Constraints to the Adoption of New Cocoa Cultivars (CRIN TC1-TC8) among Farmers in Osun State

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ABSTRACT

This study examines the adoption dynamics of improved cocoa cultivars (CRIN TC1-TC8) among smallholder farmers in Osun State, Nigeria, a key cocoa-producing region facing productivity declines due to aging trees, pests, diseases, and climate variability. Despite governmental initiatives like the Cocoa Growth Enhancement Support program and the introduction of high-yielding, disease-resistant TC varieties by the Cocoa Research Institute of Nigeria (CRIN), adoption remains suboptimal. A cross-sectional descriptive survey design was employed, and data were collected from 104 farmers across seven Local Government Areas (Atakumosa East, Ede South, Ife Central, Ife East, Ife North, Ife South, and Ilesha East) using structured questionnaires. Stratified proportionate random sampling ensured representation of adopters (30.8%) and non-adopters (69.2%). Findings reveal a low adoption rate of 30.8%. Socio-economic profiles indicate an aging farmer base ($\bar{x}$ = 52.85 years), high literacy (94.2%), small farm sizes ($\bar{x}$ = 4.87 ha), and reliance on rain-fed systems (95.2%), hired labor (78.8%), and traditional pest management (85.6%). Key constraints, ranked by severity, include pest and disease pressure ($\bar{x}$ = 2.34), inadequate extension services ($\bar{x}$ = 1.99), financial limitations ($\bar{x}$ = 1.98), and limited access to quality planting materials ($\bar{x}$ = 1.94). Remarkably, 98.1% of farmers expressed willingness to adopt, highlighting systemic rather than attitudinal barriers. Grounded in Diffusion of Innovations and Theory of Change frameworks, the study underscores the need for targeted interventions: enhanced IPM training, revitalized extension, financial support, and decentralized seedling distribution. These measures could bridge the adoption gap, boost yields, enhance resilience, and sustain Nigeria's cocoa sector, ultimately improving smallholder livelihoods and economic contributions.

Keywords: Cocoa adoption, CRIN TC cultivars, Adoption constraints, Smallholder farmers, Osun State, Nigeria

INTRODUCTION

Cocoa cultivation plays a pivotal role in Nigeria's agricultural economy, having historically been recognized as a significant source of income for rural households and a major contributor to the country's foreign exchange earnings (Adeniyi *et a*l., 2014). Its importance is especially evident in the southwestern region of Nigeria, where smallholder farmers contribute substantially to the non-oil sector through cocoa production, supporting community livelihoods and national economic growth (Esan *et al*., 2025; Amuda *et al*., 2020).

Despite this economic relevance, cocoa production in Nigeria has faced numerous setbacks over the past decades. The sector suffered a noticeable decline in overall output during the 1970s and 1980s, a trend that persists to the present day (Idowu *et al*., 2007; Adeniyi et al., 2014). Several challenges threaten the sustainability of the industry, including climatic variations such as inconsistent rainfall, temperature fluctuations, and sunshine levels, alongside agricultural constraints like pest infestations, diseases, and aging trees (Adeniyi *et al*., 2014). Additional barriers include environmental degradation, irregular production cycles, yield reductions, and inefficiencies in equipment and supply chain systems (Esan *et al*., 2025).

In response to these challenges, the Nigerian government has launched initiatives, such as the Cocoa Growth Enhancement Support (GES) program, which began in 2012. This program has notably improved yields and farm incomes among its beneficiaries (Kolawole *et al.*, 2020). Subsidy schemes for seedlings in southwestern states have also aimed to revive production, with significant distribution efforts reported in Ondo and Oyo (Alamu *et al*., 2013). Complementing these efforts, the Cocoa Research Institute of Nigeria (CRIN) introduced improved cocoa varieties (CRIN TC1-TC8) characterized by higher yield potential, early maturity, and increased disease resistance (Akinwale *et al.*, 2018). The effective adoption of these new cultivars is crucial for sustainably reviving cocoa production. This study aims to assess the extent of CRIN TC1-TC8 adoption among farmers in Osun State and, more importantly, to identify the socio-economic, enterprise-related, and institutional constraints that inhibit wider adoption.

LITERATURE REVIEW

The sustainability and long-term profitability of the Nigerian cocoa sector are critically dependent on the successful replacement of senile, low-yielding tree stock with new, genetically improved cultivars, such as the Cocoa Research Institute of Nigeria (CRIN) TC1-TC8 series (Olasupo & Aikpokpodion, 2019). These varieties offer superior attributes, including enhanced disease tolerance and earlier maturity, which are essential for boosting national output and enhancing farmer resilience against biotic and abiotic stresses. Despite this clear technological superiority, the observed uptake remains sluggish, a phenomenon corroborated by multiple studies that highlight the pervasive influence of socio-economic, institutional, and environmental barriers that impede the diffusion of technology (Ogunniyi & Jaiyeoba, 2015). Empirically, farmers' investment decisions are consistently hampered by economic constraints, notably the lack of capital to purchase certified seedlings and hire necessary labor (Idris & Usman, 2021). Furthermore, key socio-demographic factors, such as the advanced age of the farming population and the small, subsistence-level scale of most operations, often increase risk aversion, thus limiting the capacity and willingness for the long-term, high-investment requirement of tree crop rehabilitation (Nmadu *et al.*, 2015; Okidim *et al*., 2023).

The theoretical understanding of this adoption challenge is primarily derived from Everett M. Rogers' Diffusion of Innovations (DOI) Theory (Rogers, 2003). The DOI framework posits that the adoption of an innovation, the CRIN TC cultivars, is not an instantaneous act but a gradual process influenced by how potential users perceive the technology based on five key attributes. For the improved cocoa cultivars, the barriers identified in this study directly impair these attributes. For instance, inadequate extension services reduce the perceived Complexity and Trial-ability of the innovation by failing to transfer the technical know-how required for optimal management effectively, a failure widely noted in developing agricultural systems (Adebayo *et al*., 2022). Furthermore, severe pest and disease pressure reduces the perceived Relative Advantage by making potential high yields uncertain. At the same time, chronic financial constraints limit the capacity to invest in necessary inputs, thereby stalling the diffusion process within the social system of cocoa farmers (Feder & Umali, 1993).

Complementing the DOI's focus on perception is the Theory of Change (ToC), which provides the necessary framework for understanding the causal logic of interventions aimed at addressing the constraints (Funnell & Rogers, 2011). The ToC articulates the causal pathway, asserting that achieving the desired Outcome (high adoption) requires specific Inputs (e.g., credit, subsidies, training) that lead to measurable Outputs (e.g., increased farmer knowledge, greater access to credit). By using the ToC lens, the study posits that overcoming the specific, ranked constraints identified by the DOI framework constitutes the crucial intermediate change required to bridge the gap between farmers' high willingness to adopt and the currently low actual adoption rate (Weiss, 1995). Therefore, the ToC informs the policy implications by mapping which constraints must be targeted and to what severity to achieve a positive shift in adoption behavior.

To systematically investigate these relationships, a Conceptual Framework (Figure 1) is employed, linking the observable variables that determine the rate of adoption. The framework is structured into three primary constructs: Input Variables (Farmer and Enterprise Characteristics), Intervening Variables (Constraints to Adoption), and the Output Variable (Adoption of CRIN TC1-TC8). Farmer and Enterprise Characteristics, such as the age and education of the farmer, the size of the farm, and reliance on rainfall and hired labour, define the *propensity* or capacity for adopting new technology. However, the presence of Intervening Variables, including critical barriers such as pest and disease pressure, limited access to seedlings, inadequate extension services, and

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financial limitations, significantly alters this relationship. The conceptual linkage is that the constraints act as mediating variables, diminishing the otherwise positive influence of favourable farmer capacity characteristics on the ultimate adoption decision, thus explaining the observed low adoption equilibrium.

Empirical framework

Empirical studies across Nigeria and West Africa consistently identify a range of constraints that hinder the adoption of agricultural technologies, particularly for high-value tree crops such as cocoa. These constraints can be broadly categorised into economic, institutional, and environmental factors.

Financial constraints are almost universally cited as significant barriers to the adoption of improved cocoa varieties (Ogunniyi & Jaiyeoba, 2015). Planting new cocoa cultivars requires significant upfront capital investment for purchasing certified seedlings, agrochemicals, and securing labour, especially given the long gestation period before returns are realized (Idris & Usman, 2021). The prevalence of small farm holdings, as observed in this study, indicates that farmers often lack the necessary collateral or capacity for significant investments. Furthermore, studies confirm that older farmers tend to be more risk-averse, which negatively influences their propensity to adopt new techniques compared to younger, more educated farmers (Nmadu *et al*., 2015; Okidim *et al.,* 2023). The reliance on hired labour noted in this study also translates into higher operating costs, making the enterprise financially sensitive to new, labour-intensive technology.

Inadequate extension services are consistently identified as a fundamental institutional failure that hinders the diffusion of knowledge and skills necessary for managing complex innovations, such as CRIN TC cultivars. Low farmer-to-extension agent ratios mean that critical information on planting, spacing, fertilizer application, and integrated pest management (IPM) techniques is not effectively disseminated, which reduces the perceived Relative Advantage of the innovation (Adebayo *et al.,* 2022). Compounding this is the limited access to quality planting materials. Even when farmers are willing to adopt, the lack of accessible, affordable, and certified seedlings creates a severe supply-side bottleneck, forcing farmers to rely on non-validated, often low-quality seedlings (Olasupo & Aikpokpodion, 2019). Tenure issues also play a role, as insecure land tenure arrangements discourage long-term investments necessary for tree crop production and rehabilitation (Ogunniyi & Jaiyeoba, 2015).

Finally, pest and disease pressure remains arguably the most pressing operational constraint. Despite the improved disease resistance of CRIN TC cultivars, the sheer prevalence and economic damage caused by diseases like the Cocoa Black Pod Disease (Phytophthora megakarya) and pests continue to rank high among farmers' concerns (Nmadu *et al*., 2015). This is exacerbated by the low adoption of IPM, making the risk of crop failure high and the returns on investment uncertain. Furthermore, the reliance on natural rainfall, as identified in the enterprise characteristics, makes the cocoa system highly vulnerable to the impacts of climate change and unpredictable weather patterns, creating another layer of environmental risk that discourages the adoption of high-investment planting materials.

METHODOLOGY

Description of the Study Area

The study was conducted in Osun State, one of the leading cocoa-producing states in Nigeria. Located in the southwestern geopolitical zone, the state lies approximately between 7°30′N and 4°30′E. The state is primarily situated within the tropical rainforest zone, characterised by a climate suitable for tree crops, specifically cocoa. The annual rainfall averages between 1,200 mm and 1,500 mm, with a distinct bimodal pattern that supports two main cropping seasons. The soils in the cocoa belt are predominantly well-drained ferralsols (reddish-brown to yellowish-red tropical soils) derived from basement complex rocks, offering the necessary depth and fertility for cocoa cultivation.

The state's economy is predominantly agrarian, with cocoa as a crucial cash crop, alongside significant production of food crops such as cassava, maize, and yams, often integrated through agroforestry systems. For this study, seven Local Government Areas (LGAs) known for their high concentration of cocoa farming activities were purposively selected: Atakumosa East, Ede South, Ife Central, Ife East, Ife North, Ife South, and Ilesha East. These areas represent the typical socioeconomic and ecological conditions of the Nigerian cocoa belt, providing a representative sample of the target farmer population.

Research Design

This research employed a cross-sectional descriptive survey design. The design is cross-sectional because data were collected from all respondents at a single point in time, providing a snapshot of current adoption status, farmer characteristics, and prevailing constraints without manipulating variables. It is descriptive because its primary objective is to accurately describe the characteristics of the farming population, their cocoa enterprises, and the frequency and severity of the constraints they face in adopting the CRIN TC1-TC8 cultivars. This design is highly suitable for exploratory studies in adoption research as it allows for the examination of associations between socio-economic and institutional factors and technology uptake under existing field conditions, serving as a critical first step before more complex causal studies are undertaken.

Sampling Procedure and Sample Size

The sample was derived using a multistage sampling procedure to ensure geographical representation and accurate proportional representation of farmers by adoption status. The procedure began with the purposive selection of seven Local Government Areas (LGAs) within Osun State known for their significant cocoa production. The selected LGAs are Atakumosa East, Ede South, Ife Central, Ife East, Ife North, Ife South, and Ilesha East. In the second stage, cocoa farming communities within the selected LGAs were stratified into two mutually exclusive groups: adopters (farmers using at least one of the CRIN TC1-TC8 cultivars) and non-adopters (farmers using only traditional or non-TC varieties). This stratification was necessary to ensure that both groups were adequately represented.

From the stratified population, a proportionate random sampling technique was applied to select the final respondents. A total sample of 104 cocoa farmers was selected, providing adequate statistical power for descriptive analysis. This sample was subsequently stratified: 32 farmers (30.8%) were identified as adopters of the CRIN TC cultivars, while 72 farmers (69.2%) were categorised as non-adopters. This proportional selection ensures that the final sample accurately reflects the actual distribution of adoption status within the study area.

Data Collection and Analysis

Primary data were collected using structured questionnaires administered by trained enumerators. The questionnaire captured data on six key areas: demographic and socio-economic characteristics; enterprise characteristics (farm size, age, labour source, and cropping system); adoption status and practices; production output; and a scaled measure of the constraints to adoption. Constraints were measured using a three-point Likert-type scale, where 1 = Not a constraint, 2 = Mild constraint, and 3 = Serious constraint. Data analysis involved descriptive statistics, including frequency distributions, percentages, mean scores, and standard deviations, to describe the respondents' profile and rank the identified constraints.

RESULTS AND DISCUSSION

Socio-economic Characteristics of Respondents

The farming population in the study area is characterized by a dominant ageing profile (Table 1), with a calculated mean age of 52.85 years. A large majority, approximately 75% of the farmers, are aged 45 years and above, with the highest concentration (38.5%) found in the 45–56 years bracket. This demographic structure is widely recognized as a potential impediment to technological innovation (Nmadu *et al*., 2015). This is consistent with the study by Okidim *et al.* (2023), which found that older farmers generally exhibit greater risk aversion and are often less receptive to adopting complex, management-intensive practices that require significant initial capital and a long gestation period before returns. The implications of this finding for the adoption of the CRIN TC series are critical, as these improved cultivars require substantial long-term investment, intensive management, and a fundamental shift from existing practices. The older demographic may lack the necessary long-term horizon, financial capacity, or willingness to assume the inherent risks associated with tree crop rehabilitation. This factor contributes significantly to the observed low adoption rate.

The cocoa farming sector in the study area is predominantly male (Table 1), with men accounting for 65.4% of the respondents. This finding aligns with the work of Okidim *et al.* (2023), which found that male heads of households in the region frequently dominate agricultural decision-making and control over productive resources. Nmadu *et al*. (2015) reported similar gender disparity in technology adoption studies among cocoa farmers in Ondo State, reflecting the patriarchal structure standard in Nigerian agrarian communities. However, the substantial involvement of women (34.6%) highlights their significant role in the cocoa value chain. However, their lower representation indicates the persistence of gender disparities in access to essential resources and information (Ogunniyi & Jaiyeoba, 2015). This suggests that gender bias in the delivery of support services (such as technical training, credit access, and certified seedling distribution) directly limits the diffusion and effective management of the new cultivars and ultimately their adoption.

In terms of education, the surveyed cocoa farmers exhibited a relatively high level of literacy, with 94.2% having some form of formal education (Table 1), and over half (51%) have completed their secondary education. This high literacy rate serves as a positive attribute, suggesting that educational materials and training programs are likely to be effective in disseminating information about the new cultivars. This aligns with the work of Kolapo *et al*. (2025), which found that literate farmers are better able to understand and apply new technologies, such as fertilizers and pesticides, thereby boosting productivity, profitability, and efficiency in cocoa production. Similarly, Asigbaase *et al*. (2025) reported that higher levels of education positively influence the intensity of organic pesticide adoption among cocoa producers, as educated farmers are more likely to seek out, access, and use information on new agricultural technologies and practices. Kouassi *et al*. (2023) also highlighted that higher education levels positively increase the propensity to replant and adopt agroforestry in cocoa farming, drawing on prior evidence that higher literacy enhances farmers' capacity to evaluate and implement innovative techniques. The implications of these findings for the adoption of the CRIN Cocoa TC series are substantial. With such elevated literacy rates, farmers are well-positioned to engage with extension services, workshops, and informational resources that explain the benefits of these tissue-culture-derived improved varieties, such as enhanced yield, disease resistance, and adaptability. This could accelerate uptake rates, foster sustainable cocoa production, and ultimately improve livelihoods and sector-wide resilience in Nigeria's cocoa industry by reducing barriers to the comprehension and application of novel cultivars.

The enterprise scale among the surveyed cocoa farmers is predominantly small-scale, with 62.5% operating farms of 1-4 hectares and a mean farm size of 4.87 hectares. Coupled with a high reliance on agriculture as the primary livelihood, this underscores the critical importance of profitability while highlighting the resource limitations smallholders face when considering investments in new, high-value planting materials, such as improved cultivars. This is in tandem with the work of Johnson et al. (2025), which found that cocoa farmers in Idanre Local Government Area, Ondo State, Nigeria, have an average farm size of 2.8 hectares, reflecting the dominance of smallholders facing financial constraints and limited economies of scale that affect technology adoption. Similarly, Ademuwagun *et al.* (2024) reported comparable small-scale operations in Ondo State, with nearly 50% of farmers cultivating 2.0-5.9 hectares, underscoring how such limited landholdings constrain productivity gains. The typical household size among farmers is 4-6 members (65.4%), which bolsters the available family labor force for farm activities but also imposes greater consumption demands on the farm's output, potentially diverting resources from reinvestment. This aligns with findings by Arimi *et al*. (2025), who noted that 64.2% of cocoa farmers in Oyo State have households of 0-5 persons, and that larger households negatively influence resource allocation and adaptation decisions. Likewise, Olutumise et al. (2025) reported an average household size of 6, where larger households were associated with barriers to adoption due to increased labor demands and resource strains. This implies that, given the prevalence of small-scale farms and resource constraints, farmers may face challenges affording or accessing the initial investments required for tissue-culture-derived varieties, despite their potential for higher yields and disease resistance. However, the availability of family labor from moderate household sizes could facilitate labor-intensive aspects of adoption, such as planting and maintenance, though competing consumption needs might limit surplus for such innovations.

Enterprise Characteristics of Respondents

The characteristics of the cocoa enterprise (Table 2) reveal the production context within which adoption decisions are made.

Cocoa production among the surveyed farmers in Osun State is overwhelmingly rain-fed, with 95.2% relying solely on natural rainfall for their operations (Table 2). This high dependency on precipitation exposes the farms to considerable vulnerability from climate change, including erratic rainfall patterns, droughts, and floods, which can adversely affect the establishment and long-term productivity of new cultivars that may benefit from or require more consistent moisture conditions. This is in tandem with the work of Kolapo *et al*. (2025), which stated that cocoa production in Nigeria, particularly in Southwest regions like Ondo State, is heavily dependent on rain-fed systems aligned with seasonal precipitation, rendering it highly susceptible to climate variability such as unpredictable rainfall and extreme weather events that contribute to declining yields and environmental degradation. Similarly, Obaniyi *et al*. (2024) reported the same, noting that cocoa farming in southwest Nigeria, including Osun State, relies entirely on rain-fed agriculture, with 90% of farmers perceiving changes in rainfall patterns that heighten vulnerability to floods, erosion, and droughts, thereby impacting productivity and necessitating adaptive measures.

Among the surveyed cocoa farmers (Table 2), pest and disease control practices are predominantly traditional (85.6%), with a notably low adoption rate of Integrated Pest Management (IPM) practices (14.4%) (Table 2). This reliance on traditional methods represents a critical structural constraint, as the improved CRIN TC varieties are engineered to perform optimally under modern, intensive management systems that incorporate IPM to enhance pest resistance and yield sustainability. This aligns with the work of Agulanna et al. (2025), which found that cocoa farmers in Osun State, Nigeria, exhibit low perceptions and adoption of IPM, with many continuing to depend on conventional chemical applications and cultural practices that limit productivity and expose farms to ongoing pest pressures. Similarly, Uwagboe *et al*. (2016) reported the same, highlighting that in Cross River and Osun States, limited awareness, limited access to training, and resource constraints result in subdued IPM uptake among cocoa producers, perpetuating traditional approaches that hinder the integration of advanced pest control strategies. Furthermore, there is significant crop diversification, with over 90% of farmers engaging in intercropping cocoa with staples like cassava (91.3%) and maize (90.4%) (Table 2), a strategy that mitigates risk through diversified income streams but may also divert attention and resources from addressing the specialized agronomic requirements of the cocoa enterprise. This aligns with the findings of Nwokoro *et al.* (2022), who noted that cassava-maize intercropping is extensively practiced in southern Nigeria's cocoa systems, offering complementary resource use but potentially competing for nutrients, water, and labor that could otherwise optimize cocoa performance. Likewise, the CRIN Annual Report (2023) documented similar intercropping patterns in experimental and farmer fields across Nigeria, including Osun State, where cassava and maize are commonly integrated with cocoa to enhance land productivity while posing challenges for focused crop

Labour constitutes a significant expense for the surveyed cocoa farmers, with 78.8% relying on hired labour for farm operations (Table 2). This heavy dependence indicates that the elevated labour demands typically associated with the intensive management of improved cultivars would directly escalate operating costs, posing a financial barrier to their adoption. This resonates with the work of Alabi *et al.* (2025), which stated that the majority (79.2%) of cocoa farmers in Osun State, Nigeria, relied on hired labor despite large households, with the high cost of hired farm workers being the primary effect of rural-urban migration on cocoa production, leading to decreased incomes and productivity challenges. Similarly, Oladokun et al. (2023) reported the same, noting that hired labor predominates in Nigerian cocoa farming, accounting for 88% of total farm labor, which reduces farmers' income as costs eat into potential earnings, particularly for labor-intensive activities such as land clearing, weeding, and harvesting.

Regarding market access, the majority of farmers (60.6%) sell their produce to off-takers (middlemen), while only a scant 3.8% maintain direct linkages with processing companies (Table 2). This intermediary-dominated market structure often fails to deliver sufficient price premiums for the superior quality attributes of improved cocoa varieties, thereby diminishing farmers' economic incentive to invest in these new cultivars. This aligns with the findings of Tracex Technologies (2025), which stated that Nigerian cocoa farmers often receive low prices due to middlemen and volatile market conditions, hindering investments in farm improvements and perpetuating unstable earnings. Likewise, Abdulmalik (2025) reported similar issues, emphasizing that while cocoa exports surged in 2024 due to high global prices, the value chain's structure limits farmers' benefits through intermediary dependencies. However, initiatives like the National Cocoa Plan aim to enhance governance and traceability. Finally, the inadequacy of extension support is apparent: only 48.1% of farmers have received any form of training in recent years, and the original developers, CRIN, have delivered training to only 23.1% of them. This is in tandem with the work of Oyenpemi *et al*. (2024), which stated that only about 18% of cocoa farmers in Nigeria have access to extension services, with over 70% provided by private entities due to public system inefficiencies, limiting dissemination of innovations like approved pesticides and training. Similarly, Badiru *et al.* (2023) reported the same, highlighting that while 51.9% of cocoa farmers in Osun State showed high participation in Farmers Business Schools (FBS) activities for business management training, overall extension efforts, including those involving CRIN, need expansion to boost knowledge and livelihoods amid constraints like inadequate funding.

Adoption Rate and Willingness to Adopt CRIN TC cultivars

The study revealed a low adoption rate of merely 30.8% for the CRIN TC1-TC8 cultivars among the surveyed cocoa farmers in Osun State (Table 3). This is in tandem with the work of Kolapo *et al*. (2025), which stated that only 23.33% of smallholder cocoa farmers in Ondo State, Southwest Nigeria, adopted good planting materials, including the CRIN TC varieties, with high non-adoption rates of 76.67% attributed to partial uptake of intensification technologies amid climate and resource challenges. Similarly, Johnson *et al.* (2025) reported moderate adoption intensity of cocoa farm rehabilitation techniques in Idanre Local Government Area, Ondo State, where farmers integrated an average of 4.7 of the available techniques, reflecting partial rather than comprehensive adoption due to varying integration levels across practices such as grafting and replanting. Despite this, an encouraging 98.1% of the farmers expressed a willingness to adopt the improved varieties, underscoring that the primary obstacles are practical and institutional rather than stemming from farmer skepticism or disinterest. This is in tandem with the work of Kolapo *et al*. (2025), which stated that 79.17% of farmers slightly agreed with adopting intensification technologies, including CRIN TC varieties, for yield enhancement, with positive perceptions significantly boosting the likelihood of combined adoption packages. Similarly, Okoffo *et al.* (2016) reported a high willingness rate of 85.4% among cocoa farmers in Ghana to adopt risk-mitigating innovations such as crop insurance, driven by socioeconomic factors such as age, education, and marital status, which parallel drivers of variety adoption in similar smallholder contexts.

Constraints to Adoption

The analysis of constraints, summarized in Table 4, identifies specific barriers impeding the translation of willingness into actual adoption, with pest and disease pressure ranked first (2.34) and cited as a severe constraint by 45.2% of respondents. This suggests that even with the genetically improved resistance of the TC cultivars, the on-farm realities of pest and disease management, coupled with the prevailing use of traditional control methods, remain the most formidable operational barrier. This is immediately followed by two critical institutional and economic barriers: inadequate extension services (1.99), which limit the transfer of technical knowledge for new cultivars, and financial constraints (1.98), which restrict farmers' ability to purchase seedlings, fertilizers, and other required inputs. The 4th-ranked constraint, limited access to quality planting materials (1.94), represents a direct supply-side issue, indicating that even when farmers are willing and able to pay, the physical availability of authentic CRIN TC seedlings is a significant hurdle. This finding is in accordance with the work of Kolapo *et al*. (2025), which stated that key barriers to sustainable intensification in Ondo State include pest and disease infestations exacerbating yield declines, inadequate extension services, financial constraints with poor access to credit, high input costs, supply chain inefficiencies, and limited access to improved varieties like CRIN TC. Similarly, Johnson *et al*. (2025) reported comparable constraints in Idanre, Ondo State, including environmental factors such as pests and weather unpredictability, resource inadequacies such as finance, inputs, and credit, and poor extension services, which negatively influenced adoption intensity through factors such as household size and farming experience. Agulanna *et al*. (2025) also highlighted related barriers in Osun State, noting that constraints to IPM adoption, crucial for pest management, include inadequate extension services that fail to provide guidance, high input costs, knowledge gaps, and limited market information, leading to reliance on traditional methods. Likewise, Ademuwagun *et al.* (2024) reported low adoption of improved technologies in Ondo State due to barriers like insufficient extension for awareness creation, financial limitations from low incomes, and challenges in accessing quality planting materials (e.g., only 52.94% adoption of improved seedlings), compounded by pests requiring better control practices.

CONCLUSION AND RECOMMENDATIONS

The study has illuminated the persistent challenges facing cocoa production in Osun State, Nigeria, particularly in the context of adopting the improved CRIN TC1-TC8 cultivars. Despite the historical and economic significance of cocoa as a key cash crop that contributes to rural livelihoods and national foreign exchange, the sector continues to grapple with declining productivity, driven by aging tree stocks, environmental vulnerabilities, and institutional inefficiencies. The findings reveal a starkly low adoption rate for these high-yielding, disease-resistant varieties, juxtaposed against an overwhelmingly positive willingness to adopt. This discrepancy underscores that the barriers to adoption are not attitudinal but rather systemic, encompassing operational, economic, and institutional constraints that hinder translating intent into action.

Central to these barriers is the predominance of pest and disease pressure as the foremost constraint, exacerbated by the widespread reliance on traditional management practices and low uptake of Integrated Pest Management (IPM). Institutional shortcomings, such as inadequate extension services and limited access to quality planting materials, further compound the issue by restricting knowledge dissemination and supply chain reliability. Financial constraints emerge as a critical economic hurdle, particularly for small-scale farmers with limited landholdings and who depend on hired labor, thereby amplifying the upfront costs associated with cultivar rehabilitation. These findings align with the Diffusion of Innovations (DOI) Theory, which posits that constraints impair the perceived relative advantage, compatibility, and trialability of the CRIN TC cultivars, thereby slowing diffusion within the social system of smallholder farmers. Similarly, the Theory of Change (ToC) framework highlights the need for targeted inputs, such as enhanced extension and financial support, to generate outputs like improved knowledge and access, ultimately leading to the desired outcome of widespread adoption.

To bridge the adoption gap and harness the potential of the CRIN TC series for enhanced productivity, resilience, and economic viability, the following comprehensive recommendations are proposed, grounded in the study's findings and supported by empirical evidence:

1. **Enhance Integrated Pest and Disease Management (IPM) Initiatives**: Prioritization of subsidized access to IPM inputs, including approved pesticides and bio-agents, alongside hands-on training programs tailored to traditional farmers. This should integrate with climate adaptation measures to address vulnerabilities in rain-fed systems. This aligns with the work of Agulanna *et al.* (2025), which found that low IPM adoption in Osun State stems from inadequate extension, high costs, and knowledge gaps, and recommended targeted training and subsidies to boost cocoa production and income by 20-30% through effective pest control. Similarly, Kolapo *et al.* (2025) reported the same, advocating bundled intensification packages that include IPM, improved varieties, and fertilizers to mitigate climate-induced pest escalation and yield losses in Southwest Nigeria.

2. **Strengthen Extension Services and Capacity Building**: Expand public-private extension networks, increasing agent-to-farmer ratios and incorporating digital tools for disseminating CRIN-specific agronomic knowledge, with a focus on literate, older farmers to reduce complexity perceptions. Special emphasis should be placed on gender-inclusive training to empower women farmers. This aligns with the findings of Badiru *et al.* (2023) and Oyenpemi *et al.* (2024), but more recently, Arimi *et al.* (2025) highlighted that micro-scale adaptations in Oyo State require enhanced extension to promote practices like improved seedlings and IPM, suggesting collaborative workshops to overcome awareness barriers. Likewise, Ademuwagun *et al.* (2024) reported low technology adoption in Ondo State due to insufficient extension, and recommended frequent demonstrations and information campaigns to increase uptake rates to 52.94% for improved seedlings.

3. **Provide Financial Support Mechanisms**: Introduce low-interest credit schemes, grants, and insurance products linked to CRIN TC adoption, targeting smallholders with limited collateral. This could include revolving funds through cooperatives to cover seedling and input costs. This is in tandem with the work

of Maluh *et al*. (2025), who reported resource inadequacies, such as capital constraints limiting adoption, and advocated for subsidized financing to support intercropping optimization and variety upgrades.

4. **Improve Supply Chain for Quality Planting Materials**: Decentralize CRIN nurseries and establish certified seedling distribution hubs in key LGAs, ensuring affordability and authenticity to address supply-side bottlenecks. Partner with NGOs for monitoring. This aligns with Olasupo & Aikpokpodion (2019), but is updated by CRIN (2023), which emphasized genetic resource conservation and nursery expansion to facilitate access to TC varieties, projecting yield increases of 50-100% with proper distribution.

5. **Promote Climate-Resilient and Market-Oriented Practices**: Encourage irrigation adoption and agroforestry models compatible with intercropping to mitigate rain-fed risks, while fostering direct linkages with processors for quality premiums. Youth engagement programs could rejuvenate the aging workforce. This resonates with the work of Arimi *et al.* (2025), which stated that climate adaptation among Oyo farmers includes variety changes and irrigation, and recommended policy support for resilient practices to counter erratic weather. Similarly, Abdulmalik (2025) and Tawiah (2025) reported market volatility and climate as key challenges, suggesting value chain reforms and sustainable certifications to incentivize adoption.

6. **Address Land Tenure and Policy Gaps**: Advocate for secure tenure reforms to encourage long-term investments, integrated with national policies like the Cocoa Plan for holistic sector revival. Monitoring and evaluation frameworks should track progress in adoption.

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Tables

Table 1: Socio-economic Characteristics of Respondents

Variable	Categories	Frequency (n = 104)	Percentage (%)	Mean	Standard Deviation
Age	21 – 32	1	1	52.85	11.87
	33 – 44	25	24		
	45 – 56	40	38.5		
	57 – 68	25	24		
	69 – 80	11	10.6		
	81 – 92	2	1.9		
Sex	Male	68	65.4		
	Female	36	34.6		
Marital Status	Single	3	2.9		
	Married	93	89.4		
	Widowed	8	7.7		
Education Level	No formal education	6	5.8		
	Primary education	21	20.2		
	Secondary education	53	51		
	Tertiary education	14	13.5		
	Postgraduate	10	9.6		

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Farm Size (ha)	1 – 4	65	62.5	4.87	3.43
	5 – 8	24	23.1		
	9 – 12	13	12.5		
	13 – 16	2	1.9		
Household Size	1 – 3	9	8.7	5.83	2.07
	4 – 6	68	65.4		
	7 – 9	20	19.2		
	10 – 12	6	5.8		
	13 – 15	1	1		

Table 2: Enterprise Characteristics of Respondents

Variable	Categories	Frequency (n = 104)	Percentage (%)	Mean	Standard Deviation
Source of Water	Natural rainfall	99	95.2		
	Irrigation	14	14.56		
Pest Management Practice	Traditional	89	85.6		
	Integrated	15	14.4		
Other Crops Cultivated	Cassava	95	91.3		
	Maize	94	90.4		
Source of Labour	Family Member	42	40.4		
	Hired Labour	82	78.8		
Selling Point	Off Takers	63	60.6		
	General Market	34	32.7		
	Companies	4	3.8		
Farm age (years)	1 – 18	30	28.8	28.7	17.42
	19 - 36	43	41.3		
	37 - 54	21	20.2		
Training in the Past Years	Yes	50	48.1		
	CRIN	24	23.1		

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Table 3: Adoption Rate and Willingness to Adopt CRIN TC cultivars

Adoption Category	**Frequency**	**Percentage (%)**
Low Adoption	72	69.20%
High Adoption	32	30.80%
Willingness to adopt	**Frequency**	**Percentage**
Yes	102	98.1

Table 4: Constraints to the Adoption of CRIN TC Cultivars

Constraints	Not a constraint F(%)	Mild constraints F(%)	Serious constraints F(%)	Mean±SD	Rank
Pest and disease pressure	12(11.5)	45(43.3)	47(45.2)	2.34±0.68	1st
Inadequate extension services	33(31.7)	39(37.5)	32(30.8)	1.99±0.79	2nd
Financial constraints	34(32.7)	38(36.5)	32(30.8)	1.98±0.80	3rd
Limited access to quality planting materials	37(35.6)	36(34.6)	31(29.8)	1.94±0.81	4th
Infrastructure deficiencies	36(34.6)	43(41.4)	25(24.0)	1.89±0.76	5th
Climate change impacts	37(35.6)	51(49.0)	16(15.4)	1.80±0.69	6th
Labor shortages	43(41.4)	41(39.4)	20(19.2)	1.78±0.75	7th
Land tenure issues	45(43.3)	46(44.2)	13(12.5)	1.69±0.69	8th
Policy and institutional challenges	49(47.1)	39(37.5)	16(15.4)	1.68±0.73	9th
Market access and price volatility	48(46.2)	43(41.4)	13(12.5)	1.66±0.69	10th
Cultural preferences	48(46.2)	43(41.4)	13(12.5)	1.66±0.69	10th
Lack of technical know-how	51(49.0)	40(38.5)	13(12.5)	1.64±0.70	12th

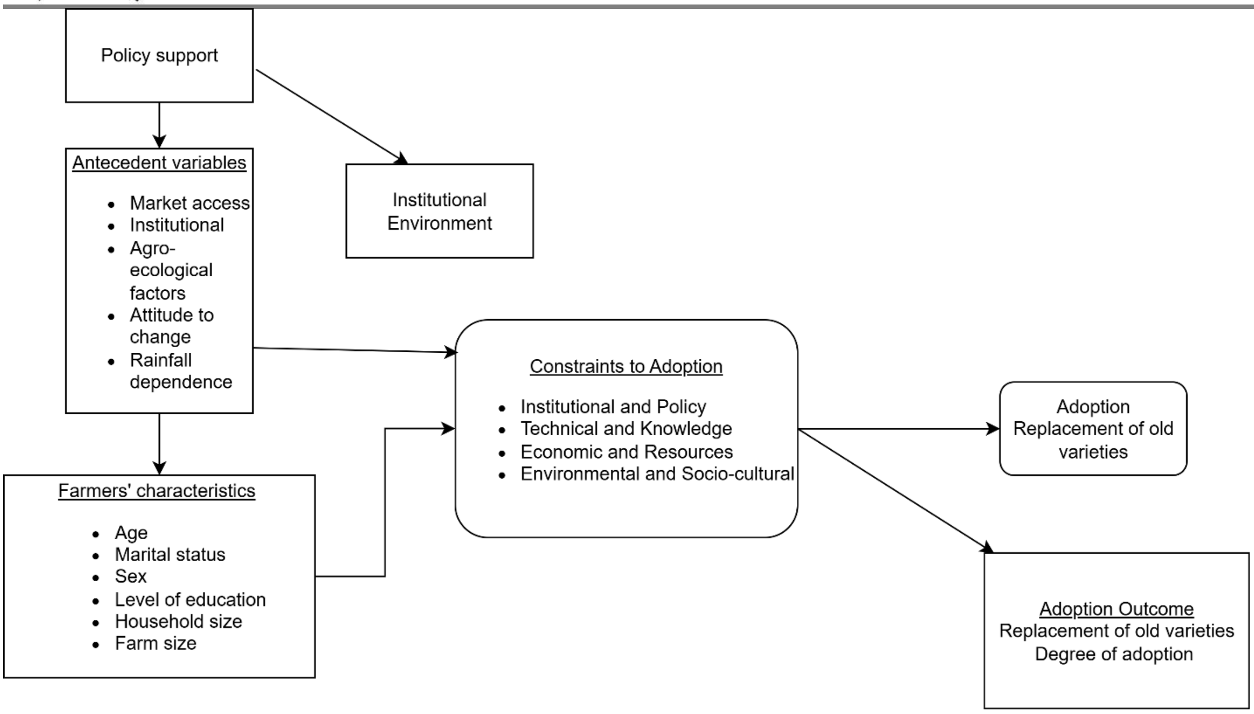

Figure 1: Conceptual framework

Source: Authors' concept