World Development Perspectives 42 (2026) 100789

Contents lists available at ScienceDirect

World Development Perspectives

journal homepage: www.sciencedirect.com/journal/world-development-perspectives

Role of credit access, improved varieties, and gender dynamics in commercialization of cassava seeds in Nigeria

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ARTICLE INFO

Keywords:
Cassava seed entrepreneurship
Financial inclusion
Improved varieties
Gender-responsive policy
Smallholder commercialization
Policy simulation
Nigeria

ABSTRACT

Cassava seed entrepreneurship is critical for strengthening seed systems and advancing agricultural transformation in Nigeria. This study examines the determinants of smallholder participation in cassava seed entrepreneurship and simulates the effects of targeted policy interventions using survey data from 993 cassava farmers in Benue State. The analysis applies a binary logit framework with counterfactual scenario simulations and production-regime, specific estimations to account for heterogeneity between low- and high-productivity environments, alongside additional robustness checks. The results show that access to credit ($dy/dx = 13.2\%$, $p < 0.01$), adoption of improved cassava varieties ($dy/dx = 14.3\%$, $p < 0.01$), use of an area-calculation mobile application ($dy/dx = 7.1\%$, $p < 0.05$), and access to extension services ($dy/dx = 5.2\%$, $p < 0.05$) significantly increase the likelihood of participation in cassava seed entrepreneurship. Gender-disaggregated analysis indicates that male farmers have a modest but meaningful advantage ($\beta = 0.92$, $dy/dx = 5.8\%$), reflecting differential access to productive resources and institutional support. The production-regime analysis reveals important structural differences in participation drivers. In low-productivity environments, participation is primarily constrained by financial capital, with credit access emerging as the dominant determinant. In contrast, in high-productivity environments, participation is more strongly influenced by technological complementarities, particularly adoption of improved varieties, digital decision-support tools, and extension services that enhance productivity and market coordination. These findings highlight that entrepreneurial engagement is context-dependent rather than uniform across farming systems. Policy simulations further indicate that the joint provision of credit and improved varieties could increase participation probabilities by 36.1 percentage points for men, 32.0 percentage points for youth (≤35 years), and 25.8 percentage points for women, demonstrating substantial untapped entrepreneurial potential among women and youth if structural barriers are relaxed. As part of the robustness analysis, conflict exposure, used as a proxy for local political instability, shows a positive and statistically significant association with participation, suggesting that farmers in conflict-affected environments may adopt cassava seed entrepreneurship as a resilience or income-diversification strategy. Consistency across alternative specifications confirms that institutional access, technological adoption, and productive capacity remain more decisive for participation than most demographic characteristics. Overall, the study underscores the need for gender- and youth-responsive policies that integrate financial inclusion, technological support, institutional strengthening, context-sensitive interventions as well as attention to productivity regimes and local security conditions, to promote inclusive and resilient cassava seed systems in Nigeria.

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https://doi.org/10.1016/j.wdp.2026.100789
Received 10 July 2025; Received in revised form 24 February 2026; Accepted 8 May 2026
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1. Introduction

Agriculture remains the backbone of rural livelihoods in Nigeria and much of sub-Saharan Africa. As Africa's largest cassava producer, Nigeria engages over 4.5 million farmers in cassava cultivation (Mukaila, 2024). Cassava fresh root production grew steadily between 1961 and 2023, with harvested areas expanding from 780,000 ha in 1961 to over 10 million hectares by 2022 (see details in Annex 1 and Figs. 1-2 below). However, yields as shown in Fig. 3 have declined from 12.2 tons/ha in 2010 to 5.8–6.3 tons/ha between 2019 and 2023 (FAO, 2024). Beyond its role as a staple food, cassava holds significant potential for rural economic transformation by raising incomes, enhancing food security, and fostering inclusive growth (Geffersa & Islam, 2024; Manganyi et al., 2023). Yet, production remains dominated by resource-constrained smallholders with limited access to improved inputs, mechanization, and profitable markets (Adebayo, 2023). Moreover, weak seed systems continue to constrain cassava's contribution to economic development and food security, despite opportunities to strengthen smallholder market participation (Olayide et al., 2021).

To address these constraints, several interventions have sought to strengthen Nigeria's cassava seed system through the government and development partners. Notably, the Building an Economically Sustainable Integrated Cassava Seed System (BASICS) initiative was launched in 2016 by CGIAR Root and Tuber (RTB) program in partnership with the International Institute of Tropical Agriculture (IITA), Catholic Relief Services (CRS), National Root Crops Research Institute (NRCRI) and the National Agriculture Seed Council(NASC). The BASICS initiative introduced Village Seed Entrepreneurs (VSEs) to produce, certify, and market improved cassava stems, scaled Semi-Autotrophic Hydroponics (SAH) laboratories for disease-free seed multiplication, and developed the Cassava Seed Tracker for enhanced certification and traceability (Legg et al., 2022; Owoade et al., 2025). These efforts have improved breeder seed availability and commercialization. However, constraints such as limited access to finance, high certification costs, low demand due to entrenched recycling practices, project dependency, and gender inequities in seed entrepreneurship hampered the success of the initiative in in Nigeria (Olayide et al., 2021).

The improved cassava stem varieties developed through partnerships between IITA and NRCRI offer significant potential for productivity gains and commercialization (Hanna et al., 2017; Owoade et al., 2025). However, adoption among smallholder farmers has been inconsistent. Women farmers, in particular, face disproportionate barriers to accessing inputs, credit, and institutional support due to challenges such as inadequate collateral and limited access to extension services (Olayide et al., 2021; Balana & Oyeyemi, 2022; Adebayo & Worth, 2024). Existing studies have largely focused on mapping adoption patterns of improved planting materials (Bentley et al., 2020; Wossen et al., 2020; Opata et al., 2021; Pircher et al., 2022; Legg et al., 2022). Collectively, these studies highlight both notable progress and persistent challenges in developing commercial seed systems for vegetatively propagated crops (VPCs), particularly cassava, in Nigeria. First, the emergence of formal seed enterprises,supported by programs like BASICS, shows promise in supplying certified cassava planting material, though their long-term viability depends on sustained demand and ongoing programmatic support. Second, the unique biological and economic characteristics of VPCs necessitate tailored technologies and policies to address seed market imperfections and ensure widespread access to high-quality planting materials. Third, evidence from DNA fingerprinting studies reveals substantial misidentification of improved cassava varieties in farmers' fields, underscoring the need for more robust varietal identification systems and highlighting the role of biofortification traits in driving adoption decisions.

Such evidence is critical for Nigeria for several reasons. First, as the world's largest producer of cassava, Nigeria depends heavily on smallholder farmers to sustain production, yet these farmers often face limited access to credit and improved inputs. Second, facilitating a vibrant cassava seed system is central to national efforts to improve food security, enhance rural incomes, and create employment opportunities, especially for women and youth, who are often excluded from higher-value agricultural enterprises. Third, understanding the combined role of credit and improved inputs is essential to designing targeted interventions that can unlock smallholder participation in seed entrepreneurship at scale. Despite this, there is little or no evidence that systematically examines how access to credit and improved inputs jointly influence smallholder engagement in seed entrepreneurship, or that forecasts differentiated impacts for women and youth in Nigeria through simulation analysis.

This study contributes to filling this knowledge gap by investigating how access to credit and the adoption of improved cassava varieties influence commercialization, measured as participation in cassava stem sales. Using data from 993 cassava farmers in Benue State, Nigeria, and applying a Logit model with simulation analysis, the study explores pathways to enhance the participation of youth and women in cassava seed entrepreneurship. Using data from 993 cassava farmers in Benue State, Nigeria, and a Logit model with simulation analysis, it explores pathways to enhance youth and women's participation in cassava seed

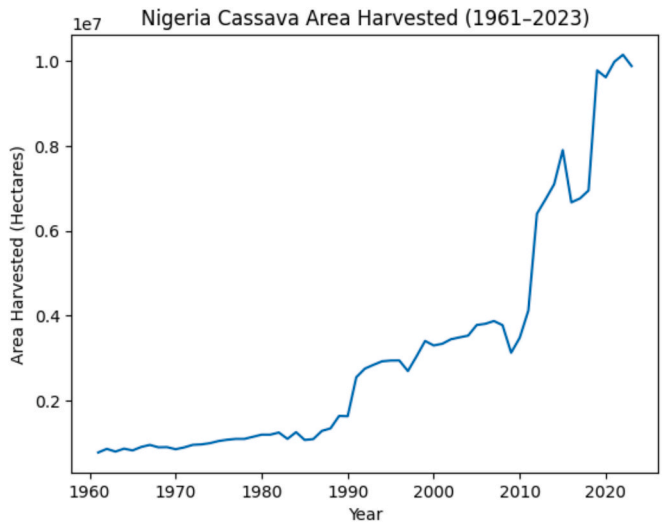

Fig. 1. Area harvested for cassava in Nigeria from 1961 to 2023. Source: FAOSTAT, 2024.

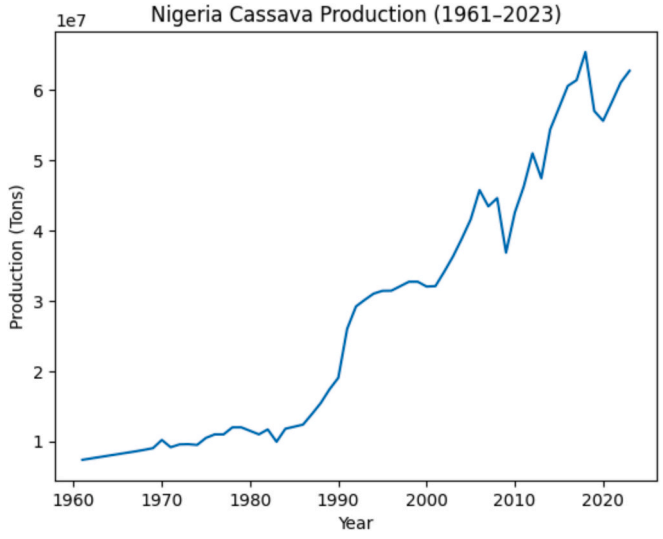

Fig. 2. Trend of cassava production in Nigeria from 1961 to 2023. .
Source: FAOSTAT, 2024

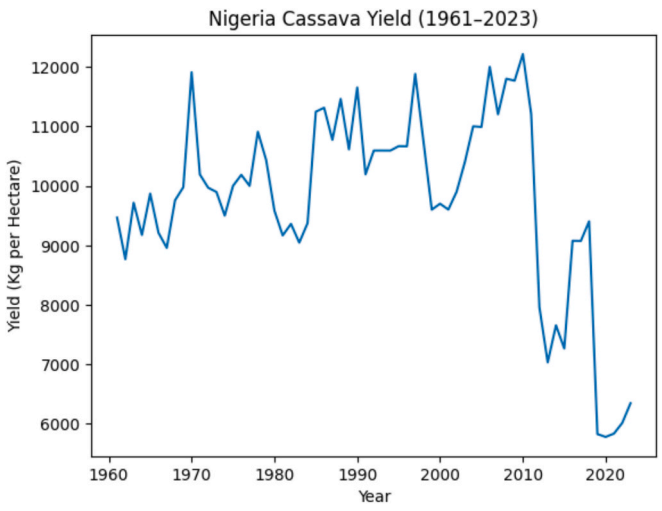

Fig. 3. Trend of the yield of cassava in Nigeria from 1961 to 2023. .
Source: FAOSTAT, 2024

entrepreneurship. The paper is structured as follows: the next section presents the literature review. Then, a methodology section with details on data collection and analysis follows. After that, a section on the results follows. The last section presents the discussion and conclusions of the study.

2. Literature Review

The commercialization of agriculture is widely recognized as a pathway to rural development and poverty reduction (Chamberlain & Anseeuw, 2018). Yet, its realization depends on multiple enabling factors, including access to credit, improved input availability, extension services, and gender-sensitive institutional frameworks (Shilomboleni et al., 2023; Hambloch et al., 2021). In the Nigerian context, rural credit markets remain underdeveloped, especially for women and smallholders who face systemic barriers such as collateral requirements, lack of financial literacy, and limited institutional outreach (Balana & Olanrewaju, 2024).

Improved seed varieties, particularly in staple crops like cassava, have been shown to significantly boost productivity and market engagement (Mukaila, 2024; Donovan et al., 2021). The dissemination of improved cassava stem varieties through formal and informal seed systems has been a focus of agricultural development efforts, with institutions such as IITA and NRCRI spearheading varietal innovation and Quality Declared Seed (QDS) promotion (Legg, 2022).

Gender dynamics play a critical role in shaping access to these resources. Studies indicate that women farmers often have less access to credit, extension, and improved inputs due to sociocultural norms, limited mobility, and weaker bargaining power within households and communities (Adebayo & Worth, 2024; Nyberg et al., 2025). Failure to integrate gender considerations into seed system interventions risks reinforcing inequalities and undermining the effectiveness of commercialization efforts (Guthridge et al., 2022; Nchanji et al., 2024).

Despite acknowledging these challenges, there are few empirical studies that look at credit access, better input use, and gender aspects in smallholder commercialization together. In another vein, most gender-focused studies stop at access and adoption with little attention on commercialization outcomes Additionally, few apply counterfactual simulation techniques alongside econometric modeling to estimate the joint impact of credit and input interventions on different outcomes based on gender and age. This study fills these gaps by using logit regression and counterfactual scenario analysis to offer insights for developing an inclusive cassava seed system.

3. Materials and Methods

3.1. Study Area and Sampling Design

This study was conducted in Benue State, located in Nigeria's North Central geopolitical zone. Benue was purposively selected for several reasons. First, it is a major cassava-producing state due to its favorable agroecological conditions within the Southern Guinea Savanna zone, characterized by fertile loamy soils and bimodal rainfall (1,200–1,800 mm annually). Second, Benue serves as a regional hub for cassava markets and processing clusters, with a high density of smallholder farmers engaged in cassava-based livelihoods. Third, the state was a focal area for the implementation of the Building an Economically Sustainable Integrated Cassava Seed System (BASICS) and Agricultural Transformation in Nigerian Federal States and Togolese Regions towards Achieving Zero Hunger projects, providing a relevant context for assessing participation in cassava seed entrepreneurship.

A multistage sampling technique was employed. In the first stage, seventeen Local Government Areas (LGAs) with high cassava production intensity and active seed entrepreneurship interventions were purposively selected: Ushongo, Tarka, Otukpo, Okpokwu, Oju, Ohimini, Ogbadibo, Obi, Logo, Kwande, Konshisha, Gwer West, Gwer East, Guma, Gboko, Buruku, and Agatu. Some of these LGAs are located along state boundaries and share borders with neighboring states. For example, Kwande LGA borders Cameroon, while Agatu and Gwer West LGAs are situated near boundary areas with Nasarawa and Kogi States. In such locations, several farming communities are positioned very close to administrative boundaries, and agricultural plots may lie within short distances of adjacent states.

In the second stage, eighty-one communities were randomly selected from the sampled LGAs. Finally, 993 cassava farmers were randomly selected from these communities. Stratification by gender and age ensured adequate representation of women and youth farmers. Geographic coordinates of respondents were collected using GPS-enabled mobile devices during field surveys. Because some sampled communities are located near state borders, and considering normal GPS positional error, a small number of recorded coordinates appear slightly outside Benue State when mapped. However, all respondents were administratively verified to belong to communities within the selected LGAs of Benue State (Fig. 4).

3.2. Data Collection Procedures

Primary data were collected between February and May 2024 through structured questionnaires administered by trained enumerators. The survey captured data on household demographics, farm characteristics, access to credit, improved varieties, extension services, and use of digital tools. Prior to data collection, ethical approval was obtained from the International Institute of Tropical Agriculture Ethics Committee, and informed consent was secured from all respondents.

3.3. Variables and Measurements

This study uses a binary logit model to explore the factors that influence farmers' participation in cassava seed entrepreneurship. It also includes simulation analysis to evaluate the marginal impact of specific policy interventions. The key variables are defined and measured as follows:

3.3.1. Treatment Variables

Two central treatment variables are introduced: access to credit and adoption of improved cassava varieties.

Adoption of Improved Cassava Variety is coded as 1 if a farmer reported actual usage (not just awareness) of improved cassava planting materials during the cropping season, and 0 otherwise. This approach follows classification methods used in similar adoption and

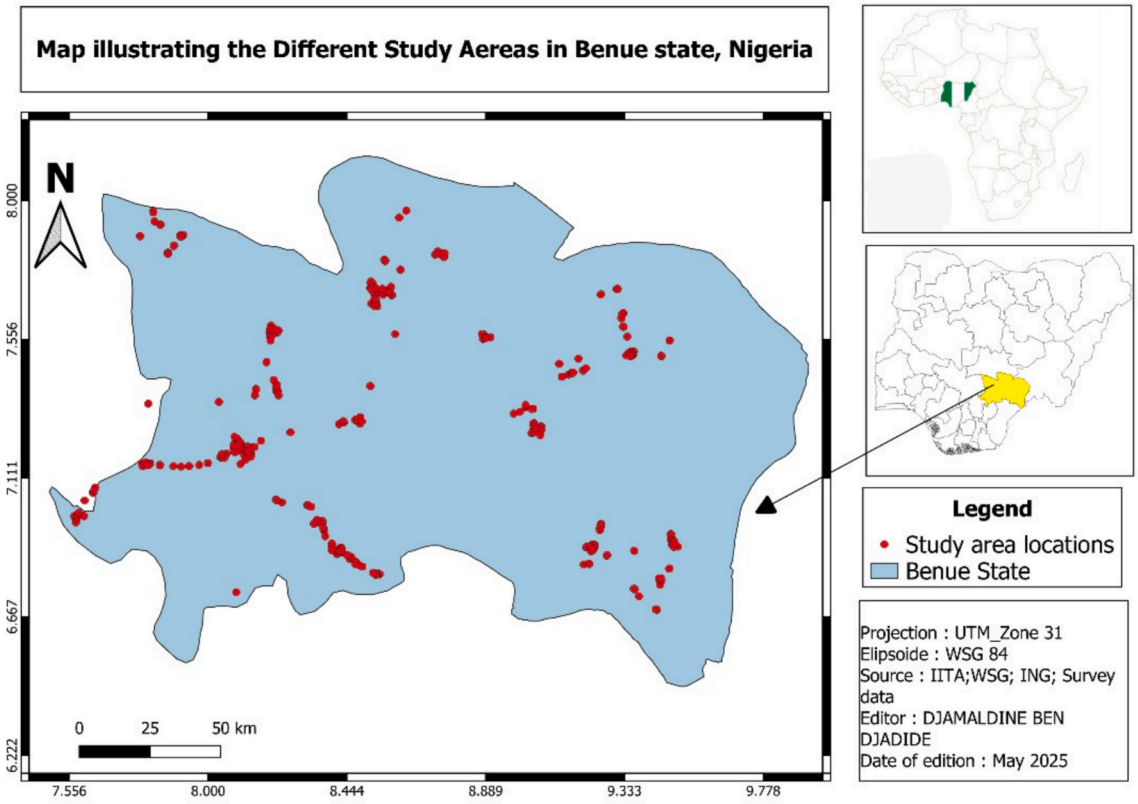

Fig. 4. Study area map. Source: Author, 2025.

commercialization studies in sub-Saharan Africa (Wossen et al., 2020; Louwaars & Manicad, 2022; Pircher et al., 2022), where actual usage is prioritized over awareness to capture meaningful behavioural change.

Access to Credit is defined as 1 for farmers who obtained either formal or informal credit specifically for agricultural purposes, and 0 otherwise. This classification is consistent with approaches used in recent literature on financial inclusion and agricultural commercialization (Balana & Oyeyemi, 2022; Gichuki & Kamau, 2022; Houensou et al., 2021), where both formal and informal access are considered due to the widespread reliance on informal credit among rural smallholders in Africa.

The binary specification of these treatment variables enhances clarity in modelling and allows straightforward simulation of marginal and joint effects in a counterfactual policy analysis framework, as applied in related agricultural intervention studies (Mukaila, 2024; Donovan et al., 2021).

However, it is acknowledged that this classification may introduce potential measurement errors, particularly in distinguishing between temporary credit arrangements or partial use of improved varieties. Future studies may consider more granular scales or triangulation with observational or administrative data to minimize this limitation. Nonetheless, given the study's emphasis on policy relevance and feasibility in field survey contexts, this binary classification provides a useful approximation of access and adoption behaviours among smallholder farmers in Nigeria.

3.3.2. Outcome Variable

The dependent variable, or outcome, is participation in cassava seed entrepreneurship. This is measured as a binary indicator:

$$y = \begin{cases} 1, if the farmer sold cassava seed during the 2023/2024 season (formal or informal channels \\ 0, Otherwise \end{cases}$$

This definition goes beyond self-identification or registration as a seed entrepreneur. It reflects actual market engagement, consistent with prior empirical studies (e.g., Olayide et al., 2021; Owoade et al., 2025). The emphasis is on seed sales made under the Quality Declared Seed (QDS) framework, while acknowledging the importance of informal sales, particularly at the early stages of seed enterprise development. This approach ensures that the outcome variable is a practical, observable proxy for entrepreneurial activity.

3.3.3. Control Variables

A detailed set of covariates was included in the logit model to account for individual, household, and farm-level differences that may affect entrepreneurial participation. These variables include:

- **Demographic Characteristics**:
  - o Age (years),
  - o Gender (1 = male, 0 = female),
  - o Marital status (1 = married, 0 = otherwise),
  - o Education level (years of schooling),
  - o Household size (number of household members).
- **Socioeconomic and Institutional Factors**:
  - o Farming experience (years),
  - o Membership in a farmer association (1 = member, 0 = non-member),
  - o Access to agricultural extension services (1 = yes, 0 = no),
  - o Access to the internet (1 = yes, 0 = no),
  - o Ownership of a smartphone (1 = yes, 0 = no),

- o Income sources (number of income-generating activities).
- **Production and Technological Variables**:
  - o Farm size (in hectares),
  - o Cassava yield per hectare (ton/ha),
  - o Use of mobile applications for calculating farm area (1 = yes, 0 = no),
  - o Participation in training on Good Agricultural Practices (1 = yes, 0 = no),
  - o Type of household (1 = male-headed, 0 = female-headed).

To account for contextual heterogeneity related to political stability, a conflict exposure variable was included as a control based on the data from the Armed Conflict Location & Event Data Project (ACLED, 2024) . The variable was constructed as a binary indicator equal to 1 if the respondent resided in a Local Government Area (LGA) that experienced reported farmer–herder conflict or insecurity incidents during the study period (2023 season), and 0 otherwise. Conflict-affected LGAs included areas such as Guma, Logo, Agatu, Gwer West, and Kwande, which have historically experienced varying levels of insecurity. This variable serves as a proxy for political stability conditions that may influence farmers' production decisions, market access, and participation in cassava seed entrepreneurship.

These variables were selected based on theoretical relevance and empirical evidence from existing literature on agricultural entrepreneurship and technology adoption (Awotide et al., 2025, Owusu, 2017, Wale, & Mkuna, 2025). Their inclusion enables robust estimation of the average marginal effects and the simulation of heterogeneous policy outcomes by demographic subgroup.

3.4. Analytical Framework and Theoretical Underpinning

This study is grounded in two complementary theoretical perspectives: the Theory of Planned Behavior (TPB) (Afshar & Ghaleh, 2021) and the Resource-Based View (RBV) (Barney et al., 2021). According to TPB, individuals' intentions to perform a behavior are influenced by their attitudes, subjective norms, and perceived behavioral control. In the context of this study, farmers' decisions to participate in cassava seed entrepreneurship are shaped by their perceptions of control over resources (such as access to improved seed and credit), as well as the normative and informational environment created by extension services and farmer associations. The RBV argues that having and controlling strategic resources, like better technologies or access to finance, creates competitive advantage and drives entrepreneurial activity. In smallholder agriculture, the RBV indicates that farmers with valuable resources are more likely to engage in and maintain innovative activities, such as seed production and marketing.

Building on these theoretical foundations, a two-step empirical strategy is employed. This includes: (i) estimation of a logit model to analyse the factors driving smallholder participation in seed entrepreneurship; and a robustness check with probit (ii) policy simulation analysis to assess the potential effect of universal access to credit and improved seeds among targeted subgroups, notably women and youth.

3.4.1. Model Specification

To analyze the factors influencing farmers' participation in cassava seed entrepreneurship, a binary logistic regression model was employed. The dependent variable is binary and defined as:

$$Y_i = \begin{cases} 1, & \text{if farmer } i \text{ participates in cassava seed entrepreneurship} \\ 0, & \text{otherwise} \end{cases} \quad (1)$$

Let X_i represent a vector of explanatory variables (such as access to credit, age, gender, institutional support, and conflict exposure), and β the vector of associated parameters. The logistic model estimates the probability P_i that farmer i participates in cassava seed entrepreneurship using the logistic cumulative distribution function:

$$P_i = P(Y_i = 1|X_i) = \Lambda(X_i'\beta) = \frac{1}{1 + e^{-X_i'\beta}} \quad (2)$$

Taking the logit transformation yields the log-odds specification:

$$\ln\left(\frac{P_i}{1 - P_i}\right) = X_i'\beta \quad (3)$$

The model includes nineteen explanatory variables capturing farmers' socioeconomic characteristics, institutional support, access to digital technologies, production factors, and exposure to conflict. The conflict variable serves as a proxy for political stability and is defined as a binary indicator equal to 1 if the respondent resides in a local government area that experienced reported insecurity or farmer–herder conflict during the study period, and 0 otherwise. Including the conflict variable also allows assessment of whether insecurity conditions systematically constrain participation in seed entrepreneurship

3.4.2. Policy Simulation Analysis

A set of ex-ante policy simulations was conducted using the estimated logit model to predict the effect of targeted interventions. Specifically, we simulated the scenario where all farmers in a given demographic group (e.g., women, youth, men) received both access to credit and improved cassava varieties.

Simulation Procedure:

The predicted probability under intervention is computed as:

$$P^{intervention} = \frac{1}{1 + e^{-X^{*'}\beta}} \quad (4)$$

Where:

- X^* is the modified covariate vector (setting Credit = 1, Improved Var = 1),
- β is the vector of estimated coefficients.

The difference between $P^{intervention}$ and the baseline predicted probability $P^{baseline}$ gives the mean change in probability due to the policy intervention.

The simulation was conducted using post-estimation prediction from a logit model of cassava seed entrepreneurship. The baseline model incorporated key explanatory variables including access to credit, improved variety adoption, demographic characteristics, and institutional access. After estimating the model, we computed baseline predicted probabilities and linear predictions for each farmer.

We then implemented three policy simulations by systematically assigning credit access and improved seed variety to specific demographic subgroups (women, men, and youth), holding other variables constant. For each simulation, we recalculated predicted probabilities using the adjusted linear prediction values and the inverse logit transformation. The mean difference between the simulated and baseline probabilities represents the predicted marginal effect of the intervention for each group.

This counterfactual modelling approach allows us to isolate the potential gains from targeted interventions and provides empirical evidence to support differentiated policy design based on demographic characteristics.

4. Results

4.1. Descriptive Statistics

Table 1 presents the socio-economic and demographic characteristics of sampled cassava farmers, which provide context for understanding participation patterns in seed entrepreneurship. The result shows an unequal representation among the genders. 60% of the

Table 1
Cassava Farmers Characteristics.

Characteristics	Frequency	Percentage
Gender of Farmer		
Male	597	60.12
Female	396	39.88
Age of Farmer		
18–35	345	34.74
36–45	388	39.08
46–60	225	22.66
above 60	35	3.51
Mean	*40.04(9.88)*	
Household Size of farmer		
<=5	268	26.99
6–10	530	53.39
11–15	142	14.3
above 15	53	5.33
Mean	*8.16(4.57)*	
No formal edu	58	5.84
Non formal	29	2.92
Primary	177	17.82
Secondary	449	45.22
Tertiary	280	28.2
Marital Status of Farmer		
Divorced	8	0.81
Married	802	80.77
Single	129	12.99
Widowed	54	5.44
Membership of farmers' cooperative		
Member	761	76.64
Non-Members	232	23.36
Access to credit		
Yes	68	6.85
No	925	93.15
Access to extension services		
No	393	39.58
Yes	600	60.42
Cassava farming experience		
≤ 5	267	26.88
6–10	332	33.43
11–15	147	14.8
>15	247	24.85
Mean	*11.64(8.10)*	
Smartphone Ownership		
No	705	71
Yes	288	29
Farm size		
<1	322	32.41
1–5	669	67.35
> 5	2	0.2

Source: Data Analysis, 2025. Note: Figures in parentheses are standard deviations.

sampled farmers are men, while women constitute 40%. Even though women still have an appreciable representation, the result shows an increasing need to improve women's participation in agriculture. These findings echo those of Adebayo and Worth (2024) and Guthridge et al. (2022), who highlight that without deliberate gender-sensitive interventions, women's contributions to agricultural commercialization remain underutilized.

The mean age of approximately 40 years, with more than a third under 35, suggests a relatively young farming population. This challenges the dominant narrative of an aging farmer base in sub-Saharan Africa (Geffersa & Islam, 2024). Younger farmers are generally more receptive to innovation and the adoption of new technologies (Shilomboleni et al., 2023), positioning them as key agents for scaling improved cassava varieties. Nevertheless, youthful age alone cannot improve participation in seed entrepreneurship; vital support like access to credit, market information, and access to extension services are key ingredients to further appropriate the benefitss the age brings.

Household size, averaging just over eight members, suggests the availability of family labor, an important asset for labour-intensive crops like cassava. In another vein, this result shows a tendency of high dependency, which can raise pressure on the output of the farm to meet consumption and basic needs of life. This underlines the need for productivity-enhancing technologies for a resilient food system (Ruml and Parlasca, 2022).

The educational attainment of the sampled farmers is relatively high, with nearly 75% having completed at least secondary education. Education plays a crucial role in the adoption of technology and market participation (Akter et al., 2021). This level of education offers a strong base for training programs, delivery of services, and even digital solutions. However, this potential is limited by low smartphone ownership, which stands at 29%. In today's increasingly digitized agricultural environment, limited digital access hampers farmers' ability to receive timely market information, weather updates, and agronomic guidance, thereby entrenching information asymmetries (Mukaila, 2024).

Social capital is a significant factor, with more than 76% of farmers belonging to cooperatives. This group structure is an important way to access inputs, training, and gather produce for the market. However, this strength suffers from poor financial inclusion; only 6.85% of farmers report having access to credit. Rayhan et al. (2024) stress that access to finance is essential for smallholder commercialization. The low penetration of credit services limits investments in improved seeds, mechanization, and productivity-enhancing inputs, reinforcing subsistence farming.

Extension service delivery shows a moderately positive trend, with around 60% of farmers receiving support. While this is a good percentage, the 40% left out remain a concern, particularly given the growing need for climate-smart practices and disease-resistant varieties. Prior research (Amrullah et al., 2025) shows that farmers who have access to extension are more likely to adopt improved technologies and participate in output markets.

The result shows an average farming experience of 11.64 years. This indicates that the sample farmers have a good knowledge of agriculture. However, experience needs to be paired with quality support and market access to turn into commercialization benefits.

Finally, the landholding pattern confirms the dominance of smallholder farming, with more than two-thirds cultivating between 1 and 5 hectares, and nearly a third managing less than 1 hectare. Such small plots, while central to food production, face significant constraints in achieving scale, including limited capital, low bargaining power, and fragmentation (Mutea et al., 2025). Interventions targeting productivity per hectare, through improved seed, cooperative marketing, and better access to inputs, are essential.

4.2. Determinants of Cassava Seed Entrepreneurship

The findings in Table 2 show the main factors that affect farmers' involvement in cassava seed entrepreneurship. Several variables are both statistically and practically important. They provide insights into how policy support and program design can make a difference.

Access to credit is the key factor in seed entrepreneurship. It has a significant coefficient ($\beta = 2.10$, $p < 0.01$) and a marginal effect of 13.2%. This highlights the important role that rural finance has in encouraging smallholders to commercialize. Credit gives farmers the funds they need for labor, inputs, and marketing, allowing them to shift from subsistence farming to active participation in seed markets. This supports earlier studies that emphasize the need for financial inclusion in agricultural development (Gichuki & Kamau, 2022; Houensou et al., 2021).

The use of improved cassava varieties shows a strong connection, $\beta = 2.28$, $dy/dx = 14.3\%$. This highlights the importance of using technology as a move toward entrepreneurship. Improved varieties usually produce higher yields, mature faster, and resist pests and diseases. This makes them more productive and marketable. Farmers who use these varieties are more likely to produce surplus and meet the quality needs of buyers in both formal and informal seed markets (Louwaars &

Table 2
Distribution of factors affecting farmers' participation in cassava seed entrepreneurship.

Variables	Coefficient	Standarderror	t-value	dy/dx	Marginal effect Standard error.	t-value
Access to Credit	2.101764***	0.3923109	5.36	0.1320531***	0.023264	5.68
Improved varieties	2.277328***	0.4735348	4.81	0.1430837***	0.029977	4.77
Age	0.0936547*	0.1714025	0.55	0.0058843*	0.010764	0.55
Gender	0.92320*	0.4513362	2.05	0.0580044*	0.028259	2.05
Marital Status	0.5140054*	0.2012219	2.55	0.0322948*	0.012594	2.56
Household size	0.2989039	0.1497048	2.00	0.01878	0.00938	2.00
Experience	0.0490333	0.1328907	0.37	0.0030807	0.008356	0.37
Education	0.0052933	0.148006	0.04	0.0003326	0.0093	0.04
Membership of Farmer Ass.	0.233121	0.3767535	0.62	0.0146469	0.023683	0.62
Internet Access	0.5661992	0.3492573	1.62	0.0355741	0.02191	1.62
Ownership Smartphone	0.3946098	0.3311151	1.19	0.0247932	0.021	1.19
Farm Size	0.1829956	0.148812	1.23	0.0114976	0.009339	1.23
Access to Extension	0.8214332*	0.3768221	2.180	0.0516104*	0.023666	2.18
Training on GAP	−0.310483	0.361191	−0.86	−0.0195075	0.022701	−0.86
Adoption of Area Calc App	1.13454***	0.3104208	3.65	0.0712827***	0.019314	3.69
Income Sources	−0.8803492	0.5455448	−1.610	−0.055312	0.034207	−1.62
Type of household	−0.6496959	0.3879671	−1.67	−0.0408202	0.024327	−1.68
Yield Per Hectare	0.0000211**	6.19E-06	3.41	0.00000133***	3.88E-07	3.42
Conflict Exposure	−0.2871174	0.3194806	−0.90	−0.01804	0.02008	−0.90
Constant	−8.356005	1.454893	−5.74			
Number of observations	993					
LR chi2(18)	179.59					
Prob > chi2	0.0000					
Log likelihood	−216.66828					
Pseudo R2	0.2930					

Asterisks indicate different levels of significance (***p < 0.01, **p < 0.05, *p < 0.10).

Manicad, 2022).

The adoption of area calculation mobile applications is another important factor (β = 1.13, dy/dx = 7.1%), showing the growing role of digital agriculture. These tools help farmers plan, manage, and scale their production effectively. The finding aligns with recent research that highlights how mobile technology transforms access to information, decision-making, and market connections (Naika et al., 2021).

Access to extension services also positively affects seed entrepreneurship (β = 0.82, dy/dx = 5.2%, p < 0.05). Extension agents often serve as links between farmers and innovations, training, and input and output markets. This finding emphasizes the need for public and private investment in agricultural advisory systems to enhance farmer capacity and technology use (Antwi-Agyei & Stringer, 2021).

Marital status (β = 0.51, dy/dx = 3.2%) and gender (β = 0.92, dy/dx = 5.8%) are both statistically significant at the 5% level. Married farmers may enjoy household stability and collaborative decision-making, which can aid in business planning and financial risk-taking (Akter et al., 2021). The modest positive effect of being male shows some gender differences in access to productive resources. While the model did not show a strong statistical effect of gender by itself, the positive marginal effect suggests that female farmers could gain from targeted support to increase their participation in cassava seed markets.

Yield per hectare, despite a small numerical coefficient (0.0000211), is statistically significant. It indicates that higher productivity relates to greater involvement in seed entrepreneurship. While the coefficient on yield is numerically small, its significance indicates that even marginal increases in productivity can make seed entrepreneurship more viable by creating consistent surplus.

Other variables, including household size (β = 0.30, dy/dx = 1.9%) and internet access (β = 0.57, dy/dx = 3.6%), while not statistically significant at the 5% level, indicate the importance of human capital and digital connectivity. These factors could have a greater impact as digital services and rural internet access improve.

Variable like conflict exposure (β = -0.29, dy/dx = -1.8%) is negative but not statistically significant, implying that residing in areas affected by insecurity does not strongly limit participation in cassava seed entrepreneurship in this sample. This may indicate resilience among farmers or the predominance of other enabling factors such as access to credit, improved varieties, and extension services.

Several variables often assumed to influence entrepreneurship, such as age, education, farm size, income sources, and membership in farmer associations, did not show significant effects. This suggests that cassava seed entrepreneurship is more dependent on access to institutions, technologies, and market-enabling resources than on demographic characteristics or structural factors. Policies that enhance credit access, extension services, digital tools, and improved varieties are likely to be more effective in promoting seed entrepreneurship than interventions based solely on demographics.

4.3. Robustness model

The results in Tables 2a–2c present alternative model specifications to test the robustness of the baseline finding in Table 2.

4.3.1. Model A: Robustness checks with technology variables (Internet, Smartphone, Area Calculator) dropped

Table 2a presents Model A, which mirrors the baseline specification but focus on key institutional, socio-demographic, and productivity-related factors. The results show that access to credit is highly significant, with a coefficient of 2.53 and an average marginal effect of 0.169, indicating its pivotal role in enabling farmers to participate in cassava seed entrepreneurship. This finding is consistent with prior studies demonstrating that liquidity constraints often limit smallholders' capacity to commercialize agricultural outputs (Melkani et al., 2025). Similarly, adoption of improved cassava varieties emerges as a strong positive determinant of participation (coef = 2.49, dy/dx = 0.166), suggesting that farmers cultivating improved varieties are more likely to get involved in seed entrepreneurship, likely due to higher yields and the market preference for quality planting materials (Vernooy et al., 2022; Dey et al., 2022). Household and demographic characteristics also play a facilitating role; larger household size and marital status positively influence participation, indicating that family labor availability and social networks support engagement in seed entrepreneurship, in line with findings by Ofolsha et al(2022). Among institutional factors, access to extension services significantly increases participation (dy/dx = 0.076), highlighting the importance of technical guidance, risk mitigation, and improved market access (Vernooy et al., 2022). Yield per hectare remains a significant predictor (coef = 1.87e-5, dy/dx = 1.25e-6),

Table 2a
Distribution of factors affecting farmers' participation in cassava seed entrepreneurship (Model 1).

Variables	Coefficient	Std. Error	z-value	dy/dx	Marginal Effect Std. Error	z-value
Access to Credit	2.52835***	0.36780	6.87	0.16867***	0.02290	7.37
Improved varieties	2.49361***	0.47897	5.21	0.16635***	0.03247	5.12
Age	0.14019	0.16394	0.86	0.00935	0.01093	0.86
Gender	1.14240**	0.45358	2.52	0.07621**	0.03024	2.52
Marital status	0.55905***	0.19386	2.88	0.03729***	0.01291	2.89
Household size	0.25178*	0.14615	1.72	0.01680*	0.00975	1.72
Experience	0.00859	0.12536	0.07	0.00057	0.00836	0.07
Education	0.10876	0.12806	0.85	0.00726	0.00855	0.85
Membership of farmer ass.	0.15837	0.36040	0.44	0.01057	0.02405	0.44
Farm size	0.18553	0.13987	1.33	0.01238	0.00933	1.33
Access to extension	1.13739***	0.35278	3.22	0.07588***	0.02354	3.22
Training on GAP	0.10448	0.33238	0.31	0.00697	0.02217	0.31
Income source	−0.55783	0.53154	−1.05	−0.03721	0.03544	−1.05
Type of household	−0.71064*	0.39420	−1.80	−0.04741*	0.02630	−1.80
Yield per hectare	0.0000187***	5.70E − 06	3.29	0.00000125***	3.79E − 07	3.29
Conflict Exposure	−0.28712	0.31948	−0.90	−0.01804	0.02008	−0.90
Constant	−8.96358***	1.41265	−6.35			
Number of observations:	993					
LR chi^2 (15):	152.43					
Prob > chi^2:	0.0000					
Log likelihood:	−230.24887					
Pseudo R^2:	0.2487					

Asterisks indicate different levels of significance (***p < 0.01, **p < 0.05, *p < 0.10).

Table 2b
Distribution of factors affecting farmers' participation in cassava seed entrepreneurship (Model 2).

Variables	Coefficient	Std. Error	z-value	dy/dx	Marginal Effect Std. Error	z-value
Improved varieties	2.219891***	0.449436	4.94	0.1515523***	0.030856	4.91
Age	0.108886	0.162184	0.67	0.0074336	0.011066	0.67
Gender	0.854857**	0.428185	2.00	0.0583612**	0.029138	2.00
Marital status	0.380643*	0.188714	2.02	0.0259865*	0.012836	2.02
Household size	0.306430**	0.144032	2.13	0.020920**	0.009788	2.14
Experience	−0.005431	0.128237	−0.04	−0.0003708	0.008754	−0.04
Education	−0.132591	0.132376	−1.00	−0.009052	0.009019	−1.00
Internet access	0.634033*	0.344233	1.84	0.0432855*	0.023473	1.84
Smartphone ownership	0.380465	0.314993	1.21	0.0259744	0.021488	1.21
Farm size	0.146626	0.142603	1.03	0.0100102	0.009715	1.03
Training on GAP	−0.106635	0.338677	−0.31	−0.00728	0.023122	−0.31
Adoption of Area Calculator	1.719527***	0.302958	5.68	0.1173923***	0.020058	5.85
Income source	−0.634739	0.544182	−1.17	−0.0433337	0.037100	−1.17
Type of household	−0.758289**	0.369034	−2.05	−0.0517685**	0.025128	−2.06
Yield per hectare	0.000024***	0.00000699	3.44	0.00000164***	0.000000474	3.46
Conflict Exposure	0.591404*	0.290128	2.04	0.0403752*	0.019719	2.05
Number of observations	993					
LR chi^2 (15):	148.27					
Prob > chi^2:	0.0000					
Log likelihood:	–232.32941					
Pseudo R^2:	0.2419					

Asterisks indicate different levels of significance (***p < 0.01, **p < 0.05, *p < 0.10).

confirming that productive capacity is a prerequisite for entering commercial seed markets (Vernooy et al., 2022). Conflict exposure, included as an additional robustness check, has a negative coefficient (β = -0.29, dy/dx = -0.018) but is not statistically significant. This indicates that, within this sample, living in areas affected by conflict does not strongly limit participation in cassava seed entrepreneurship. While insecurity might be expected to hinder market-oriented farming, the result suggests that other enabling factors, such as credit access, adoption of improved varieties, extension services, and household supportmay offset potential negative effects of conflict.

Other variables, including age, education, farm size, income sources, and membership in farmer associations, do not show statistically significant effects, indicating that access to resources and institutional support is more crucial than demographic or structural factors in driving participation.

Overall, Model A corroborates the baseline results, showing that financial resources, adoption of improved technologies, household labor, extension support, and farm productivity are key determinants of participation in cassava seed entrepreneurship, while conflict exposure does not significantly deter involvement in this context.

4.3.2. Model B: Robustness checks with Institutional variables (Credit, Extension, Association and Training on GAP) dropped

Table 2b presents Model B, which further extends the baseline analysis by incorporating digital technology adoption, specifically internet access and the Area Calculator mobile tool, alongside socio-demographic and farm-level factors. The results indicate that technology adoption is a significant driver of participation in cassava seed entrepreneurship. Adoption of the Area Calculator mobile application shows a strong positive effect (coef = 1.54, dy/dx = 0.105), while internet access also significantly increases participation (coef = 0.81, dy/dx = 0.055). These findings align with the broader literature on ICT

Table 2c
Distribution of factors affecting farmers' participation in cassava seed entrepreneurship (Model 3).

Variables	Coefficient	Std. Error	z-value	dy/dx	Marginal Effect Std. Error	z-value
Access to Credit	1.92217***	0.37662	5.10	0.12373***	0.02297	5.39
Improved varieties	2.24741***	0.46478	4.84	0.14466***	0.03019	4.79
Household size	0.25044*	0.14285	1.75	0.01612*	0.00917	1.76
Experience	0.08782	0.11798	0.74	0.00565	0.00761	0.74
Education	−0.03514	0.14162	−0.25	−0.00226	0.00912	−0.25
Membership of Farmer Ass.	0.17685	0.36634	0.48	0.01138	0.02359	0.48
Internet access	0.64841*	0.34167	1.90	0.04174*	0.02197	1.90
Smartphone ownership	0.42373	0.32498	1.30	0.02728	0.02092	1.30
Farm size	0.15099	0.14610	1.03	0.00972	0.00940	1.03
Access to extension	0.86989**	0.37229	2.34	0.05599**	0.02395	2.34
Training on GAP	−0.21493	0.35783	−0.60	−0.01384	0.02304	−0.60
Adoption of Area Calculator	1.17867***	0.30586	3.85	0.07587***	0.01952	3.89
Income source	−0.80888	0.54263	−1.49	−0.05207	0.03487	−1.49
Type of household	−0.26826	0.23033	−1.16	−0.01727	0.01482	−1.16
Yield per hectare	0.0000212***	5.97E-06	3.56	0.00000137***	3.84E-07	3.56
Conflict Exposure	0.25431	0.31714	0.80	0.01634	0.02037	0.80
Constant	−6.07732	1.18855	−5.11			
Number of observations:	993					
LR chi^2 (15):	168.33					
Prob > chi^2:	0.0000					
Log likelihood:	–222.30014					
Pseudo R^2:	0.2746					

Asterisks indicate different levels of significance (***p < 0.01, **p < 0.05, *p < 0.10).

adoption in agriculture, which demonstrates that digital tools reduce information asymmetry, enhance farmers' decision-making, and facilitate engagement with input and output markets (Mapiye et al., 2023; Miehe & Swinnen, 2023). Adoption of improved cassava varieties remains highly significant (coef = 2.19, dy/dx = 0.151), indicating that the benefits of digital technologies complement rather than substitute traditional agronomic improvements. Socio-demographic factors such as household size, gender, and marital status continue to positively influence participation, highlighting the enduring role of social capital and family labor in supporting seed entrepreneurship. Yield per hectare remains a positive and significant determinant (coef = 2.45e-5, dy/dx = 1.69e-6), confirming that productive capacity is essential for engagement in commercial seed markets.

Conflict exposure, included as a proxy for political instability and localized insecurity, exhibits a positive and statistically significant association with participation in cassava seed entrepreneurship (coef = 0.59, dy/dx = 0.040, p < 0.05). Although conflict is typically expected to suppress agricultural investment through mechanisms such as land abandonment, asset destruction, and disrupted market access, the observed relationship suggests a more complex behavioral response. Farmers operating in conflict-affected environments may increasingly engage in cassava seed entrepreneurship as an adaptive or resilience strategy, leveraging relatively flexible production systems and potential income premiums associated with seed markets to buffer against uncertainty. This finding aligns with emerging development literature emphasizing that households exposed to shocks do not only withdraw from markets but may also reconfigure livelihood portfolios toward activities perceived as more robust under risk (Nguyen et al., 2023; Nkurunziza et al., 2025). It therefore highlights the dual role of insecurity as both a constraint and a catalyst for strategic adaptation in rural economies.

Overall, Model B corroborates the baseline results while extending the analysis by providing additional insights into the interaction between technological adoption, household capacity, and contextual risk. The evidence confirms that digital tools and improved agronomic practices are strong drivers of participation in cassava seed entrepreneurship, reinforcing the importance of innovation diffusion for smallholder commercialization. Concurrently, household characteristics and farm productivity remain critical enabling conditions, reflecting the continued relevance of labor availability and production capacity in entrepreneurial engagement. The significance of conflict exposure further indicates the importance of incorporating political and security dimensions into analyses of rural market participation, suggesting that local instability can shape farmer decision-making by inducing adaptive or risk-mitigating responses, particularly in fragile production environments.

4.3.3. Model C: Robustness checks with demographic variables (Age, Gender, Marital status) dropped

Table 2c presents Model C, which integrates access to credit, improved cassava varieties, digital technology adoption, and institutional support factors. The results show that access to credit (coef = 1.92, dy/dx = 0.124) and adoption of improved varieties (coef = 2.25, dy/dx = 0.145) remain significant and robust across all models, reaffirming that financial capital and agronomic improvements are critical drivers of participation in cassava seed entrepreneurship (Vernooy et al., 2022).

Digital and institutional factors also play an important role. Adoption of the Area Calculator mobile tool (coef = 1.18, dy/dx = 0.076) and access to extension services (coef = 0.87, dy/dx = 0.056) significantly enhance participation, showing the complementary effect of technology and institutional guidance in supporting commercialization (Tabe-Ojong et al., 2024). Household size retains a positive and marginally significant effect (coef = 0.25, dy/dx = 0.016), suggesting that family labor continues to be an enabling resource for seed entrepreneurship (Farnworth et al., 2024).

Yield per hectare remains a strong positive predictor (coef = 2.12e-5, dy/dx = 1.37e-6), reinforcing the notion that productive capacity is a prerequisite for market-oriented seed activities (Zhang & Zhu, 2023). Internet access is now marginally significant (coef = 0.65, z = 1.90), implying that the impact of digital technologies may depend on the presence of complementary resources, such as credit, improved varieties, and extension support.

The model also incorporates conflict exposure as a proxy for local political instability to account for contextual constraints that may shape farmers' entrepreneurial decisions. Although the estimated coefficient is positive and not statistically significant (coef = 0.25, dy/dx = 0.016), its inclusion remains conceptually relevant, as insecurity can influence production incentives, disrupt access to land and markets, and reshape risk perceptions among rural households. The lack of statistical significance in this specification suggests that, once financial, institutional, and technological factors are controlled for, the direct effect of conflict

exposure on participation may be limited or mediated through these complementary channels. Nevertheless, the positive direction of the relationship indicates that contextual fragility remains an important consideration when interpreting spatial heterogeneity in entrepreneurial engagement.

Overall, Model C reinforces the robustness of the baseline findings and demonstrates that participation in cassava seed entrepreneurship is shaped by an interconnected set of financial, technological, institutional, and productivity-related factors. At the same time, the inclusion of conflict exposure draws attention to the broader enabling environment within which smallholder commercialization decisions occur, pointing to the potential moderating role of local insecurity conditions. These results underscore the importance of integrated policy approaches that address multiple constraints simultaneously, improving access to finance, strengthening advisory systems, facilitating technology adoption, and enhancing rural stability, to support sustainable smallholder entrepreneurship and market participation.

4.3.4. Robustness Check: Probit Analysis

To ensure the validity and robustness of the baseline logit model (Table 2), a probit regression was estimated using the same set of explanatory variables. Table 3 presents the results, including marginal effects, for determinants of cassava stem sales.

The probit estimates closely mirror the logit findings, providing confidence in the baseline model's conclusions. Access to credit (coef = 1.01, dy/dx = 0.117) and adoption of improved cassava varieties (coef = 1.04, dy/dx = 0.121) remain significant, confirming that access to capital and agronomic improvements are major enablers of smallholder participation in seed entrepreneurship (Raza et al., 2024). Similarly, the adoption of the Area Calculator mobile tool (coef = 0.66, dy/dx = 0.077) and access to extension services (coef = 0.46, dy/dx = 0.054) are statistically significant, reinforcing the complementary role of digital technologies and institutional support in facilitating market-oriented production (Paul et al., 2024).

Socio-demographic factors, including gender, marital status, and certain education levels, continue to influence participation, indicating the importance of social capital, labor availability, and human capital in enabling seed entrepreneurship (Zeleke et al., 2023). Yield per hectare is also a positive and significant predictor (coef = 1.11e-5, dy/dx = 1.29e-6), consistent with the notion that productive capacity underpins market engagement (Zhang & Zhu, 2023). Notably, non-agricultural income sources negatively affect participation (coef = -0.57, dy/dx = -0.053), suggesting that households with diversified non-farm income may allocate less labor or resources to cassava seed sales, aligning with prior findings on opportunity costs in smallholder commercialization (Beban & Gironde., 2023).

In conclusion, the probit results corroborate the logit baseline model, indicating that the observed relationships are not sensitive to the choice of binary response function. This robustness check strengthens confidence in the identified determinants: credit, improved varieties, technological adoption, institutional support, productivity, and household characteristics as key drivers of participation in cassava seed entrepreneurship.

4.3.5. Determinants of Farmers' Participation in Cassava Seed Entrepreneurship by Production Regime

To address potential overparameterization, a series of robustness checks were conducted. First, the full sample was partitioned into high- and low-producing local government areas (LGAs) based on median community-level cassava yield. Separate logit models were then estimated for each subsample.

The results demonstrate that key determinants of participation differ systematically across production regimes, confirming that the baseline estimates are not driven by a single subset of observations. In high-producing LGAs, participation is primarily explained by technology-related and informational factors, including improved variety use, smartphone ownership, extension access, and digital area measurement tools. In contrast, participation in low-producing LGAs is largely driven by access to credit, indicating binding liquidity constraints in these settings.

4.3.5.1. High-Producing Local Government Areas. Based on the result in Table 4 below, in high-producing areas, improved variety adoption remains a strong and highly significant determinant (dy/dx = 0.110, p <

Table 3
Probit Regression Estimates and Marginal Effects for Determinants of Cassava Stem Sales.

Variables	Coefficient	Standard Error	z-value	dy/dx	Marginal Effect Std. Error	z-value
Access to Credit	1.0087***	0.1976	5.11	0.1170***	0.0224	5.23
Improved Variety Grown	1.0419***	0.2255	4.62	0.1209***	0.0240	5.03
Age	0.0189	0.0928	0.20	0.0022	0.0108	0.20
Gender	0.4435*	0.2428	1.83	0.0515*	0.0280	1.84
Marital Status	0.3059***	0.1057	2.89	0.0355***	0.0126	2.82
Household Size	0.1238	0.0803	1.54	0.0144	0.0093	1.55
Farming Experience	0.0006	0.0711	0.01	0.0001	0.0082	0.01
Education (Non-formal)	0.7435*	0.4012	1.85	0.0919*	0.0504	1.82
Education (Primary)	0.7207**	0.3376	2.13	0.0881**	0.0329	2.68
Education (Secondary)	−0.0316	0.3508	−0.09	−0.0025	0.0286	−0.09
Education (Tertiary)	0.5365	0.3596	1.49	0.0596*	0.0339	1.76
Membership of Farmer Association	0.1360	0.1862	0.73	0.0158	0.0217	0.73
Internet Access	0.2709	0.1818	1.49	0.0314	0.0211	1.49
Smartphone Ownership	0.2377	0.1906	1.25	0.0276	0.0222	1.24
Farm Size	0.1001	0.0735	1.36	0.0116	0.0087	1.34
Access to Extension	0.4633**	0.1788	2.59	0.0538**	0.0210	2.56
Training on GAP	−0.2764	0.1713	−1.61	−0.0321	0.0202	−1.58
Adoption of Area Calculator	0.6616***	0.1568	4.22	0.0767***	0.0179	4.30
Income Source (Non-Agriculture)	−0.5737**	0.2990	−1.92	−0.0534**	0.0219	−2.44
Type of Household	−0.2317	0.2091	−1.11	−0.0269	0.0240	−1.12
Yield per Hectare	0.0000111***	0.0000036	3.08	0.00000129***	0.00000042	3.10
Constant	−5.1046***	0.6614	−7.72	—	—	—
Number of obs	993					
Wald χ^2 (21)	135.89					
Prob > χ^2	0.0000					
Log pseudolikelihood	−207.7401					
Pseudo R^2	0.3221					

Asterisks indicate different levels of significance (***p < 0.01, **p < 0.05, *p < 0.10).

Table 4
High-Producing Local Government Areas.

Variable	Marginal Effect
Access to credit	Omitted†
Improved variety grown	0.110*** (0.038)
Age	−0.003 (0.017)
Gender	0.012 (0.038)
Marital status	0.046** (0.021)
Household size	0.000 (0.015)
Experience	0.027 (0.017)
Education	−0.007 (0.015)
Membership of Association	−0.006 (0.033)
Internet access	0.006 (0.037)
Smartphone ownership	0.125*** (0.038)
Farm size	−0.022 (0.017)
Access to extension services	0.096** (0.039)
Training on GAP	−0.098** (0.039)
Adoption of area calculator	0.107*** (0.032)
Income source	−0.064 (0.046)
Type of household	0.009 (0.030)
Yield per hectare	2.12e − 06*** (7.46e − 07)
Observations	421
Pseudo R^2	0.308

Reported values are average marginal effects. Standard errors in parentheses. Asterisks indicate different levels of significance (***p < 0.01, **p < 0.05, *p < 0.10).

Table 5
Low-Producing Local Government Areas.

Variable	Marginal Effect
Access to credit	0.240*** (0.037)
Improved variety grown	Omitted†
Age	0.012 (0.025)
Gender	0.142* (0.079)
Marital status	0.041 (0.030)
Household size	0.033 (0.022)
Experience	−0.013 (0.017)
Education	0.018 (0.021)
Membership of Association	Omitted†
Internet access	0.039 (0.049)
Smartphone ownership	−0.068 (0.047)
Farm size	0.014 (0.019)
Access to extension services	0.055 (0.047)
Training on GAP	−0.008 (0.049)
Adoption of area calculator	0.082** (0.040)
Income source	Omitted†
Type of household	−0.117* (0.068)
Yield per hectare	7.52e − 07 (7.03e − 07)
Observations	292
Pseudo R^2	0.401

Reported values are average marginal effects. Standard errors in parentheses. Asterisks indicate different levels of significance (***p < 0.01, **p < 0.05, *p < 0.10).

0.01), consistent with the idea that farmers in more productive regions are more likely to engage in commercialization when they have access to improved seeds (Marenya, et al., 2022). Access to credit was omitted in this subgroup due to perfect prediction, suggesting that nearly all credit-receiving farmers participate in stem sales, a sign of the critical role of financial access in high-yield contexts.

Institutional support and digital tools remain significant: extension services (dy/dx = 0.096, p < 0.05) and adoption of the Area Calculator (dy/dx = 0.107, p < 0.01) positively influence participation, while training on GAP shows a small negative effect (dy/dx = −0.098, p < 0.05). These findings suggest that farmers in high-production regions selectively adopt practices and tools that directly enhance marketable output, reflecting a nuanced interaction between technical guidance and entrepreneurial behavior (Amoussohoui, et al., 2024).

Household labor, gender, and yield per hectare also play roles: yield remains highly significant (dy/dx = 2.12e−06, p < 0.01), reinforcing that productive capacity underpins market engagement (Zeleke et al., 2023, Beban & Gironde., 2023), while household size is not significant, indicating that in these regions, productivity and technology may substitute for labor availability.

4.3.5.2. Low-Producing Local Government Areas. In contrast, for low-producing LGAs, access to credit is highly significant (dy/dx = 0.240, p < 0.01), highlighting that liquidity constraints are particularly binding in less productive contexts. In these areas, improved variety adoption and membership in farmer associations were omitted due to perfect prediction, reflecting that few farmers in low-yield regions have adopted these technologies or organized within formal groups.

Other factors such as gender (dy/dx = 0.142, p < 0.1), adoption of the Area Calculator (dy/dx = 0.082, p < 0.05), and household type (dy/dx = −0.117, p < 0.1) also influence participation. The positive effect of digital tools indicates that even in low-yield contexts, access to decision-support technologies facilitates engagement with seed markets (Amoussohoui, et al., 2024). The negative effect of household type suggests that male-headed households may allocate labor to subsistence rather than commercial activities, consistent with evidence on opportunity costs of labor in low-resource settings (Maindiet et al., 2025).

Yield per hectare is not significant in low-producing LGAs, indicating that when overall productivity is low, marginal differences in yield are insufficient to drive participation (Table 5).

5. Policy Simulation Results

The simulation results provide valuable insights into how specific interventions, such as access to credit and better cassava varieties, can affect participation in cassava seed entrepreneurship among different demographic groups. These findings emphasize the importance of customized strategies that tackle structural inequalities and meet the specific needs of each group. A universal approach will not work.

The scenario with the greatest predicted impact happened when all male farmers received both credit and improved cassava varieties. This led to a 36.1 percentage point increase in their chances of engaging in seed entrepreneurship. This indicates that men, who often already have better access to resources, still gain significantly from additional support. It may be because male farmers generally operate on larger scales or have better access to market information, extension services, trainings compared to women, enabling them to quickly increase their participation when barriers are lowered.

Young farmers, those aged 35 and under, responded positively to the intervention, showing a 32-percentage point increase in predicted participation. This is an encouraging finding, as it highlights the potential of young farmers when they receive appropriate support. Despite the common belief that young people are not interested in agriculture, these results confirm that access to resources, not a lack of interest or skill, is a major barrier to their involvement in cassava seed commercialization. While interventions aimed at youth might not provide immediate returns, they can offer significant long-term benefits by nurturing the next generation of seed entrepreneurs. Interestingly, when all women farmers received the same access, their expected participation increased by 25.8 percentage points. Although this rise is slightly lower than what was observed among youth and men, it is still important. This backs up earlier research showing that structural problems, such as unequal access to land, funding, information, training, business networks, and extension services constrain women from engaging and benefiting in cassava seed markets more than lack of entrepreneurial skills among women. The strong response from women in this simulation underscores the need for gender-responsive agricultural programs and supports addressing gender-specific constraints in developing seed systems. The result from youth and women supports findings from gender and youth studies in agriculture that suggest barriers, rather than a lack of ability, limit participation and productivity (Boye et al., 2024;

Hernandez et al., 2023; Yami et al., 2024). Structural issues like lack of collateral, access to land, and discrimination have long limited the entrepreneurial potential of women and youth (Senou & Manda, 2022; Mashapure et al., 2022). The changes observed in this study show that removing these barriers with focused resources can lead to significant improvements in economic engagement.

These results suggest three key policy implications. First, men could benefit from improved access to inputs despite their already better position in accessing and benefiting from opportunities compared to women. Men are more likely to access opportunities to engage in commercial pathways, and expanding their access to inputs improves their ability to grow their operations further. This indicates that universal policies may be biased towards dominant groups unless measures are taken to address existing gender disparities. Second, women and youth, starting from a more disadvantaged position, demonstrate significant potential when given fair access to productive resources. These groups often receive little support from traditional programs, yet the predicted increases show they are highly responsive to well-targeted interventions. Strategies that explicitly focus on women and youth could help close existing equity gaps and strengthen the resilience of seed systems.

Third, policy design should go beyond uniform models. The varied responses from each demographic group show the need for specific policy strategies. Simply providing equal distribution of resources could exacerbate gender inequality, and may not result in gender equal outcomes. Instead, targeting different segments of the population based on age, gender, and current access can improve fairness and efficiency in cassava seed commercialization.

These findings support using predictive modeling and policy simulation as useful tools for making informed decisions. By forecasting the possible outcomes of various interventions, these methods help policymakers use limited resources more effectively and boost development impact (Gische et al., 2021; Celis et al., 2024). As agricultural systems evolve in response to demographic changes, climate challenges, and market dynamics, this kind of empirical evidence will be crucial for effective planning and intervention.

Policy Scenario	Mean Change in Predicted Probability	**Std. Dev.**
All females Gain Access to Credit & Improved Variety	0.258	0.164
All Males Gain Access to Credit & Improved Variety	0.361	0.161
All Youth (Age $\leq$ 35) Gain Access to Credit & Improved Variety	0.32	0.17

5.1. Discussions

5.1.1. Access to credit and cassava seed entrepreneurship

The strong positive effect of access to credit on cassava seed entrepreneurship ($\beta = 2.10$, $dy/dx = 13.2\%$) reinforces the critical role of rural finance in enabling smallholder commercialization. This finding aligns with studies across sub-Saharan Africa, which consistently identify credit access as a cornerstone for agricultural transformation (Houensou et al., 2021; Gichuki & Kamau, 2022). In the context of Nigeria, where most cassava producers are smallholders with limited liquidity, credit facilitates investments in labor, inputs, and marketing that are prerequisites for engaging in seed markets. This result corroborates earlier findings by Olayide et al. (2021), who noted that limited financing options constrain farmers' ability to scale production and meet formal market standards. Additionally, it aligns with Fieve & Chrysostome (2024), who confirmed that credit support and promote women entrepreneurship by providing their members with access to long-term interest-free credit support to start or expand their businesses. The present analysis suggests that with appropriate targeting and financial literacy support, credit access can serve as a powerful lever for entrepreneurship. This insight expands existing theories of rural commercialization by highlighting financial inclusion as a key structural driver rather than a supplementary factor.

5.1.2. Improved cassava varieties as a technological catalyst

The adoption of improved cassava varieties was also found to significantly enhance participation in seed entrepreneurship ($\beta = 2.28$, $dy/dx = 14.3\%$). This finding is consistent with previous research demonstrating that improved planting materials, offering superior yields, disease resistance, and market-preferred traits, create opportunities for smallholders to produce surplus and enter seed markets (Louwaars & Manicad, 2022; Legg et al., 2022). Unlike Bentley et al. (2020), who noted that adoption rates of improved varieties in Nigeria remained modest due to limited dissemination channels, this study reveals a direct pathway between varietal adoption and commercialization. Importantly, the findings show that technology adoption is not just about productivity gains but also about enabling market participation. This reinforces the concept of agricultural technology as a "gateway" to entrepreneurial opportunities and highlights the need for robust seed systems that ensure equitable access to quality planting materials.

5.1.3. Gender disparities and inclusive seed systems

The study's findings on gender ($\beta = 0.92$, $dy/dx = 5.8\%$) reveal subtle yet significant inequalities in cassava seed entrepreneurship. Male farmers had a modest advantage, which may stem from their relatively better access to land, credit, and extension services, factors well-documented in gender and agriculture literature (Yami et al., 2024; Senou & Manda, 2022). Interestingly, the policy simulation showed that targeted interventions for women could result in a 25.8 percentage point increase in their participation, underscoring their latent entrepreneurial potential if structural constraints are addressed. This finding aligns with Mashapure et al. (2022) and Begum (2025), who argued that women's underrepresentation in seed systems and agriculture in general is not due to lack of capability but to systemic barriers such as limited collateral, discriminatory norms such as limited control in leadership, lack of access to land, and lower access to networks. The insight contributes to gender theories in agriculture by providing empirical evidence for the "resource access gap" rather than a gendered skills gap, emphasizing the importance of gender-responsive programming in seed system development.

5.1.4. Contributions to theory and policy

This study advances the literature on smallholder commercialization and seed system development by demonstrating that participation in agricultural entrepreneurship is fundamentally context-dependent and regime-specific. By explicitly distinguishing between high- and low-productivity environments, the analysis moves beyond standard adoption and commercialization models that assume homogeneous decision-making among smallholder farmers. Instead, the findings provide empirical support for a dual-regime participation framework, in which the constraints and incentives shaping cassava seed entrepreneurship differ systematically across productivity regimes.

In low-productivity settings, participation is primarily constrained by financial capital, with access to credit emerging as the dominant driver of engagement in seed entrepreneurship. In contrast, in high-productivity environments, where production risks are lower and surplus is more likely, participation is driven by technological complementarities and information access, particularly through digital tools and extension services that enhance precision, coordination, and market integration. By incorporating productivity thresholds and digital technologies into the entrepreneurial decision process, this study extends existing theories of agricultural technology adoption and commercialization that typically treat technologies as independent inputs rather than interacting systems.

An additional contribution of this study is the integration of conflict exposure as a contextual factor capturing political instability and local

insecurity. This is an aspect that is often overlooked in commercialization research despite its importance in many developing-country agricultural systems. The results across the various models suggest that the influence of conflict exposure is nuanced rather than uniform. In some specifications, conflict exposure does not exert a statistically significant effect, implying that access to institutional and technological enablers—such as credit, improved varieties, and extension services, can buffer farmers against the adverse consequences of insecurity. In other specifications, the positive and significant association observed indicates that farmers in conflict-affected environments may adopt entrepreneurial strategies, including cassava seed production, as adaptive or resilience-oriented responses to risk and livelihood uncertainty. Together, these findings show that political instability operates less as a simple deterrent and more as a contextual moderator that interacts with institutional capacity, productivity levels, and market opportunities. This contributes to emerging theoretical debates that frame agricultural entrepreneurship not only as a profit-maximizing activity but also as a risk-management and resilience strategy under conditions of uncertainty.

Beyond regime heterogeneity, the study contributes to inclusive growth and development debates by showing that institutional and technological enablers, credit access, improved varieties, extension services, and digital tools, are more decisive for participation than fixed demographic characteristics such as education or farm size. This challenges classical modernization perspectives that emphasize structural household attributes and instead supports contemporary frameworks that prioritize access to enabling resources. Importantly, the policy simulations provide a nuanced understanding of how these interventions affect different demographic groups, reinforcing arguments for intersectional approaches to agricultural development (Hernandez et al., 2023). The results suggest that uniform policy interventions may disproportionately benefit already advantaged groups, particularly male farmers, while targeted support for women and youth can generate more equitable participation outcomes and strengthen the resilience of cassava seed systems.

From a policy perspective, the inclusion of conflict exposure highlights the importance of integrating agricultural development interventions with broader rural stability and resilience strategies. In contexts affected by insecurity, strengthening rural financial systems, decentralized extension delivery, and digital advisory platforms may help sustain entrepreneurial participation even when mobility and market access are disrupted. This suggests that agricultural commercialization policies should not be designed in isolation from governance and security considerations, particularly in fragile and conflict-prone regions.

More broadly, the findings challenge one-size-fits-all policy prescriptions and offer a theoretically grounded explanation for why similar technologies and policies yield uneven outcomes across rural contexts. By linking productivity regimes and conflict-sensitive contexts to heterogeneous participation drivers and demographic responses, the study clarifies how spatial, institutional, and social conditions mediate the effectiveness of agricultural interventions. Finally, the analysis demonstrates the utility of predictive and regime-sensitive modeling as a tool for designing context-sensitive agricultural policies capable of responding to dynamic rural realities, thereby bridging empirical evidence and policy design in smallholder seed systems.

6. Conclusion and Policy Implications

This study highlights the need for a fundamental reorientation of agricultural policies and programs aimed at promoting cassava seed entrepreneurship in Nigeria. Across multiple robustness checks, including probit estimation, productivity-regime-specific models, and alternative model specifications—the results consistently show that access to financial, technological, and institutional resources is more decisive for participation than most demographic characteristics such as age, education, or farm size. While some socio-demographic factors remain relevant in specific contexts, the evidence indicates that participation is shaped primarily by structural access to enabling resources rather than inherent farmer attributes.

The analysis also incorporates conflict exposure as a proxy for political instability and local insecurity, thereby responding to an important but often neglected dimension of agricultural entrepreneurship in fragile rural environments. The findings suggest that the relationship between insecurity and participation is neither uniform nor purely deterrent. In some specifications, conflict exposure does not significantly reduce participation, indicating that access to credit, improved technologies, and institutional support can mitigate the potential adverse effects of insecurity. In other cases, the positive association observed suggests that farmers in conflict-prone areas may adopt entrepreneurial strategies such as cassava seed production as adaptive responses to livelihood risks and uncertainty. Taken together, these results imply that insecurity functions as a contextual moderator rather than a deterministic barrier, shaping incentives and opportunities depending on the availability of complementary resources.

A key implication is that policy design should move away from demographic targeting based on assumptions about entrepreneurial capacity and instead focus on relaxing binding resource constraints, particularly in low-productivity environments. The regime-specific analysis shows that in these settings, limited access to credit remains the dominant barrier to participation, underscoring the importance of expanding rural financial services tailored to smallholders. Reducing collateral requirements and designing flexible credit products are especially critical for improving inclusion among women and youth, who are disproportionately excluded from formal finance. Strengthening financial inclusion may also enhance resilience in conflict-affected areas by enabling farmers to maintain production and entrepreneurial activities despite disruptions.

In higher-productivity areas, the robustness checks reveal that participation is more strongly driven by technological complementarities, including access to improved cassava varieties, digital tools, and extension services. Policies in these contexts should therefore prioritize the scaling of high-quality planting materials, the integration of digital farm management tools, and the strengthening of extension systems that facilitate information flow and market coordination. These interventions can accelerate farmers' transition from subsistence production to commercial seed entrepreneurship while also providing adaptive capacity in regions exposed to climatic or security-related shocks.

More broadly, the findings challenge one-size-fits-all agricultural development strategies and demonstrate the importance of spatially, institutionally, and contextually differentiated interventions. Rather than viewing certain groups as less entrepreneurial, effective policies must address the structural barriers, including financial exclusion, limited technological access, and local instability, that condition participation opportunities across contexts. Coordinated efforts among government agencies, the private sector, and development partners are essential for designing gender-responsive and youth-inclusive programs that align financial, technological, institutional, and resilience-oriented support.

Investing in inclusive rural finance, productivity-enhancing technologies, robust extension systems, and locally responsive risk-mitigation strategies offers a transformative pathway for scaling cassava seed entrepreneurship. Such an approach not only enhances individual livelihoods but also strengthens Nigeria's seed systems, contributing to broader goals of food security, rural employment, agricultural transformation, and rural stability.

7. Limitations and Directions for Future Research

This study provides valuable insights into the factors underlying cassava seed entrepreneurship, but several limitations should be acknowledged. The primary limitation relates to the cross-sectional nature of the data, which constrains the ability to draw causal

inferences. Although the analysis identifies strong associations between institutional access, technology adoption, and participation in seed entrepreneurship, the directionality and stability of these relationships cannot be definitively established without longitudinal or experimental evidence. In addition, the use of yield per hectare as a proxy for productivity may introduce endogeneity concerns, particularly in a cross-sectional framework, since yield outcomes may themselves be influenced by entrepreneurial participation, technology adoption, or unobserved farmer ability. A more exogenous measure, such as agroclimatic suitability or land potential indices, could provide a cleaner identification of productivity effects. Consequently, future research should incorporate robustness checks that replace yield with agroecological suitability indicators to better isolate structural production conditions from behavioral or managerial influences.

Another limitation is that the study does not explicitly capture unobserved behavioral and psychosocial dimensions, including entrepreneurial orientation, innovation perceptions, aspirations, and risk attitudes. These factors are increasingly recognized as critical determinants of entrepreneurial engagement and technology adoption among smallholders, and their omission may reduce the explanatory depth of the empirical models. Furthermore, while the study incorporates conflict exposure as a proxy for local insecurity, the cross-sectional design limits the ability to disentangle short-term shocks from persistent structural instability, suggesting the need for more refined temporal and spatial measures of political risk.

Given these limitations, several avenues for future research emerge. First, the use of panel or longitudinal datasets would enable researchers to examine dynamic pathways into and out of seed entrepreneurship, thereby improving causal inference and capturing temporal adaptation processes. Second, experimental or quasi-experimental approaches—such as randomized controlled trials (RCTs), phased program rollouts, or natural experiments—could provide more rigorous evidence on the impacts of interventions related to credit access, digital technologies, and extension services. Third, incorporating agroclimatic suitability measures alongside or in place of realized yield would help address potential endogeneity and strengthen the identification of productivity-related constraints. Fourth, future studies should integrate behavioral and psychosocial constructs, including entrepreneurial mindset, innovation readiness, and market orientation, to enhance the explanatory power of participation models. Fifth, a deeper examination of seed system governance—covering seed quality assurance, trust mechanisms, regulatory frameworks, and market structure—would provide insights into the long-term sustainability and scalability of cassava seed enterprises. Finally, adopting an intersectional analytical lens would improve understanding of how gender, age, education, and household leadership interact with institutional access to shape entrepreneurial opportunities, thereby informing more inclusive and equitable agricultural development policies, particularly for marginalized populations.

Nigeria's Trend of cassava production, area harvested, yield 1961-2023

Year	Area harvested(Ha)	Yield(Kg/Ha)	Production(ton)
1961	780000.0	9466.7	7384000
1962	865000.0	8766.5	7583000.0
1963	801000.0	9716.6	7783000.0
1964	870000.0	9174.7	7982000.0
1965	829000.0	9869.7	8182000.0
1966	910000.0	9211.0	8382000.0
1967	958000.0	8957.2	8581000.0
1968	902000.0	9757.2	8801000.0
1969	906000.0	9977.9	9040000.0
1970	857000.0	11909.0	10206000.0
1971	900000.0	10191.1	9172000.0
1972	960000.0	9968.8	9570000.0
1973	970000.0	9896.9	9600000.0
1974	1000000.0	9500.0	9500000.0
1975	1050000.0	10000.0	10500000.0
1976	1080000.0	10185.2	11000000.0
1977	1100000.0	10000.0	11000000.0
1978	1100000.0	10909.1	12000000.0
1979	1150000.0	10434.8	12000000.0
1980	1200000.0	9583.3	11500000.0
1981	1200000.0	9166.7	11000000.0
1982	1250000.0	9360.0	11700000.0
1983	1100000.0	9045.5	9950000.0
1984	1259000.0	9372.5	11800000.0
1985	1075000.0	11246.5	12090000.0
1986	1095000.0	11313.2	12388000.0
1987	1288000.0	10773.3	13876000.0
1988	1347000.0	11461.8	15439000.0
1989	1639778.0	10613.6	17404000.0
1990	1634130.0	11653.3	19043008.0
1991	2551000.0	10193.6	26004000.0
1992	2755000.0	10593.1	29184000.0
1993	2844000.0	10593.5	30128000.0
1994	2927000.0	10592.8	31005000.0
1995	2944000.0	10667.1	31404000.0
1996	2946000.0	10664.6	31418000.0
1997	2697400.0	11881.8	32050000.0
1998	3042500.0	10746.1	32695000.0
1999	3406000.0	9599.8	32697000.0
2000	3300000.0	9700.0	32010000.0
2001	3340000.0	9601.2	32068000.0
2002	3446000.0	9901.3	34120000.0
2003	3490000.0	10402.3	36304000.0
2004	3531000.0	11001.1	38845000.0
2005	3782000.0	10990.2	41565000.0
2006	3810000.0	12000.3	45721000.0
2007	3875000.0	11202.6	43410000.0
2008	3778000.0	11800.4	44582000.0
2009	3129030.0	11767.9	36822248.0
2010	3481900.0	12215.5	42533180.0
2011	4120166.0	11210.8	46190248.0
2012	6401996.0	7958.5	50950292.0
2013	6741300.0	7032.3	47406770.0
2014	7096300.0	7655.4	54324700.0
2015	7900630.0	7265.9	57405060.0
2016	6668996.0	9076.3	60529864.0
2017	6761350.0	9073.7	61350199.0
2018	6949400.0	9403.8	65350850.0
2019	9776650.0	5827.1	56969160.0
2020	9614230.0	5779.5	55565610.0
2021	9979330.0	5835.8	58237500.0
2022	10144641.0	6014.5	61015339.2
2023	9878773.0	6345.9	62690091.2

(continued on next column)

(continued)

Nigeria's Trend of cassava production, area harvested, yield 1961-2023

8. Institutional Review Board Statement

The authors applied and got the approval of the ethical review board of the International Institute of Tropical Agriculture before proceeding with the data collection, and the ethical processes were followed.

9. Informed Consent Statement

Informed consent was obtained from all participants.

10. Consent for publication

Yes, consent is granted for publication.

Funding statement

The authors appreciate the International Fund for Agricultural Development for the funding provided for the study.

Authors contribution

First author conceived and designed the study; led the data

collection, analyzed and interpreted the data, and led the manuscript development.

Second, third, and fourth authors contributed to the data analysis idea and review of the manuscript. the fifth to last author reviewed the manuscript and made input in the discussion of findings

CRediT authorship contribution statement

D.O. Abioye: Writing – original draft, Project administration, Methodology, Formal analysis, Data curation, Conceptualization. **M. Yami:** Writing – review & editing, Conceptualization. **V. Fillipi:** Writing – review & editing, Methodology, Conceptualization. **S. Omitoyin:** Writing – review & editing. **A.I. Ogunniyi:** Writing – review & editing. **A.P. Olufemi:** Writing – review & editing. **D.A. Fadare:** Writing – review & editing. **B. Olorode:** Writing – review & editing. **J. Adeyeye:** Writing – review & editing. **S.Z. Sore:** Writing – review & editing. **R. Atser:** Writing – review & editing, Data curation, Conceptualization. **G. Atser:** Writing – review & editing, Data curation, Conceptualization. **L. Sanni:** Writing – review & editing. **B. Popoola:** Writing – review & editing. **A. Shaibu:** Writing – review & editing. **F. Nwilene:** Writing – review & editing. **A. Akande:** Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

We thankfully acknowledge the support of all the team members for their valuable discussions. We greatly appreciate the contribution of all authors.

Data availability

Data will be made available on request.

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