Assessment of Climate Change Vulnerability and Adaptation among Smallholder Cocoa Farmers in Osun State, Nigeria

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Abstract: Climate change is among the factors that pose serious threats to sustainable cocoa production in Nigeria. This paper analyzed farmers' vulnerability and adaptation to climate change in Osun state. A total of 125 cocoa farmers were sampled using multi-stage sampling method. Data were analyzed with Factor Analysis (FA), descriptive statistics and Ordinary Least Square (OLS) regression. The results show that farmers in the oldest age group (≥ 70 years) have the highest average climate change vulnerability index (0.2790) and the youngest group (< 30 years) had the highest average climate change adaptation index (0.8378). Illiterate farmers and those that could not complete primary education had the highest vulnerability index (0.1504) and lowest average adaptation index (-0.3489). Households with less than 5 members had average vulnerability index of 0.2666 and average adaptation index of -0.3044. Farmers that planted cocoa as primary crop and those whose primary occupation was farming had low average vulnerability indices of -0.0389 and -0.0312, respectively. Cocoa farmers with extension contacts also had lower vulnerability to climate change. The regression results show that households' dependency ratio significantly increased climate change vulnerability ($p<0.05$), while access to extension services and television significantly reduced it ($p<0.01$). Adaptation to climate change significantly reduced ($p<0.05$) with dependency ratio and sickness of household members. It was concluded that integration of adequate climate change information into the mechanisms of agricultural extension delivery systems will assist in reducing cocoa farmers' vulnerability to climate change.
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Introduction

The importance of cocoa for foreign exchange generation in Nigerian economy cannot be overemphasized. In 1890, the crop was first cultivated in the then western region of Nigeria. Since then, its cultivation has become prominent as a major cash crop with the country attaining second highest global production in 1965. Recently, cocoa production in Nigeria has experienced significant stagnation, and many factors are responsible. Smallness of farm holdings, inadequate road, depleting farm labour, low capital investment and unfavourable climatic change are among the notable contributory factors (Oyekale, 2012).

Because of its sensitivity to some critical weather situations, cocoa production is largely affected by unfavourable climate. Available data have shown that cocoa production in Nigeria was 280,000 metric tonnes in 2009 with a forecast of 300,000 metric tones for 2011/2012 due to expected favourable climate. Specifically, Nkang *et al* (2009) noted that in Cross River state, young school leavers were encouraged by some corporate organizations to take a career in cocoa farming. Gyampoh *et al.* (2008) also submitted that due to rehabilitation of old cocoa farms, cocoa farmer support services in the form of production education, introduction and availability of seedlings of improved cocoa varieties and farmers' compliance with chemical usage, cocoa yields are bound in modestly increase in the nearest future.

Changes in the pattern of rainfall are having unfavourable impacts on cocoa production due to prevalence of pest and diseases and death of cocoa trees. In many instances, the beginning of rainy season can no longer be accurately predicted. Even when it starts on time, there have been cases of sudden stoppage of rainfall that have constituted serious production shocks with obviously adverse consequences. Also, farmers can no longer fairly predict accurately when crops will be due for planting and what quantity of harvests to expect.

The impact of climate change is more pathetic for cocoa farmers due to sensitivity of the crop to weather vagaries. Specifically, every stage of cocoa development requires favourable climate for optimum performance. As a matter of fact, too high rainfall promotes incidence of black pod disease, which normally accounts for the bulk of annual production losses. It should also be emphasized that high incidence of black pod disease raises cocoa production cost through increased chemical usage and labour cost. Reduction in sunlight hours is also inimical to cocoa production because black pod disease and other pests are largely promoted under too high humidity. Some pathogens and pest can as well adjust to host resistance through genetic mutation. This often results in complete resistance to chemical control, thereby constituting more havocs to cocoa pods and trees. Specifically, Davis (2010) submitted that drastic reduction in sunlight hours is able to adversely affect the growth of cocoa trees and yields. In addition, effective drying of cocoa beans becomes very difficult if sunshine hours reduce. This ultimately affects the quality of processed cocoa beans and generated revenues.

The impact of climate change on cocoa agriculture also poses additional social cost because cocoa agro-forestry responds adequately to the goals of environmental conservation through reduction in soil erosion. The implication is that if coca farmers are unable to grow the crop due to inadequate climate, such environmental conservation matrix which has served in protecting many of Nigeria's fragile ecological systems over the past few decades will be broken. Cocoa is a very important source of income for many farmers in the cocoa producing states. The subsector also generates some form of employment on-farm and off-farm. This is in addition to being an important source of foreign exchange to the Nigerian government. Precisely, cocoa beans are exported to developed countries where they are transformed into products like cocoa butter, cocoa wine, cocoa powder, among others (Akinwale, 2006). Devising adequate coping strategies to mitigate the impact of climate change on cocoa production is therefore imperative given its central importance in rural economy. Also, understanding the extent of farmers' vulnerability and the adaptation methods can trigger means of assisting the farmers through some marginal reforms.

Materials and Methods

Area of study and sampling procedures

The study was carried out in Osun State in the south western part of Nigeria. The state was separated from the old Oyo State on 27th August 1991. The study made use of data that were obtained from primary source. The source involves the use of structured questionnaire which were administered directly to the farmers by trained enumerators. The questionnaire has four parts, the first dealt with the socio-economic characteristics of respondents, the second part dealt with cocoa farm inputs and outputs, the third dealt with climate change, vulnerability and cocoa agriculture while the forth dealt with farmers' household assets and consumption. The multi-stage random sampling method was used for selecting the respondents. The first stage involved random selection of the local government areas (LGAs) where the data were collected. At the second stage, cocoa growing villages within the LGA were randomly. Within the selected villages, households were randomly selected. A total of 125 farmers were interviewed from Aiyedaade Local Government (43), Irewole Local Government (31), Isokan Local Government (25) and Atakunmosa West Local Government (26). Table 1 shows the distribution of the villages in the sampled LGAs. It shows that 20.8 percent of the respondents were from Osu village, 16.0 percent were from Araromi village, 15.2 percent were from Ayepe village, 12.0 percent from Orile Owu village, 9.6 percent from Odeyinka village, 8.0 percent from Bembe village, 7.2 percent from Ayetoro, 6.4 percent from Mokore village, and 4.8 percent from Oja-Oba.

Table 1: Distribution of respondents in the sampled villages

Villages	Frequency	Percentage
Araromi	20	16.00
Ayepe	19	15.20
Ayetoro	9	7.20
Bembe	10	8.00
Mokore	8	6.40
Odeyinka	12	9.60
Oja Oba	6	4.80
Orile Owu	15	12.0
Osu	26	20.8
Total	125	100

Source: Field Survey 2011

Analytical Techniques

The data collected for this study were analyzed using some descriptive statistical techniques such as frequency counts, percentages, mean etc. Factor Analysis and Ordinary Least Square (OLS) regression were also used for data analysis. The Factor Analysis was used to construct indices of climate change vulnerability and adaptation using information that were obtained on those weather variables that recently had adverse welfare impacts on the farm households. The questionnaire was designed to retrospectively seek for the impact of extremely high temperature, extremely low temperature, too much rainfall, too low rainfall, delay in rainfall commencement, delay in rainfall stopping and stormy rainfall on the households. The choice of composite vulnerability index was inspired by the nature of the data since it probed into 2009, 2010 and 2011 and the fact that the weather attributes are seven. It was therefore resolved to have a composite vulnerability index that can vividly portray the extent of vulnerability of the households using the factor analysis (FA).

We also constructed indices of adaptation using information that was obtained on the coping options that were used by the farmers which include diversifying into growing other crops and involving themselves in non-farm activities, monitoring weather change by indigenous knowledge or through the media, regular cocoa spraying, credit support from friends and relatives, migration and increasing the intake of alcohol and cigarette. The choice of composite adaptation index was inspired by the nature of the data probing into 2009, 2010 and 2011. It was therefore resolved to have a composite adaptation index that can estimate the level of adaptation of the farmers to climate change over the periods that the data probed into.

Regression Analysis

We subjected the computed vulnerability and adaptation indices to further parametric analysis using the Ordinary Least Square (OLS) method. This is to explore the correlates of climate change vulnerability by estimating the specified equation:

$$V_j = \alpha + \beta_i \sum_{i=1}^{n} X_j + \varepsilon_i \quad .1$$

$$A_j = \omega + \eta_i \sum_{i=1}^{k} X_j + \rho_i \quad .2$$

With α, ω, η_i and β_i being the estimated parameters and ε_i and ρ_i are the error terms. The X_js are the explanatory variables with sex (male -1, 0 otherwise), years of education,, household size, dependency ratio (number of household members that are less than 15/Number that are more than 15 years old), age of household head (years), cocoa as primary crop (yes = 1 , 0 otherwise), primary occupation is faming (yes= 1,0 otherwise), number of time the farmer was sick during the cropping season, malaria as a major sickness during the cropping season (yes =1, 0 otherwise), missed cocoa spraying due to illness (yes =1,0 otherwise), number of cocoa farms, farm ownership type (personal =1,0 otherwise), cocoa land area (acres), proportion of land covered with cocoa (percentage), age of cocoa trees (years), years of cocoa farm rehabilitation, cocoa farm distance to village (miles), number of cocoa sprayers owned by the farmer, climate affects health (yes =1,0 otherwise), ownership of radio (yes =1,0 otherwise), ownership of television (yes =1,0 otherwise), ownership of motorcycle (yes =1,0 otherwise), ownership of bicycle (yes =1,0 otherwise), ownership of vehicle (yes =1,0 otherwise), ownership of mobile phone (yes =1,0 otherwise), access to extension services (yes =1,0 otherwise) and cocoa market distance (miles).

Results and Discussions

Socio-economic profiles of cocoa farmers across their climate change vulnerability and adaptation

Table 2 shows the age distribution of the farmers. It shows that majority of the farmers (35.20 percent) were 60 years or more old. Also, a total of 21.60 percent were in the age brackets of 50<60 years. This clearly shows that the cocoa farming population is ageing. The table also shows the indicators of vulnerability and adaptation with respect to farmers' age groups. The vulnerability distribution across age group shows that the farmers within age groups of 35<40 years, 45<50 years and ≥70 years were more vulnerable to climate change with average vulnerability indices of 0.2629, 0.2380 and 0.2790, respectively. The results also show that farmers that were aged are highly vulnerable to climate change. This may have resulted from different ways they might have been affected by climate change. For instance, aged farmers may have some health challenges that may be triggered by adverse climatic situations. Also, in terms of responding to cocoa production challenges, aged farmers may be unable to cope with disease incidence and pest infestation resulting from climate change. The results also show that farmers in the middle age were highly vulnerable to climate change. This can be explained from different reasons not probed into by the study. For instance, there are several issues underlying climate vulnerability which may really go beyond farm characteristics and access to production resources.

The results further show that farmers within the age groups of 30<35 years, 35<40 years, 50<55 years, 55<60 years, 65<70 years and ≥ 70 years had very low average adaptation indices of -0.1774, -0.0804, -0.0681, -0.2398, -0.8388 and -0.1840 respectively. The group of the youngest farmers (< 30 years) had the highest average climate change adaptation index of 0.8378. Also, farmers in the age groups of 40<45 years and 45<50 years had average adaptation indices of 0.2079 and 0.3876, respectively. The results show a diverse pattern of vulnerability and adaptation to climate change with respect to age groups.

Table 2: Cocoa farmers' climate change vulnerability and adaptation indices across age

Age group	Frequency	% Frequency	Vulnerability		Adaptation	
			Mean	Std. Dev.	Mean	Std. dev.
< 30	9	7.20	-.4082	0.6315	0.8378	1.5670
30 < 35	11	8.80	-0.540	0.9302	-0.1774	1.1629
35 < 40	11	8.80	0.2629	0.8219	-0.0804	1.4574
40 < 45	12	9.60	-0.0651	0.8030	0.2079	1.5668
45 < 50	11	8.80	0.2380	1.0360	0.3876	1.9787
50 < 55	17	13.60	-0.1415	0.7979	-0.0681	1.4308
55 < 60	10	8.00	-0.1616	0.9076	-0.2398	1.0013
60 < 65	13	10.40	-0.1827	0.7255	0.2839	1.4979
65 < 70	9	7.20	-0.0223	0.8314	-0.8388	1.2836
≥ 70	22	17.60	0.2790	0.8771	-0.1840	1.7544
Total	125		0.0000	0.84119	0.0000	1.51541

Source: Field Survey, 2011

Table 3 shows the results of cocoa farmers' vulnerability and adaptation to climate change with respect to their years of education. The results show that majority of the farmers (66.40 percent) either had no formal education or could not complete secondary education. Only 8.8 percent had tertiary education with fifteen years or more spent on schooling. Furthermore, those farmers that had either no education or unable to complete primary education have the highest vulnerability index (0.1504) and also able to least adapt with average adaptation index of -0.3489. This may have also resulted from several other socio-economic challenges that are associated with illiteracy. Also, farmers that spent fifteen years or more in school were vulnerable to climate change, but also with positive average adaptation index. This can be explained from engagement of most of those farmers in other primary employment. Majority of them leased out their farms to some workers for cocoa output sharing but absence of some of these people from the farm made it difficult to obtain total job commitments from the labourers. Also, the farmers with six to nine years of schooling were not so vulnerable but adapted to climate change. The table also reveals that farmers with ten to fourteen years of schooling had low average climate change vulnerability and adaptation indices.

Table 3: Distribution of vulnerability and adaptation indices across household heads' education

Year of Schooling	Frequency	% Freq	Vulnerability		Adaptation	
			Mean	Std. dev.	Mean	Std. dev.
0 – 5	40	32.00	0.1504	0.87898	-0.3489	1.69673
6 – 9	43	34.40	-0.0804	0.79482	0.3704	1.52640
10 – 14	31	24.80	-0.1025	0.85927	-0.1832	1.43226
≥ 15	11	8.80	0.0562	0.85937	0.3371	1.07814
Total	125	100.00	0.0000	0.84119	0.0000	1.51541

Source: Field Survey, 2011

Table 4 shows the results of climate change vulnerability and adaptation with respect to farmers' household size. The table shows that 85.60 percent of the respondents had more than six household members. This is expected in rural areas where family members form a pool of labour for agricultural production activities. Farmers with members less than 5 people or exactly five had high average vulnerability index (0.2666) and low average adaptation index (-0.3044). Farmers with household size between six and ten had low average climate change vulnerability index (-0.0646) and adaptation index (-0.0238). Farmers with more than ten family members had average climate change vulnerability index of 0.0084 and with average adaptation index of 0.2530. In summary, small and big families were vulnerable to climate change as against medium size (6-10) families. However, the results show that cocoa farming households with large family sizes possessed higher climate change adaptation capacities.

Table 4: Distribution of vulnerability and adaptation by household size

Household Size	Freq	% Freq	Vulnerability		Adaptation	
			Mean	Std. dev.	Mean	Std. dev.
≤ 5 (Small)	18	14.40	0.2666	0.81097	-0.3044	1.78177
6 – 10 (medium)	78	62.40	-0.0646	0.82747	-0.0238	1.43681
≥ 10 (Big)	29	23.20	0.0084	0.89110	0.2530	1.56139
Total	125	100.00	0.0000	0.84119	0.0000	1.51541

Source: Field Survey, 2011

Table 5 shows that 56.80 percent of the respondents had less than 30 years cocoa growing farming experience. The results also show that average vulnerability indices of farmers with between 20 and 40 years experience and more than 50 years are high. Generally, the result shows a diverse pattern of vulnerability and adaptation to climate change as regards farmers' years of farming.

Table 5: Distribution of vulnerability and adaptation indices by farming experience

Year of Farming	Freq	% frequency	Vulnerability		Adaptation	
			Mean	Std. dev.	Mean	Std. Dev.
< 10	13	10.40	-0.01668	0.84593	0.3243	1.20879
10 - 20	33	26.40	-0.1562	0.80642	-0.1596	1.19667
20 - 30	25	20.00	0.0780	0.85403	0.1760	1.32535
30 - 40	18	14.40	0.1102	0.84336	0.1689	2.15709
40 - 50	11	8.80	-0.0844	0.91066	0.1837	1.60984
50 - 60	12	9.60	0.1487	0.85245	0.1021	1.91454
> 60	13	10.40	0.1947	0.91693	-0.7410	1.37775
Total	125	100.00	0.0000	0.84119	0.0000	1.51541

Source: Field Survey, 2011

Table 6 shows the results of vulnerability and adaptation among farmers with cocoa being the primary crop. The results show that farmers that planted cocoa as primary crop had low average vulnerability index of -0.0389. These farmers also had low average adaptation index of -0.0514. However, those farmers that did not plant cocoa as primary crop had high average vulnerability index, although their average adaptation index was also high. The table also shows that respondents that were not primarily into farming had higher average vulnerability and adaptation indices than those that are primarily farmers. Also, those with agricultural extension contacts had lower vulnerability and adaptation indices to climate change. This may have resulted from extension services in the form of information on climate change.

Table 6: Distribution of vulnerability and adaptation indices with cocoa as primary crop, primary occupation and extension contacts

Cocoa Primary Crop	Freq	Vulnerability		Adaptation	
		Mean	Std. dev.	Mean	Std. dev.
Primary crop is cocoa					
No	15	0.2851	0.88400	0.3772	1.37340
Yes	110	-0.0389	0.83181	-0.0514	1.53231
Farming is Primary occupation					
No	25	0.1248	0.92160	0.3495	1.53373
Yes	100	-0.0312	0.82188	-0.874	1.50584
Extension contacts					
No	67	0.1260	0.86612	0.1169	1.64803
Yes	58	-0.1455	0.79407	-0.1351	1.34771

Source: Field Survey, 2011

Parametric Analysis of Determinants of Cocoa Farmers' Vulnerability and Adaptation to Climate Change

Table 7 shows the diagnostic statistics of the linear regression model. The model produced a good fit for the data and 23 percent of the variations in the vulnerability indices of the cocoa famers were jointly explained by the independent variables. Also, the table shows that four out of fourteen explanatory variables in the model significantly influenced cocoa farmers' vulnerability to climate change. Two variables have positive effect on vulnerability to climate change. These are dependency ratio and possession of radio. This implies that having more dependents increased vulnerability of cocoa farmers to climate change. This is expected because these dependents may not be able to add significantly to the pool of family labour. Also, the fact that they are largely children may imply higher frequency of falling sick in the event of adverse climatic situations. Also cocoa farmers that owned radio had higher climate change vulnerability. This is not expected if radio stations have programmes that educate farmers on climate change and vulnerability.

However, possession of television and contact with extension agent reduced vulnerability. These findings are expected, and point at the need to explore television programmes and extension contacts for educating farmers more on climate change management in relation to cocoa production.

Table 7: Determinant of cocoa farmers' vulnerability to climate change

Variables	Coefficient	Standard error	P> /t/
Age	.0082908	.006698	0.218
Years of schooling	-.0119019	.0158702	0.455
Depreciation ratio	.2541751	.0982949	0.011**
Years of cocoa farming	-.0060463	.005828	0.302
Cocoa farming as Primary Occupation	-.0636057	.2675789	0.813
Primary Occupation	-.0926491	.2204286	0.675
Malaria	-.1755946	.159554	.274
Other type of sickness	.1425806	.1655111	0.391
Radio	.8481372	.3775079	0.027**
Television	-.5468726	.1798916	0.003***
Vehicle	.4019646	.2466037	0.106*
Motorcycle	.2056491	.166715	0.220
Extension agent	-.2654584	.1501896	0.080*
Distance market	.0073166	.0179053	0.684
Constant	-.792864	.5445089	0.148

Note: *** Statistical significance at 1% ** Statistical Significance at 5% * Statistical Significance at 10%.
Source: Field Survey, 2011

Table 8 shows the factors explaining climate change adaptation indices of cocoa farmers. It shows that the model produced a good fit for the data and 35 percent of the variations in adaptation indices was explained by the independent variables. Also, two out of the explanatory variables significantly influence cocoa farmer adaptation to climate change. These are dependency ratio at $p<0.10$ and the farmers being sick ($p<0.05$). Furthermore, these two variables have negative effect on adaptation of the farmers to climate change. This implies that incidence of illness reduces the rate at which this farmer will be able to adapt to the effect of climate change. This is expected because sick farmers" adaptation will reduce due to resource diversion, labour days reduction and the need for care-giving by adult males or females.

Conclusion

The study examined the vulnerability and coping options among cocoa farmers in Osun State, Nigeria. Agricultural production is directly linked to favourable climate. The short term implications of climate change are to be greatly felt by farmers, majority of which depend on one form of weather variable or the other for productivity. The study showed that farming households were vulnerable to climate change due to the presence of many dependents, farming as primary occupation and low educational levels. It is therefore recommended that government should create more awareness about climate change. This can be in form of intensive media involvements to provide weather forecast and other useful information. Government should also provide functioning health care delivery system that can adequately respond to health problems arising from unfavourable weather. Adequate extension efforts should be channeled towards assisting farmers on climate change problem. Government should also encourage the youths to go into cocoa farming because cocoa farm populations are ageing.

Table 8: Determinant of Cocoa Farmers' Adaptation to Climate Change

Variables	Coefficient	Standard error	P> /t/
Sex	1.159289	1.102564	0.295
Age	-.0088697	.0127145	0.487
Years of school	-.0035954	.0302406	0.906
Depreciation ratio	-.5373836	.1847383	0.004*
Years of cocoa farming	-.0072407	.0113161	0.524
Cocoa farming as Primary Occupation	-.2579336	.4995076	0.607
Primary Occupation	-.2746337	.4122497	0.507
Malaria	.3822687	.2983426	0.203
Other type of sickness	-.7668788	.313136	0.016**
Radio	.3515885	.7052627	0.619
Television	-.419917	.3450593	0.903
Vehicle	-.0717737	.4760518	0.880
Motorcycle	-.0717737	.4760518	0.899
Mobile phone	.0097181	.3520579	0.978
Extension agent	-.2087987	.2851461	0.466
Distance market	.0236484	.0335502	0.482
Constant	.2863901	1.505839	0.850

Note: ** Statistical significance at 5% * Statistical Significance at 10%.
Source: Field Survey, 2011

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