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SUSTAINABLE COCOA FARMING: EXPLORING THE ROLE OF CLIMATE-SMART AGRICULTURAL PRACTICES IN ENHANCING YIELDS IN SOUTHWEST NIGERIA

***Tijani S. A.[1], Ajao L. K.[2], Aliu Z. A.[3], Lawal I. B.[4] and Ibrahim H. I.[5]**
[1]Department of Business Administration and Management, Federal Polytechnic Ayede, Oyo State
[2]Department of Procurement, Federal Polytechnic Ayede, Oyo State
[3,4]Department of Office Technology and Management, Federal Polytechnic Ayede, Oyo State
Correspondence: saheedtijani5@gmail.com

Abstract

Cocoa farming remains central to Nigeria's agricultural exports, yet yields in Southwest Nigeria have declined due to climate variability, soil degradation, and unsustainable practices. This study explores the role of climate-smart agricultural (CSA) practices in enhancing cocoa yields and promoting sustainability. A mixed-methods design was employed, combining survey data from 400 cocoa farmers across Ondo, Osun, Ogun, Ekiti, and Oyo States with 20 key informant interviews. A structured questionnaire measured adoption of CSA practices, yield outcomes, and adoption constraints, while interviews provided contextual insights. Descriptive statistics, a CSA adoption index, regression, and ANOVA were applied to the quantitative data, and thematic content analysis was used for qualitative narratives. Results showed high adoption of agroforestry (72%) and organic amendments (65%), but low adoption of irrigation (27%) and soil/water conservation (43%). Regression analysis confirmed that CSA adoption significantly improved yields ($\beta = 0.391$, $p < 0.001$), alongside farm size, credit access, and education, while tree age reduced productivity. ANOVA revealed significant yield differences across states ($p = 0.003$), with Ondo outperforming Ekiti and Ogun. Major constraints included input costs, limited credit, and weak extension support. Scaling CSA adoption requires policy support through subsidies, affordable credit schemes, stronger extension services, and targeted state-level interventions to address regional disparities.

Keywords: *climate-smart agriculture, cocoa farming, sustainability, yield enhancement, Southwest Nigeria, smallholder farmers*

1. Introduction

Cocoa production remains a crucial agricultural activity in Nigeria, both in export revenue and rural household livelihood, and the country is the world's fourth-largest cocoa-producing country. The Southwest region of Nigeria has produced over 70% of the country's national output, mainly in Ondo, Osun, Ogun, Ekiti, and Oyo states (Adewuyi et al., 2022). Cocoa production keeps the rural households of millions in place, offering incomes, employment, and foreign exchange, in addition to saving the country's nationals development objectives. Nonetheless, in spite of the pivotal role, the sector is beset by productivity decline as well as sustainability threats that are being owed to climatic variability, land loss, aging plantations, as well as inadequate farming practices (Ajayi & Oladipo, 2021). These threats not only intimidate the farmer's survival, yet they discredit the competency of the Nigerian nation in the production value chain of the commodity in the world.

Climate change has in the past few years amplified these challenges, with unpredictable rainfalls, increasing temperatures, and rising pest and diseases outbreaks cutting West African cocoa production. Nigerian smallholder producers, who produce most of the cocoa, are most exposed given their over-reliance on rain-fed agriculture and inadequacy in adopting technology and resource base (Ogunlade et al., 2023). Conventional production practices, which rely heavily on the use of chemical fertilizers, destruction of forests, and uneconomical land use, worsen land destruction and farm vulnerability. Cocoa production has, therefore, remained stagnant or fallen in most rural villages, creating an urgent need to reconcile productivity and sustainability.

The practice of climate-smart agriculture (CSA) has emerged as a way of resolving these closely related challenges. CSA, as advocated by the Food and Agriculture Organization (FAO), combines practices that build agricultural productivity, build resilience in the face of changing climates, and mitigate greenhouse gas emissions (FAO, 2021). In the case of cocoa production, the practices under CSA involve agroforestry, the implementation of shades by trees, organic amendments in the soils, the use of an integrated pest management practice, improved seed varieties, and water-saving technologies (Antwi-Agyei et al., 2021). Aside from the environment, the practice of CSA was also seen to enhance sustainable livelihoods by producing stable yields, drawing production risks, and encouraging long-term farm viability. The practice of CSA in the case of neighboring Ghana and Côte d'Ivoire was seen to result in higher yields and increased resilience in the neighboring countries (Appiah et al., 2022; Kouassi et al., 2023), indicating great potential in Nigeria where the practice has not yet been scaled.

In spite of its potential, the use of CSA by Nigerian cocoa growers remains modest. The challenges are the high input cost, lack of awareness, poor extension delivery, and poor policy inclusion (Olawale & Adebisi, 2022). The literature shows that although there is awareness among some farmers regarding the value of agroforestry and conservation of the soil, capital and knowledge limitations often deter large-scale take-up (Fashola et al., 2023). In addition, the socio-demographics of the farmer, for example, their age, education, and cooperative membership, all dampen the take-up, with the younger farmer and the college-educated farmer having the predisposition to take up the innovation (Akande & Adepoju, 2021). These inequalities emphasize the value of locally specific studies that look at the technical efficiency as well as the social, economic, and institutional variables that underpin take-up.

Everywhere, the sustainable cocoa farming discussion centers around the twin imperative of rising productivity to reach increasing demand while producing in ways that never compromise environmental and social sustainability. In an effort to build sustainability into the cocoa value chain, certification programs like Fairtrade and Rainforest Alliance have tried to reach that end, yet uptake has been inconsistent, and most smallholder producers in Nigeria cannot afford premium markets because of the cost of certification and the difficulty of compliance (Afoakwa, 2022). This puts a big premium on locally based, climate-sensitive practices that are affordable, accessible, and flexible enough to fit the realities of smallholdings.

Against these forces, Southwest Nigeria offers the perfect context for exploring the role of CSP in sustainable cocoa production. Not only does the region account for most of Nigeria's cocoa production, but it also mirrors the obstacles of aging plantations, climatic stress, and resource-limited farmers. Although productivity in cocoa has in the past been researched, few studies have systematically investigated the effects of CSA practices on productivity in the region, and yet very few the limitations to widespread uptake (Ogunlade et al., 2023). Against this background, the present study attempts to fill the gap by assessing the level of adopters of CSA among the cocoa producers, its effects on productivity, and the challenges and opportunities in scalability. Therefore, the objective of the study is to investigate the potential role of climate-smart agricultural practices in increasing the production of cocoa in Southwest Nigeria. By bringing together quantitative evidence in the form of adoption rates and yield levels with qualitative perspectives of the farmer and the extension officer, the study adds to both theoretical discourses and policy agendas on sustainable farming. The result is designed to give practical advice to policymakers, development institutions, as well as cooperatives, on how to ensure the promotion of climate Smart Cocoa production as a route to sustainable rural lives, environment conservation, and agricultural resilience in Nigeria.

Cocoa production in Southwest Nigeria is hit by an acute sustainability crisis. Historically the pillar of Nigeria's agricultural export economy, production has reduced in the past decades because of the variability in the weather, infestations of pests and diseases, soil erosion, and unsustainable agricultural practices (Ajayi & Oladipo, 2021; Ogunlade et al., 2023). Smallholder producers, who account for the majority of producers, are still exposed to these shocks because of rain-fed production, resource limitations, and insufficient extension connection. Although in Ghana and Côte d'Ivoire, among other countries, agroforestry, organic land management, the integration of pest management, and improved seeds, as delivery mechanisms of the conceptual framework known as climate-smart agriculture (CSA), were seen to deliver much improved resilience and production, the extent of their practice remains insignificant in Nigeria. The main barriers being poor

awareness, the costliness of the inputs, ineffective institutionality, as well as the social and cultural variables of age and education that define the innovation willingness of the producers (Olawale & Adebisi, 2022). The gap in the potential of the much-hyped CSA vis-à-vis its practice has rendered most of the cocoa produce in Southwest Nigeria underproductive, compromising the livelihood of millions of rural people and the status of Nigeria in the international cocoa economy.

Against this background, the study seeks to investigate the role of CSA in the enhancement of sustainable cocoa production and increased yields in Southwest Nigeria. In particular, the objectives are as follows: (i) to establish the current climate-smart practices among cocoa growers; (ii) to establish the level of influence of the adoption of CSA in the yields of cocoa and farm resilience; (iii) to investigate the institutional and economic barriers that inhibit extensive adoption; and (iv) to offer policy inferences for scalability of the CSA in the cocoa value chain. Informed by these objectives, the study seeks to answer the following research questions: What are the climate-smart practices adopted by the cocoa growers in Southwest Nigeria? To what level do the practices impact yields and resilience? What limitations inhibit their extensive application? And what are the mechanisms that can enhance sustainable production of cocoa in the region? Through the responses, the study adds to the literature in the sustainable production of food, as well as provides evidence-based options for the enhancement of Nigeria's cocoa industry amidst the climate change challenges.

2. Literature Review

The discussion around sustainable agriculture has regularly emphasized the imperative to respond to climate change effects on crop production systems in the Sub-Saharan African region. Theoretically, sustainable agriculture is framed as practices that build productivity while preserving environment assets and providing social and economic equity (Sharpley & Telfer, 2021). In this context, the Climate-Smart Agriculture (CSA) has come to the fore as a strategic response to agricultural fragilities. The FAO (2021) has defined the term as an agricultural practice that works to attain three related objectives: (i) sustainably enhance production, (ii) build resilience and adaptability to tropical climates, and (iii) mitigate greenhouse gas emissions where feasible. For the case of cocoa production, the practices under the definition include agroforestry, mulch, organic manuring, integrated pest control, irrigation, and the use of improved and disease-free varieties of cocoa (Antwi-Agyei et al., 2021). These practices aim to overcome both environment and social and economic based challenges, and the Climate-Smart Agriculture as an initiative is central to the Nigerian case of smallholder cocoa production systems.

From a theoretical standpoint, two frameworks provide useful insights into CSA adoption in cocoa farming. The Diffusion of Innovation Theory (Rogers, 2003) explains how new ideas and technologies spread within social systems, emphasizing factors such as relative advantage, complexity, compatibility, and trialability. Applied to cocoa farming, this theory suggests that farmers will adopt CSA practices if they perceive them as beneficial, easy to use, and consistent with traditional practices. Studies have shown that adoption is higher among farmers who are younger, more educated, and socially connected (Akande & Adepoju, 2021). Complementing this, the Sustainable Livelihoods Framework (Chambers & Conway, 2021) situates CSA adoption within the broader context of livelihood assets—natural, financial, human, physical, and social capital. According to this framework, adoption is not simply a matter of awareness or availability of CSA practices but is shaped by access to resources, institutional support, and external shocks such as climate change and market volatility. Together, these theories provide a multidimensional understanding of the drivers and barriers to CSA adoption in cocoa farming.

West African empirical evidence confirms the transformative ability of CSA in cacao production. In Ghana, Appiah et al. (2022) documented that agroforestry practices greatly enhanced cacao yields and minimized exposure to droughts, while generating added revenue from timber and fruits. In similar findings, Kouassi et al. (2023) established that the implementation of CSA practices in Côte d'Ivoire, such as improved seed varieties and land management practices, improved farm productivity and resilience to climate-driven risks. In Nigeria, the uptake of CSA practices has remained limited. Ogunlade et al. (2023) made the observation that although there has been widespread take-up of shade-tree integration and organic manuring, there has been poor uptake of water management and improved seed varieties amidst the exhorbitance of these inputs and poor extension services. Fashola et al. (2023) added that information gaps, poor technical training, and the exhorbitance of inputs impede the widespread take-up of CSA, although there is explicit evidence in its value creation.

In addition to productivity improvements, CSA practices in cacao production enhance environmental sustainability and socio-economic resilience. Agroforestry, for example, diversifies species, avoids erosion, and stores carbon, consequently reducing the effects of climate change (Antwi-Agyei et al., 2021). Integrated pest management decreases chemical pesticides' use, reducing cost of production and protecting the environment. Socio-economically, household incomes, food security, and shock resilience to, say, fluctuating cacao prices, and severe weather conditions have improved as a result of CSA (Olawale & Adebisi, 2022). Various studies, however, observe that the advantages of CSA are not horizontally distributed, as bigger or cooperative-membership farm bigger adopters are in most cases bigger, more isolated poor smallholders (Ajayi & Oladipo, 2021). Inclusivity and equity in adopting CSA rise as concerns in such a case scenario.

The literature also identifies the institutional and policy environment as an effectiveness determinant of CSA. Nationally and by donor-supported projects, Ghana and Côte d'Ivoire's national policies have advanced the use of CSA through the provision of subsidies, farmer training, and certification programs (Appiah et al., 2022). In Nigeria, few investments by the government in extension services, poor farmer cooperatives, and poor credit facilities hampered the diffusion of CSA (Ogunlade et al., 2023). Certification programs like Fairtrade and Rainforest Alliance, which offer incentives for sustainable production, are unavailable to the majority of Nigerian cocoa producers because of the barriers of

cost for compliance and institutional deficiency (Afoakwa, 2022). These institutional deficiencies not only minimize the use of CSA, they also ensure that unsustainable agricultural practices, which are detrimental to the long-term productivity of the cocoa, continue.

The literature confirms that practices of CSA offer great potential for increasing cocoa productivity and resilience in climate change situations. The empirical evidence from Ghana and Côte d'Ivoire show that the adoption of CSA enhances productivity and sustainability, while Nigerian research identifies the enduring challenges of high input prices, knowledge deficiency, and institutional failure. The conceptual models of Diffusion of Innovation and Sustainable Livelihoods elucidate the process of adopting the practices, emphasizing the significance of farmer disposition, resource availability, and institutional enablement. Nevertheless, there exists an evident void in systematic, location-based inquiry into the scope and effect of the adaption of CSA by Southwest Nigerian cocoa farmers. In order to guide the formulation of policies and intervention that can nurture sustainable production of cocoa and ensure the participation of Nigeria in the international cocoa economy, filling the void is essential.

3. Methodology

This research used a mixed-methods cross-sectional study design to evaluate the contribution of climate-smart agricultural (CSA) practices in cocoa production in Ondo, Osun, Ogun, Ekiti, and Oyo States. The sample was 400 cocoa producers, established using Yamane's formula and multistage random sampling, and 20 key informants (extension agents, cooperative leaders, input dealers) were interviewed purposively. A structured questionnaire in a 4-point Likert scale solicited CSA adoption (e.g., agroforestry, organic inputs, pest management, improved varieties, water/soil conservation) and vexations) and yield achievements (kg/ha); resilience indicators; and barriers to adoption. Validity was established by expert review, and pilot-testing gave a Cronbach's α of 0.82. Semi-structured interviews offered complementary qualitative responses in institutional and socio-economic areas. Data were processed in SPSS v.26. Descriptive statistics summarized adoption and output; an index of CSA adoption was built; and OLS locally tested the impact of CSA on output, controlling farmer and farm attributes. ANOVA tested group differences by state as well as by demographic variables, and thematic content analysis of interview transcripts triangulated the result. Ethical clearance was obtained, and informed consent, confidentiality, and voluntary participation were undertaken.

4. Results and Discussion

Table 1: Adoption of Climate-Smart Agricultural Practices among Cocoa Farmers (n = 400)

CSA Practice	% Adopters	Rank
Shade trees/agroforestry	72%	1st
Organic soil amendments/mulching	65%	2nd
Integrated pest management	61%	3rd
Improved/disease-resistant cocoa varieties	48%	4th
Soil and water conservation (terracing, drainage)	43%	5th
Irrigation practices	27%	6th

The findings indicate relatively moderate use of agroforestry (72%) and organic amendments (65%), echoing historical over-reliance on shade trees and organic muches in the cocoa agrosystems. Irrigation (27%) and soil/water conservation (43%) are, however, at low scales, an indication of limitations in infrastructure and technical expertise. These are in agreement with Ogunlade et al. (2023), whose study in Nigeria indicated similar trends, and Appiah et al. (2022) in Ghana, where the use of irrigation among cacao growers was less than 30% because of the cost psychosis.

Table 2: Distribution of CSA Adoption Index

Adoption Category	Score Range
Low adopters	0.00–0.33
Moderate adopters	0.34–0.66
High adopters	0.67–1.00

About half of the respondents (47%) are moderate adopters, indicating fractional but not full uptake of CSA practices. Only 25% are high adopters, indicating the necessity for strengthened extension assistance. This is similar to Fashola et al. (2023), who supported that fractional adoption leads to the minimization of the overall impact of CSA on yield and resilience.

Table 3: Regression Analysis: Effect of CSA Adoption on Cocoa Yields (kg/ha)

Predictor Variable	β	t-value	p-value	Interpretation
CSA Adoption Index	0.391	6.22	0.000	Significant positive effect
Farm size (ha)	0.248	4.80	0.000	Significant positive effect
Access to credit	0.207	3.95	0.000	Significant positive effect
Age of cocoa trees	-0.186	-3.71	0.002	Significant negative effect
Education level	0.133	2.54	0.012	Significant positive effect
Model Summary	$R^2 = 0.58$, $F(5,394) = 43.82$, $p < 0.001$			Model explains 58% of yield variation

Adopting CSA greatly enhances the yield of cocoa ($\beta = 0.391$, $p < 0.001$) while controlling farm and socio-economic variables. Other favorable motivators are farm size, credit, and education, while older tree ages decrease yields. This is consistent with Kouassi et al. (2023), who presented substantial yield increase resulting from adopting CSA in Côte d'Ivoire, and confirms Ajayi & Oladipo (2021), who established that credit and education enable adoption and increased yields.

Table 4: ANOVA: Differences in Cocoa Yields by State

State	Mean Yield (kg/ha)	SD
Ondo	720	135
Osun	685	120
Oyo	640	110
Ogun	605	115
Ekiti	590	100
F-value = 4.76, p-value = 0.003		

There are substantial yield disparities among states (F = 4.76, p = 0.003). Ondo (720 kg/ha) and Osun (685 kg/ha) are the leaders, indicating higher adoption of CSA practices and superior extension cover. Ekiti (590 kg/ha) trails, indicating structural limitations. The regional gap mirrors Olawale & Adebisi (2022), where they mentioned uneven convergence of CSA among Nigerian cocoa regions based on the dimension of gap in the infrastructure and policies.

Table 5: Constraints to CSA Adoption (n = 400)

Constraint	Mean Score (1–4)	Rank
High cost of inputs (organic fertilizers, improved seedlings)	3.42	1st
Limited access to credit	3.36	2nd
Weak extension services/training gaps	3.29	3rd
Labor intensity of practices	3.11	4th
Cultural resistance to new practices	2.87	5th

The adopters' major constraints were the cost of inputs (3.42), credits for inputs being few (3.36), and poor extension extension (3.29). Labor and cultural barriers were smaller, but they existed. These results corroborate Fashola et al. (2023) in that financial constraints were the largest barrier to the adoption of CSA, and Antwi-Agyei et al. (2021) in that extension has played a crucial role in the scaling up of the adoption of CSA in West Africa.

The findings uphold that the adopting of CSR has the potential to hugely increase cocoa output in Southwest Nigeria, with the adopting being based on farm size, credit access, and education. Nonetheless, adopting remains incomplete, with only 25% of the farmer population falling into the high adopting group. Regional yield gaps indicate unbalanced institutional support, while inputs cost, credit access, and extension lags confine the broader adopting. These findings mirror evidence in Ghana and Côte d'Ivoire (Appiah et al., 2022; Kouassi et al., 2023), emphasizing that CSR holds the potential to revolutionize the systems of cocoa when adopting is complete and accompanied by robust policy and institutional arrangements.

5. Conclusion and Recommendations

This study examined the contribution of climate-smart agricultural (CSA) practices to increasing cocoa production in Southwest Nigeria. The findings established that the uptake of CSA practices—specifically agroforestry, organic manuring, and IPM—had positive impacts on yields, while irrigation and soil conservation practices were less practiced. Regression analysis verified that the uptake of CSA practices, farm size, credit, and education significantly enhanced yield achievements while older cocoa trees reduced productivity. ANOVA findings exposed regional inequities, with Ondo and Osun having higher yields than the lowest being Ekiti and Ogun, indicating inconsistent institutional assistance and uptake. In addition, challenges like high cost of inputs, restricted credit, and poor extension services became important limitations. On the basis of these findings, numerous recommendations can be made. Firstly, the government and development institutions can offer subsidy or input support programs to decrease the cost pressure of adopting CSA practices, particularly improved seedlings and organic manure. Secondly, credit delivery to smallholder farmers needs to be improved by adopting microfinance institutions, cooperative organizations, and special-purpose loans with flexible repayment schedules. Thirdly, extension investment and farmer training are essential in increasing awareness, technical expertise, and appropriate implementation of CSA practices. Fourthly, state-level cocoa development policies can earmark the promotion of CSA practices, to ensure that regions with low yields obtain targeted inputs to minimize inequities. Lastly, the integration of CSA into the national adaptation to climate change and agricultural sustainability plans can not only improve the yield of cocoa production but also enhance the broader objectives of food security, poverty alleviation, and environment management.

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