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Yam Farmers' Adaptation Practices towards Climate Change Disaster in Cross River State, Nigeria

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Abstract
This paper focused broadly on exploring yam farmers' adaptation practices towards climate change disaster in Cross River State, Nigeria. The study employed a survey design involving 150 respondents (farmers). Ordinary Least Squares (OLS) regression and descriptive statistics were employed to actualize the objectives while t-test was adopted to test the hypothesis. The results show that some of the socio-economic variables such as; age, number of years in school, farmer's membership in associations, access to extension facilities and hectarage of farm land significantly influenced farmer's adoption of climate change adaptation strategies at $P<0.05$. The result also shows that the strategies adopted by farmers in order of widespread use by farmers were; multiple cropping, crop diversification, multiple planting dates, cover cropping and fertilizer application, irrigation practices, mulching, land fragmentation, tree planting, organic manure and fallowing. The paper recommended that farmers should organise sensitisation programs in their communities to educate themselves on the more effective measures to employ to adapt to climate change in their yam production.

Keywords: Climate Change, Adaptation Practices, Yam Production.

1. Introduction

1.1 Background Information

Yam is an annual tuber and monocot plant. It belongs to the genus "*Dioscorea*" and the family "*dioscoreacea*". The food plant comprises of 600 species out of which ten species produces edible tubers and only six are cultivated in Africa (Musa, Onu, Vosanka& Anonguku, 2011). As a root crop, the place of yam in the diet of the people in West Africa and in Nigeria in particular cannot be overemphasized. Akinola, Oke, Adesiyan & Famuyini (2019) reported that yam holds important position as a food and industrial crop in the Nigerian economy. Babaleye (2003) noted that yam contributes more than 200 dietary calories per capita daily for more than 150 million people in West Africa while serving as an important source of income to the people. Yam production in Nigeria is entirely dominated by small-scale farmers (Baimey,2006). Yam production in Nigeria is among the most susceptible to the deleterious effects of climate change (Oluwasusi & Tijani, 2013). This is because; the production of this crop like every other crop is affected by factors varying from physical through economic to cultural factors. Climate, one of the physical factors, is the most crucial factor, which determines the nature of the natural vegetation, the characteristics of the soils, the crops that can be grown, and the type of farming that can be practiced in any region (Obiokoro, 2005). Hence, any variation in climatic condition will have significant effects on crop productivity, especially yam yield.

Elijah, Osuafor and Anarah (2018) asserted that climate change is no longer a trivial issue; it is a reality that is seriously affecting the earth already, especially challenging agricultural productivity and food security in both developed and developing economies of the world and thus requires urgent attention. Similarly, Falola and Achem (2017) posited that climate change is gradually attaining a catastrophic dimension given the associated impacts in the various key socio-economic sectors in recent time. One of these sectors is agriculture, specifically the crop sector, which appears to be most susceptible to this phenomenon. Climate affects various aspects of plant growth and development. In fact, it has been earlier predicted that climate change is likely to reduce yields and/or damage crops in the 21st century (IPCC 2001). Climate change will affect all economic sectors of Africa and will therefore present unprecedented challenges for the continent, particularly in terms of meeting its Sustainable Development Goals (SDGs). Indeed, climate change is already eroding decades of hard-won national and international development gains, thus the need for concerted and coherent efforts in urgently tackling the development challenge. This challenge has further exacerbated poverty in Africa as rising temperature and sea level results in undue flooding, droughts, and salinization in low lying areas. Reconnaissance surveys and pan-African stakeholder consultations carried out by the African Technology Policy Studies Network (ATPS) and its partners, including the United Nations Environment Program (UNEP) in 2007, 2008 and 2009 show that the sectors that are mostly affected by climate variability in Africa are agriculture, water and biodiversity. These sectors were prioritized as most critical as they will have direct impacts on rural livelihoods (Ozor, Madukwe, Enete*et al*.,2012).

Adaptation seems to be the most significant option for the subsistence farmers if they must thrive in the business of farming. According to Zilberman, Zhao and Heirman (2012), adaptation is the response of economic agents and societies to major shocks such as climate change. Adaptation practices are adjustments intended to enhance resilience or reduce vulnerability to observed or expected changes in climate (IPCC,2001). IPCC (2007) defined adaptation to climate change as an adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. It also refers to all adjustments in behaviour or economic structure that reduce the vulnerability of society to changes in the climate system including its current variability and extreme events as well as longer-term climate change. Adaptation to climate change is imperative to sustain and promote agricultural productivity, and site-specific empirical evidence is needed to facilitate policy making (Roco, Bravo-Ureta, Engler& Jara-Rojas, 2017).

Obayelu, Adepoju, and Idowu(2014) noted that the goal of adaptation to climate change is neither to prevent its negative impacts nor merely clean up after its adverse effects. Rather, it is a long-term resilience, to create the conditions in which the society is largely able to absorb the impacts, such that any residual impact beyond the coping capacity of the society remains within a socially defined acceptable limit of risks. They also noted that adaptation to climate change necessitates that farmers first notice the change, and then identify useful adaptations and implement them. Adaptation measures are widely recognized as a vital component of any policy response to climate change. Brussel (2009) posited that adaptive measures to climatic change in agriculture range from technological solutions to adjustments in farm management or structures and to political changes such as adaptation plans. Smit and Skinner (2002) substantiated that agricultural adaptation options can be categorised into technological development, government programmes and insurance; farm production practices, and farm financial management. At farm level, the practice of organic agriculture is one of the most important measures for adaptation to climate change by farmers. Organic agriculture according to IFOAM (2007) is a holistic production management system which enhances agro-ecosystem health, utilizing both traditional and scientific knowledge. It prevents nutrient and water loss through high organic matter content and soil covers, thus making soils more resilient to floods, drought and land degradation processes.

Some strategies that serve as an important form of insurance against rainfall variability are: increasing diversification by planting crops that are drought tolerant and/or resistant to temperature stresses, taking full advantage of the available water and making efficient use of it, and growing a variety of crops on the same plot or on different plots, thus reducing the risk of complete crop failure since different crops are affected differently by climate changes (Benhin, 2006). Such farm-level adaptations aim at increasing productivity and dealing with existing climatic conditions and draw on farmers' knowledge and farming experience (Enete*et al*.,2011).Adebayo et al. (2011) in their study on Emerging and Indigenous Technology for Climate Change Adaptation in Southwest Nigeria established that the main strategies and technologies promoted by extension officers for farmers to cope with the effects of climate change in southwest Nigeria are; tree planting and timely planting of crops. In the rainforest zone, it is provision of small scale irrigation, mulching especially on yam farms,avoidance of felling of trees and avoidance of bush burning in the swamp zone. In the savanna zone, the main coping strategies and technologies are: avoidance of tree felling, avoidance of bush burning, small scale irrigation and studying weather condition before planting crops.

1.2 Statement of the Problem

The impact of climate change in agricultural productivity is increasingly becoming alarming to agriculturists in Africa and Nigeria in particular. Crop production which is largely subsistence in Africa is constantly being hindered by the substantial effects of climate change. This has affected food prices, food security, land use as observed by Lobell and Field (2007). Kahil, Connor and Albiac (2015) asserted that the severity of climate change impact depends on the degree of adaptation at the farm level, farmers' investment decisions and policy choices. However, farmers are constantly confronted with the challenges of choosing the best adaptation option(s) that will be resilient to the impact of climate change. Moreover, some of the farmers' socio-economic factors may also influence their decisions and choices in adopting relevant adaptation strategies.

Although, there are influx of literatures on climate change and adaptation strategies among farmers in Africa (Maddison, 2007; Deressa et al., 2008; Agabi, 2012; Ozor, et al., 2012;Bosello, Campagnolo &Eboli, 2013;

Umunakwe, Nnadi, Chikaire & Nnadi, 2014;Amusa, Okoye & Enete, 2015; Roco, et al., 2017), stakeholders keep wondering whether these bulk of literatures have effected any significant positive outcome in crop production (Bosello, *et al*., 2013). The current escalation in food prices, decrease in crop yields among farmers, increased poverty among the farming households, and the likes seem to reveal that more studies are needed in this area to proffer feasible solutions to the rural farmers. Moreover, Enete and Onyekuru (2011) observed that much of climatic change agricultural research has tended to concentrate on assessing the sensitivity of various attributes of crop systems (e.g. crop yields, pest, diseases, weeds etc.) – the biophysical aspects of food production, with little or no regard to the socioeconomic aspects. These partial assessments most often consider climatic change effects in isolation, providing little insight into the socio-economic factors influencing farmers' decisions and choices of adaptation strategies and what they are doing to cope with climate change. This could be one of the reasons why the farmers are still facing critical setback in crop production. This therefore, makes this study worthwhile.

1.3 Objectives of the Study

The broad objective of this study was to explore yam farmers' adaptation practices towards climate change disaster in Cross River State, Nigeria. Specifically, the study was meant to:

- Ascertain socio-economic factors influencing the adoption of strategies for mitigating the problems of climate change and variability; and
- Determine the adaptation strategies adopted and intensity of adoption by yam farmers in adjusting to the impacts of climate change on yam production in the study area.

1.4 Hypothesis of the Study

The relevant hypothesis considered was:

H_0: Farmers' socio-economic factors have no significant influence on farmer's adoption of adaptation strategies.

2. Materials and Methods

This study was carried out in Cross River State. Cross River State, lies between latitudes $5^0$32' and $4^0$27' North and longitudes $7^0$50' and $9^0$28' East, bounded in the North by Benue State, in the South-west by Akwa Ibom State, in the West by Ebonyi and Abia States. The State shares an internal frontier to the East with the United Republic of Cameroon, and its Atlantic coastline is to the south, where the Calabar River meets the sea (Cross River State Government of Nigeria [CRSG], 2004). Cross River State has a land area of about 21,787 km^2 and a population of about 2,892,988 people (NPC, 2006). It has the largest rainforest covering about 7,290 square kilometres described as one of Africa's largest remaining virgin forest harbouring as many as five million species of animals, insects and plants (MOFINEWS, 2004).The climate of the area is controlled by two tropical air masses namely the equatorial maritime (MT) air mass, which originates from the South-West and the tropical continent (CT) air mass, which originates from North East (Alobi, 1992), with average temperatures ranging between 15°C - 30°C, and the annual rainfall between 1300 – 3000mm. The high plateau of Obudu experience climatic conditions which are markedly different from the generalized dry and wet period in the rest of Cross River State. Temperatures are 4°C - 10°C lower due to high altitude than in the surrounding areas. Similarly, the annual rainfall figures are higher than in areas around them, particularly on the windward side (CRSG, 2011).

Multi-stage sampling technique was used to select the respondents. This procedure considered the delineation of the study area into agricultural zones by the Cross River Agricultural Development Project (CRADP). These zones are Ogoja Zone, Ikom Zone and Calabar Zone of the state (Adinya, Ibom, Ayuk, Agiopu, Umoh& Umeh, 2008). Each of the agricultural zones comprises six Local Government Areas. At the first stage one Local Government Area was selected randomly from each of the zones. In the second stage, five farming communities were randomly selected from each of the Local Government Areas (making a total of 15 farming communities). In the third stage, 10 respondents (farming households) were finally selected from each of the farming communities making a total of 150 farm households.

Only Primary data were used for the analysis. The primary data were collected with the aid of detailed and well-structured questionnaire administered to the selected yam crop farmers and was complemented by scheduled interview. The questionnaire was designed to capture information on socioeconomic and demographic data like age, gender, household size, size of land holding, etc. In this study, OLS regression was used to achieve objective i. Objective ii was realized using descriptive statistics. T-test statistic was employed to test the hypothesis.

2.1 Model Specification

Ordinary Least Squares (OLS) Regression

The model can be expressed implicitly as:

$$\gamma = \varphi_0 + \varphi \sum_{i=0}^{n} \beta_i + \mu_i -------------------------- 1$$

Explicitly, the OLS equation can be expressed as;

$$\gamma = \varphi_0 + \varphi_1\beta_1 + \varphi_2\beta_2 + \varphi_3\beta_3 + \cdots + \varphi_{18}\beta_{18} + \mu ----------------- 2$$

Where γ = Adoption Index, derived by censoring four (4) and above adaptation strategies practiced by the respondents. The variables and their measurement are thus described:

β_1 = Sex of farmer (1, if male, 0 otherwise)

β_2 = Marital status (1, single; 2, married; 3, widowed; 4, divorced)

β_3 = Age of farmer (years)

β_4 = Level of education (number of years spent in school)

β_5 = Experience in farming (years)

β_6 = Cost due to excessive rainfall (₦)

β_7 = Cost due to extra supply of yam (₦)

β_8= Cost of disease prevention (₦)

β_9= Loss from diseases (₦)

β_{10} = Whether climate change affects agriculture (1 if yes, 0 otherwise)

β_{11} = Access to market(1 if yes, 0 otherwise)

β_{12} = Spray intervals (in number)

β_{13} = Re-spray intervals (in number)

β_{14} = Household size (number of persons)

β_{15} = Member of association (1 if yes, 0 otherwise)

β_{16} = Access to extension facilities (1 if yes, 0 otherwise)

β_{17}= Farm size (ha)

β_{18}= Average annual income of farmer (₦)

μ = stochastic term.

3. Results and Discussion

Objective 1: Socio-Economic Factors Influencing the Adoption of Strategies

To determine socio-economic factors influencing the adoption of strategies to mitigating the problems of climate change on yam production, we employed an OLS regression. The adoption of strategies was censored into two. The respondents that practiced up to 4 and above of the 11 strategies were selected and the results are illustrated in table 1.

Table 1. Results of the socioeconomic determinants of the adoption of strategies

Variable Name	Coefficient	Standard error	t-test	p-value
Sex	0.130559	0.1670936	0.78	0.436
Marital status– single	0.1253903	0.1715602	0.73	0.466
– married	0.1365397	0.1958683	0.70	0.487
– widowed	-0.1056218	0.223144	-0.47	0.637
– divorced	0.1567532	0.3902937	0.81	0.363
Age	-0.2887816	0.1328545	-2.17	0.032
Years in school	0.1481436	0.027326	5.42	0.000
Experience in farming	0.114494	0.0137465	0.83	0.407
Cost due to excessive rainfall	-7.10e-07	0.0000117	-0.06	0.952
Cost due to extra supply of yam	-0.0000146	0.0000139	-1.05	0.294
Cost of disease prevention	1.14e-06	6.44e-06	0.18	0.860
Loss from diseases	9.62e-06	0.0000155	0.62	0.535
Whether climate change affects agriculture	-0.0716991	0.1670935	-0.43	0.669
Access to market	0.3843645	0.2166113	1.77	0.079
Spray intervals	-0.0048456	0.0101822	-0.48	0.669
Re-spray interval	0.01155125	0.0141071	1.10	0.274
House hold size	-0.0594967	0.0374586	-1.59	0.115
Member of association	0.4415376	0.4415376	3.7	0.000

Access to extension facilities	0.6547313	0.1318776	4.96	0.000
Farm size	0.2548498	0.098196	2.6	0.011
Average annual income of farmer	0.377416	0.3049237	1.24	0.218
Constant	-1.640632	3.301837	-0.5	0.620
Prob> chi^2	0.0000			
Pseudo R^2	0.6320			

Table 1 above shows the results of the OLS regression of the censored adaptation strategies practiced with respect to its socio-economic determinants. The OLS regression was tested for its overall significance which is based on the probability and pseudo R^2. The Prob>chi^2 is 0.0000 which shows a high overall significant model as it is not only less than 0.05 as required, but 0.000. Also the pseudo R^2 is equally relatively high at 0.6320. This implies that the independent variables considerably explained the censored dependent variable. Tobit model was employed to further test the predicting power of the independent variable. Figure 1 illustrates the outcome.

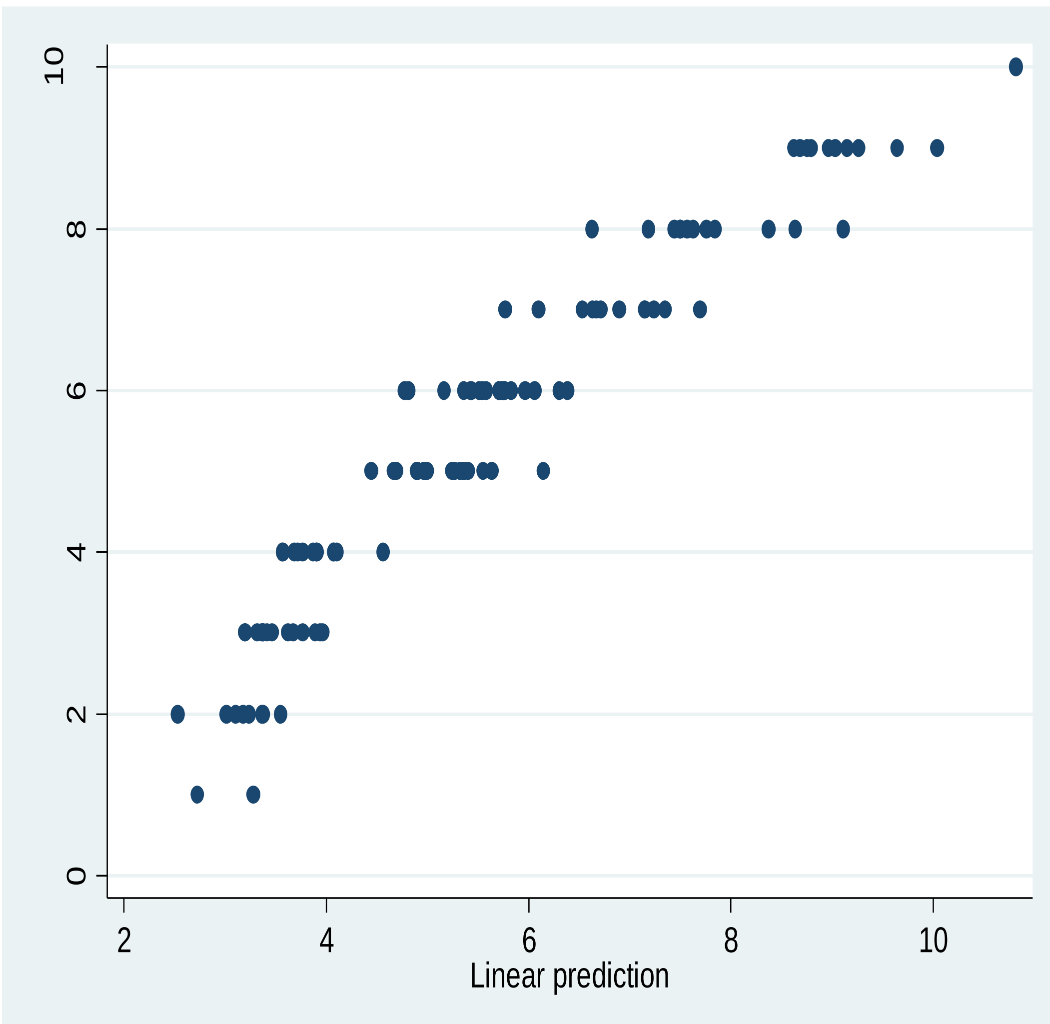

Figure 1. Predicting power of Tobit model

It can be seen in figure 1 that the predicting model is scattered and follows a 45^0 line pattern. This shows an excellent potency of the predicting power of the independent on the censored dependent variables.

Based on the foregoing, the results from table 1 show that sex insignificantly determined farmers' adoption of adaptation practices as its t-statistic is seen to be 0.78 which is less than two. Also, it can be seen from the table that the various categories of marital status do not significantly determine farmers' adoption of adaptation practices as all their t-values are less than two. The table shows that the three categories of marital status; single, married and divorced are positively related with the adoption of adaptation practices, whereas one of the categories; the widowed is negatively related. This means an increase in the number of farmers that are single, married or divorced might increase the intensity of adaptation measures, while an increase in the number of widowed farmers might reduce their adaptation to climate change mitigation measures. Nevertheless, marital status remains an insignificant factor. This finding is noteworthy as it implies that of all the categories of marital status, once a farmer becomes widowed, the likelihood of participating in adaptation practices reduce.

Age happens to be a significant determinant of the practice of climate change adaptation as its t-value is -2.17 (since its absolute value is greater than two). For every unit increase in age there is a 0.2887816 point decrease in the predicted value of adaptation practice. The negative sign suggests an inverse relationship between age and climate change adaptation implying that, the older the farmer is, the less likely he/she is to get involved in adaptation practices. This is not surprising as the effects of climate change has worsened in the last two decades and some of these farmers had been farming without such measures of adaptation, therefore agriculture related organizations should take up the responsibility to sensitize older farmers on the need for climate change adaptation to them and the world at large.

The results also suggest that the more years spent in school by the farmer, the more likely he/she is to participate in adaptation practices. The t-value for years in school is 5.42, which is the highest and most significant of all the independent variables. It is interesting to note that the education system has inculcated the notion and need for climate change adaptation such that farmers with higher educational level are more conscious and actually practice adaptation measures to climate change. For every unit increase in the years spent in school, there is a 0.1481436 point significant increase in the predicted value of adaptation practices.

Among the other independent variables, the results suggest that farmer's experience, cost of disease prevention, loss due to diseases, market access, re-spray intervals, and farmer's income are not significant in determining the ability of a farmer to practice adaptation strategies. However, they are all positively related with adaptation practices; meaning they increase the likelihood that an individual may be involved in adaptation practices. Also, the cost of disease prevention and the loss due to diseases are positively related as they are indicators of climate change effects and so farmers that expend on the disease prevention would be more engaged in climate change adaptation in order to reduce the effect of climate change on their yield. Again, we expect that the higher a farmer's income the more likely he/she should be involved in adaptation practices, though the farmer's income is not significant in determining whether a farmer is highly involved in participation or not.

Finally, we observed that farmers' associations, farmers' access to extension facilities and the farm size are significant positive determinants of adaptation practices with t-values that are 3.7, 4.96 and 2.6 respectively. This is interesting to note, as it implies that associations play a significant role in determining farmer's participation in adaptation practices. Many more of such associations should be encouraged in different products and in other states nation-wide to encourage climate change adaptation. Also access to extension facilities is also significant in determining adaptation practices and this should therefore be promoted by policy makers and implementers. Farm size is also significant in determining adaptation practices. This is expected because farmers with larger farm size should be more encouraged in using adaptation practices than the small farm owners in the study area.

On the other hand, the results show that the cost due to excessive rainfall, cost due to extra supply of yam seeds, spray intervals, and household size are all negatively related and not significant determinants of adaptation practices.

Hypothesis Testing

H_0: Socio-economic factors do not have influence on farmer's adoption of adaptation strategies.

Variables such as sex, marital status, experience, cost due to excessive rainfall, cost due to extra supply of yam, cost of disease prevention, loss due to diseases, access to market, spray intervals, re-spray intervals, household size and income of farmer were not significant. We therefore fail to reject the null hypothesis and conclude that socio-economic factors do not have any significant effect on climate change adaptation practices.

Objective 2. Adaptation Strategies Adopted by Yam Farmers in Adjusting to the Impacts of Climate Change on Yam Production

In order to determine the adaptation strategies adopted by yam farmers in adjusting to the impacts of climate change on yam production in the study area, descriptive statistics was adopted. The results are presented in table 2.

Table 2. Adaptation strategies adopted by yam farmers

Variable Name	**Dummy**	**Proportion**	**Percentage (%)**
Multiple cropping/ varieties	0	0.0785714	7.8
	1	0.9214286	92.1
Land fragmentation	0	0.6857143	68.6
	1	0.3142857	31.4
Use of alternative fallow practices	0	0.8857143	88.6
	1	0.1142857	11.4
Multiple planting dates	0	0.2785714	27.9
	1	0.7214286	72.1
Irrigation practice types	0	0.5428571	54.3
	1	0.4571429	45.7
Crop diversification	0	0.2285714	22.9
	1	0.7714286	77.1
Mulching	0	0.6071429	60.7
	1	0.3928571	39.3
Cover cropping	0	0.3928571	39.3
	1	0.6071429	60.7
Fertilizer application	0	0.3928571	39.3
	1	0.6071429	60.7
Organic manure	0	0.7571429	75.7
	1	0.2428571	24.3
Planting of trees	0	0.7285714	72.9
	1	0.2714286	27.1

This study considered eleven adaptation practices and the dummy variable represents; 1 for farmers that adhered to the practice of each of the listed adaptation practices and 0 otherwise. The table above shows that the major proportion (0.9214286) of the farmers that were interviewed practiced multiple cropping; few of the farmers with a proportion of 0.3142857 practiced land fragmentation, very little proportion of the farmers (0.1142857) practiced the use of alternative fallow practices. A large proportion (0.7214286) of the farmers adopted multiple planting dates, a substantial proportion (0.4571429) practiced irrigation, another large proportion (0.7714286) of the farmers practiced crop diversification and lesser proportion (0.3928571) practiced mulching. The table also shows that an ample proportion of 0.6071429 practiced cover cropping and fertilizer application. A little proportion (0.2428571) of them applied manure and 0.2714286 proportion of the farmers planted trees. The table therefore suggests that multiple cropping was the highest practiced climate change adaptation measure with about 92.1% of the farmers practicing it, closely followed by crop diversification (77.1%) and those that used multiple planting dates (72.1%). On the other hand, the least practiced adaptation strategies by the farmers were use of organic manure (24.3%) and use of alternative fallow practices (11.4%). The intensities of the adaptation practices are better revealed in the bar chart in figure 1 below.

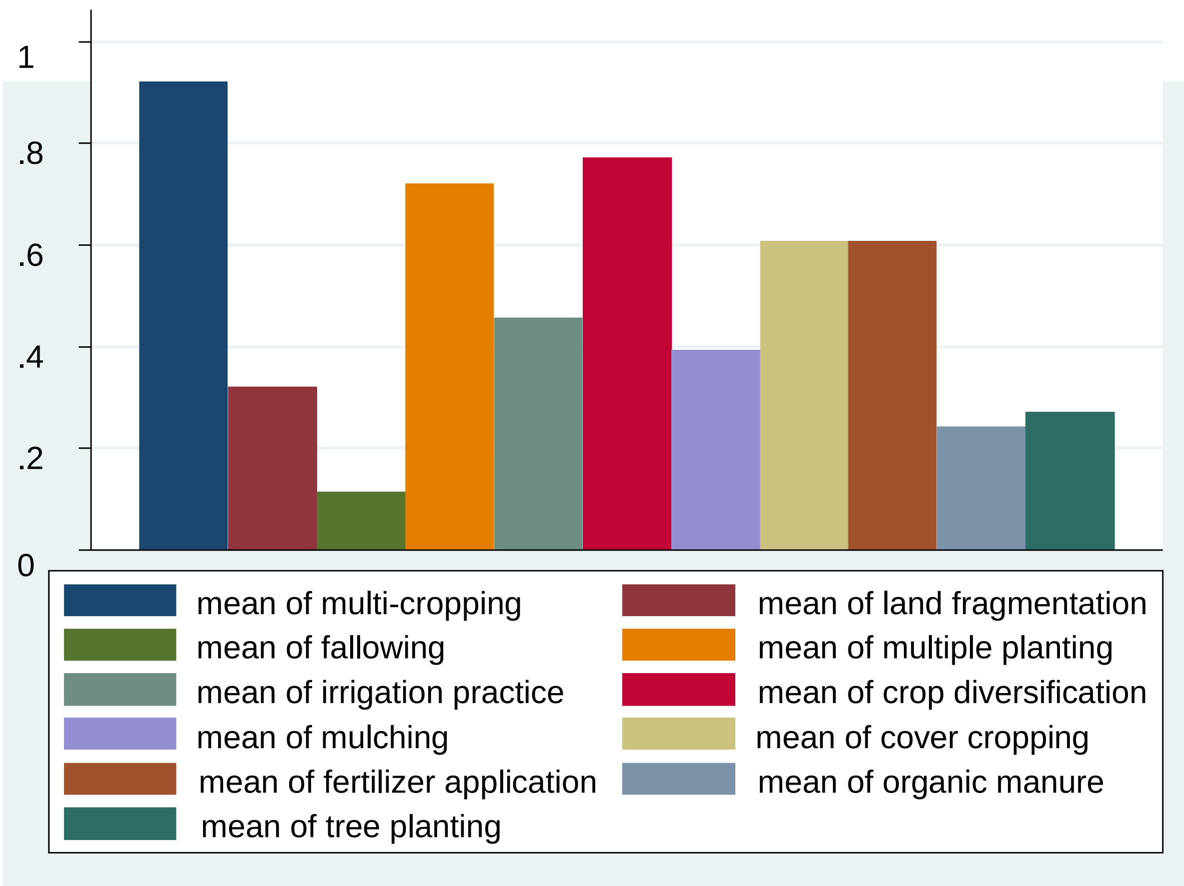

Figure 2. Means of the proportion of yam farmers practicing the adaptation practices

Based on the means (averages) of adaptation practices, it becomes apparent from figure 2 that multiple cropping seems to be the highest practiced measure, followed by crop diversification and then the multiple planting dates. On the other hand, the use of fallowing appears to be the least practiced measure by the farmers, followed by mulching and tree planting as shown in the figure 2above. Still in an attempt to get a clearer picture of the contribution of each adaptation strategy the study used a pie chart to illustrate the findings as shown in Figure 3.

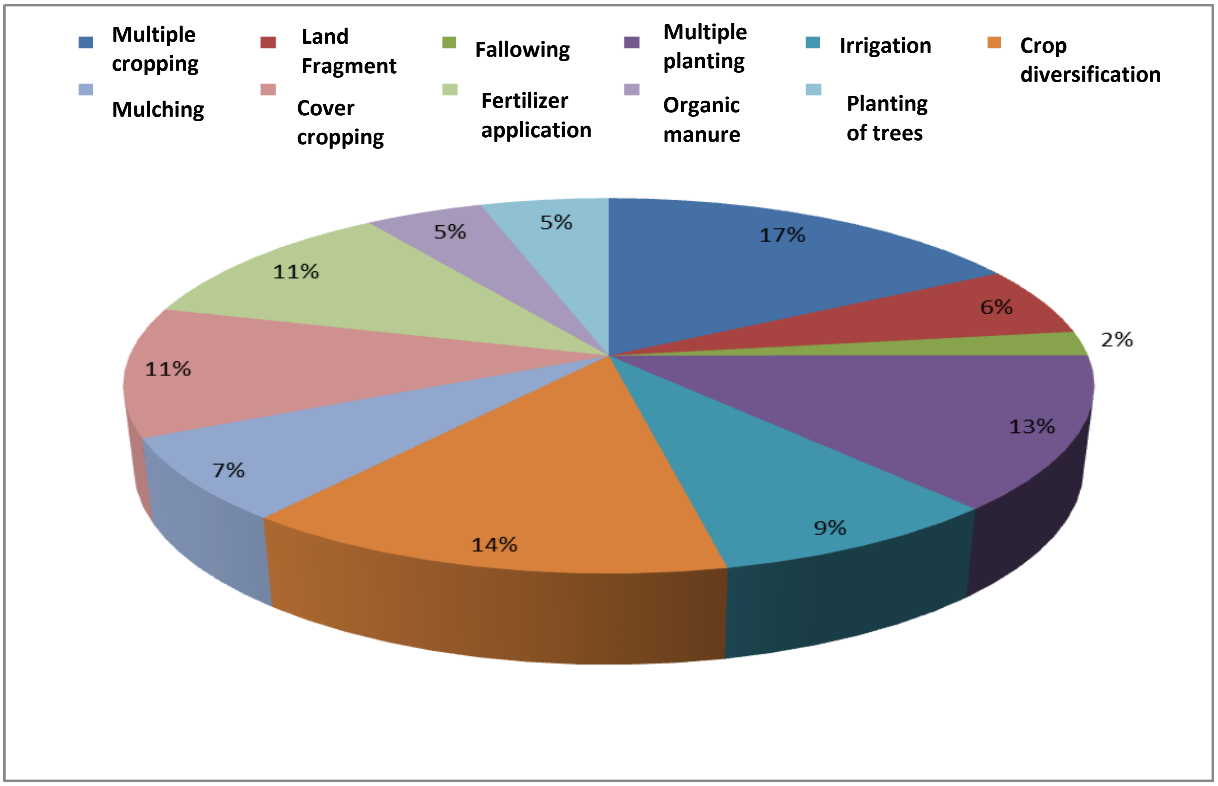

Figure 3. Pie Chart for Adopted Cropping strategies

The pie chart above (figure 3) shows that multiple cropping contributes 17% of the climate change adaptation strategies practiced by the farmers, 14% of the farmers practiced crop diversification, while 13% of the farmers practiced multiple planting dates. Cover cropping and fertilizer application was practiced by 11%, 9% practiced irrigation practices, 7% practiced mulching, 6% practiced land fragmentation. Also, planting of trees and organic manure was adopted by a very low percentage (5%) of the farmers followed by use of fallowing which was practiced by negligible proportion (2%) of the farmers which is relatively very poor as well. This implies that government and non-governmental organizations that are interested in the adaptation of climate change should encourage farmers to be involved in more of these practices.

4. Conclusion and Recommendation

The study shows that some of the farmers' socio-economic variables such as; age, number of years in school, farmer's membership in associations, access to extension facilities and hectarage of farm land are significant determinants in a farmer's practice in climate change adaptation identified to be driving farmers' practice of climate change adaptation practices.

This study also shows that majority of the farming households use different adaptation strategies to combat the deleterious effects of climate change on the farm operations. The results of the mean values established that the key strategies adopted by farmers in the area in order of relatively high intensity were; multiple cropping, crop diversification and multiple planting dates. Fallowing was the least strategy adopted by farmers in the area of study.

Based on the findings of this study, the following recommendations were made:

- The farmers should organize sensitization programs and outreach in their various communities and educate themselves on the more effective measures (such asmulti-cropping, crop diversification and cover cropping) to employ in their adaptation attempt.

- Agricultural Programs such as Value Chain Development Program (VCDP) need to visit the farmers in the study area and assist the farmers to review their adaptation practices from time to time to ensure consistent positive effect of these strategies on yam production in the study area.
- Agricultural policy makers should encourage widowed farmers to adopt the key adaptation practices.

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