Original Research Article

ANALYSIS OF CLIMATE ADAPTATION STRATEGIES AND CONSTRAINTS FACED MY COCOA FARMERS IN CROSS RIVER STATE, NIGERIA.

ABSTRACT

This study analysis the climate adaptation strategies and constraints faced my cocoa farmers in cross river state, Nigeria, using the factor analysis. This study identifies three major climate change adaptation strategies used by cocoa farmers, explaining 72.4% of the variance in the dataset. Factor 1 (crop management) includes practices like changing planting dates, drought-resistant varieties, and crop diversification. factor 2 (water and soil conservation) focuses on irrigation, mulching, shade trees, and contour farming. Factor 3 (institutional and financial strategies) highlights training programs, weather forecasts, credit access, and collaboration. These strategies demonstrate farmers' proactive efforts to manage climate risks through a combination of on-farm practices, resource management, and external support systems. The study also identifies key constraints faced by cocoa farmers in adapting to climate change using factor analysis. Two main factors explain 94.3% of the variance. Factor 1, (representing institutional, economic, and resource constraints), includes issues like price volatility, lack of mechanization, poor infrastructure, and limited access to technology, which hinder adaptation efforts. Factor 2 (social and organizational challenges), highlights challenges such as resistance to change, lack of training, ineffective cooperatives, and financial constraints. These barriers reduce productivity, limit resilience, and stall adaptation. The study calls for improved infrastructure, government support, cooperatives, and training to enhance farmers' capacity for climate adaptation.

Keywords: Climate change, adaption, constraints, cocoa farmers.

1. INTRODUCTION

Cocoa production is a critical economic activity and source of livelihood for many rural households in Cross River State, Nigeria. During the country's early post-independence period, from the 1950s to the mid-1960s, cocoa exports were the foundation of the nation’s economy. By the 1950s, Nigeria had emerged as a leading global cocoa exporter, with exports surpassing 280,000 tons and contributing approximately 30% of its foreign exchange income (Kehinde, Adeola, and Molatokunbo, 2022). Cocoa is generally known to be a tropical tree crop, part of the evergreen family that is used in a wide range of industries including food and drinks, cosmetics, and pharmaceuticals (Oniah, 2023). It is a valuable commodity with a wide range of applications in numerous products, owing to its nutritious qualities and adaptability.

Agricultural activities face significant risks, with climatic risks being the most critical due to their unpredictability and inevitability. The Agricultural sector is progressively threatened by the adversative impacts of climate change, including rising temperatures, erratic rainfall patterns, prolonged droughts, and the occurrence of extreme weather events, (Wikipedia, 2021). However, this challenges not only reduce cocoa yields but also worsen the socioeconomic vulnerability of farming communities relying on this cash crop. Although numerous climate change adaptation strategies have been introduced to mitigate these impacts yet their adoption by cocoa farmers remains limited.

Yengoh (2010) highlighted soil conservation techniques, such as planting shade trees, mulching, and contour farming, as adaption strategies used my farmers in preventing soil erosion and retaining moisture, making farms more resilient to extreme climate conditions. Factors such as limited access to information, inadequate financial resources, weak institutional support, and socio-cultural barriers hinder the effective uptake of these strategies (Nguyen, Beukes, Huber, & Rohrer, 2017). However, Cross River State lacks comprehensive data on the specific constraints faced by cocoa farmers which complicates the efforts to design and implement sustainable solutions tailored to their needs.

Given the significance of cocoa farming to the economy of Cross River State and the livelihoods of its people, it is imperative to analyze the adaptation strategies currently employed by cocoa farmers and identify the key constraints limiting their adoption. Addressing these challenges is essential for enhancing the resilience of cocoa farmers to climate change, safeguarding their productivity, and ensuring the long-term sustainability of the cocoa industry in the region.

2.0 METHODOLOGY

2.1 Study Area

This study was conducted in cross river state, Nigeria, a Niger delta state bordering Benue state to the north, Ebonyi and Abia to the west, Akwa Ibom to the south, and Cameroon to the east. the state spans 20,156 km², located between latitude 4˚15'n and 7˚00'n and longitude 7˚15' e and 9˚30' e. it is part of the tropical rainfall belt with seasonal and heavy rainfall, experiencing a humid tropical climate with 1300-3000 mm of annual rainfall and a mean temperature of 30°c, except for the sub-temperate Obudu plateau (15-23°c). emerging industries, such as manufacturing, mining, and hospitality, drive employment and economic diversification. agroecologically, the state is divided into Calabar, Ikom, and Ogoja agricultural zones. it has a robust agricultural sector that produces cocoa, oil palm, groundnut, cassava, yams, vegetables, and fruits, supported by fertile soils and a favorable climate, contributing to food security and economic stability.

2.2 Sources and methods of data collection

Data for this study was collected from primary source. The primary data was collected through the use of structured questionnaires. Data was collected on adaptation strategies employed by cocoa farmers to mitigate the effect of climate change on cocoa output as well as constraints related to climate change adaptation. Personal visits were also made to some of the farmers to attest to the validity of the information provided by the respondents in the questionnaire.

2.3 Sampling technique

A multistage sampling technique was employed to select respondents for this study. The eighteen (18) Local Government Areas (LGAs) constituting the state were stratified into three agricultural zones: Calabar, Ikom, and Ogoja. In the first stage, a purposive sampling technique was used to select LGAs based on their agricultural characteristics. From the Calabar Agricultural Zone, Akamkpa and Biase LGAs were purposively selected. Similarly, Ikom Agricultural Zone includes Ikom, Etung, and Obubra LGAs, while Obudu and Obanliku LGAs represent the Ogoja Agricultural Zone due to their significant cocoa farming activities. In the second stage, three cocoa farming communities were purposively selected from each of the chosen LGAs based on the concentration of cocoa farmers, giving a total of twenty-one (21) communities. The third stage involves obtaining a list of cocoa farmers from the Agricultural Development Programme Office in the selected Local Governments. The sample frame for the study was derived from the list of cocoa farmers provided by the Agricultural Development Programme (ADP) offices in the selected LGAs. To determine the sample size, the “Taro Yamani” formula was applied, resulting in a total of 390 randomly selected cocoa farmers for the study. The Taro Yamane formula for sample size calculation used is presented as follows:

$$n = \frac{N}{1+N(\varepsilon)^2}$$

$$n = \frac{15,291}{1+15291(0.05)^2}$$

$$n = \frac{15,291}{1+15291(0.0025)}$$

$$n = \frac{15,291}{39.2275}$$

$$n = 390$$

where; n = sample size, N = Population of cocoa farmers, and ε = adjusted margin error (5%).

A stratified proportional sampling approach or formula was employed to get the representative samples in each stratum (table 1). This formula ensures that each stratum (or subgroup) of the population is represented proportionally in the sample.

$$S_h = \frac{P_h}{N}\ x\ n$$

where: S_h = sample representative for stratum h,
P_s = population size for stratum h,
N = Sample frame/ total population size
n = total sample size

Table 1. Showing selection of respondents

Agric zones	LGAs	Communities	Sample frame	Sample size
	Akamkpa	Osomba	1034	26
		Ojork	830	21
		New Ndebigi	512	13
		Total	**2376**	**61**
	Biase	Ehom	910	23
Calabar				
		Ikot Esai	570	15
		Iko Ekperem	1067	27
		Total	**2547**	**65**
	Ikom	Ekukunela	850	22
		Okuni	745	19
		Nde	478 **2073**	12
		Total	1000	**53**
	Etung	Efrayi	1299	26
		Etomi		33
Ikom				
		Bendeghe	928	24
		Total	**3227**	**82**
	Obubra	Iyamitet	742	19
		Iyamoyong	480	12
		Ochon	641	16
		Total	**1863**	**48**
	Obanliku	Busi	400	10
		Basang	386	10
		Bebi	759	19
		Total	**1545**	**39**
	Obudu	Okweriseng	490	12
Ogoja				
		Araruh	670	17
		Ofambe	500	13
		Total	**1660**	**42**
		Grand Total	**15291**	**390**

2.4 Analytical techniques

<u>2.4.1 Factor analysis</u>

Factor analysis was used to determine the adaption strategies employed by cocoa farmers to mitigate the effect of climate change and also to identify the constraints faced by cocoa farmers in adapting to climate change adaptation strategies. Principal Component Analysis (PCA) was applied to reduce the dimensionality of the variables and identify the key factors that explained the most variance. This principal component was used as an independent variable in subsequent analyses.

The factor analysis model can be expressed in matrix form as: $\mathbf{x = \Lambda f + e}$

$$Y_1 = a_{11}X_1 + a_{12}X_2 + * * * + a1nX_n$$

$$Y_2 = a_{21}X_1 + a_{22}X_2 + * * * + a2nX_n$$

$$Y_3 = a_{31}X_1 + a_{32}X_2 + * * * + a3nX_n$$

$$Y_n = an1X_1 + an2X_2 + * * * + annX_n$$

where:

x is the vector of *n* observable variables

f is the vector of *m* unobservable factors,

Λ is called the loading matrix of the order

e is the error vector

Y_1, Y_2 …Y_n = observed variables/ adaptation strategies employed by cocoa farmers to mitigate the effect of climate variables on cocoa output.

a1 – an = factor loadings or correlation coefficients.

X_1, X_2, … X_n = unobserved underlying adaptation strategies employed by cocoa farmers to mitigate the effect of climate variables on cocoa output.

3. RESULTS AND DISCUSSION

3.1 Climate change adaptation strategies used by cocoa farmers

Table 2: Factor analysis showing the climate change adaptation strategies used by cocoa farmers

Variables	F1	F2	F3	Uniqueness	Communalities
Changing planting dates	0.938			0.106	0.894
Planting drought-resistant cocoa varieties	0.931			0.128	0.872
Crop diversification	0.889			0.087	0.913
Replanting	0.872			0.138	0.862
Early harvesting	0.865			0.131	0.869
Wait for rainfall before planting	0.808			0.283	0.717
Irrigation systems		0.827		0.281	0.719
Planting shade trees		0.805		0.110	0.890
Using mulch or cover crops		0.783		0.404	0.596
Making contours around the farm		0.709		0.368	0.632
Pond for water storage		0.683		0.297	0.703
Building of fences and windbreaks around the farm		0.670		0.225	0.775
Diversion of the direction of water flow		0.643		0.275	0.725
Planting of plantains		0.582		0.378	0.622
Participating in training programs on climate change adaptation			0.834	0.183	0.817
Utilizing weather forecasts and climate information for decision-making			0.771	0.098	0.902
Accessing credit and insurance products			0.677	0.212	0.788
Using chemical or organic fertilizers			0.664	0.367	0.633
Using chemical pesticides			0.662	0.365	0.635
Collaborating with other farmers and local organizations to implement adaptation strategies			0.641	0.323	0.677
Diversification into non-farm activities			0.536	0.470	0.530
Eigen value	12.098	2.112	1.000		
Percentage variance	0.576	0.101	0.048		
Cumulative percentage	0.576	0.677	0.724		

Bartlett test of sphericity	0.000**
Kaiser-Meyer-Olkin test	0.941
Cronbach's test of reliability	0.948

Source: Field survey Data, 2023 F1, F2, and F3 = factors

Hint: Factor 1: Crop management and climate resilience strategies.
Factor 2: Water and soil conservation strategies.
Factor 3: Institutional, financial, and support-based strategies

To assess the suitability of the data for factor analysis, Bartlett's test of sphericity and the Kaiser-Meyer-Olkin (KMO) measure were employed. The Bartlett's test of sphericity was highly significant (p = 0.000) at a probability level of 0.05. As the p-value (0.00) was less than 0.05, the null hypothesis, which posits that the variables are not intercorrelated, was rejected. Rejection of the null hypothesis implied that the variables were indeed correlated, indicating that the factor analysis was appropriate. The factor analysis was further substantiated by a high Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy (KMO = 0.941), which exceeded the acceptable threshold of 0.7, suggesting that the data were excellent and suitable for factor analysis. Internal consistency of the items within the identified factors was also evaluated. The overall reliability coefficient was 0.948, indicating excellent internal consistency among the variables.

The analysis extracted three factors with eigenvalues greater than 1 (12.098, 2.113, and 1.000, respectively), representing the adaptation strategies used by cocoa farmers to adapt to climate change, and explained 72.4% of the variance in the dataset. The first factor accounted for 57.6% of the variance, the second explained 10.1%, and the third explained an additional 4.8%. These factors were characterized by strong loadings of 0.536 – 0.938, as shown in Table 2. Furthermore, individual components with loadings of 0.50 and above were considered significant, while variables with factor loadings of less than 0.50 were discarded.

Communalities represent the shared variance between each variable and all other variables in the model. In this study, the communalities for all the variables included in the factor analysis were greater than 0.50, indicating that over 50% of the variance in each variable was explained by the retained factors. This high level of variance indicates that the key variables contributing to adoption strategies were effectively captured by these factors.

Table 2 shows the climate change adaptation measures used by the cocoa farmers in the study area. Three critical factors were extracted based on the factor analysis loadings. These factors represent the major climate change adaptation measures used by the cocoa farmers in the study area. Specifically, the items that loaded high under Factor 1 (crop management and climate resilience strategies) were changing planting dates (0.938), planting drought-resistant cocoa varieties (0.931), crop diversification (0.889), replanting (0.87), early harvesting (0.865), and waiting for rainfall before planting (0.808). These variables as used by the farmers represent strategies directly related to the timing and selection of crops, indicating that cocoa farmers in the study area focused on proactive farming decisions regarding planting and harvesting to mitigate climate risks. This result is consistent with that of Morton (2007), who reported that crop diversification, changing planting dates, and early harvesting are effective strategies for reducing the risks associated with climate shocks.

Factor 2 (water and soil conservation practices) variables that were highly loaded included irrigation systems (0.827), planting shade trees (0.805), using mulch or cover crops (0.783), making contours around the farm (0.709), pond for water storage (0.683), building fences and windbreaks around the farm (0.670), diversion of the direction of water flow (0.643), and planting of plantains (0.582). These represent structural and water management strategies, revealing that cocoa farmers in the study area concentrated on on-farm infrastructure and water management adaptation measures to combat climate change. To reinforce this finding, Yengoh et, al. (2010) reported that soil conservation techniques, such as planting shade trees, mulching, and contour farming, play a critical role in preventing soil erosion and retaining moisture, making farms more resilient to extreme climate conditions.

The variables that loaded high under Factor 3 (institutional, financial, and support-based strategies) included participating in training programs on climate change adaptation (0.834), utilizing weather forecasts and climate information for decision making (0.771), accessing credit and insurance products (0.677), using chemical or organic fertilizers (0.664), using chemical pesticides (0.662), collaborating with other farmers or local organizations to implement adaptation strategies (0.641), and diversification into non-farm activities (0.536). These variables reflect approaches that are less about physical farm adjustments and more about knowledge and financial and collaborative support, signifying those cocoa farmers in the study area also focused on financial, informational, and collaborative adaptation measures. This implies that cocoa farmers also rely on external support, such as access to training, climate information, financial resources, and collaboration, to help them adopt and sustain climate-smart practices in the study area.

This finding is consistent with that of De Pinto et al. (2018), who posited that farmers who participate in training programs on climate change adaptation are more likely to adopt new technologies and practices. Chiputwa et al., (2019) also reported that farmers with access to credit and insurance products are better equipped to invest in climate-smart practices and recover from climate-related losses.

3.2 Constraints faced by cocoa farmers in adapting to climate change

Table 3: Factor analysis showing the constraints faced by cocoa farmers in adapting to climate change

Variables	Factor 1	Factor 2	Uniqueness	Communality
Price volatility	0.939		0.031	0.969
Lack of mechanized farming	0.937		0.057	0.943
Lack of government support	0.929		0.031	0.969
Lack extension agent	0.918		0.044	0.956
Limited access to technology	0.911		0.088	0.912
Limited available land	0.870		0.060	0.94
Lack of improved varieties of cocoa	0.853		0.163	0.837
High cost of labour	0.829		0.062	0.938
Poor feeder roads	0.670		0.085	0.915
Limited access to irrigation facilities	0.648		0.075	0.925
Lack of collateral to secure available credit facilities	0.550		0.064	0.936
Lack of access to weather information	0.547		0.091	0.909
Resistance to change		0.958	0.226	0.774
Lack of sufficient farming experience to tackle some climate exigencies		0.957	0.265	0.735
Ineffectiveness of existing co-operatives in my area		0.793	0.070	0.930
Non-existence of cooperatives in my area		0.778	0.082	0.918
Lack of training and education		0.773	0.092	0.908
Market access		0.768	0.068	0.932
High cost of adaptation measures		0.677	0.072	0.928
Lack of access to credit facilities		0.660	0.085	0.915
Lack of financial resources		0.623	0.095	0.905
Complexity of adaptation measures		0.563	0.071	0.929
Eigenvalue	18.648	1.373		
Percentage variance	0.877	0.065		
Cumulative percentage	0.877	0.943		
Bartlett test of sphericity	0.000**			
Kaiser-Meyer-Olkin (KMO) test	0.947			
Cronbach's test of reliability	0.989			

Source: Field survey data, 2024

Hint: Factor 1: Institutional, economic, and resource constraints.
Factor 2: **Social, educational, and cooperative-related** constraints.

Factor analysis was conducted to identify the constraints faced by the cocoa farmers. To assess the suitability of the data for factor analysis, Bartlett's test of sphericity and the Kaiser-Meyer-Olkin (KMO) measure were employed. Bartlett's test of sphericity was highly significant (p = 0.000) at a 0.05 probability level. Because the p-value (0.00) is less than 0.05, the null hypothesis, which states that the variables are not intercorrelated, is rejected. Rejecting the null hypothesis implied that the variables were indeed correlated, meaning that the factor analysis was appropriate. Factor analysis requires that variables be correlated to uncover the underlying structure or common factors among them. Therefore, this result supports the validity of applying factor analysis. Factor analysis was further supported by a high

Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy (KMO = 0.947), which is above the acceptable threshold of 0.7, suggesting that the data were excellent and suitable for factor analysis. The internal consistency of the items within the identified factors was assessed. The overall reliability coefficient was 0.989, indicating excellent internal consistency among the items.

Table 3 shows that two factors with eigenvalues above 1 (18.648 and 1.373), explaining 87.7% and 6.5% of the variance, respectively. These two factors represent the main constraints faced by cocoa farmers in adapting to climate change and explain 94.3% of the variance in the dataset. These factors were characterized by strong loadings of 0.55-0.96 as shown in Table 2. However, components with corresponding eigenvalues less than one were dropped. Furthermore, variables with a factor loading of less than 0.50 were discarded and individual components with loadings of 0.50 and above were considered significant. Communalities represent the shared variance between each variable and all other variables in the model. In this study, the communalities for all variables included in the factor analysis were greater than 0.65, indicating that over 65% of the variance in each variable was explained by retained factors. This high level of variance indicates that the key variables contributing to the constraints were well captured by these factors.

Factor 1 has high loadings on variables mostly related to institutional, economic, and resource constraints. These constraints highlight the challenges farmers face in accessing the tools and support required for climate change adaptation. Key variables with strong loadings on Factor 1 included price volatility (0.939), lack of mechanized farming (0.937), lack of government support (0.929), lack of extension agents (0.918), limited access to technology (0.911), limited available land (0.870), lack of improved cocoa varieties (0.853), and high cost of labour (0.829). Constraints such as poor feeder roads (0.670) and limited irrigation (0.648) were also loaded into this factor. These high loadings suggest that Factor 1 represents institutional, economic, and resource or infrastructural barriers that prevent farmers from accessing the necessary resources to cope with climate change adaptation measures.

These constraints created a cycle of vulnerability, reduced productivity, and limited adaptation for cocoa farmers in the study area. Economic barriers, such as price volatility and high labour costs, lower financial resilience and the ability to invest in adaptive practices. Limited mechanization, restricted access to technology, and scarce extension services hinder knowledge transfer modern farming methods, and stalling adaptation efforts. Scarce land and a lack of improved cocoa varieties constrain crop diversification, making farmers more susceptible to climate impacts. This highlights the need for better infrastructure development and institutional support. The results support the findings of Mertz, Halsnæs, Olesen, & Rasmussen, (2009) who also identified major constraints such as poor infrastructure, lack of government support, and limited mechanization as key barriers to climate change adaptation. Antwi-Agyei et al. (2014) reported that a lack of access to technology, poor feeder roads, and insufficient government support are critical barriers to climate change adaptation among Ghanaian farmers.

Factor 2 captures variables related to social and organizational challenges as well as individual barriers that make it difficult for farmers to adopt climate change adaptation strategies. Key variables with strong loadings on Factor 2 included resistance to change (0.958), lack of sufficient farming experience (0.957), ineffectiveness of existing cooperatives (0.793), non-existence of cooperatives (0.778), lack of training and education (0.773), and market access (0.768). These high loadings indicate that Factor 2 represents social, educational, and cooperative challenges. Farmers lack sufficient knowledge and experience in implementing adaptation measures. On the other hand, weak or nonexistent cooperatives further prevent collective action by farmers in the study area in adopting climate change adaptation strategies. These findings correspond with that of Nguyen, Beukes, Huber, & Rohrer, (2017) whose study identified resistance to change, lack of education and training, and financial constraints as key factors limiting the adoption of climate adaptation measures. Ribeiro et al. (2016) also in their study highlighted the importance of cooperatives in supporting farmers' adaptation to climate change, noting that ineffective or nonexistent cooperatives hinder adaptation efforts.

Other variables loaded onto Factor 2 included the high cost of adaptation measures (0.677), lack of access to credit (0.660), lack of financial resources (0.623), and the complexity of adaptation measures (0.563). Financial limitations, lack of credit, and the complexity of adaptation practices were also revealed as major constraints in the study area. These findings agree with that of Fisher, Ackerman, & Bailey, (2015), who in their study identified that lack of financial resources, credit access, and educational support as major barriers to climate change adaptation.

4. CONCLUSION

This study examines climate adaptation strategies and the challenges faced by cocoa farmers in Cross River State, Nigeria, using factor analysis. Three key adaptation strategies were identified, accounting for 72.4% of the dataset variance. Factor 1 (crop management) includes measures like adjusting planting dates, adopting drought-resistant varieties, and crop diversification. Factor 2 (water and soil conservation) involves practices such as irrigation, mulching, shade tree planting, and contour farming. Factor 3 (institutional and financial strategies) emphasizes training, weather forecasts, credit access, and collaboration. The study also highlights key constraints to adaptation, explaining 94.3% of the variance. Factor 1 (institutional, economic, and resource constraints) includes issues like price volatility, limited mechanization, poor infrastructure, and restricted access to technology. Factor 2 (social and organizational challenges) reflects barriers like resistance to change, insufficient training, ineffective cooperatives, and financial limitations. These obstacles hinder productivity, reduce resilience, and slow adaptation. The study advocates for improved infrastructure, government support, stronger cooperatives, and training programs to enhance farmers' capacity to adapt to climate change.

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