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Micro-scale adaptations to climate change among cocoa farmers in Oyo State, Nigeria

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Abstract

Climate change-related environmental disruption is harming cocoa trees, increasing the cost of chocolate, and hindering global efforts in cocoa production to achieve sustainable development goals for food and nutrition security. There is a knowledge gap in the literature on the factors influencing the adoption of climate change adaptation strategies among smallholder cocoa farmers in Nigeria. Hence, this research aims to identify the factors influencing micro-scale adaptation to climate change among cocoa farmers in Oyo State, Nigeria, with the goal of promoting the broader adoption of adaptation strategies for sustainable cocoa production. A multi-stage sampling procedure was employed to select the respondents. Oyo State was divided into four zones, each containing eight blocks and eight cells. The Ibadan/Ibarapa zone was purposively selected due to the high level of farmers' involvement in cocoa production. Three blocks and two cells were randomly selected, resulting in six cells. Each cell contained at least 138 cocoa farmers. There are 1,204 registered cocoa farmers in the selected cells, from which 10% (120 farmers) were randomly selected for the interviews. The interviews focused on factors affecting coping mechanisms for climate change. The statistical tools used for data analysis were both descriptive and inferential. Coping mechanisms for climate change included anticipatory, reactive, or proactive measures. Common coping mechanisms used were frequent rehabilitation of old plants (52.5%), the use of minimum soil tillage for raising seedlings (68.3%), and changing cropping patterns (65.8%). Lack of technical know-how ($p < 0.05$; $\beta = -0.15$), access to information ($p < 0.05$; $\beta = 0.21$), and access to capital ($p < 0.05$; $\beta = 0.31$) significantly influenced micro-scale adaptation to climate change. Supporting the implementation of micro-scale adaptations, such as cocoa rehabilitation programmes with significant incentives (e.g., seedlings), can reduce vulnerability to climate-related hazards and improve farmers' overall resilience.

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Introduction

The challenges of climate change on a global basis are widely researched, with a consensus in the findings affirming its negative impact on poor communities and their limited capacities to adapt due to exposure to various climate risks[1]. According to Schaar et al.[2], the impacts of climate change on Asia, the Middle East, the Caribbean, and sub-Saharan Africa are becoming more damaging to people and their sources of income and livelihood than ever anticipated.

Globally, the literature reveals varying impacts of climate change, but there is widespread agreement that these impacts are more severe for the poor than for those who are better off, due to greater exposure to climate risks and limited adaptation capacity[1]. Climate change impacts are currently occurring more rapidly than forecasted by climate models and are increasingly observed to create more complexity and difficulty in management than previously projected[2]. In highlighting the outcomes of climate change conditions, the International Monetary Fund (IMF)[3,4] revealed that biological and physical changes have resulted in negative consequences for the agricultural industry. The World Bank[5] discovered that approximately 6% of landlocked areas are vulnerable to these extreme weather events. It is also important to recognize that lower-middle- and low-income countries on the African continent are particularly vulnerable to the impacts of climate change due to their limited resilience capacity[6,7]. These sudden climate changes pose severe risks to global socio-economic activity if emissions are not managed to prevent significant disruptions[8].

As these climate conditions continue to aggravate the social vulnerabilities of people[9], especially among farmers in low-income communities in unindustrialized countries, there is a need for studies in development to focus on new approaches to governance that support inclusive politics, which will result in greater capacities for climate resilience[10], including adaptation measures among farmers. This suggests that equality and justice must be prioritized in developing adaptation and mitigation strategies that ensure resilience through carbon dioxide (CO_2) reduction in a transformative way that leaves no one behind.

The world needs a solution to mitigate greenhouse gas concentrations and maintain CO_2 emissions at a stabilized level to prevent dangerous outcomes, such as an increase in CO_2 emissions[11]. Future climate change depends on the extent to which global emissions are reduced. Emission reduction is determined by several factors, including the ecosystem's response to climate change, the rate of deforestation[11], technical know-how, information exchange, and the rate of greenhouse gas emissions. A high-end climate change (HECC) scenario has been predicted to occur in the future if the current trend of CO_2 emissions is not addressed.

With an increased average global temperature of 2 °C, a high-end climate change (HECC) scenario is expected[11]. The context of HECC implies that the rise and variability in climate change will make environmental changes difficult to predict. According to the

Intergovernmental Panel on Climate Change (IPCC)[12], data on global warming indicate a significant difference in the impacts experienced when temperatures rise between 1.5 and 2 °C. This implies that the outcomes of climate change at HECC are expected to be more severe than currently experienced. With ongoing HECC research on the effects on health, rising sea levels, flood risks, heat stress, water scarcity, and low agricultural production, Parkes et al.[13] noted that solutions to climate change issues have yet to address the consequences, and any plans to meet unanticipated socio-economic costs remain insufficient.

In offering sustainable solutions to these problems, Prost et al.[14] stated that redesigning farming systems would provide a strong link to food production and the storage of agroforestry products such as bananas, coffee, firewood, fruits, and timber, while Simon et al.[15] observed that regulating the application of pesticides to control coffee pests and other crop diseases, maintaining soil fertility, and promoting carbon sequestration are likely to provide sustainable solutions. They also contend that agroforestry practices, such as planting cocoa seeds alongside other food crops, assist in carbon sequestration. Furthermore, cocoa-based agroforestry practices have the potential to store a substantial amount of carbon that could help mitigate climate change. Somarriba et al.[16] stated that carbon stocks, when implementing agroforestry systems with cocoa, may range from 12 to 228 milligrams per hectare (Mg ha^{-1}) and help alleviate climate change. Additionally, Nnko[17] corroborated this finding, asserting that carbon sequestration mitigates climate change through stored carbon stocks in the soil, which can be applied to combat land degradation and ensure food security.

Currently, climate change is significantly impacting cocoa production at every stage[18,19]. Cocoa is one of the most important cash crops in West Africa (Ghana, Nigeria, Côte d'Ivoire), providing income for many farming families[20,21]. However, its production is threatened by rising temperatures and erratic rainfall due to the negative impacts of climate change[22]. More detrimental effects of climate change are predicted to occur in West and Central Africa, where more than 70% of cocoa is grown[21]. In West Africa, average temperature increases are likely to approach or exceed 1.5 °C by 2040, with rises of up to 2 and 3 °C predicted under mid- and high-emission scenarios, respectively, which are associated with more frequent and intense climate extremes[23]. In addition to erratic rainfall patterns, rising temperatures burden the cocoa production system, reducing cocoa yields[20]. Climate change presents additional issues, such as cocoa black pod disease and swollen shot disease, which are particularly destructive to maturing pods and cocoa stems. Furthermore, climate change leads to pest attacks, delayed ripening of cocoa pods, reduced cocoa bean weight, and contamination of cocoa beans, particularly in Nigeria.

Cocoa production in Nigeria has significantly declined. Nigeria dropped from being the third-largest cocoa producer in 2013/2014, with a production capacity of 248,000 metric tonnes, to sixth place in 2016/2017, with a capacity of 230,000 metric tonnes[23]. The decrease in cocoa production was linked to unfavorable climatic factors[24], which forced cocoa producers to adopt climate change coping mechanisms[25]. However, the current literature has a knowledge gap regarding farmers' micro-scale climate change adaptation strategies, their relationship with cocoa productivity[23], and the factors influencing their choice of adaptation measures. Although Carlos et al.[26] discovered that farmers' perspectives on climate change influence their planting decisions and the adoption of adaptation techniques in Ghana, this knowledge is limited among cocoa producers in Nigeria. Micro-scale adaptation refers to small-scale, localized actions undertaken by individuals, households, or communities to manage climate change impacts. These adaptation strategies are typically based on available local resources. There is a need to identify the current micro-scale coping mechanisms used by cocoa farmers in Oyo State, Nigeria, to improve farmers' adaptation skills and build a cocoa-resilient community.

Objective of the study

The overall objective of the paper is to ascertain factors that influence micro-scale adaptation to climate change among cocoa farmers in Oyo State, Nigeria.

Specific objectives of the study

• Determine the socioeconomic characteristics of cocoa farmers in Oyo State.

• Identify the various climate change coping mechanisms employed by these farmers.

• Ascertain the sources of information on climate change adaptation accessible to the farmers.

• Establish relationships between demographic factors (age, sex, educational level, marital status) and adaptation methods.

• Identify constraints to the adoption of effective adaptation strategies.

Methodology

This research, undertaken in Oyo state, Nigeria, is a hot spot of climatic change vulnerability, affecting cocoa production and livelihood. It lies between the latitudes of 8.1° N and 3.5° E. The local farmers mostly rely on traditional tools and loamy soil ideal for growing tree crops.

This study used a multi-stage sampling procedure, as shown in Table 1, which included a descriptive survey research method to determine the factors influencing the types of adaptation methods used by the population under investigation. The sampling procedure followed a multi-stage process using the Agricultural Development Programme (ADP). The ADP project classified the study location, Oyo State, into four agricultural zones: Ibadan/Ibarapa, Ogbomoso, Saki, and Oyo. The Ibadan/Ibarapa zone was purposively selected due to the high level of farmers' involvement in cocoa production and was later divided into eight blocks, with three blocks randomly selected. Each block contains eight cells. The

Table 1. Shows the sampling procedure and sample size.

ADP zones in Oyo State	Purposively selected zone	No. of blocks	No. of blocks selected	No. of cells	No. of cells selected	Community in the cells	No. of registered farmers	10% registered farmers selected as sample size
Ibadan/Ibarapa zone	Ibadan/Ibarapa	8	3	8	6	Aba Agbo	302	30
Ogbomoso zone						Olubi	181	18
Saki zone						Owobale	240	24
Oyo zone						Alugbo	161	16
						Foworogu	182	18
						Elese Erin	138	14
Total							1,204	120

simple random technique was adopted to select two cells from each block, resulting in a total of six cells. Each cell has about 138 cocoa farmers, with 302 farmers in Aba Agbo, 181 in Olubi, 240 in Owobale, 161 in Alugbo, 182 in Fowerogu, and 138 in Elese Erin. In total, there are 1,204 registered cocoa farmers in the selected cells, and 10% of them were randomly selected, providing a sample size of 120 farmers.

Data collection is a critical stage in any research or analysis but is prone to various biases. To prevent selection bias that could lead to inaccurate results, 10% of the total population was selected. Respondents who did not return their questionnaires were replaced. Instrument bias was minimized by ensuring the questionnaire underwent face and content validity testing, as well as reliability testing.

The data for the study were collected in April 2023 through structured interviews. The research instrument (questionnaire) was pilot-tested in Ido Village, Iddo LGA, Oyo State, Nigeria, with a reliability coefficient of 0.71. Respondents' data included socio-economic characteristics such as age, gender, income, level of education, and household size. Some of the questions posed to respondents included choices among specific climate change adaptation mechanisms, such as restoration of old cocoa plantations, utilization of minimum soil tillage for nurturing cocoa seedlings, varying cropping patterns to 3.1 m × 3.1 m, and refraining from bush burning. Additional questions on adaptation constraints were posed, including financial constraints, insufficient land, lack of technical know-how, lack of knowledge, poor access to necessary climate information, irregular visits by extension officers, poor benefits from carbon funds, inadequate government assistance, and water scarcity. Data were analyzed using frequency distribution, simple percentages, and influential statistical tools.

Results

Socioeconomic characteristics

Table 2 presents the results of the socio-economic characteristics of participants, including age, sex, marital status, household size, educational levels, religion, and farming experience. Most of the farmers (60.0%) were between 31 and 50 years old, and there were more males (70.0%) involved in cocoa production than females (30.0%). Most respondents (54.2%) were married, while 45.8% were single. The majority (64.2%) had at least five persons in their household, while 33.3% had more than six persons as household members. A larger percentage of the respondents (82.5%) had formal education, while 17.5% did not attend school. About 56.7% of the respondents were Christians, 37.5% were Muslim, and 5.8% were traditionalists. Half of the respondents (50.0%) had been involved in cocoa farming for over ten years.

Constraints to climate change coping mechanism

Table 3 shows the results of the constraints to climate change coping mechanisms. The major constraints to climate change adaptation included financial constraints (70.8%), insufficient land (37.5%), lack of technical know-how (27.5%), lack of knowledge (22.5%), poor access to necessary climate information (55.8%), irregular visits by extension officers (40.8%), poor benefit from carbon fund (100.0%), poor government attitude toward assisting victims (53.3%) and water scarcity (55.8%). According to these results, financial constraints, poor benefits from the carbon fund, poor access to climate information, and water scarcity are critical factors affecting sustainable cocoa production among the respondents.

Table 2. Socioeconomic characteristics of the respondents (n = 120).

		Frequency	Percentage (%)
Age category	21–30	22	18.3
	31–40	45	37.5
	41–50	27	22.5
	51–60	17	14.2
	≥ 61	9	7.5
	Total	120	100.0
Sex	Male	84	70.0
	Female	36	30.0
	Total	120	100.0
Marital status	Single	55	45.8
	Married	65	54.2
	Total	120	100.0
Household size	0–5	77	64.2
	6–10	40	33.3
	11–15	3	2.5
	Total	120	100.0
Educational status	No formal education	21	17.5
	Primary	18	15.0
	Secondary	39	32.5
	Tertiary	43	35.0
	Total	120	100.0
Religion	Muslim	45	37.5
	Christian	68	56.7
	Traditional	7	5.8
	Total	120	100
Farming experience	0–10	60	50.0
	11–20	47	39.2
	21–30	12	10.0
	31–40	1	0.8
	Total	120	100.0

Source: Field Survey, 2023.

Table 3. Constraints to climate change coping mechanism.

S/no.	Constraints	Very serious		Mild		Not a serious constraint	
		F	%	*F*	%	*F*	%
1	Financial constraints	85	70.8	21	17.5	14	11.7
2	Inadequate land	45	37.5	54	45.0	21	17.5
3	Lack of technical know-how	33	27.5	66	55.0	21	17.5
4	Lack of knowledge	27	22.5	66	55.0	27	22.5
5	Poor access to necessary climate information	67	55.8	37	30.8	16	13.3
6	Irregular visits of extension officers	49	40.8	59	49.2	12	10
7	Poor benefit from carbon fund	120	100.0	–	–	–	–
8	Poor attitude of the government toward assisting victims	64	53.3	43	35.8	13	10.9
9	Water scarcity	67	55.8	40	33.3	13	10.8

Source: Field Survey, 2023. Note: Multiple responses.

Farmers' sources of information on climate change adaptation

Table 4 provides data on sources of information accessible to farmers. Most respondents (68.3%) occasionally obtained information from agricultural extension officers. Agricultural input suppliers also provide needed information to 42.5%, family members (68.3%), Internet (55.0%), leaflets (33.3%), neighbors or friends (54.2%), television (44.2%), and village leaders (63.3%). Mobile phones (66.7%), fellow farmers (60.0%), and radio (51.7%) were identified as the most important sources of information.

Climate change micro-scale coping mechanisms adopted by the cocoa farmers

The most commonly adopted coping mechanisms are frequent rehabilitation of old cocoa plants (52.5%), adoption of minimum soil tillage for raising seedlings (86.3%), changing cropping pattern to 3.1 m × 3.1 m (65.8%), avoidance of bush burning (53.3%), and prompt weeding (69.2%). Early harvesting to avoid wastage (66.7%) is an occasionally used technique, while 64.2% of the respondents did not adopt planting trees along the edges of cocoa plantations at all (Table 5).

Regression analysis of factors influencing micro-scale coping mechanism to climate change

The regression analysis reveals that constraints to the coping mechanisms ($p < 0.05$; $\beta = -0.15$), such as lack of technical know-how, have a significant negative influence on adaptation. Access to information ($p < 0.05$; $\beta = 0.21$) has a positive significant influence on climate change adaptation. Access to funds ($p < 0.05$; $\beta = 0.31$) also statistically influenced coping mechanisms for climate change. However, respondents' age ($p > 0.05$; $\beta = 0.01$), marital status ($p > 0.05$; $\beta = 0.05$), sex ($p > 0.05$; $\beta = 0.09$), and educational status ($\beta = 0.06$; $p \geq 0.05$) did not statistically influence climate change adaptation method utilization (Table 6).

Discussion

The majority of the respondents were found to be middle-aged, while most of them are considered active in cocoa farming. This corroborates Orifah et al.'s study[27], which highlighted that most cocoa farmers in Nigeria are young and in their productive ages, allowing them the physical and health advantages necessary for adopting climate change adaptation processes. Aside from age, gender affects cocoa production through the farmers' capacity to

Table 4. Farmers' sources of information on climate change adaptation.

S/no.	Sources of information on climate change adaptation	Always		Occasionally		Never	
		F	%	F	%	F	%
1	Agricultural Extension Officer	31	25.8	82	68.3	7	5.8
2	Agricultural inputs suppliers	18	15.0	51	42.5	51	42.5
3	Family members	25	20.8	82	68.3	13	10.9
4	Internet	29	24.2	66	55.0	25	20.8
5	Leaflets	19	15.8	40	33.3	61	50.8
7	Mobile phones	80	66.7	36	30.0	4	3.3
8	Neighbours or friends	41	34.2	65	54.2	14	11.7
9	Fellow farmer	72	60.0	40	33.3	8	6.7
10	Radio	62	51.7	52	43.3	5	5.0
11	Television	56	46.6	53	44.2	11	9.2
12	Village leaders	25	20.8	76	63.3	19	15.8
13	Social media (Facebook, WhatsApp, Twitter, etc.)	27	22.5	61	50.8	32	26.7

Source: Field Survey, 2023. Foot Note: multiple responses.

Table 5. Climate change coping mechanism among cocoa farmers (n = 120).

S/no.	Climatic change adaptation strategies used	Levels of used					
		Always		Occasionally		Never used	
		F	%	F	%	F	%
1	Rehabilitation of old cocoa plant	63	52.5	10	8.3	47	39.2
2	Increased fertilizer application	25	20.8	59	49.2	36	30
3	Planting of trees along edges for cocoa production	22	18.3	21	17.5	77	64.2
4	Listening to the weather forecast	25	20.8	56	46.7	39	32.5
5	Adoption of minimum soil tillage for raising seedlings	82	86.3	15	12.5	23	19.2
6	Planting drought-resistant variety	19	15.8	34	45.0	47	39.2
7	Planting of improved / resistant varieties	38	31.7	51	42.5	31	25.8
8	Diversification into other livelihood activities	45	37.5	36	30.0	39	32.5
9	Changing in cropping pattern to 3.1 m × 3.1 m	79	65.8	23	19.2	18	15.0
10	Mixed cropping for cocoa	57	47.5	48	40.0	15	12.5
11	Early harvesting to avoid wastage	20	16.7	80	66.7	20	16.7
12	Mulching for cocoa seedlings	52	43.3	52	43.3	16	13.3
13	Avoid bush burning or cocoa plantations	64	53.3	38	31.7	18	15.0
14	Prompt weeding	83	69.2	17	14.2	20	16.7
15	Use of organic manure to prevent leaching	55	45.8	47	39.2	18	15.0
16	Adoption of Irrigation techniques for seedlings on the field	38	31.7	43	35.8	39	32.5
17	Diversification into livestock production	42	35.0	36	30.0	42	35.0

Source: Field Survey, 2023; Foot Note: multiple responses.

Table 6. Regression analysis of cocoa farmers' climate change coping mechanism.

Model	Unstandardized coefficients		Standardized coefficients	T	Sig	Decision
	B	Std Error	B			
Constant	10.80	4.15		2.61	0.01	S
Age	−0.00	0.04	−0.01	−0.09	0.93	NS
Gender	−0.00	0.77	0.09	0.48	0.63	NS
Marital status	0.37	0.19	0.05	0.29	0.77	NS
Educational status	0.06	0.12	0.06	0.59	0.56	NS
Constraints to coping mechanism	−0.18	0.14	0.15	−2.22	0.02	S
Access to information	0.34	0.18	0.21	1.81	0.04	S
Access to fund	0.41	0.11	0.31	0.17	0.05	S
R = 0.56						
R^2 = 0.58						
Adjusted R square = 0.61						

S = significant value; NS = Not significant; R = regression value; T = T-value.

adjust to climate change risks. Moreover, gender plays a substantial role in accessing various productive resources and opportunities, with the female gender having little or no access to farm assets and inputs. Gender differences in harnessing available opportunities help shape how the agricultural sector functions under climate change conditions across different farming systems[28]. In this study, there were more males than females in cocoa farming and production. This finding affirms Okona et al.'s research[29], which observed that cocoa farming is a difficult task and one of the reasons more men are found in the sector.

Many of the respondents were married and had at least five people in their households. This finding shows that most of the respondents had large family sizes possibly because most of the farm work is done by family members to save costs. In addition, most of the respondents were literate. The high literacy level may have influenced the farmers' information-seeking behavior regarding climate change adaptation. The World Cocoa Foundation[30] supports this, emphasizing the importance of education in increasing cocoa farmers' openness to new production technologies.

Many of the respondents belonged to different religious organizations. This indicates that there is no religious prohibition against cocoa production or adaptation to climate change in Oyo state, Nigeria. Experience has shown that farmers' organizations have helped boost agricultural activities in the past; this may explain why many had joined farmers' group for more than five years. Likewise, half of the farmers had been growing cocoa for more than ten years. This suggests that the farmers were possibly exposed to different climate change effects on cocoa production, which informed their adaptation decisions.

The primary constraint to adopting climate change adaptation strategies is poor access to formal financial institutions for finance. A significant proportion of the respondents faced serious financial constraints, which may hinder the utilization of adaptation technologies. Poor access to early warning information also impedes cocoa farmers' ability to adapt to climate change. Access to climate change information is key to building a climate-resilient community. Farmers with adequate information and improved skills will adapt better than their counterparts without access to information. This finding is consistent with Orifah et al.'s study[27], which identified a lack of financial capacity, limited access to early warning information, an adverse government policy attitude toward supporting vulnerable farmers, and water scarcity as barriers to adopting adaptation techniques.

Water shortage due to climate change is a major problem in raising cocoa seedlings. This has prompted farmers to adopt water harvesting and appropriate irrigation systems. Water scarcity was also confirmed by Leihner[31] in West Africa during the dry season, ranking second only to nutrient limitations.

The weak government response to addressing the vulnerable conditions of cocoa farmers hinders their climate change adaptation capabilities. For instance, no farmer was reported to benefit from carbon funding. This may be attributed to the relative small farm sizes of the farmers. The context of carbon fund payments is designed to assist vulnerable communities, especially tree crop farmers, in sustaining forest conservation financing over the long term. The major objective is to reduce climate change impacts arising from arable land loss and degradation, thereby making forests more adaptable to capturing CO_2. As a result, farmers would benefit from carbon credits, which aim to reduce carbon dioxide emissions from farming activities.

Other constraints that were less common among the respondents included inadequate land and irregular visits by extension officers. This finding shows that most respondents faced several constraints, and if not addressed, these issues will hinder sustainable cocoa production in Oyo state, Nigeria. Most farmers in the study area had access to land for cocoa plantations, possibly because they were community natives who inherited the lands from their fathers. Similarly, access to extension services was not a major problem. Agricultural extension officers serve as liaisons between researchers and farmers; they facilitate communication and assist farmers in making informed decisions to ensure that relevant knowledge is applied to achieve optimal results in sustainable cocoa production[23]. The Extension Division of the Agricultural Development Programme (ADP) in Nigeria directly visits and trains cocoa farmers, with a primary focus on managing Cocoa Swollen Shoot and Virus Disease (CSSVD), pests, diseases, and soil improvement in response to climate change.

The various sources of information used by cocoa farmers include agricultural extension officers, agricultural input suppliers, family/community members, social media/internet, information leaflets, fellow farmers, mobile phones, personal experience, radio, television, and village leaders. Among these sources, the most commonly used were mobile phones, fellow farmers, and radio. Climate change intervention programs can target these useful sources to disseminate relevant information to farmers. According to Orifah et al.[27] some farmers had contact with extension agents and may have gained some understanding of climate change adaptation technologies, which may have influenced their perception of the beneficial effects of adaptation strategies.

Micro-scale adaptation mechanisms are typically preventive, reactive, or proactive measures used to reduce the effects of climate change, depending on the farmers' socio-economic status. Farmers utilized various coping mechanisms to mitigate climate change. The most popular micro-scale coping mechanisms included frequent rehabilitation of old cocoa plants, the use of minimum soil tillage for raising seedlings, changing cropping patterns, avoiding burning cocoa plantations, and prompt weeding. Climate change resilience among farmers depends on the effectiveness of the adaptation measures used. Farmers use minimum tillage to conserve soil and water. Water erosion under extreme rainfall conditions must be controlled to prevent land degradation. In contrast, water erosion presents no serious challenge on dry, flat, or rolling lands; instead, erosion may be caused primarily by wind in low-rainfall, high-evaporation areas. Thus, the design of water-conserving cropping systems should consider the adaptation of reduced evaporation components. The planting of hedges was not popular among the cocoa farmers. Planting indigenous and improved low-water-demand trees can alleviate many of the problems associated with a changing climate. The findings align with those of Oyekale[19], who found that the majority of adaptation methods relate to agronomic practices such as replanting old trees, regularly spraying cocoa pods, and intentionally wetting young cocoa plants during the dry season.

The regression analysis shows that age, sex, marital status, and educational status did not influence micro-scale climate change coping mechanisms. However, constraints to coping mechanisms, access to information, and access to capital significantly influenced cocoa farmers' micro-scale coping mechanisms to climate change. There was a significant negative influence of constraints on climate change coping mechanisms. This implies that poor knowledge of adaptation skills discouraged farmers from using coping mechanisms or adaptation technologies outside their cultural practices. Access to information had a positive contribution to climate change coping mechanisms. Farmers with access to necessary information are likely to adapt better than their counterparts without access. A positive relationship between access to funds and coping mechanisms indicates that farmers with sufficient funds will buy the necessary technology to facilitate their adaptation process. This finding corroborates Schroth et al.[32], who discovered that farmers' socio-economic characteristics influence their ability to adapt to climate change. Farmers who specialize in cocoa farming and rely on cocoa production as a major source of income cannot overlook the importance of implementing climate change adaptation measures.

Conclusions

This paper assesses micro-scale climate change coping mechanisms among cocoa farmers in Oyo State. It asserts that climate change adaptations impact the sources of income of cocoa farmers, especially the smallholder farmers, thereby necessitating the adoption of several coping mechanisms among cocoa growers. The majority of cocoa growers were found to be middle-aged, predominantly male, married, and living in households with at least five members. Most cocoa farmers acquired knowledge of climate change adaptation skills through agricultural extension officers, agricultural input providers, family members, fellow farmers, and village leaders. Other sources included the internet, booklets, radio programs, television channels, and social media platforms. Information received through these media clearly influenced farmers' micro-scale adaptation techniques. The coping mechanisms adopted were anticipatory, reactive, or proactive, with their utilization largely determined by the farmers' socio-economic status. The most common coping mechanisms included frequent rehabilitation of old cocoa plants, the use of minimal soil tillage for raising seedlings, crop rotation, avoiding the burning of cocoa plantations, and prompt weeding. The challenge to coping mechanisms, access to information, and access to capital had a significant negative impact on cocoa farmers' coping mechanisms when considering climate change challenges. Additionally, a lack of adequate resources discouraged the use of potential adaptation technology among cocoa farmers. This presents serious consequences for the long-term sustainability of cocoa production amid changing environmental conditions. To address this dilemma, cocoa farmers and researchers must investigate climate-resilient cocoa varieties, agroforestry practices, and sustainable agricultural techniques.

The study did not examine the gender dimension of adopting the micro adaptation technique, leaving the potential for further research by other researchers. Nonetheless, investing in micro-scale climate change adaptation technology will promote climate resilience in cocoa communities. Furthermore, retraining farmers on coping strategies by extension officers will improve cocoa farmers' coping mechanisms to environmental changes posed by climate change. Investment by the government and non-governmental organizations in continuous capacity development and key adaptation measures—such as the introduction of drought-tolerant seedlings—will improve farmers' ability to sustain and improve cocoa production.

Author contributions

The authors confirm their contribution to the paper as follows: study conception and design: Arimi SK, Adenubi OO, Owolade EO, Adegbuyi B, Joshua TA; data collection: Arimi SK, Adegbuyi B, Adenubi OO; analysis and interpretation of results: Arimi SK, Joshua TA, Owolade EO; draft manuscript preparation: Arimi SK, Josua TA, Adenubi OO. All authors reviewed the results and approved the final version of the manuscript.

Data availability

All data generated or analyzed during this study are included in this published article. Additional data can be obtained from the National Open University of Nigeria repository upon request.

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Conflict of interest

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