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The determinants of post-harvest management practice adoption in Anambra and Ebonyi State, Nigeria

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Abstract

This study examined the factors influencing the adoption of post-harvest management practices among rice farmers in Anambra and Ebonyi States, Nigeria. Employing a mixed-method approach, data was collected from a random sampling of 320 rice farmers (160 per State). The study utilized the Logit model and Principal Component Factor Analysis techniques from Open Directory R-software and SPSS version 25 to achieve the specific objectives. The study identified key post-harvest management practices, evaluated their level of adoption, and determined the socioeconomic variables impacting their implementation. The findings indicate that post-harvest management practices are significantly adopted in both states, with a grand mean score above 3.0 (Anambra: 3.18, SD = 1.322; Ebonyi: 3.22, SD = 1.24). Ebonyi farmers demonstrated a marginally higher adoption rate and consistency in these practices compared to their counterparts in Anambra. Notably, proper harvesting techniques were more significantly adopted in Ebonyi (Mean = 3.10) than in Anambra (Mean = 2.88), implying a reduction in post-harvest losses and improved grain quality in Ebonyi. Quick drying, the use of drying facilities, pest management, proper threshing, and quality seed utilization emerged as critical factors enhancing post-harvest efficiency and economic gains for rice farmers in both states. Socioeconomic determinants such as gender, marital status, education, and household size significantly influenced the adoption of post-harvest management practices. In Anambra, male farmers (Exp(B) = 2.611) and married individuals (Exp(B) = 1.560) were more likely to adopt post-harvest practices, whereas in Ebonyi, education negatively correlated with adoption (Exp(B) = 0.916). The study revealed the role of agricultural extension services in promoting best practices, thereby reducing post-harvest losses and enhancing farmers' economic outcomes. Targeted interventions focusing on education, training, and market access can further optimize adoption rates and improve the livelihoods of rice farmers.

Keyword: Management; Determinants; Adoption; Practices; Nigeria

1 Introduction

One of the major global challenges is how to ensure food security for a growing population whilst ensuring sustainable development (Olalereadisa et al., 2020). This is why it is important to ensure that smallholder farmers involved in rice production are properly trained on how to integrate post-harvest management practices to help ensure sustained economic value of their produce. Obianefo et al (2020) opined that post-harvest management is a crucial element of any agricultural activity, and it is particularly important in developing countries such as Nigeria, where rice is the second most important staple crop in the country. Sani and Ibrahim (2022) allude that Nigeria has been characterized by a shortage in rice production due to inefficiency in the utilization of the available resources and post-harvest losses which account for about 20-25% of total production annually. In the same light, Danbaba (2023) submitted that post-harvest

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loss accounts for a 17-30% loss in rice production. It is therefore evident that post-harvest management problems among rice farmers in Nigeria may be the chief architect of rice insufficiency in Nigeria and these problems need to be addressed urgently (Egwuonwu, 2020).

The main objective of post-harvest management is to preserve the harvest for consumption, sale or for storage for later use (Danbaba, 2023). This is of particular importance for smallholder farmers who dominate the agricultural sector in Nigeria and rely on their harvest for food security (Anumudu *et al.*, 2021). In Anambra and Ebonyi State, a combination of factors can lead to post-harvest losses. Egwuonwu (2020) summarized these factors of post-harvest losses to include inadequate funding, delay in harvesting, lack of technical knowledge, dependency on traditional threshing methods, incomplete threshing, improper handling operations, heavy rainfall during harvesting and drying sessions, over or/and under-boiling of the paddy during parboiling, inadequate and low efficiency in the use of machinery, improper drying operations, lack of mechanical drying facilities, biological deterioration, poor defective packaging of grain, birds/insect attack, infestation by storage pests, poor transport conditions, and poor marketing system.

However, given the status of Anambra and Ebonyi as top rice producing states in the south east or Nigeria, it is not yet known, the current status of post-harvest management practices in use by rice farmers the states. Several studies have been carried out on rice production in the area but so far, none on post-harvest management practices adopted by the rice farmers. Thus, this study aims to conduct a comparative assessment of postharvest management practices among rice farmers in Anambra and Ebonyi states to understand the current post-harvest loss management practices adopted by rice farmers in the area and to investigate how these practices affect their output and contribution in the quest to achieve food security.

There is also a dearth in the literature of post-harvest management practices adopted by rice farmers in the study area. The closest to the study was conducted by Nwalieji (2016) focusing on the comparative profit analysis of rice production enterprise among farmers in Anambra and Ebonyi States, Nigeria. While Umeh and Olojade (2016) compared what was obtainable in Abia and Enugu States. In line with this background of the study, the study intend to address the following specific objectives:

- To identify the post-harvest management practices adopted by the rice farmers;
- To determine the influence of rice farmers' socioeconomic factors on post-harvest management practices adopted; and
- To identify the constraints faced by the farmers in post-harvest management practices in the study.

2 Review of Related Empirical Studies

2.1 Determinants of Post-harvest Management Practice Adoption

The empirical review highlights various studies on post-harvest losses (PHL) across different crops and study locations, emphasizing key factors influencing these losses and potential mitigation strategies. Esmat et al. (2012) found that farm size, household size, and labor availability significantly affect PHL management in rice and wheat farming in Bangladesh. Dick and Ogei (2022) explored access to PHL management training among Ugandan maize farmers, identifying farm size, group membership, and maize output as positive determinants, while distance to training centers had a negative impact. Similarly, Sani et al. (2022) examined the technical efficiency of rice farmers, noting that harvesting methods, farm size, education, and experience influenced PHL. Oni (2017) extended this analysis to food grain supply chains, finding that field drying time, traditional storage methods, and scale of operations significantly increased losses.

Additional studies focused on broader socio-economic and technological factors affecting PHL. Luo et al. (2022) highlighted the inverse relationship between farm size and rice harvest losses in China, advocating for mechanization and farm expansion. Bime et al. (2015) in Cameroon identified marital status, grain quantity, and group membership as key determinants of pre- and postharvest management adoption, with financial constraints and inadequate machinery posing major challenges. Rishi et al. (2020) explored the adoption of PHL reduction techniques for large cardamom in Nepal, finding that access to credit played a crucial role. In Nigeria, Egwuonwu (2020) and Liambee & Onu (2022) investigated rice farmers' PHL management, revealing that harvesting delays, technical knowledge gaps, and financial limitations significantly contributed to losses. Overall, these studies underscore the need for improved access to training, credit, mechanization, and policy support to reduce PHL and enhance food security.

2.2 Constraints to the Adoption of Post-harvest Management Practices

The empirical review highlights various studies on post-harvest losses and challenges in rice production across different countries. Latiful (2015) emphasized that Bangladesh faces high post-harvest losses due to its dense population, unfavorable land-population ratio, and lack of access to modern post-harvest technologies. Muthukumar et al. (2020) examined post-harvest technology adoption challenges in India, revealing issues such as high labor costs, lack of technical expertise, and inadequate credit. Nguyen and Baldeo (2006) explored agroecological and socioeconomic constraints in India and Vietnam, identifying reliance on monsoons, poor infrastructure, pests, and financial limitations as major barriers. Misganaw (2020) investigated rice production challenges in Ethiopia, citing inadequate mechanization, post-harvest management issues, and biotic stresses as key constraints affecting farmers.

Qu et al. (2021) reviewed global research on rice harvest losses, attributing them to inefficient techniques, lack of infrastructure, and poor knowledge, while also highlighting potential social trade-offs in loss reduction. Wazis (2021) focused on Nigeria, finding that threshing losses significantly impact farmers' income, with inadequate harvesting equipment being a major challenge. The studies collectively underscore that postharvest losses remain a critical issue across different regions due to infrastructural, financial, and knowledge-related constraints. Addressing these challenges requires targeted interventions, improved technologies, and policies that balance productivity with socio-economic realities.

2.3 Post-Harvest Loss Management Practices

The empirical review highlights various studies on post-harvest management across different agricultural value chains, with a particular focus on rice storage and loss reduction strategies. Aremu et al. (2022) emphasize the low utilization of modern storage facilities among rice farmers, revealing that most store their paddy for short durations using local cribs or warehouses. While a significant number are aware of modern storage techniques, only a few implement them, leading to losses primarily due to rodents and insects. Danbaba et al. (2021) explore ways to minimize post-harvest losses by adding value to low-quality milled rice and rice husks, while Anshah et al. (2018) demonstrate that proper post-harvest handling significantly improves farmers' welfare by reducing storage losses. Similarly, Fiamohe and Agossadou (2019) identify modernizing post-harvest operations as a means to attract youth into agribusiness, particularly through mechanization of harvesting and threshing.

Gupta et al. (2020) provide insights into post-harvest losses in Goa, highlighting traditional storage methods and the urgent need for mechanization and training to improve efficiency. Na et al. (2021) introduce the 5T management system, a process-driven approach that significantly reduces post-harvest losses through strict time-based interventions in storage and drying. Beyond rice, Kojo et al. (2015) focus on tomato production, stressing the importance of preharvest practices and proper postharvest handling to reduce quality losses. Collectively, these studies underscore the need for improved storage facilities, modernized processing techniques, and targeted training programs to mitigate post-harvest losses and enhance profitability across agricultural value chains.

3 Research Methodology

3.1 Study Area

The study was conducted in Anambra and Ebonyi States, two major rice-producing states in Southeast Nigeria (Mba et al., 2021). Anambra State, located between longitude 6° 36′E and 7° 21′E and latitude 5° 38′N and 6° 47′N, consists of 21 Local Government Areas (LGAs) and four Agricultural Zones: Aguata, Anambra, Awka, and Onitsha. It shares borders with Kogi, Rivers, Delta, Imo, and Enugu States and spans 4,416 square kilometers with a 2016 projected population of 5,527,809 (NBS, 2018). The state has a tropical equatorial climate with distinct rainy and dry seasons and a vegetation mix of rainforest, woody savannah, and grasslands. The farming system includes crops, livestock, and fisheries, with off-farm activities such as processing and marketing playing a vital role. Key crops include rice, cassava, yam, maize, and legumes. Notably, 5,396 rice farming households contribute to the annual production of 210,000 metric tonnes of milled rice, with a processing efficiency rate of 50.6% (Obianefo et al., 2022; 2023).

Also, Ebonyi State, created in 1996, is among Nigeria's youngest states and shares boundaries with Benue, Enugu, Imo, Abia, and Cross River States. It consists of 13 LGAs and three senatorial zones: Ebonyi North, Ebonyi Central, and Ebonyi South. Geographically, it lies between latitude 5° 40′N and 6° 45′N and longitude 7° 30′E and 8° 46′E, covering an area of 5,935 square kilometers, approximately 5.8% of Nigeria's total land area, with a 2016 projected population of 2,880,383 (NBS, 2018). The state has a semi-savannah landscape with a mix of agrarian, forestry, and swampy vegetation, making it highly suitable for rice farming. It experiences a tropical humid climate with high rainfall, temperature, and sunshine, divided into rainy and dry seasons. Agriculture is the dominant occupation, with a

significant number of rice farmers (145,109) and 202 public extension officers supporting production. The state is a leading producer of rice, yam, maize, cassava, and other staple crops, solidifying its status as a key agricultural hub in Nigeria.

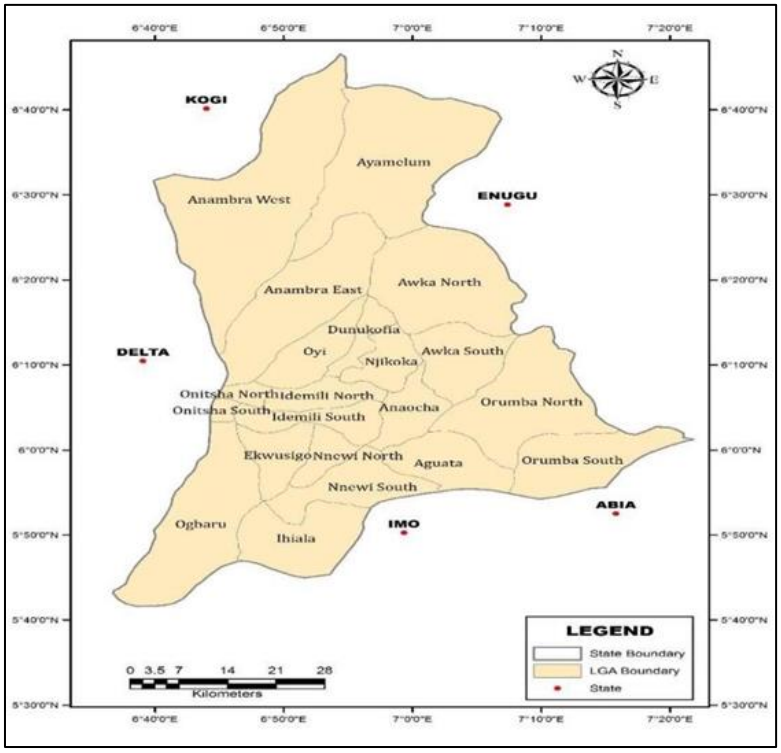

Figure 1 Map of Anambra State

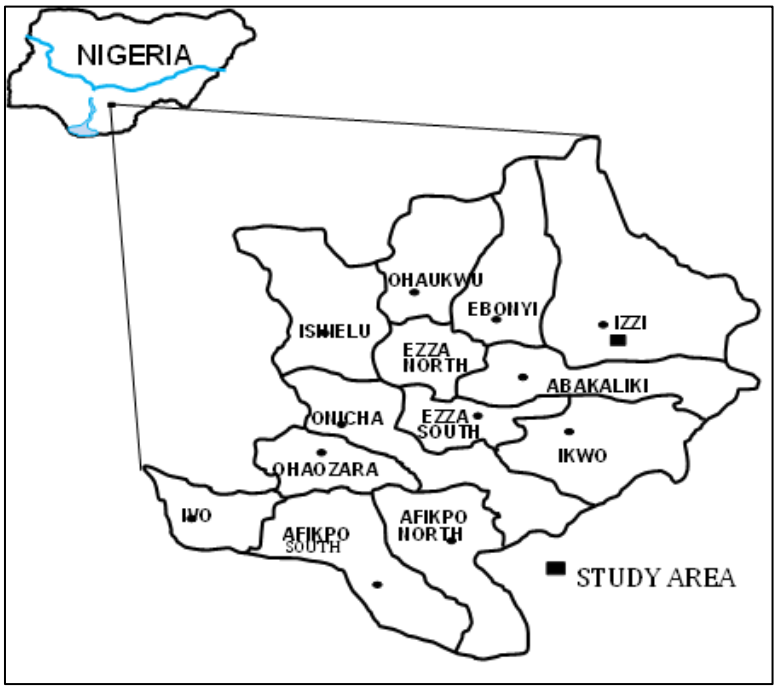

Figure 2 Map of Ebonyi State

3.2 Sampling Procedure

The population of the study comprises all rice farmers in Anambra and Ebonyi States. A multistage sampling procedure, incorporating purposive and simple random sampling techniques, were employed to select the LGAs, communities, villages, and respondents.

In Stage I, four LGAs were purposively selected from each State based on their high rice production activities. These LGAs include Anambra East, Awka North, Ayamelum, and Orumba North LGAs in Anambra State, and Abakalikki, Izzi, Ikwo, and Ezza North LGAs in Ebonyi State. In stage II, all the communities in each LGA were purposively selected from each of the chosen LGAs in both States, resulting in a total of 71 communities.

Table 1 Number of communities from the selected LGAs

State	Local Government Areas	No of community
Anambra	Ayamelum	8
	Awka North	10
	Anambra East	11
	Orumba North	8
Ebonyi	Abakilikki	6
	Izzi	4
	Ikwo	13
	Ezza North	11
Total		71

Source: Researcher's Compilation, 2024.

In Stage III, four villages were randomly selected from each community to make the study location sixty-four (64) villages. In the last stage, five rice farmers were randomly selected from each of the chosen villages, giving a total of 320 respondents (160 rice farmers from each State). This sample size for the study is the 320 rice farmers.

3.3 Methods of Data Collection

Data for the study was collected from primary source using a validated structured interview schedule. The interview schedule was organized into sections corresponding to the objectives of the study. The data collection instrument underwent validation by three academic staff members, two from the Department of Agricultural Economics and Extension at Chukwuemeka Odumegwu Ojukwu University, Igbariam Campus, and one from the Department of Agricultural Economics and Extension at Nnamdi Azikiwe University, Awka. To assess reliability, a test-retest technique was employed. Twenty copies of the questionnaire (10 in each State, Anambra and Ebonyi) were administered to rice farmers outside the selected study locations over a two-week period; these respondents were not part of the final study participants. The reliability of the instrument was determined using Cronbach's alpha test at a 0.05 level of probability. To aid in data collection, four research assistants were recruited and trained on the questionnaire's content.

Table 2 Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
0.806	0.817	20

Source: Field Survey Data, 2024.

3.4 Model Specification

Logit model for objective two is specified as:

$$P_1^* = \beta_0 + \beta_1 X_1 + \cdots \beta_n X_n + \varepsilon_i$$

$$P_2^* = \gamma_0 + \gamma_1 X_1 + \cdots \gamma_n X_n + \varepsilon_i$$

Where:
P_1^* = management practice index below 50%
P_2^* = management practice index from 50% and above
β and γ are vectors of respective parameters to be estimated.
X_i= vectors of explanatory variables (age, sex, marital status, experience, level of education, annual income, farm size, and post-harvest management training)

ε_i = error terms.

Principal factor analysis for objective three is specified as:

$$Z_i = \delta_{i1}F_{i1} + \delta_{i2}F_{i2} + \cdots \delta_{im}F_{im} + \varepsilon_i$$

Where:
Z_i = observation on variable X_j for the *ith* sample number
F_1-F_m = number of common factors rotated
ε_i = the stochastic error term
δ_{i1} .... δ_{im} = factor loading (regression weight).

SPSS version 25.0 software was used on Promax method of rotation. The benchmark correlation coefficient was set on 0.30 to enhance the degree of accuracy.

4 Results and Discussion

4.1 The post-harvest management practices adopted by the rice farmers

Table 3 presents the post-harvest management practices adopted by rice farmers in Anambra and Ebonyi States. The items of consideration was captured in a 5-oints Likert Scale. We focused on practices where the mean score is 3.0 or above, indicating that these practices are significantly adopted by the farmers. The grand mean scores in both States are above the benchmark of 3.0 (Anambra State: Grand Mean = 3.18, Std. Dev. = 1.322, and Ebonyi State: Grand Mean = 3.22, Std. Dev. = 1.24), indicating that, on average, the post-harvest management practices listed are significantly adopted by farmers. The slightly higher mean in Ebonyi suggests a marginally greater overall adoption of these practices compared to Anambra. The lower standard deviation in Ebonyi implies more consistency among farmers in their post-harvest management practices. The grand mean suggests that post-harvest management practices are generally well-adopted in both states, leading to reduced post-harvest losses and improved economic outcomes. The outcome of the result suggested that several agricultural extension interventions are yielding fruits.

Farmers in Ebonyi state agree that proper harvesting techniques are significantly adopted as a post-harvest management practice, with a mean score of 3.10, suggesting a moderate consensus. In contrast, Anambra farmers do not significantly adopt this practice (Mean = 2.88, Std. Dev. = 1.444). The adoption of proper harvesting techniques in Ebonyi implies reduced losses during the initial stages of post-harvest handling, leading to better grain quality and higher market value. This finding is consistent with the report of Benyam et al. (2018); and Aminou et al. (2021) in their study. In Anambra, where this practice is less prevalent, there may be higher losses at this stage, reducing potential profits. Again, both states recognized the importance of quick drying in reducing post-harvest losses (Anambra State: Mean = 3.08, Std. Dev. = 1.364, and Ebonyi State: Mean = 3.33, Std. Dev. = 1.131). Onu (2018) believes that quick drying prevents the growth of Mold and reduces the risk of rice spoilage. Also, the use of drying facilities is recognized in both (Anambra State: Mean = 3.11, Std. Dev. = 1.454, and Ebonyi State: Mean = 3.17, Std. Dev. = 1.375) states as a critical factor in minimizing post-harvest losses. However, effective drying facilities can significantly reduce the moisture content in rice, which is essential for preventing spoilage (Chidiebere-Mark et al., 2019). This economically, leads to a higher quality product that can command better prices, thus improving the income of rice farmers.

Equally, in Ebonyi State, pest management is considered crucial in reducing post-harvest losses (Mean = 3.45, Std. Dev. = 1.132). Effective pest management reduces the damage caused by pests during storage, ensuring that a larger quantity of rice remains marketable (Danbaba, 2023). This leads to better economic returns. In Anambra State, where pest management is not seen as significant, the higher post-harvest losses due to pests could be reducing farmers' income. Again, proper threshing techniques are important in both Anambra State: Mean = 3.05, Std. Dev. = 1.404, and Ebonyi State: Mean = 3.43, Std. Dev. = 1.125) states for minimizing post-harvest losses. Mba et al. (2021); and Bethlehem et al. (2022) reported that proper threshing ensures that the rice grains are separated from the straw without causing damage to the grains. Also, the use of quality seeds is seen as a significant practice in both (Anambra State: Mean = 3.48,

Std. Dev. = 1.144, and Ebonyi State: Mean = 3.95, Std. Dev. = 0.823) states, with a higher mean in Ebonyi State. Using quality seeds results in better yield and more resilient crops, which reduces post-harvest losses and leads to higher overall production (Kumar, and Kalita, 2017). Economically, this means that farmers can produce more rice of higher quality, leading to increased income.

Furthermore, education and training are essential for the adoption of best practices in post-harvest management. Farmers in both (Anambra State: Mean = 3.20, Std. Dev. = 1.359, and Ebonyi State: Mean = 3.49, Std. Dev. = 1.076) states who receive training are more likely to implement effective post-harvest techniques, reducing losses and increasing their economic gains. Lastly, market access is crucial for the economic success of rice farmers in both (Anambra State: Mean = 4.03, Std. Dev. = 0.831, and Ebonyi State: Mean = 4.02, Std. Dev. = 0.789) states. With mean scores above 4.0, both states highly value market access. It is important to note that better access to markets ensures that farmers can sell their produce at competitive prices, leading to higher income. This corroborates the assertion of Anshah et al (2018) that market access will improve the livelihood of rice farmers implementing adequate post-harvest management practices. The low standard deviation indicates strong agreement among respondents, highlighting the importance of market access in the rice value chain.

Table 3 Post-harvest management practices adopted by the rice farmers

		Anambra State			**Ebonyi State**		
Sn.	**Post-harvest management techniques**	**Mean**	**Std. Dev.**	**Remark**	**Mean**	**Std. Dev.**	**Remark**
1	Timely Harvesting	2.96	1.455	Disagree	2.99	1.357	Disagree
2	Proper Harvesting Techniques	2.88	1.444	Disagree	3.10	1.388	Agree
3	Quick Drying	3.08	1.364	Agree	3.33	1.131	Agree
4	Use of Drying Facilities such as drying platforms or mechanical dryers, etc.,	3.11	1.454	Agree	3.17	1.375	Agree
5	Optimal Storage Conditions	2.92	1.401	Disagree	3.01	1.412	Agree
6	Pest Management	2.82	1.449	Disagree	3.45	1.132	Agree
7	Proper Threshing Techniques	3.05	1.404	Agree	3.43	1.125	Agree
8	Packaging Techniques	3.46	1.098	Agree	2.73	1.298	Disagree
9	Access to post-harvest infrastructure	2.98	1.490	Disagree	2.79	1.473	Disagree
10	quality Testing	2.04	1.345	Agree	2.08	1.469	Agree
11	use of quality seed	3.48	1.144	Agree	3.95	0.823	Agree
12	education and Training	3.20	1.359	Agree	3.49	1.076	Agree
13	market Access	4.03	0.831	Agree	4.02	0.789	Agree
14	adoption of modern technologies	3.58	1.157	Agree	2.89	1.383	Disagree
15	sustained access to financial support	3.10	1.433	Agree	2.88	1.348	Disagree
	Grand Mean	3.18	1.322	Agree	3.22	1.24	Agree

Source: Field Survey, 2024.

4.2 The socioeconomic factors influencing post-harvest management practices adoption

The socioeconomic factors influencing post-harvest management practices adopted by rice farmers in Anambra and Ebonyi State are presented in Table 4. The analysis of logistic regression was done in SPSS version 25. Diagnostically, the Akaike's Information Criterion (AIC) value of 113.007 which is expectedly lower than the Pearson Chi-Square of 144.457 implied that the selected model was well fitted. Again, the Likelihood Ratio Chi-Square value of 23.35***, significant at a 1% level of probability is an indication that at least, one of the independent variables has a significant relationship with postharvest management practices adopted.

In Anambra State, the coefficient of sex (0.960) with a Z-value of 2.34** is statistically significant at 5%, and the Exp(B) value of 2.611 suggests that being male increases the likelihood of adopting post-harvest management practices by 2.6 times. This result disagrees with the report of Bime et al (2015) who found that female rice farmers are akin to postharvest management practices in their study. The implication is that male farmers in Anambra are more likely to invest in post-harvest technologies, which could improve rice quality and reduce post-harvest losses. This can lead to higher profits and more efficient market participation. The none significant in Ebonyi State indicates no gender-based influence on adoption in this state. Thus, gender does not play a role in adoption, suggesting a more equal opportunity for both men and women in rice post-harvest management, potentially leading to a balanced economic contribution across genders. This result in Ebonyi is in agreement with Esmat et al (2012); Dick and Ogei (2022) who did not observe a significant relationship between gender and postharvest management among rice farmers in their study.

The coefficient of marital status (0.445) in Anambra State with a Z-value of 4.05*** at a 1% significance level and an Exp(B) of 1.560 indicates that married individuals are 1.560 times more likely to adopt post-harvest practices. Implicatively, married farmers may have better access to household labour and resources, making them more capable of handling post-harvest operations efficiently. This can enhance rice production quality and income levels. On the other hand, the coefficient is -0.430 with a Z-value of 3.39***, significant at 1%. This means that marital status negatively influences adoption in Ebonyi, reducing the likelihood by a factor of 0.651. suggestively, married farmers in Ebonyi may face constraints, possibly due to household responsibilities, limiting their ability to adopt post-harvest innovations. This could reduce their competitive edge and profits in rice production. The result in Ebonyi is in agreement with Rishi et al. (2020) who observed an inverse relationship between marital status and postharvest management practices in their study.

The coefficient of level of education (-0.088) in Ebonyi State with a Z-value of 1.96** at a 5% significance level and an Exp(B) of 0.916 indicating that for each additional unit increase in education level, the likelihood of adopting post-harvest management practices decreases slightly. This could imply that as farmers become more educated, they might prioritize other opportunities over investing time and resources in agricultural practices. This result disagrees with the findings by Egwuonwu (2020) who noted that education positively correlates with postharvest management practices in the study.

The coefficient of household size (-0.095) in Anambra State with a Z-value of 2.45** at a 5% level of probability and an Exp(B) of 0.909 indicates that a unit increase in the number of household size will slightly reduce the adoption of postharvest management practices by 0.909 units. Larger households may have more immediate needs and responsibilities, which could affect the time and resources available for post-harvest activities. The demands of a larger household may lead to prioritizing immediate consumption and short-term needs over the longer-term benefits of investing in post-harvest management practices. The result from Ebonyi is in agreement with Liambee and Onu (2022) who could not establish any significant result with household size in their study.

The coefficient of farming experience (-0.216) in Ebonyi State with a Z-value of 6.89*** at a 1% significance level and an Exp(B) of 0.806 indicate that additional increase in experience reduces the adoption of postharvest management practice to 80.6% of the previous level. Since farming experience often correlates with age, this result was in agreement with Uchemba et al. (2021) who noted that older farmers might be less inclined to change established practices. This age-related conservatism can limit the adoption of modern and potentially more effective post-harvest management techniques.

The coefficient of cooperative membership (1.731) with a Z-value of 7.10*** at 1% significance and Exp(B) of 5.645 shows a strong positive effect. Cooperative membership increases the likelihood of adopting post-harvest practices by 5.6 times. Anambra farmers in cooperatives benefit from shared resources, knowledge, and market access, leading to better post-harvest management and increased profitability in rice production. This can foster rural development and economic resilience. This result on cooperative membership agreed with Egwuonwu (2020) who observed a similar pattern in his results.

The coefficient of access to entrepreneurship training (-1.120) in Anambra State with a Z-value of 3.24*** at 1% significance indicates that access to entrepreneurship training reduces the likelihood of adopting post-harvest practices by a factor of 0.326. Surprisingly, this may indicate that those who received entrepreneurship training might focus on other aspects of agribusiness rather than post-harvest activities. This diversion could limit the direct economic benefits of rice production efficiency.

The coefficient of access to credit is 1.275 with a Z-value of 3.28*** at 1% significance and an Exp(B) of 3.579. Access to credit significantly increases the likelihood of adopting post-harvest practices by 3.6 times. Access to credit provides

financial support for farmers to invest in post-harvest technologies, improving rice quality, reducing losses, and boosting income. This has a positive economic impact on rice production and the broader local economy. The coefficient of annual income (1.264) in Ebonyi State with a Z-value of 4.28*** at 1% significance shows that higher annual income increases the likelihood of adopting post-harvest practices by 3.5 times. Wealthier farmers in Ebonyi can afford post-harvest technologies, resulting in better management, reduced losses, and higher profitability. This can lead to more investment in production and an improved economic standard of living. These results are consistent with the report of Rishi et al. (2020) who found a positive impact of access to credit and income on the adoption of postharvest management practices.

Furthermore, in Anambra State, the coefficient of output (0.503 with a Z-value of 2.61** at 5% significance and an Exp(B) of 1.653 indicates that higher output increases the likelihood of adopting post-harvest practices by 1.65 times. Larger-scale farmers are more inclined to adopt post-harvest practices due to their need to manage higher volumes of rice efficiently. This contributes to greater economic returns and improved market competitiveness.

However, significant factors such as sex, marital status, cooperative membership, access to credit, and annual income play crucial roles in post-harvest management adoption, influencing economic outcomes in Anambra and Ebonyi states. The economic implications vary between the two states, with cooperatives and credit access driving greater adoption in Anambra, while income and credit availability are critical in Ebonyi. Improved adoption of post-harvest practices can lead to higher rice production efficiency, reduced losses, and increased profitability, ultimately enhancing the economic viability of rice farming (Eric, 2024) in both States.

Table 4 The socioeconomic factors influencing post-harvest management practices adoption

	Anambra State				**Ebonyi State**			
Parameter Estimates	**Coeff.**	**Std. Error**	**Z-value**	**Exp(B)**	**Coeff.**	**Std. Error**	**Z-value**	**Exp(B)**
(Intercept)	-2.014	7.713	0.07	0.133	-16.671	8.1212	4.21	0.00
Sex	0.96	0.6279	2.34**	2.611	-0.096	0.6839	0.02	0.909
Age	-0.001	0.0248	0.00	0.999	0.004	0.0267	0.02	1.004
Marital status	0.445	0.2209	4.05***	1.56	-0.43	0.2336	3.39***	0.651
Level of education	-0.011	0.0494	0.05	0.989	-0.088	0.0627	1.96**	0.916
Household size	-0.095	0.0608	2.45**	0.909	-0.12	0.0899	1.79	0.887
farming experience (Yrs.)	0.015	0.0382	0.16	1.016	-0.216	0.0824	6.89***	0.806
Farm size (ha)	-0.46	0.4018	1.31	0.631	-0.307	0.3831	0.64	0.735
Cooperative membership	1.731	0.6496	7.10***	5.645	0.829	0.7585	1.20	2.291
Access to entrepreneurship training	-1.12	0.6227	3.24***	0.326	0.286	0.7005	0.17	1.332
Access to extension	0.122	0.1494	0.67	1.13	0.277	0.1718	2.61	1.32
Access to credit	-0.642	0.6039	1.13	0.526	1.275	0.7038	3.28***	3.579
Annual income (Naira)	-0.161	0.5116	0.10	0.851	1.264	0.611	4.28***	3.539
Output (tons)	0.503	0.3112	2.61**	1.653	-0.034	0.3314	0.01	0.967
Likelihood Ratio Chi-Square	23.35***				23.71***			
Pearson Chi-Square	144.457				140.375			
Akaike's Information Criterion (AIC)	113.007				103.851			
Observation	160				160			

Source: Field Survey, 2024. Significant @ 5% (**), and 1% (***)

4.3 The constraints faced by the farmers in post-harvest management practices

The principal factor analysis (PFA) results in Table 5 reveal the key constraints faced by rice farmers in Anambra State regarding post-harvest management practices. The analysis identifies four main factors that contribute to these challenges, with the percentage of variance explained by each factor indicating their relative importance. The Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy of 0.727 suggests a middling adequacy of the sample for factor analysis. Values above 0.7 are generally considered acceptable, indicating that the data is suitable for PFA (Obianefo et al., 2021). This level of adequacy implies that the constraints identified by the PFA are based on sufficiently reliable data, providing a solid foundation for understanding the challenges facing rice farmers in Anambra State. The researchers adopted the naming system used in Obianefo et al. (2020) based on variable with the highest factor loading.

Factor 1 (Environmental) Explained 32.43% of the Variance, suggesting that Factor 1 is the most significant, explaining 32.43% of the variance in the data. It includes constraints such as climate change, limited knowledge, and training, inadequate infrastructure, lack of post-harvest extension services, lack of access to modern technology, lack of credit facilities, pest and disease management, financial constraints, limited storage capacity, land tenure issues, and unrealistic government policies. Equally, the high loading of climate change (0.859) emphasizes its significant impact on rice production. Farmers may face unpredictable weather patterns, leading to increased post-harvest losses (Misganaw, 2020). Again, limited knowledge (0.841), training, and infrastructure (0.832) hinder the adoption of effective post-harvest management practices, leading to inefficiencies and higher losses, directly affecting the profitability of rice farming. The inability to access credit (0.650) and financial resources (0.638) limits farmers' capacity to invest in necessary post-harvest technologies and infrastructure, reducing overall productivity and profitability.

Factor (Institutional) 2, explained 14.34% of the variance, which is associated with poor transportation facilities, seed quality issues, lack of market access, and inadequate quality testing facilities. The inadequate transportation (loading of 0.865) results in delays and inefficiencies in getting rice to market, leading to deterioration in quality and increased post-harvest losses. Equally, limited access to markets restricts farmers' ability to sell their produce at competitive prices, reducing their income and discouraging investment in better post-harvest practices. This result is consistent with the variables identified by Muthukumar et al (2020),

Furthermore, factor (Energy) 3 explained 10.25% of the variance, which includes constraints related to rural energy, post-harvest loss measurement, and limited research and development. Rural energy constraints (loading of 0.861) impact the ability to power essential post-harvest technologies, leading to inefficiencies in processing and storage, increasing the likelihood of losses. Inadequate measurement tools hinder the ability to assess and manage losses accurately, preventing effective intervention strategies, which perpetuates inefficiencies in the rice value chain.

Furthermore, factor 4 (Management), explaining 7.19% of the variance, includes constraints such as limited research and development and inadequate packaging materials. limited R&D (loading of 0.661) means that innovations in post-harvest management are not being developed or disseminated, keeping farmers dependent on outdated practices that may not be effective in minimizing losses.

Lastly, inadequate packaging materials reduce the shelf life and marketability of rice, leading to decreased income and wasted produce. These variables were in agreement with those outlined by Qu et al. (2021) as the challenges to postharvest management practices in Asia and Africa.

The total variance explained by the four factors is 64.20%, indicating that these factors collectively account for a significant portion of the challenges faced by rice farmers in post-harvest management. The total variance explained underscores the multifaceted nature of the constraints, suggesting that addressing these challenges requires a comprehensive approach that tackles various interrelated issues. Failing to address these constraints could continue to limit the efficiency, profitability, and sustainability of rice production in Anambra State.

Table 5 Constraints faced by the farmers in post-harvest management practices

Sn.	Constraints: Anambra State	Factor 1	Factor 2	Factor 3	Factor 4
1	Climate Change	0.859			
2	Limited Knowledge and Training	0.841			

3	Inadequate Infrastructure	0.832			
4	Lack of Post-harvest Extension Services	0.735			
5	Lack of Access to Modern Technology	0.713			
6	Lack of Credit Facilities	0.683			
7	Pest and Disease Management	0.65			
8	Financial Constraints	0.638			
9	Limited Storage Capacity	0.583			
10	Land Tenure Issues	0.557			
11	Unrealistic Government Policies	0.543			
12	Poor Transportation Facilities		0.865		
13	Seed Quality Issues		0.813		
14	Lack of Market Access		0.788		
15	Quality Testing Facilities		0.628		
16	Rural Energy Constraints			0.861	
17	Post-harvest Loss Measurement			0.787	
18	Limited Research and Development				0.661
19	Inadequate Packaging Materials				0.605
	Kaiser-Meyer-Olkin Measure of Sampling Adequacy.	0.727			
	% Variance of Factor 1 % variance	32.43			
	% Variance of Factor 2 % variance	14.34			
	% Variance of Factor 3 % variance	10.25			
	% Variance of Factor 4 % variance	7.19			
	Total variance explained	64.20			

Source: Field survey, 2024.

The constraints for Ebonyi State are presented in Table 6. again, the analysis identifies four main factors, each contributing to the overall variance in the data. The KMO measure of 0.837 indicates a good adequacy of the sample for factor analysis. Values above 0.8 are considered meritorious, suggesting that the data is highly suitable for PFA. This strong adequacy implies that the identified constraints are based on reliable data, providing a robust foundation for understanding the challenges rice farmers in Ebonyi State face.

Factor (Environment) 1 is the most significant, explaining 30.31% of the variance in the data. It includes constraints such as a lack of post-harvest extension services, unrealistic government policies, land tenure issues, limited storage capacity, and lack of market access. The high loading of lack of post-harvest extension services (0.711) uncovered the crucial need for technical support to improve post-harvest practices. Without this, farmers may continue using inefficient methods, leading to higher losses and reduced profitability. Policies that do not align with the practical realities of farming can create barriers to adopting effective post-harvest practices. This could stifle innovation and discourage investment in necessary infrastructure, limiting the growth of the rice sector. The problems related to land ownership and access (loading of 0.652) can lead to under-investment in long-term improvements, including post-harvest facilities, further reducing productivity.

Factor (Institutional) 2 explained 12.76% of the variance and includes constraints such as rural energy constraints, post-harvest loss measurement, limited research and development, and quality testing facilities. The lack of reliable energy (loading of 0.764) impacts the ability to power post-harvest processing equipment, leading to inefficiencies and increased losses during storage and processing.

Also, inadequate systems for measuring post-harvest losses (loading of 0.717) prevent farmers from accurately assessing the extent of losses, making it difficult to implement effective interventions. This result is similar to the variables identified by Olalereadisa et al. (2020) in their study.

Factor (Energy) 3, which explained 7.04% of the variance, includes constraints related to limited knowledge and training, climate change, and seed quality issues. The high loading for limited knowledge and training (0.794) suggests that farmers lack the necessary skills and information to adopt improved post-harvest practices. This gap contributes to inefficiencies and higher post-harvest losses. The impact of climate change (loading of 0.758) introduces variability in harvest periods, affecting the timing and effectiveness of post-harvest management. This can lead to increased spoilage and reduced income.

Furthermore, factor (Management) 4, which explains 5.49% of the variance, includes constraints such as lack of access to modern technology, poor transportation facilities, and inadequate infrastructure. The absence of modern technology (loading of 0.695) in post-harvest processes limits the ability to efficiently process, store, and transport rice, resulting in quality degradation and higher post-harvest losses. inadequate transportation (loading of 0.612) and infrastructure (loading of 0.548) create bottlenecks in moving rice from farms to markets, leading to delays and spoilage, further reducing the economic returns for farmers.

Lastly, the total variance explained by the four factors is 55.59%, indicating that these factors collectively account for a substantial portion of the challenges faced by rice farmers in post-harvest management. The fact that more than half of the variance is explained by these factors highlights the multifaceted nature of the constraints. Addressing these issues comprehensively by improving extension services, adjusting policies, enhancing infrastructure, and providing better access to technology could significantly boost rice production efficiency and profitability in Ebonyi State.

Table 6 Constraints faced by the farmers in post-harvest management practices

	Ebonyi state	**Rotated Component Matrix**			
Sn.	**Constraints**	**Factor 1**	**Factor 2**	**Factor 3**	**Factor 4**
1	Lack of Post-harvest Extension Services	0.711			
2	Unrealistic Government Policies	0.656			
3	Land Tenure Issues	0.652			
4	Limited Storage Capacity	0.644			
5	Lack of Market Access	0.52			
6	Lack of Credit Facilities				
7	Rural Energy Constraints		0.764		
8	Post-harvest Loss Measurement		0.717		
9	Limited Research and Development		0.658		
10	Quality Testing Facilities		0.63		
11	Inadequate Packaging Materials				
12	Limited Knowledge and Training			0.794	
13	Climate Change			0.758	
14	Seed Quality Issues			0.61	
15	Pest and Disease Management				
16	Lack of Access to Modern Technology				0.695
17	Poor Transportation Facilities				0.612
18	Inadequate Infrastructure				0.548
19	Financial Constraints				

20	Cultural Practices				
	Kaiser-Meyer-Olkin Measure of Sampling Adequacy.	0.837			
	% Variance of Factor 1	30.31			
	% Variance of Factor 2	12.76			
	% Variance of Factor 3	7.04			
	% Variance of Factor 4	5.49			
	Total % variance explained	55.59			

Source: Field Survey, 2024.

5 Conclusion and Recommendation

The study examined the factors influencing the adoption of post-harvest management practices among rice farmers in Anambra and Ebonyi States, Nigeria. The findings revealed that while both states significantly adopted post-harvest management practices, Ebonyi State exhibited slightly higher adoption rates, particularly in proper harvesting techniques, pest management, and threshing methods. The analysis further highlighted that education, access to training, and market participation were crucial in enhancing the adoption of best practices, leading to reduced post-harvest losses and improved economic outcomes. Additionally, key socioeconomic factors such as gender, marital status, education level, and household size influenced the likelihood of farmers adopting post-harvest management practices, with variations observed between the two states. The use of Logit regression and principal component factor analysis provided robust statistical evidence, revealing the importance of targeted interventions to improve post-harvest handling.

In conclusion, the study suggests that policymakers and agricultural extension services should intensify their efforts in training and awareness campaigns, particularly in areas with lower adoption rates. Special emphasis should be placed on promoting efficient drying facilities, pest control measures, and proper threshing techniques to enhance rice quality and market competitiveness. Furthermore, gender-sensitive policies and initiatives addressing household constraints could encourage wider adoption of these practices. Future research could explore the long-term economic benefits of post-harvest management interventions and their impact on the overall sustainability of rice farming in Nigeria. Strengthening institutional support and fostering collaboration among stakeholders will be essential for maximizing the economic benefits of improved post-harvest management practices in the Southeast, Nigeria.

Compliance with ethical standards

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