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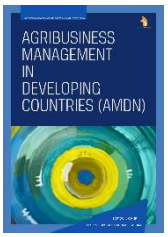

RESEARCH ARTICLE

ECONOMETRIC ANALYSIS OF FACTORS AFFECTING THE INTENSITY OF ADOPTION OF COCOA REHABILITATION TECHNIQUES IN ONDO STATE, NIGERIA

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ABSTRACT

Despite a series of government interventions aimed at bolstering cocoa production in Nigeria, cocoa output continues to decline due to aging trees and other factors. This study examines the factors influencing the intensity of adoption of cocoa farm rehabilitation techniques (CRTs) in Idanre Local study examines, Ondo State, Nigeria. A multistage random sampling procedure was used to select cocoa farmers through a well-structured validated and pretested questionnaire. Data were collected from150 farmers and analyzed with both descriptive and inferential statistics. The fractional probit regression model was used to identify factors influencing the adoption of CRTs. Results revealed that the average age of farmers was 56 years, with a mean household size of 8 and an average farm size of 2.8 hectares. Farmers adopted an average of 4.7 CRTs, reflecting moderate adoption. The marginal effect results showed that farm size (0.341), education (0.052), and yield change (0.158) had a positive significant influence on CRT adoption intensity. Conversely, household size (-0.021), farming experience (-0.032), and cocoa tree age (-0.024) had a negative influence on CRTs adoption rates. It was also revealed that CRT adoption was predominantly hampered by environmental factors (56.1%), such as unpredictable weather and pests, followed by resource inadequacies (21.9%) and resistance to change (13%). Despite these barriers, 82.7% of farmers reported income improvements post-adoption, with 48% experiencing significant increases. The study concludes that farmers should be given the opportunity to have access to financial resources, education, land and and climate-resilient practices to improve CRT adoption and boost cocoa productivity in Nigeria.

KEYWORDS

Probit regression, Productivity, coppicing, pruning, grafting

1. INTRODUCTION

Cocoa (Theobroma cacao) is a major agricultural commodity, contributing significantly to the Africa's economy, particularly in terms of foreign exchange earnings. Africa dominates global cocoa production, accounting for 70% of total output, followed by Latin America and the Asia-Pacific regions (Camargo and Nhantumbo, 2016; FAO.,2017). The major cocoa-producing countries in Africa include Côte d'Ivoire, Ghana, Nigeria, and Cameroon, with Côte d'Ivoire and Ghana leading global production (Muhammed et al., 2024). Latin American countries such as Brazil, Ecuador, and Colombia, together with Asian countries like Indonesia and Malaysia, also contribute significantly to global cocoa production.

Cocoa production is a critical source of income for millions of smallholder farmers across West Africa, Southeast Asia, and Latin America (Merem et al., 2020; Kongor et al., 2024). In Nigeria, cocoa production is a key livelihood activity in cocoa-producing states and communities. It forms the foundation of rural livelihoods and contributes significantly to the economies of developing nations. Southern Nigeria, with its favourable climatic and soil conditions, is particularly well-suited for cocoa cultivation. Over 1.4 million people depend on cocoa farming for their livelihoods (USAID., 2012). Across the downstream and upstream sectors, contributing significantly to Nigeria's gross domestic product.

Despite these contributions, Nigeria's cocoa production sector is characterized by low productivity. Persistent declines in productivity per hectare over the years have caused Nigeria to lose its prominent position in global cocoa production. Currently, Nigeria ranks fourth in Africa (Shahbandeh, 2021; Adetarami et al., 2022). And fifth in the world, with its output trailing significantly behind Côte d'Ivoire and Ghana. The challenges faced by the Nigerian cocoa industry include aging plantations, pest and disease infestations, declining farm productivity, soil degradation, and the impacts of climate change (Amfo et al., 2021; Owusu, 2022; Raju., 2024). Efforts to enhance Nigeria's share of global cocoa production have necessitated a focus on the adoption of cocoa rehabilitation techniques.

Cocoa rehabilitation techniques have begun as a vital strategy to address these challenges. These techniques aim to restore the health and productivity of cocoa plantations. These techniques are those that include coppicing, complete replanting, side grafting, top grafting, phased farm replanting, shading, pesticide application, fertilizer application, and planting under cocoa trees (Osun et al., 2015; Akinnagbe., 2017). Among these methods, farmers generally prefer restoring existing fields due to their cost-effectiveness, quicker returns, and ability to enhance the early maturity of cocoa trees.

In Nigeria, cocoa production per hectare ranges between 250 and 450 kg, which is less than 25% of the yields obtained under ideal conditions (Adebiyi et al., 2021). This significant yield gap is attributed to factors such

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as aging cocoa trees and poor agronomic practices by farmers.The study identified aging trees among many other factors contributing to yield reduction in cocoa farming. Many cocoa farms in Nigeria have been in existence for over 30 to 40 years (Adeogun et al., 2010; Nwachukwu et al., 2010; Wessel and Quist-Wessel, 2015). making them urgently in need of replacement (ICCO., 2023).
The reported that cocoa output in Côte d'Ivoire and Ghana during the 2022/23 production season was 8 times and 2 times greater, respectively, than Nigeria's share (Nwachukwu et al., 2010). Nigeria's underperformance in cocoa production may be attributed to a number of complex factors that require thorough investigation.

The Federal Government of Nigeria has taken steps to promote the adoption of rehabilitation techniques developed by the Cocoa Research Institute of Nigeria (CRIN) through the National Cocoa Development Committee (NCDC). For instance, in 1999, the government initiated a resuscitation program through the NCDC, which aimed to provide inputs, training, and distribute improved cocoa seedlings sourced from CRIN (Akinnagbe., 2015). However, despite these interventions, the desired outcomes have not been achieved, and productivity continues to decline (Taiwo, 2016; Afolayan, 2020; Adetarami et al., 2022).

In light of these challenges, the current study aims to explore the factors influencing the adoption of cocoa farm rehabilitation practices in Idanre LGA of Ondo State, with a view to providing actionable information to policymakers on cocoa rehabilitation techniques. The outcome will benefits the improve farmers' welfare, foreign exchange earnings, businessmen and others.

Table 1: Production of Cocoa Beans in Thousand Tonnes

	2020/21	Percentage	2021/22	Percentage	2022/23	Percentage
Africa	4056	77	3589	74	3634	73.4
Americas	935	18	973	20	1052	21.2
Asia& Oceania	254	5	265	5	268	5.4
World total	5245	100	4826	100	4953	100

Source: ICCO, Quarterly Bulletin of Cocoa Statistics, Vol. XLIX,NO. 4, 2023

2. Empirical Review

Several studies, such as those by Adeogun and Oyeyinka (2011), Adeogun (2008), and Oluyole et al. (2015); e.t.c have explored factors affecting the adoption of cocoa rehabilitation techniques. Using a Pearson product moment correlation, Adeogun and Oyeyinka (2011) investigated the implementation accuracy (IA) of Cocoa Rehabilitation Techniques (CRTs) among farmers in Southwestern Nigeria. The result showed that age, farm size, and yearly income were positively significantly related to implementation accuracy. Chi-square analysis indicated a significant association between educational level and IA.

In the same vein, descriptive statistics was used by Oluyole et al. (2015) to examine 450 respondents on cocoa rehabilitation practices in southwestern, Nigeria. The findings revealed that 56.4% of respondents were 50 years old or younger, with 28.3% having completed at least primary school. While 38.8% were aware of cocoa rehabilitation techniques, only 10.0% implemented them on their farms. The study suggested that farmers are getting more aware of these techniques in order to increase cocoa yield and improve their livelihoods. However, the adoption is low.

In southwestern Nigeria, 240 cocoa farmers were selected and interviewed through a multistage sampling procedure and structured questionnaire by Akinnagbe (2020) to examine the level of adoption of cocoa rehabilitation program (CRP) among cocoa farmers. The findings revealed low adoption rates for coppicing and complete replanting across three farmer groups, while planting young cocoa seedlings under old trees and selective planting/gapping up had higher adoption levels. The study recommended a timely provision of incentives like free cocoa seedling to the farmers. In Ghana, Abayomi et al. (2021) investigated 378 farmers to find out factors influencing climate change adaptation and cocoa farm rehabilitation among Ghanaian farmers. The results showed that adaptation and rehabilitation decisions were influenced by farming experience, income, perceptions of climate extremes, and farm ownership. The study recommended climate awareness to be promoted among farmers.

In order to the impact of pruning on cocoa yield, Djuideu et al. (2021) looked at the effect of rehabilitation pruning on termite outbreaks and cocoa yield in rustic, intermediate, and full-sun agroforestry systems. The results revealed that pruning enhances shade tree diversity, supports beneficial termite species, and improves cocoa tree vigor and yield, with intermediate systems showing the highest yield increase. Termite infestations were positively associated with tree and farm age, but rehabilitation pruning effectively mitigated pest damage. The study concluded that pruning offers a sustainable solution for rejuvenating cocoa farms, increasing short-term yields, and conserving biodiversity.

Still on CRTs, a Multivariate Probit model was used by Adebayo et al. (2022) to analyze the factors influencing the adoption of five improved agricultural technologies among 149 cocoa farmers in Ondo State, Nigeria, The results showed that farmers in cooperatives were more likely to adopt all technologies, while older farmers and those with larger farms favored improved varieties and recommended spacing. Credit access, education, and extension contact positively influenced adoption, while larger household sizes had a negative effect. The study recommended credit access and extension services could promote technology adoption.

In Ghana, Boateng (2023) investigated the effects of a cocoa rehabilitation program on productivity and the economic status of farmers in Offinso District. Using a descriptive design and a sample of 217 farmers, the study discovered that 76.4% of farmers were willing to fully rehabilitate cocoa trees, with shaded agroforestry and selective replanting accounting for 43.3% of cocoa production. Inadequate credit, poor loan terms, and limited knowledge of modern farming were among the challenges. The study suggested that extension officers visit farmers more frequently to educate them on better practices.

The socioeconomic traits and adoption of the cocoa rebirth program (CRP), and its associated challenges were analyzed by Kayode et al. (2024) in Kwara State. They found a widespread adoption of sustainable practices and positive perceptions of CRP, despite some challenges like market access, price volatility, and climate change. Factors such as age, education, experience, and extension services exerted significant impact on farmers' attitudes. The study advocates further research and the development of pest-resistant, high-yield cocoa varieties to aid adoption of technology.

From the foregoing, empirical review shows that literature on factors affecting the intensity of adoption of cocoa rehabilitation techniques, despite emphasis on its awareness, is notably scanty. Lack of information on socioeconomic and technology-specific attributes of adopting CRTs characterizes available past studies. The methodologies and approach adopted in the previous studies were insufficient to identify factors conditioning the intensity of CRTs adoption. To fill this knowledge gap, the current study, therefore, investigated the determinants of intensity of adoption of cocoa rehabilitation techniques with the specific objectives of describing the socioeconomic characteristics of cocoa farmers; examining the intensity of adoption among farmers and identifying factor affecting the intensity of adoption of CRTs in the study area.

3. Methodology

3.1 Study Area

The study was conducted in Ondo State, Nigeria. Ondo State, one of the 36 states in Nigeria, is located in the southwest of Nigeria. It is well-known for the production of cocoa and many other cash and food crops. It shares boundaries with Osun and Ogun States in the West and Ekiti and Kogi States in the North. Ondo State also shares boundaries with Edo and Delta States in the East and the South by the Atlantic Ocean. Ondo State is blessed abundantly with both human and natural resources. It covers an area of 15,500 km^2 of the total land area of Southwest. Ondo State has eighteen (18) local government areas with a projected total population of 4.6 million (NBS., 2017).

The state lies between latitudes 5^0 45^1 and 7^0 52^1 of the equator and longitudes 4^0 30^1 and 6^0 05^1E. The state has numerous advantages over others due to its location in the tropical rainforest zone of Nigeria, Having two distinct seasons, which include the wet and dry seasons between April and October and November and March, respectively, provided an additional benefit for food croppers and livestock managers. The low rainfall is marked by the period of the August break. It has a moderate temperature of about 25°C with an annual rainfall that varies between 1150 mm in the north and 2000 mm in the south of the state. Consequent upon the favourable climatic condition, Ondo State is the largest producer of cocoa, contributing over 50% of the total cocoa output produced in

Nigeria (Oseni, 2011;Adetarami et al., 2022).

3.2 Data Collection and Estimation strategy

Data collected from cocoa farmers in the six Local Government Areas of Ondo State were disaggregated into LGA. Idanre LGA is one of the local government areas of the state. A multistage sampling procedure was adopted to select the farmers in the study area. In the first stage, five communities with a high concentration of cocoa farmers were randomly selected from the zone. In the second stage, three (3) villages were randomly chosen from each community to obtain fifteen (15) villages. The final stage involved a random selection of ten (10) farmers from each village, making a total sample size of one hundred and fifty (150) farmers selected across the 15 villages for the study. Data analysis was carried out using both descriptive and inferential statistics. All analysis is done in Stata version 14.0.

3.2.1 Fractional Regression Model

The fractional regression model is an econometric model applied to empirical studies where outcome of interest (dependent variables) is bounded between 0 and 1. Given that the rate of adoption of Cocoa Rehabilitation Techniques (CRTs) is bounded between 0 and 1, fractional regression method is considered suitable for analysing data in this study. The total rehabilitation techniques adopted by ith farmer is indexed as number of techniques adopted divided by the total number of CRTs available for adoption. It is observed that the traditional methods like Ordinary Least Squares (OLS) or Tobit models is not fit for estimating a model with a dependent variables like probability, rate, fraction, and indices patterns. The use of OLS or Tobit model can cause the predicted values to fall outside the bounded range (0, 1), thus yielding inefficient estimates. It cannot also handle issues that are related to heteroskedasticity. To address these problems, (Papke and Wooldridge., 1996). Presented the Quasi-Maximum Likelihood Estimation (QMLE) method for fractional response models, which has been widely adopted in similar studies (Ogundari, 2017; Ogoudedji et al., 2019; Pokhrel et al., 2018; Ogoudeji et al., 2019; Misango et al., 2022).

The Bernoulli log-likelihood function for estimating the model, with Y representing the proportion of CRT adoption, is specified as:

$$L_i(\beta) = Y_i \ln\left[G\left(x_i'\beta\right)\right] + (1 - Y_i) \ln\left[1 - G\left(x_i'\beta\right)\right] \quad (1)$$

Where $0 \le Y \le 1$ denotes the dependent variable, and X' refers to the vector of explanatory variables for observation i.

In this context, G(.) is the logistic or probit function, ensuring that the estimated probabilities lie within the (0,1) interval. The QMLE of β is obtained by maximizing the log-likelihood function.Revealed that the Bernoulli QMLE β is consistent and asymptotically normal, irrespective of the distribution of Y conditional on X'. This approach does not require data adjustments for extreme values, and the conditional expectation of Y, given the explanatory variables, is estimated directly (Papke and Wooldridge., 1996). Asymptotically efficient, unbiased, and consistent estimates are obtained by applying this method, which is advantageous for modeling fractional data

The empirical specification for analysing CRTs adoption using the fractional regression model is given as:

$$E(Y|X) = G\left(\phi_\circ + \psi X + \beta' X + \varepsilon_i\right) \quad (2)$$

Where Y denotes the proportion of CRT adopted, X denotes the vector of explanatory variables assumed to influence Y, ϕ_0 is the intercept, **ψ** and β are parameters to be estimated, G(.) is either a logit or probit function, and ε is the error term.

Table 2: Descriptive statistics & measurements of variables

Explanatory variable Code	Definition and Measurement	Mean	Std. dev
AGE_HH	Age of respondent, Measured in years	56.20	10.40
GEND_HH	Gender of respondent, measured as male =1,0 otherwise	0.62	0.49
HHZ_HH	Household size (number living under the same roof)	1.87	1.67
EDUC_HH >=13 Years	Years of education (years)	10.21	4.15
EXPER_HH	Farming Experience (years)	34.56	12.82
EDUC * WIDESPR_ADOP. INDEX	Education and widespread index interaction (Continuous)	1.81	1.25
AGECO_ TREES	Age of cocoa trees (years)	36.20	11.04
FARMZ	Farm size (hectares)	2.87	1.96
% of AREA_COVERED	percentage of farm covered by CRTs (ordinal)	2.88	0.80
FARMZ *AREA_COVERED	Farm size and Area covered interaction (Continuous)	8.76	7.44
% of YILED CHANGE	Percentage of yield change (Ordinal)	0.97	0.16
WIDESPR_ADOP. INDEX	Widespread adoptin index (Ordinal)	0.80	0.40
FARMZ* YIELD	Farm size and Yield (Continuous)	6.93	0.71
EXPER* AGECO_TREES	Experience and Age of cocoa trees (Continuous)	101.85	43.38

4. Results and Discussion

4.1 Descriptive statistics of the sample households

The socioeconomic characteristics of respondents are depicted in Table 2. The average age of the farmers is 56 years, indicating that cocoa farming in the study area is dominated by middle-aged people. The reason for this may be due to the labour-intensive nature of the work of cocoa farming. This result is in line with the findings of Oluyole et al. (2015) who examined the adoption of cocoa rehabilitation practices in South-western Nigeria.

Also, the average years of education of cocoa farmers computed is 10 years. This result confirms the findings by Oluyole et al. (2015) who examines the level of adoption of cocoa rehabilitation practices in Southwest, Nigeria. In the same vein, the average household size of cocoa farmers in the study area is 8.0. The household size is large and thus indicates that farmers in the study area have access to family labour availability. In African setting, it is noted that farmers cherish large family size because of high labour demand by cocoa farms. The farmers are likely to adopt CRTs package because having a large family might help reduce the cost of adoption. Years of farming experience is overwhelmed by majority (85.3%) with an average farming experience of 35 years. The result suggests that the cocoa farmers in the area have sufficient practical knowledge that can aid the rate of adoption of cocoa rehabilitation techniques (CRTs). The finding is contrary to the findings of Kayode et al. (2024) in Kwara State.

On average, majority of the farm size is 2.8 hectares, which implies that smallholder cocoa farmers dominated the study area. This may have a far-reaching implication on the adoption of CRTs by smallholder farmers due to financial constraints and economies of scale, while the mean adoption of CRTs by the farmers is 4.7, thereby suggesting a moderately adopted CRTs in the study area.

4.2 Level of Cocoa Rehabilitation Techniques (CRTs) integrated on the farms

The level of integration of various CRTs by farmers based on Likert scale is displayed in Figure 1. Majority (25.7%) of the farmers slightly integrated

pruning, with a moderate integration (23.2%) on their farms. Lack of full implementation of this technique may be attributed to lack of information on the benefits of adopting pruning on cocoa farms. Fertilizer usage here shows low levels of complete integration (2.8%), with most farmers moderately integrating it (21%).

The cost of fertilizers without subsidy is expensive in Nigeria, so farmers may lack the financial strength to bear the full cost. The result shows that pesticide application is overwhelmingly adopted compared to other techniques, with the majority (33.9%) moderately integrating it. Pest attack on cocoa is rampant and if it is not averted on time, lot of yields as well as income will be sacrificed. This reflects its perceived effectiveness in addressing pest challenges. Grafting has the lowest adoption. About 26.4% of the farmers are not integrating it at all. This response suggests that farmers are either lack the necessary technical knowledge or probably they are resource challenged.

Similarly, we find coppicing poorly adopted, with 20.3% not integrating it, phase replanting has moderate adoption (25%), but fully integrated levels remain very low (1%). Similar results was observed by (Adeogun et al., 2010; Oluyole et al., 2015 Akinnagbe., 2020). Who found that coppicing practices are relatively low in their study areas. Complete planting adoption is low, with only 0.7% fully integrating this technique. The higher level of not integrating (13.5%) this technique is an indication that the farmers are facing some challenges relating to availability of labour and finance. This agrees with the findings of (Oluyole et al., 2015; Akinnagbe., 2020; Adebiyi et al. ,2021).

Report on the use of appropriate tools, the highest percentage of adoption here is 24.6%, moderately integrating it on their farms. It is also noted that of all the techniques, this technique is relatively better adopted, with 15.3% fully integrating it. Its higher adoption levels may stem from the availability or perceived simplicity of using appropriate tools. Shading of cocoa trees (12.5%) is also reported to be moderately adopted. However, only 1% of the sample farmers fully integrated it. This might indicate a lack of understanding of the benefits or an absence of extension services in the study area. The result is contrary to the findings of (Oluyole et al., 2015; Akinnagbe., 2020).

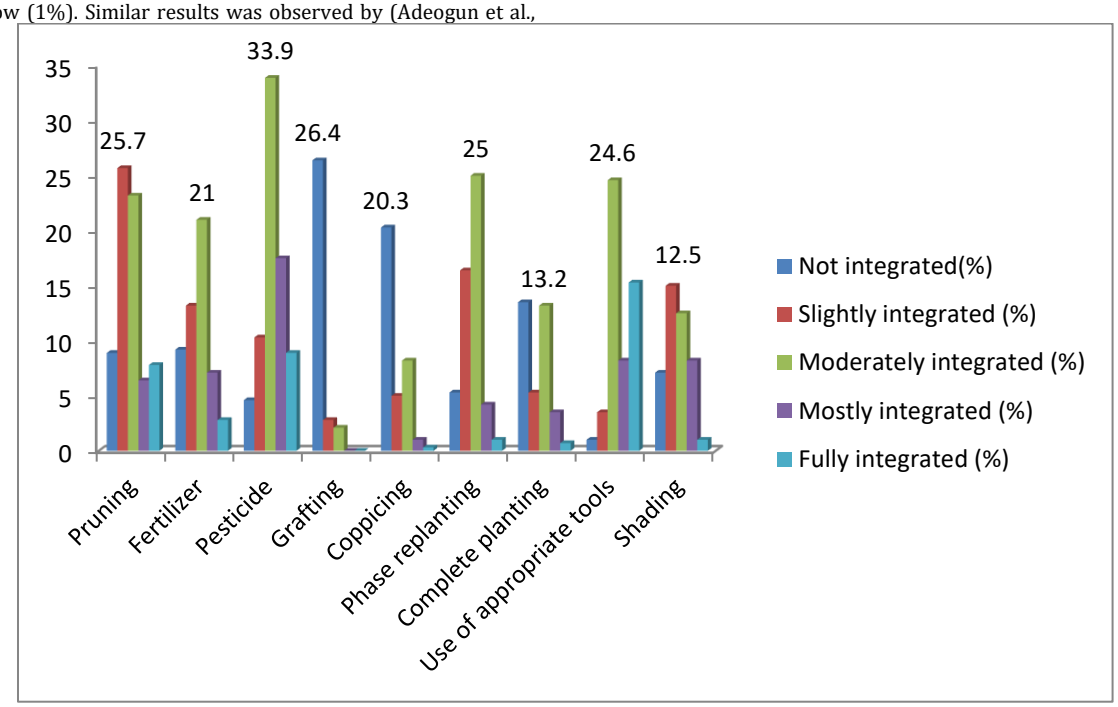

Figure 1: Level of Cocoa Rehabilitation Techniques (CRTs) Integrated by Farmers (Source: Field survey, 2024)

4.3 Factors influencing the intensity of adoption of cocoa rehabilitation techniques

The fractional probit regression results for factors influencing the intensity of (CRTs) adoption are presented in Table 3, including coefficients, standard errors and marginal effects. The diagnostic test shows that the Wald Chi-Square (571.11) was statistically significant at the 5% level, thus validating the suitability of the model used. In this study, we discuss the marginal effects rather than the coeffeicients because the marginal effect provides intuitions into both the direction and magnitude.

The marginal effects of both age and gender are statistically insignificant at the 5% level. The negative insignificant impact of farmer's age on CRT indicates that older farmers are less likely to adopt new techniques due to risk aversion or probably they have preference for traditional methods. Besides, the horizon of the older farmers compared to younger one is too short to reap the benefits associated with CRTs adoption. This findings supports the early report by (Adebiyi and Okunlola., 2013). who noted that older farmers are less receptive to adopt new cocoa production technologies. Similarly, the negative insignificance impact of gender on CRT reveals that the difference in the rate of adoption between male and female cocoa farmers is not substantial. The study by on adoption of cocoa production technologies is supported by the present study by (Adebiyi and Okunlola., 2013).

The negative significant impact of household size on CRT adoption is contrary to our a priori expectation. The marginal effect is -0.021, which indicates that a one-unit increase in the household member leads to a likelihood reduction of about 0.2% CRT adoption. The probable reason for this may be attributed to lack of resources and inability to prioritise immediate needs over long-term investments in rehabilitation by larger households.

The positive correlation of education is consistent with the study a priori expectation. Asserted that education promotes awareness, adoption and literacy level (Roger, 1962). The marginal effect (0.0518) of education on the adoption of cocoa rehabilitation techniques shows that higher education increases the likelihood of adopting CRT by 5.2%. This further translates to the fact that educated farmers are better equipped to understand and effectively implement CRTs. The result here is consistent with the findings of (Adebiyi and Okunlola, 2013).

The negative marginal effect (-0.032) for farming experience is contrary to our expectation. Though, it is statistically significant at the 1% level. The result implies that a one year increase in farming experience leads to a 0.3% likelihood reduction in CRTs adoption. The probable reason could be that experienced farmers rely on traditional methods and thus resist modern techniques. This result aligns with the findings of who found that farming experience was negatively correlated with the adoption of medium and high shade agroforestry in Ghana (Amerino et al., 2023).

Likewise the marginal effect of farm's age is -0.024. The negative sign observed here is not consistent with our a priori expectation. We hypothesized that more years of experiences would promote adoption of CRTs among farmers. This result suggests that the probability of considering the adoption of CRTs in older farms will be reduced by a 0.2%.

Again, the marginal effect of farm size obtained and its resultant impact on CRTs adoption is positively and significantly consistent with our hypothesis. The marginal effect of farm size is 0.341 at the 5% level of probability. This implies that a one-unit increase in farm size surges the likelihood of CRT adoption by 3.4%. The result can further be explained that large-scale farms are better positioned to adopt CRTs due to the fact that they have access to availability resource and economies of scale compared to small-scale farms. The study supports the findings of (Adebiyi and Okunlola.,2013 ;Varma .,2019). The majority of cocoa farms in Nigeria are in the stage I of the production function as reported by (Massaquoi et al., 2022; Johnson et al., 2024). So what this implies is that cocoa farmers, particularly in the study area, still have enough rooms to accommodate CRTs adoption on their farms.

The interaction between farm size and the percentage of land covered by CRTs is positively estimated with a marginal effect of 0.016 at the 1% level. The result suggests that a one-unit increase in the percentage of land dedicated to CRTs raises the probability of adoption rate by 0.2%, particularly for larger farms. Percentage yield change is positively and significantly associated with CRT adoption, with a marginal effect of 0.158 at the 5% level. A significant change in the yield of cocoa goes a long way to influence the adoption behaviour of cocoa farmers. This further implies that a one-unit increase in yield change boosts the likelihood of the adoption rate by 0.8%. Farmers who observe tangible productivity

benefits are more inclined to adopt and expand CRT intensity.

The widespread adoption index shows a positive and significant impact on the adoption rate as hypothesised. The estimated marginal effect is 0.075 and z = 2.88, indicating a one-unit increase in the widespread adoption

index will likely promote and expand the intensity of CRT adoption in the study area. For example, group learning and demonstration plots are major effective tools for spreading awareness and persuading doubtful farmers of CRT benefits. This study supports the findings by (Han et al.,2022). Who found that social trust has a positive impact on a farmer's willingness to adopt new agricultural technologies in China. The result also confirms that there is collaboration among the cocoa farmers in the study area.

The farm size and cocoa yield has a negative but significant impact on CRT adoption. The marginal effect of 0.121 with a z = -6.76 is statistically significant at the 5% level. This result indicates diminishing returns for yield improvements as farm size increases. The result also provides evidence that some large-scale farms in the study area are operating close to optimal capacity with no room to adopt CRTs compared to small-scale farm and thus leading to low adoption.

Table 3: Determinants of intensity of adoption of cocoa farm rehabilitation techniques

Explanatory variables	Coefficient	Std error	dydx	Std error
CONSTANT	0.8670	0.2655		
AGE_HH	-0.0180	0.0114	-0.0067	0.0043
GEND_HH	-0.0110	0.0390	-0.0040	0.0143
HHZ_HH	-0.0560**	0.0205	-0.0209**	0.0076
EDUC_HH >=13 Years	0.1410**	0.0621	0.0518**	0.0224
EXPER_HH	-0.0870**	0.0198	-0.0325**	0.0072
EDUC * WIDESPR_ADOP. INDEX	-0.0710**	0.0264	-0.0263**	0.0097
AGECO_ TREES	-0.0640**	0.0130	-0.0240**	0.0048
FARMZ	0.9180**	0.1490	0.3413**	0.0537
% of AREA_COVERED	-0.0670	0.0473	-0.0251	0.0175
FARMZ *AREA_COVERED	0.0430**	0.0104	0.0161**	0.0038
% of YILED CHANGE	0.4250**	0.1016	0.1580**	0.0374
WIDESPR_ADOP. INDEX	0.2020**	0.0708	0.0752**	0.0261
FARMZ* YIELD	-0.3260**	0.0501	-0.1214**	0.0180
EXPER* AGECO_TREES	0.0000**	0.0001	0.0002**	0.0000
Wald chi2(13)	597.11			
Prob > chi2	0.00			
Log pseudo likelihood	-48.738			
Pseudo R2	0.039			
No. of observation	150			

Source; Field survey, 2024

4.4 Challenges that hinder Farmers in Adopting CRTs

Figure 2 describes the challenges cocoa farmers faced over the adoption of cocoa farm rehabilitation techniques. The table shows that only 0.2% of farmers identified lack of knowledge and training as a barrier, suggesting it is an insignificant issue in the study area. This indicates that most farmers may already have basic awareness or training about CRTs. Also, about 8.1% of the farmers reported that CRTs are cost-intensive to implement. The result indicates that a relatively small but notable portion of farmers are struggling with the high financial burden of adopting CRTs, such as acquiring fertilisers, equipment, or labour. A significant number of the farmers (21.9%) showed they are challenged by lack of resources in the area. Lack of resources is a common phenomenon in rural areas in the African setting, including such issues as inadequate access to inputs, credit, or infrastructure, to name but a few.

Further scrutiny of the results shows that 13% of the cocoa farmers resist adopting CRTs due to cultural preferences, fear of failure, or perceived risk. This reflects a behavioural barrier. education campaigns, demonstrations, and peer-led initiatives could help reduce resistance and foster gradual adoption. Poor extension services were identified by a relatively insignificant (0.8%) number of the respondents, suggesting that most farmers in this Idanre LGA in particular and Ondo state in general have access to adequate extension services or do not perceive it as a key challenge. assessments and improvements are necessary to maintain or enhance their effectiveness. Similarly, an overwhelming majority of farmers (56.1%) mentioned environmental factors, such as unpredictable weather, pests, or soil degradation, as the primary challenge. The results here suggest the need for interventions aiming at environmental resilience strategies like climate-smart agriculture, pest-resistant cocoa varieties,

and developing and disseminating weather forecast tools for farmers.

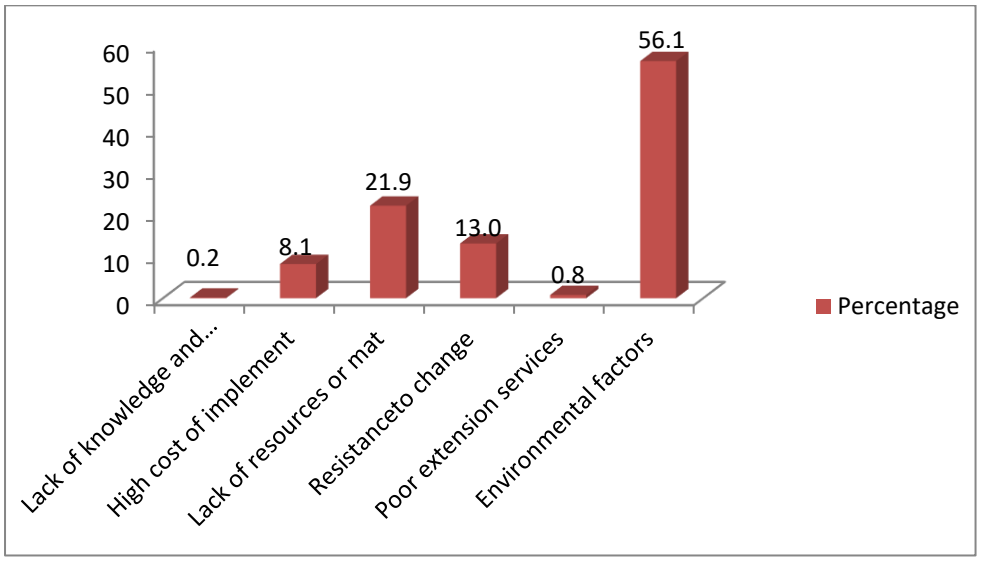

Figure 2: Challenges faced by cocoa farmers (Source: Field survey,2024)

5. Conclusion and Policy Implications

With the use of a fractional probit regression model, the study determined the factors influencing the degree of cocoa rehabilitation techniques (CRTs) adopted in Idanre Local Government Area of Ondo State. The study concluded that the adoption of CRT was found to be positively impacted by socioeconomic factors (such as education, farm size, and yield improvements), whereas household size, farming experience, and cocoa tree age had negative effects. The study also found that environmental issues, resource scarcity, and change aversion are major barriers to adoption. The majority of farmers saw an increase in income as a result of CRT adoption, despite these drawbacks, indicating the potential of these methods to improve productivity and livelihoods.

Based on these findings, the study recommends that policies that will improve farmers' access to education and on-going training programs to help them better understand and implement CRTs should receive enough attention. Once more, if prioritised, low-interest credit facilities and input subsidies can help lower the financial burden associated with CRT adoption. Since farmers are ageing, it is important to provide timely climate-related information, free seedlings, and affordable tools. To maximise CRT adoption and its associated benefits across different farm sizes, policymakers should design interventions that take into account the needs of small, medium, and large-scale farmers.

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Conflicts of Interests

The authors declare that there are no conflicts of interests.

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