in the study area. About 58 percent of cocoa farmers are using doing the non-shade cocoa production system. This result confirms a report [21], indicating that high proportion of Ghana's cocoa is grown in full sun at the expense of primary or secondary forest conversion. A study [22] reported that shaded tree densities, and average number of tree species per hectare vary according to cultural tradition and ethnic group, age of farms, proximity to markets, and intensity of farming, this situation is similar to that of the study area after personal interaction with the cocoa farmers. This current trend of no shade is not only common in Ghana but other cocoa growing countries like Cote d'Ivoire, Malaysia, Indonesia and Ecuador. A study [23] in Ecuador reported that half of the new cocoa plantations are now full-sun and are from high-yielding variety. A study [24] also revealed that in Sulawesi cocoa farmers are switching from long-fallow shifting cultivation of food crops to intensive full-sun cocoa. This current trend of cocoa production put the food security of these cocoa farmers in doubt with the impact of climate change.

Cocoa farmers acknowledge the benefits of adopting cocoa agroforestry system in cocoa production. Farmers indicated that cocoa agroforestry has the potential of maintaining soil moisture, improving soil fertility as well as suppressing weeds within the cocoa farm. A study by Bentley [23] on cocoa farmers in Ecuador also indicated similar characteristics. Cocoa farmers acknowledged that no shade cocoa system is agriculturally unsustainable and is becoming common in the study area. The study reported that cocoa agroforestry mimics the natural sub canopy cover of traditional cocoa tree in the forest thus good practice to mitigate climate change. The shade trees selected by the cocoa farmers need to provide products and additional income when sold. *Terminalia superb, Milicia excels, Terminalia ivorensis, Cedrella odorata,Ceiba pentandra* and *Ceiba pentandraas* are the most dominant shade tree on cocoa farms and are retained because of their economic importance. Eighty-five percent have little knowledge about the tree rights in the community although there are existing policies and legislations in Ghana. The average knowledge of useful species in this cocoa farming communities are fading out. For example, some of the younger farmers interviewed retain shade trees on an interest in the knowledge of their parents and grandparents.

Cocoa farmers have various levels of perception on certain characteristics of cocoa agroforestry. About 54 percent of cocoa farmers strongly perceive that cocoa agroforestry improves yield of cocoa. These trees ensure a microclimate condition which enhance the yield of the cocoa and thus mitigate climate change. Other perception held by cocoa farmers for cocoa agroforestry are enhancing soil moisture, improve farm humidity and environment, protecting young cocoa trees from pest and diseases and direct sun rays (Table 2).

Factors Affecting Adoption of Climate-Smart Agriculture Innovations in Isolation and in Combination

Farmers' adaption decisions were found to be influenced by several varying factors. The factors include farming experience, agricultural land size, belonging to farmer association, access to extension services, awareness of climate change, and experience in farming.

Results from the regression are reported here to tell the factors determining of adoption of individual farmer. The base category used in the analysis was non-adoption. Table 3 report coefficients and marginal effects from MNL regression respectively. Marginal effects (Table 3) are reported and discussed here. In this instance, the marginal effects measure the expected change in probability of a certain choice (of a cocoa agroforestry system) being made with respect to a unit change in an explanatory variable, all in comparison to the no adoption category.

Results are compared to the base category of no-adoption. The results indicated that adoption of cocoa agroforestry is negatively associated with age of farmer and positively associated with agriculture land size, experience in farming, member of farmer association, gender, awareness of climate change and access to extension service. Results imply that probability of adopting cocoa agroforestry decreases with ageing of cocoa farmer possibly due to risk aversion of innovative practices like cocoa agroforestry by older cocoa farmers. The positive association of cocoa agroforestry adoption with agriculture land size imply that larger plot sizes could be more flexible to experiment with cocoa agroforestry. Also, the positive association of extension could be due to availability of information for cocoa farmers with access to it. The factors of cocoa agroforestry adoption is in agreement with studies [25,26]. Extension services are very critical for availing necessary information on cocoa agroforestry. Overall, results show the importance of cocoa agroforestry system at the farmer level in building resilience to climate variability and change as well as other productivity related challenges in cocoa farming in Ghana. Adoption of cocoa agroforestry system reduces the impacts of climate change on cocoa productivity and hence farmer incomes. The enhanced impact of adopting cocoa agroforestry systems possibly arise as a result of the micro climatic conditions that is favorable for cocoa production. Findings of the study conform to other related literature that indicates that, adoption of new agricultural technologies needs to positively impact on productivity, income and other welfare related variables of the adaptors.

Table 2: Perception of cocoa farmers on cocoa agroforest in mitigating climate change.

Cocoa agroforestry ensure sustainable yield	
Strongly agree	162 (54)
Agree	66 (22)
Undecided	54 (18)
Disagree	18 (6)
Cocoa agroforestry improves soil fertility	
Strongly agree	195 (65)
Agree	75 (25)
Undecided	30 (10)
Disagree	
Cocoa agroforestry improve farm humidity	
Strongly agree	204 (68)
Agree	60 (20)
Undecided	18 (6)
Disagree	8 (24)
Cocoa agroforestry enhance rainfall	
Strongly agree	225 (75)
Agree	45 (15)
Undecided	21 (7.0)
Disagree	9 (3.0)
Cocoa agroforestry serves as a wind break on farms	
Strongly agree	240 (80)
Agree	45 (15)
Undecided	15 (5)
Disagree	

Table 3: Factors influencing farmers adaption decision.

Variable Name	**Estimate**	**SE**	**Wald**	**p (Sig.)**	**Odds ratio**
Agriculture land size	0.239	.139	2.944	.086*	.787
Experience in farming	0.823	.388	4.499	.034**	2.278
Member of farmer Assciation	1.037	.453	5.240	.022**	2.821
Gender	0.474	.502	.892	.345	1.607
Awareness of climate change	0.063	.054	1.378	.0240**	1.065
Age of respondent	-011	.016	.447	.504	0.989
Access to extension service	2.976	0.756	15.510	.000***	0.51
Constant	2.901	1.092	7.060	.008***	18.19
	Model chi-square 53.87 p<0.000				
	-2 log likelihood 171.058[a]				
	Nagelkerke (R Square) .730				

***Significant at 1%, **Significant at 5%, *Significant at 10%.

Conclusion and Recommendation

Cocoa researchers and development partners are becoming more concern with welfare of cocoa farm in Ghana by promoting cocoa agroforestry systems which is essential in a bid to improve climate resilience. Cocoa agroforestry has the potential to improve soil fertility, regulate soil temperature, control soil moisture among other benefits. The study outcomes have shown that climatic changes have occurred over the years and these have had effect on the annual cocoa yield. The study revealed that some cocoa farmers are presently ignorant about their tree ownership on their farms. It therefore recommended that agricultural extension officers should educate these farmers on tree rights. Cocoa farmers in the study areas have noticed changes in climate conditions through their own experiences and careful observations over the year of farmers. Also, respondents reported that cocoa agroforestry systems can offer numerous environmental, social and financial benefits, and can lead to an alternative way to mitigate climate change and variability. Land size, member of farmer association, experience in farming, awareness of climate change and access to extension service are the main factors that influence cocoa farmers' decision to adopt cocoa agroforestry system. There is the need for effective provision of extension services through farmer field school programs. Programs of this nature have the potential to change farmers' attitudes towards adopting a technology. Access to information and credit needs to be enhanced so as to get the needed logistics for managing cocoa agroforestry systems. This would facilitate farmers' access to information about technical issues of the systems and how it can be managed in mitigating climate change. Finally, government should support cocoa famers through subsidies and long-term loans. There is also the need for more concerted and strong collaborative effort among Ghana COCOBOD, the Ministry of Food and Agriculture and Forestry Commission so as to reach greater a policy impacts on cocoa agroforestry system.

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