



UTILIZATION OF CLIMATE-SMART POSTHARVEST LOSS REDUCTION STRATEGIES BY SMALLHOLDER CASSAVA FARMERS IN SOUTHEAST, NIGERIA

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ABSTRACT

The study assessed utilization of climate-smart post-harvest loss reduction strategies by smallholder cassava farmers in Southeast, Nigeria. Multi-stage sampling procedure was used in selecting 240 respondents. Data were collected through the administration questionnaire and analyzed using percentage, mean score and tobit regression. The study revealed that majority (71.3%) of the respondents were males, with an average age, farming experience and household size of 48.4 years, 18.5 years and 6 persons, respectively. The results also showed that the use of ground storage (66.3%), hermetic bags (65.4%) and evaporative cooling structures (61.3%) were the most utilized climate-smart post-harvest loss reduction strategies utilized by the smallholder cassava farmers in the study area. The results further revealed that difficulties in getting improved cassava varieties ($\bar{x}=3.41$), lack of formal education ($\bar{x}=3.41$) and high cost of labour ($\bar{x}=3.38$) were some of the challenges faced in the use of post-harvest loss reduction strategies. The study concluded age ($p<0.05$), farming experience ($p<0.05$), household size ($p<0.05$), farm size ($p<0.05$), access to credit ($p>0.05$) and cooperative membership ($p<0.05$) were the factors affecting the utilization of climate-smart postharvest loss reduction strategies among smallholder cassava farmers in the study area. The study recommends that relevant government agents such extension personnel should train cassava farmers on modern climate-smart post-harvest loss reduction strategies to ensure increased cassava production and profitability.

Keywords: Climate-smart, Postharvest, Loss, Cassava, Farmers

INTRODUCTION

Cassava (*Manihot esculenta* Crantz) is a starchy tuberous root crop that is the fourth most important source of energy in the tropics, providing food to over 800 million people globally (Musa *et al.*, 2022). Africa's total cassava production in 20219 was about 170 million tons, representing about 56% of the world's cassava production (Chimaobi *et al.*, 2023). Nigeria is the world's highest cassava producer, producing 54 million tons of cassava per year, accounting for 19% of total global production capacity (Nzeh *et al.*, 2025). Cassava production in Nigeria was estimated to be 66,602,423 metric tons in 2024, with the highest producing areas being Emuoha (Rivers), Akamkpa (Cross Rivers), Ohaji/Egbema (Imo), Gassol (Taraba), and Ikwere (Rivers), with estimated production levels of 754,741 MT, 688,061 MT, 663,446 MT, 633,699 MT, and 602,664 MT, respectively (Dia *et al.*, 2024). Cassava is called poor man's food since it is consumed in a variety of processed forms such as garri, fufu, chips, tapioca, and flour, enabling them to sustain their families and livelihoods (Nzeh *et al.*, 2025). According to Vutula (2024), cassava is an important food crop for many rural households in Africa, Asia, and South America, as well as a source of financial stability. Cassava is a good source of potassium, iron, calcium, vitamin A, folic acid, salt, vitamin C, B-6, and protein. Cassava tubers are also used as raw materials in the textile, bakery, culinary, and pharmaceutical industries (Sheela *et al.*, 2024). It is usually drought tolerant and requires less nutrient-rich soils to thrive, hence cassava is well-known for its capacity to grow well in a variety of climatic conditions with fewer external inputs. It has evolved from a traditional famine crop to a major cash crop, raw material source for industrial and pharmaceutical applications, and foreign exchange earner for producing countries Barku (2025).



Despite its importance once cassava roots are separated from their stems, deterioration occurs quickly, making it difficult to store under optimal conditions for prolonged periods of time, resulting in post-harvest losses (Anyoha *et al.*, 2023). Post-harvest loss is the drop in crop quantity and quality following harvest (Ibrahim *et al.*, 2022). In Nigeria, for example, post-harvest losses have been reported to be between 2% and 20% for grain, 20% for fish, and 50% to 60% for tubers, fruits, and vegetables (Chikiezie *et al.*, 2023). Post-harvest losses for roots and tubers, particularly cassava roots, accounted for around 35% of total post-harvest losses (Chikiezie *et al.*, 2023). Cassava post-harvest deterioration leads to reduced root quality, lower market prices, lower farmer incomes, a jeopardized supply of fresh roots for industrial use, high market risks, and significant financial losses (Anyoha *et al.*, 2023). However, the post-harvest losses in cassava are caused by climate change such as bad weather, primarily by exacerbating post-harvest physiological deterioration and promoting fungal decay within short periods (Anyoha *et al.*, 2023).

Climate change-related problems, such as changes in the duration of growing season, higher incidence of water stress, and the possibility for poor tuber quality and post-harvest cassava processing, are also affected during the drying and fermentation processes (Huang and Hong, 2024). Climate change hastens post-harvest physiological deterioration and spoilage during processing; rising temperatures encourage the growth of microorganisms that cause degradation and discoloration, musty aromas, and visible molds on cassava roots and processed products such as chips or flour. Furthermore, irregular rainfall and high wetness make it impossible for cassava products to dry; the difficulties faced while transporting cassava to markets or processing centers cause cassava roots to rot and accelerate degradation (Anyaegebu *et al.*, 2022). Hence, rendering the roots unmarketable (economic loss) and unpalatable for human and animal consumption (Anyoha *et al.*, 2023).

Farmers utilize climate-smart strategies to reduce post-harvest losses, such as storing roots in cold and humid conditions and processing them into more stable products, allowing the roots to stay longer in the soil, and harvesting them only when they will be consumed, processed, or marketed immediately (Ariyo *et al.*,). Cassava roots also use new storage tactics, such as chemical and traditional storage structures, to prevent microbial activity (Food and Agriculture Organization, 2023). Storage in boxes lined with damp sawdust in which cassava roots are packed and being arranged together in boxes containing absorbent material with layers of sawdust (Désiré *et al.*, 2023). Storage in plastic film wraps or bags includes harvesting and selecting high and improved, generally unhurt cassava roots, washing them, and then dipping or spraying them with fungicides as a post-harvest treatment. The washed roots are then placed in sealed polypropylene bags, which allow the cassava roots to be preserved for an extended length of time (Tomlins *et al.*, 2021). The use of post-harvest reduction strategies helps make food items desirable, safer, increase their shelf-life, and to the great extent minimize threats of food insecurity while also improving the living standard of rural farmers, by preserving the quality of perishable foods (Kipruto *et al.*, 2025). Cassava farmers faced various hurdles when using post-harvest loss reduction strategies, owing to high cost of inputs, financial constraints, insufficient infrastructure, low technical knowledge, lack of formal education and high cost of labour (Njoku *et al.*, 2024).

In southeast Nigeria, there is a paucity of attention and data on climate-smart post-harvest reduction strategies. This has resulted in a lack of robust government measures to raise awareness among cassava producers. For example, studies by Eze *et al.*, (2026) and Oparaojiaku *et al.*, (2025) did not focus on the use of climate-smart post-harvest loss reduction strategies among cassava farmers in Southeastern Nigeria. To fill this gap, the study assessed utilization of climate-smart postharvest loss reduction strategies by smallholder cassava farmers in Southeast Nigeria. The study specifically looked at the following objectives:

- i. described socio-economic characteristics of cassava smallholder farmers;
- ii. assessed climate-smart postharvest loss reduction strategies utilized by cassava farmers;
- iii. identified challenges hindering the utilization of climate-smart post-harvest reduction technologies by smallholder cassava farmers; and
- iv. determine factors affecting the utilization of climate-smart postharvest loss reduction strategies.



METHODOLOGY

The study was carried out in Southeast Nigeria, specifically in the states of Abia, Anambra, Enugu, Imo, and Ebonyi. Southeast, *Nigeria* is situated between latitudes 4°45'N and 7°00'N, and longitudes 6°30'E and 8°30'E (Eze *et al.*, 2025). South east has approximately 29,388 square kilometers, with a population of approximately 36 million people and has a tropical climate with distinct wet and dry seasons with an annual rainfall range from 1,500 mm to 2,500 mm (Apeh *et al.*, 2023). The vegetation of southeast is predominantly is derived savanna in inland areas and tropical lowland rainforest (Olowokudejo and Oyebanji, 2016). Agriculture is the primary occupation in the region, with more than 70% of the population engaged in smallholder farming. Cassava (*Manihot esculenta*) is the primary staple farmed in the region by more than 85% of agricultural households because to its tolerance to various soil conditions and resilience to climate change (Apeh *et al.*, 2023).

Sampling Technique and Sample Size

The study employed multi-stage sampling procedure for selection of the respondents. The first stage involved purposive selection of Abia, Enugu and Ebonyi, states, based on suitable climatic conditions and massive involvement in cassava production. At the second stage, the following Local Government areas were purposively selected; Ikwuano and Isiala Ngwa South in Abia State, Nsukka and Udeniu in Enugu state, and Abakaliki and Ikwo in Ebony state, giving a total of 6 local government areas. At the third stage, four communities in each selected Local government areas were randomly selected based on their prominence in cassava production, giving a total of 24 communities. At the fourth stage, 10 cassava farmers in each community were selected randomly to give a total of 240 cassava farmers.

Data Collection and Analysis

Data were collected through the use of questionnaire. Climate-smart post-harvest loss reduction strategies utilized by cassava farmers was measured at nominal level of yes and no. The responses were scored as '1' for yes and '0' for no. Challenges hindering the utilization of climate-smart post-harvest loss reduction strategies by cassava farmers was measured on a 5-point Likert scale of extremely (1), very (2), moderately (3), slightly (4) and not at all (5), with a mean of score of 3.0. Therefore, any variable with a mean score of ≥ 3.0 was considered a challenge, while < 3.0 was not considered a challenge. Data were analyzed using percentage, mean and Tobit regression analysis.

The Tobit model therefore expresses farmers' post-harvest loss reduction strategies as a function of a linear combination of observable explanatory variables, some unknown parameters and an error term (μ_i). The simple model can be presented as:

$$Y_i^* = \beta_0 + \beta_1 X_{i1} + \dots + \beta_{11} X_{i11} + \mu_i$$

Where,

Y_i = the observed dependent variable, that is, utilization of post-harvest reduction strategies

X 's are vectors of explanatory variables, explained as:

X_1 = Age (years)

X_2 = Farming experience (years)

X_3 = Household size (actual number)

X_4 = Farm size (ha)

X_5 = Access to credit (yes=1, no=0)

X_6 = Gender (male=1, female=0).

X_7 = Membership of farmer associations (yes=1, no=0)

X_8 = Use of climate- tolerant variety

RESULTS AND DISCUSSION

Socioeconomic Characteristics of Smallholder Cassava Farmers

The results in Table 1 showed that the average age of the respondents was 48.4 years, indicating that they were mature enough to understand the importance of using strategies that reduce post-harvest losses in cassava. Furthermore, the study found that 71.3% were males, indicating that male farmers dominate cassava production. The finding is congruent with Akomolafe *et al.*, (2023), that 62.0% of cassava farmers in Bwari Area Council, Abuja, were male. Similarly, 72.50% of respondents had spent



more than 11 years cassava farming, with an average farming experience of 18.5 years, indicating that the respondents had spent a reasonable number of years growing cassava. Years of farming experience help farmers learn how to use climate-smart strategies to reduce post-harvest losses during processing or storage. Similarly, 98.33% of the respondents reported having a household size of 1 to 10 individuals, with an average household size of 6.5 persons, indicating that the respondents had a large household size capable of supplying family labor for cassava production. Akomolafe *et al.* (2023) reported that 43.0% of cassava farmers in Bwari Area Council, Abuja, had households with 6 to 10 persons. Furthermore, majority (79.17%) of respondents had between 1-3 hectares of farm size, with an average of 2.8 hectares, showing that the bulk of the respondents were smallholder farmers who may not have access to larger farm sizes. Nwankwo and Chiekezie (2024) discovered that cassava farmers in Anambra state had a farm size of 2.44 hectares. The study also found that 73.3% of cassava farmers had access to credit, which could be attributed to farmers in rural areas are members of cooperatives and having relatives/fellow farmers who can provide soft or low-interest loans. The finding is comparable with that of Okon *et al.*, (2025), that reported 53.3% of cassava farmers in Abak Agricultural Zone, Akwa Ibom State, Nigeria, had access to loans. Table 1 also reveals that slightly above a quarter (26.7%) belonged to farmers' associations, contradicting the findings of Nwankwo and Chiekezie's (2024) that 52.5% of cassava farmers in Anambra State, Nigeria, were members of cooperatives. Majority (87.5%) of the respondents agreed that they have used climate-tolerant variety of cassava as a climate-smart strategy to reduce post-harvest losses.

Table 1: Socio-economic Characteristics of Cassava Farmers

Socio-economic characteristics	Percentage (n=240)	\bar{x}
Sex		
Male	71.3	
Female	28.7	
Age		
>30	2.92	
31-40	20.83	
41-50	39.58	48.4
>51	33.75	
Farming experience (Years)		
1-10	27.50	
>11	72.50	18.5
Household size (Number)		
1-10	98.33	6.3
>11	1.67	
Farm size (Ha)		
1-3	79.17	2.8
>4	20.83	
Access to credit		
Yes	73.3	
Membership of farmer associations		
Yes	26.7	
Use of climate- tolerant varieties		
Yes	87.5	

Source: Field survey, 2026

Climate-smart Postharvest Loss Reduction Strategies Utilized by Smallholder Cassava Farmers

The results in Table 2 showed that ground storage (66.3%) was used by the respondents to post-harvest losses in cassava and this might help shielding the crops from post-harvest deterioration. This agrees with the assertion of Vutula, (202) that ground storage is an important approach in tropical regions because it reduces severe economic and physical post-harvest losses by shielding the crop from physiological deterioration, which usually ruins harvested roots within short period of time. Ground



storage is important in combating the high perishability of cassava tubers, extend crop usefulness, raise income, and improve food security, preserve quality, allowing farmers to avoid selling at a discount, resulting in higher profits. The results also showed that cassava farmers used hermetic storage (65.4%) to reduce post-harvest losses and this suggests that use of hermetic storage and sundry was a smart strategy used by the farmers because it protects cassava products against spoiling, damage, contamination and decreased financial losses for farmers as reported by Samuel *et al.*, (2025). Another loss reduction strategy was field clamps, which is the traditional method involving storing cassava roots in trenches or clamp under high humidity conditions (61.7%). This might be because field clamps create a warm, highly humid conditions and regulating ambient temperature that stimulate curing process that heals skin wounds and form hard cork layer, suppressing post-harvest deterioration and increases cassava's marketability (Defraeye *et al.*, 2023). Use of evaporative cooling structures (61.3%) was a strategy used by cassava farmers and this might because evaporative cooling structures significantly reduce losses by creating high-humid environment and low-temperature microclimates that slow respiration and post-harvest physiological deterioration (Adetunji *et al.*, 2023). Traditional sun drying of cassava roots (54.6%) and this implies that use of sun drying helps create a harsh environment for molds and pathogenic bacteria, which cause spoilage of cassava. Value addition equipment such as graters, hydraulic presses and vibrating sieves (52.1%) was a climate-smart post-harvest loss reduction strategy used by the respondents and this implies that the use of value addition equipment transforms highly perishables like cassava into stable and value-added products before natural spoilage occurs. Another climate-smart post-harvest loss reduction strategy was knowledge-sharing and cooperatives (51.2%), which indicates that knowledge sharing plays a significant role in reducing post-harvest losses through allowing farmers to cooperate, mobilize resources and share ideas.

Table 2: Climate-smart Postharvest Loss Reduction Strategies Utilized by Cassava Farmers

Climate-smart post-harvest reduction technologies	Percentage (n=240)
Use of ground storage	66.3
Use of Hermatic storage	65.4
Field clamps, the traditional method involving storing cassava roots in trenches or clamp sunder high humidity conditions	61.7
Use of evaporative cooling structures	61.3
Traditional sun drying of cassava roots	54.6
Use of value addition equipment such as graters, hydraulic presses and vibrating sieves etc.	52.1
Knowledge-sharing and cooperatives	51.2
Modified atmosphere and controlled storage	47.5
Shelf-life enhancing technologies	44.2

Source: Field survey, 2026

Challenges Hindering the Utilization of Climate-smart Postharvest Loss Reduction Strategies by Cassava Farmers

The results in Table 4 shows that the challenges hindering the utilization of climate-smart post-harvest reduction strategies. The results showed that respondents faced challenges, which hindered utilization of climate-smart post-harvest loss reduction technologies such as high cost of obtaining climate-smart post-harvest loss reduction technologies (\bar{x} =3.60), difficulty in getting improved cassava varieties (\bar{x} = 3.41), lack of formal education (\bar{x} = 3.41), high labour cost (\bar{x} = 3.38), lack of access to climate-smart post-harvest loss reduction technologies (\bar{x} = 3.34), pest and diseases (\bar{x} = 3.30), traditional beliefs and practices (\bar{x} = 3.31) and low level of income (\bar{x} = 3.23). The finding implies that respondents encountered difficulties in utilizing climate-smart post-harvest loss reduction strategies. The high cost of obtaining post-harvest loss-reduction strategies hinders the smooth utilization of smart-strategies aimed at reduction post-harvest cassava losses. The finding is consistent with of John and Onah (2025), who discovered that cassava farmers in Otukpo, Benue State, Nigeria, were constrained by the high cost of post-harvest loss-reduction technologies. Furthermore, cassava



growers had difficulties obtaining improved varieties, such as drought- and disease-tolerant cassava, which are designed to resist variable weather and have longer shelf lives. When farmers are unable to obtain these types of varieties, they are compelled to adopt local cultivars, which are less hardy and more susceptible to quick post-harvest deterioration. Pests and diseases have an impact on cassava farmers' climate-smart postharvest loss-reduction strategies. Baffour-Ata *et al.*, (2024) found that incidence of pests and diseases was a barrier facing smallholder cassava farmers in the adoption and utilization of climate-smart agriculture in Afigya Kwabre South District, Ghana. More specifically, traditional beliefs and practices prevented smallholder cassava farmers from adopting climate-smart post-harvest reduction strategies, implying that farmers frequently trust traditional post-harvest activities such as processing or storage over modern methods for fear of failure. Lack of formal education also affects cassava farmers' ability to appropriately apply climate-smart post-harvest loss reduction strategies, and this is most likely because the majority of rural farmers are not privileged to get formal education. This is consistent with the findings of Aturamu *et al.* (2021), who found that Southwest Nigerian cassava farming households' lack of education limited their capacity to apply methods that lessen the effects of climate change on cassava. Another issue that the respondents faced was high labor costs, which is consistent with the findings of Aturamu *et al.* (2021) reported that farming households in Southwest Nigeria faced high labor costs that limited their capacity to use strategies that reduce the effects of climate change on cassava. Lack of access to climate-smart post-harvest loss-reduction technologies, such as sophisticated processing equipment, contemporary storage facilities like hermetic bags, or better transportation facilities, is a challenge for farmers.

Table 3: Challenges Hindering the Utilization of Climate smart Postharvest Reduction Strategies by Cassava Farmers

Challenges	\bar{x}	Std. Deviation
High cost of obtaining climate-smart post-harvest loss reduction technologies	3.60	1.51
Difficulty in getting improved cassava varieties	3.41	1.65
Lack of formal education	3.41	1.61
High labour cost	3.38	1.61
Lack of access to climate-smart PHL reduction technologies	3.34	1.61
Incidence of pest and diseases	3.30	1.61
Traditional beliefs and practices	3.31	1.59
Low level of income	3.23	1.64
Lack of credit	2.98	1.84
Poor extension services	2.02	1.31
Limited access to reliable, timely information on climate-smart PHL reduction technologies	1.53	0.95

Source: Field survey, 2026

Factors Affecting Utilization of Postharvest Loss Reduction Strategies by Cassava Farmers

Table 3 reveals the factors affecting utilization of post-harvest loss reduction strategies. The regression results revealed that age had a positive and significant ($P < 0.05$) effect on the utilization of climate-smart post-harvest loss reduction strategies. This may be attributed explicitly to the accumulated expertise and knowledge of indigenous techniques acquired that improve postharvest handling over time thereby improving their post-harvest loss management (Nwankwo & Chikezie *et al.*, 2024). The finding suggests that experience gained with age enhances decision-making in postharvest management, ultimately contributing to higher efficiency levels.

The results also showed that farming experience significantly and positively ($P < 0.05$) affects utilization of climate-smart post-harvest loss reduction strategies. This means that as years spent in cassava farming increase, farmers are expected to have more knowledge about utilization of climate-smart strategies in reducing post-harvest losses. Experience not only drives adoption but also enhances the effectiveness of utilization, reinforcing the link between knowledge accumulation and postharvest loss management (Nakoma-Ngoma *et al.*, 2025).



Household size had a negative and highly significant ($P < 0.05$) effect on utilization of post-harvest loss reduction strategies. This implies that larger households face financial constraints and are repeatedly found to be more food insecure as higher consumption needs strain resources and limit savings and ability to effectively utilize climate-smart post-harvest loss reduction strategies or technologies (Samuel *et al.*, 2025). Consequently, this resource dilution limits adoption of multiple technologies since they face liquidity and credit constraints which inhibits the adoption of several innovations and improved postharvest/storage technologies (Bisheko and Rejikumar, 2023).

In addition, credit access was negatively and significantly ($P < 0.05$) related to the utilization of post-harvest loss reduction strategies. It may indicate that as access to credit increased, farming households are likely to invest in consumption instead of investing in climate-smart strategies that reduce post-harvest losses (Lelisho & Lelisho, 2024). When credit is not structured or sufficient for postharvest investment, utilization of climate-smart post-harvest loss reduction strategies, hinders improvements in postharvest loss management. Furthermore, cooperative membership had a positive and significant ($P < 0.05$) effect on the utilization of post-harvest loss reduction strategies. Cooperatives and farmer organizations provide information, technical training and outsourcing services, which improve farmers' capability to adopt new technologies and good management practices such as the post-harvest loss-reduction strategies (Khan *et al.*, 2022).

Table 4: Factors affecting utilization of post-harvest loss reduction strategies

Independent variables	Coef.	T	P>t
Age	0.051	2.197**	0.023
Farming experience	0.084	2.642**	0.032
Household size	-0.419	-3.703***	0.113
Farm size	0.318	2.086**	0.153
Credit access (yes=1; no=0)	-1.271	-2.372**	0.536
Gender (m=1, f=0)	0.215	0.506	0.425
Cooperative membership (yes=1; no=0)	1.292	2.621**	0.493
Use of climate-tolerant varieties (0.084	0.220	0.380
Constant	-1.553	-1.083	1.434

Source: Field survey, 2026,

Log-likelihood: -68.968, Pseudo R²: 0.859,

CONCLUSION AND RECOMMENDATION

The study concluded age, farming experience, household size, farm size, access to credit and cooperative membership were the factors influencing the utilization of climate-smart postharvest loss reduction strategies among smallholder cassava farmers in the study area. Also, smallholder cassava farmers utilized climate-smart post-harvest loss reduction strategies such as Use of ground storage, use of Hermatic storage, field clamps, the traditional method involving storing cassava roots in trenches or clamp sunder high humidity conditions, evaporative cooling structures, etc. Farmers encountered numerous challenges high cost of obtaining climate-smart post-harvest loss reduction technologies, difficulty in getting improved cassava varieties, lack of formal education, high cost of labour, incidence of pest and diseases, traditional beliefs and practices. The study recommends that extension agents should provide farmers with access to and training on different modern climate-smart post-harvest loss reduction strategies; farmers should be provided with improved cassava varieties that withstand effects of climate change; relevant government agencies should provide with timely information on climate-smart loss reduction technologies; financial institutions should provide farmers with access to credit for adequate investment in post-harvest loss reduction strategies.

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