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Analysis of the Different Stages of Post-Harvest Loss Suffered by Rice Farmers 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 the farmers' 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 farmers' standard of living.

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1. Introduction

Agriculture plays an important role in the overall economy of developing countries in terms of GDP contribution (Kamil *et al*, 2017) [24]. Most countries earn their foreign exchange from the sector, employing 65% of the rural population (Mohammad *et al*, 2018) [26]. Rice is among the most cultivated crops across the globe. It is a major constituent of the diets consumed by many families and also a stable food in many countries in Africa. In Nigeria, rice cultivation and related production activities are important to the economic growth of the country for ages and it has been the source of livelihood for the majority of the rural

population (Sadiya *et al*, 2018) [37]. Corroboratively, Obianefo *et al* (2020) [32] and Obianefo *et al*, (2021) [33] also submitted that rice is the most popular staple food crop in Nigeria which enjoyed increased preference by many families but its demand overwhelmed supply. Equally, the International Rice Research Institute (IRRI) in 2015 noted that rice is a vital staple crop in the world, especially in Africa and Asian countries, where it provides food security and livelihoods for millions of people. However, rice production is often constrained by various issues such as postharvest losses (Danbaba *et al*, 2019; Bethlehem *et al*, 2022) [9], which can reduce the quantity and quality of the harvested grains.

In Africa, rice consumption has been growing faster than production, this widened the margin of demand and supply (Aminou *et al*, 2021) [3]. To address this challenge, many African countries have adopted the National Rice Development Strategy (NRDS), which aims to enhance farmers' productivity and production, improve food security and income, and reduce dependence on rice imports (Guillaume *et al*, 2020) [21]. One of the key components of the NRDS is to improve postharvest management practices, which can seriously reduce post-harvest losses to improve rice availability and quality (Benyam *et al*, 2018; Aminou *et al*, 2021) [8, 3].

Nigeria is the largest rice producer and consumer in West Africa, but it still relies heavily on rice imports to meet its domestic demand (Onu, 2018) [36]. The study by Danbaba *et al* (2019), credited the widening demand-supply gap to post-harvest loss experienced by rice farmers. According to the Coalition for African Rice Development (CARD), Nigeria's post-harvest losses of rice are estimated at 15-25%, which equals about 1.5-2.5 million tons of milled rice per year (Babatunde *et al*, 2019) [6]. In a more recent study, Danbaba (2023) [15] noted that post-harvest loss in Nigeria is as wide as 17-30% among smallholder farmers, these made the attainment of self-sufficiency in rice supply nearly impossible in Nigeria. This implies that improving post-harvest management practices could potentially increase the domestic rice supply by 15-25%, and reduce the need for rice imports (Chidiebere-Mark *et al*, 2019) [13].

Bethlehem *et al* (2022) [9] define Post-Harvest Loss (PHL) as a quantifiable and qualitative food loss at any stage in the postharvest value chain of a crop until its consumption. Quantity losses refer to the losses in the amount and availability of the product while quality losses refer to the losses in the nutrient/caloric composition, acceptability and edibility of the product. Post-harvest practice is therefore viewed as all the activities that farmers undertake from the time of harvesting of their rice crops to consumption (Mba *et al*, 2021; Danbaba, 2023) [25, 15]. These activities include; harvesting, threshing, winnowing, drying, cleaning, milling, grading, storage, packaging, transporting, and marketing among others (Egwuonwu, 2020) [17]. Etefa *et al* (2022) [19] submitted that around 800 million individuals worldwide suffer from malnutrition, and over a billion tons of food go to waste before reaching consumers. However, the depth of post-harvest loss varies between developed and developing countries, with Nigeria inclusive. These losses have been linked to a number of reasons as explained by Sani and Ibrahim (2022) [38] and Etefa *et al* (2022) [19] that smallholder farmers typically use poor harvesting techniques, manual operations such as hand threshing and winnowing, poor storage infrastructure, limited expertise in processing, poor packaging, and poor transportation systems. Conversely, developed nations suffer minimal post-harvest losses due to well-structured farming systems, advanced transportation networks, effective management practices, proper storage, and modern processing facilities that ensure products reach the market efficiently (Etefa *et al* 2022) [19].

In Southeast Nigeria, rice is grown in different agro ecological zones, such as swamp, lowland, and upland systems. Anambra and Ebonyi are two of the major rice-producing states in the Zone, with a combined annual production of about 1.2 million tons of paddy rice (Chidiebere-Mark *et al*, 2019) [13]. However, these states also face various challenges in post-harvest management, such as; inadequate infrastructure and equipment for processing, poor transportation and storage infrastructure, inadequate technical knowledge and skills, high cost of production, poor access to credit and climate change. These factors affect the efficiency and profitability of rice production and the quality and competitiveness of rice products (Egwuonwu, 2020; Aminou *et al*, 2021; Olalereadisa *et al*, 2020 and Sani & Ibrahim, 2022) [17, 3, 35, 39].

This study, however, aims to bring to the attention of both the audience and policymakers the significant post-harvest losses experienced by the study respondents. By shedding light on this critical issue, stakeholders will be better equipped to develop strategic interventions aimed at mitigating these losses and enhancing food security, within and outside Nigeria. Furthermore, the results of the study will provide rice farmers with valuable insights into the specific types of post-harvest losses they encounter, enabling them to allocate their limited resources more efficiently toward effective solutions. Additionally, the study will inform them about the precise stages in the production process where losses occur, allowing for targeted interventions. To this end, the specific objectives of the study include:

a) To describe the socioeconomic characteristics of rice farmers in the study;
b) To identify the losses suffered by rice farmers at different stages of post-harvest operation in the study area; and
c) ascertain the causes of post-harvest losses in rice production.

Furthermore, the study hypothesized that the causes of post-harvest loss do not differ in Anambra and Ebonyi State.

2 Review of related empirical studies

2.1 Post-harvest losses suffered at the different stages

Empirical studies have highlighted post-harvest losses as a major challenge of rice value chain, significantly impacting farmers' income. Babatunde, Omoniwa, and Aliy (2019) [7] examined the extent and determinants of post-harvest losses in Kwara State, Nigeria, revealing that farmers suffered the greatest losses (41–50 kg), followed by processors and marketers. Their study emphasized the role of farm size and household size in influencing losses. Similarly, John *et al* (2019) [23] investigated rice post-harvest losses for Uganda, identifying harvesting, threshing, and milling as the most critical loss points. Their findings showed that total grain losses varied between 14.1% and 16.8%, depending on variety and post-harvest handling practices. In Niger State, Nigeria, Coker and Ninalowo (2016) [14] found that threshing accounted for the highest post-harvest loss (25%), significantly affecting farmers' income. They also identified the lack of harvesting equipment as a key constraint to mitigating these losses.

Other studies further corroborate these findings across different regions. Appiah *et al* (2011) assessed post-harvest losses in Ghana, noting that harvesting methods influenced losses, with sickle harvesting leading to higher losses than panicle harvesting. Threshing losses were also substantial,

particularly when traditional methods were used. Tsortsi (2019) [42] investigated farmers' knowledge of post-harvest losses for Ghana's Volta Region, finding that most farmers lacked formal training and relied on speculation to estimate losses, which averaged 21.56%. Experimental trials confirmed that grain losses were highest during harvesting and field stacking. In Bangladesh, Esmat *et al* (2012) [18] linked post-harvest losses to food security, showing that late harvesting contributed to significant grain losses. Across these studies, harvesting, threshing, and improper storage were consistently identified as critical points of loss, highlighting the need for improved post-harvest management strategies to enhance food security and farmers' incomes.

2.2 Causes of post-harvest losses in rice production

Taiwo and Bart-Plange (2016) [41] investigated post-harvest losses among rice farmers in Ghana's Volta Region, identifying key causes such as delays in harvesting, incomplete threshing, improper drying, bird attacks, and low machinery efficiency. Despite having some education, many farmers lacked training in machinery maintenance, exacerbating these losses. The study highlighted the broader consequences of post-harvest losses, including food insecurity, poverty, and socioeconomic instability. Other researchers, such as Amponsah *et al* (2018) [4] and Wang *et al* (2016) [46], used surveys and regression analyses to determine the impact of environmental, socio-economic, and mechanical factors on rice losses. They emphasized the importance of harvest timing, noting that premature or delayed harvesting could lead to significant grain losses due to poor threshing efficiency or pest attacks.

Similarly, Yebirzaf and Esubalew (2021) [47] examined post-harvest losses for fruits and vegetables farming in Ethiopia, finding that factors such as vendor education, selling experience, packaging, and storage conditions played a major role. Poor handling, inadequate temperature control, and lack of market infrastructure contributed to significant losses, with estimated spoilage ranging from 5% to 83% of market share. In Nigeria, Ibrahim *et al* (2018) [22] identified post-harvest losses in rice production, highlighting losses at various stages, including harvesting, storage, processing, and transportation, due to factors such as spillage, rodent attacks, and poor packaging. They recommended targeted government and NGO interventions, including farmer education, improved storage, and modern processing facilities, to mitigate losses and enhance food security.

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) [25]. 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) [31].

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.

3.2 Technique Procedure

The population of the study comprises all rice farmers in Ebonyi and Anambra States. A multistage sampling procedure, incorporating a simple random sampling and purposive approach, 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. 20 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.

4 Results and Discussion

4.1 Socioeconomic characteristics of the respondents in Anambra and Ebonyi state

The socioeconomic characteristics of the respondents in Anambra and Ebonyi States are shown in Table 3 and Figure 1 to 5, this results uncovered various variables such as sex, age, marital status, cooperative membership, access to credit, level of education, household size, farming experience, annual income, rice output, extension contacts, and farm size. For Sex Distribution as represented in Figure 1. Anambra State recorded 55% female and 45% male, while Ebonyi State recorded 55.6% female and 44.4% male. The nearly equal distribution of male and female farmers in both states suggests that women are as actively involved in rice production than men. This balanced participation is crucial for effectively adopting post-harvest management practices, as it ensures diverse perspectives and labour contributions. Involving both genders in post-harvest training programs can lead to more widespread adoption of improved practices. Only the result from Anambra agreed with Awio *et al*, (2022) [5] who reported women's domination in their study.

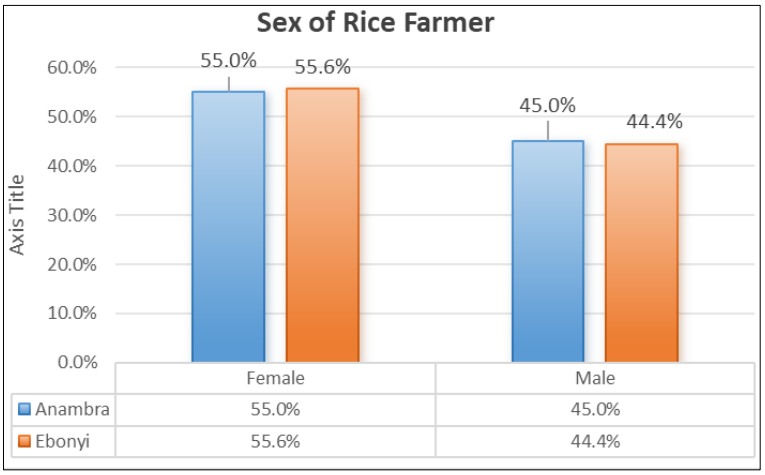

Fig 1: Sex distribution of farmers

For Age Distribution (see Table 3), Anambra State had a mean age of 44.28 years, again the majority (62.5%) are between 35-54 years. Equally, Ebonyi State had a mean age of 47.69 years; the majority (55.6%) are between 35-54 years. However, farmers in both states are predominantly middle-aged, implying that they are experienced but may also resist change. Middle-aged farmers may have established traditional post-harvest practices, making them less likely to adopt new methods unless they are beneficial. This highlights the importance of demonstrating the economic advantages of improved post-harvest practices to this age group. However, the average age of farmers in Anambra corroborates the 43 years observed in the study by Musaba and Mundia (2019) [27]. For Marital Status as represented in Figure 2. Anambra State reported 51.2% of married farmers, while Ebonyi State reported 51.9% of married farmers. The high percentage of married farmers in both states suggests that these farmers may have larger households, which could influence their labour availability for post-harvest activities. For this reason, Szetey *et al* (2021) [40] suggested that programmes promoting post-harvest practices should consider the family-oriented nature of the farmers, possibly engaging family members in training for participatory local sustainability.

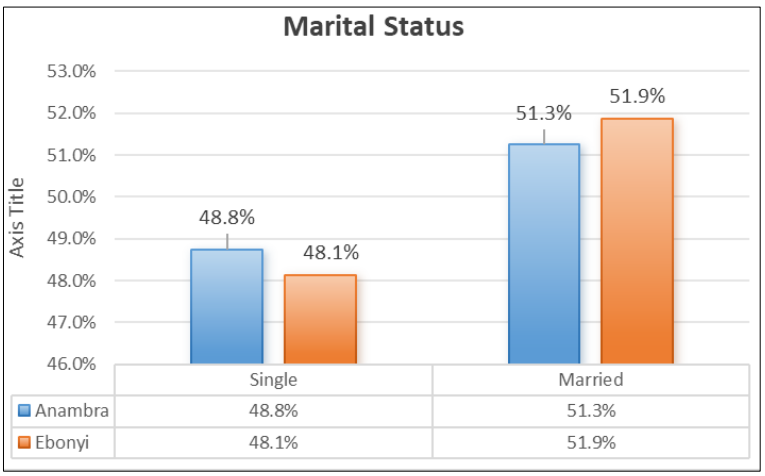

Fig 2: Marital status description of rice farmers

For Cooperative Membership as represented in Figure 3. Anambra State reported 40.6% of members of cooperatives, and Ebonyi State recorded 64.4% of farmers as members of cooperatives. Cooperative membership is significantly higher in Ebonyi State, suggesting better social capital and collective action, which can facilitate the dissemination and adoption management practices. In Anambra, efforts to strengthen cooperative movements could improve post-harvest practices adoption. The aforementioned assertion corroborates the opinion of Campbell *et al* (2023) [11] who suggested the use of cooperatives to transform the food system and climate change mitigation strategy

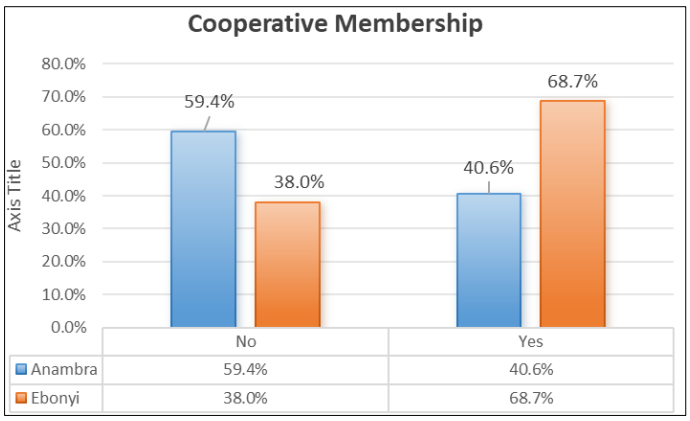

Fig 3: Cooperative membership description of rice farmers

For Access to Entrepreneurship Training as represented in Figure 4. In Anambra State; 69.4% have access to entrepreneurship training, while 39.4% of Ebonyi State farmers had access to entrepreneurship. Farmers in Anambra have better access to entrepreneurship training, which may encourage them to adopt innovative post-harvest practices. This suggests that training programs in Anambra are more likely to impact farmers' post-harvest management positively.

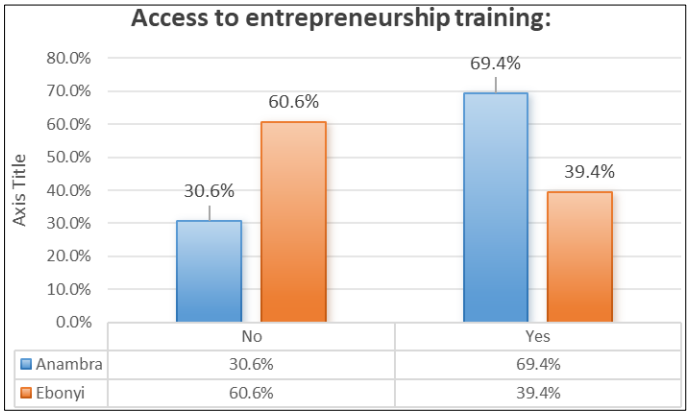

Fig 4: Distribution according to access to entrepreneurship training

For Access to Credit as represented in Figure 5, 56.9% of Anambra State farmers had access to credit, while in Ebonyi State, 27.5% have access to credit. Better access to credit in Anambra State means farmers there are more likely to invest in improved post-harvest technologies and practices. In Ebonyi, the lower access to credit could limit farmers' ability to finance improvements in post-harvest management, potentially leading to higher post-harvest losses (Bisheko, 2023) [10].

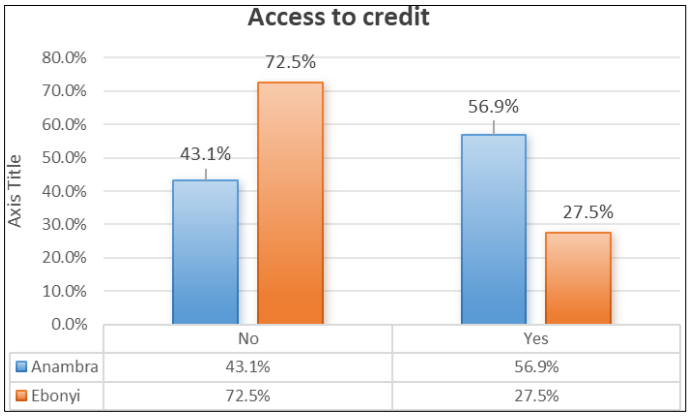

Fig 5: Distribution according to access to credit

Again, for the Level of Education in Anambra; a greater proportion (31.9%) have secondary education. Again, 37.5% of farmers in Ebonyi State have tertiary education. The higher education levels for Ebonyi State suggest that farmers may be more open to adopting new technologies and practices, including those related to post-harvest management. Education is key to understand and implement advanced agricultural techniques. The result of Anambra farmers agreed with Uchelue *et al* (2023) [43] who found that most of their respondents attended secondary school.

For Household Size, the mean household size in Anambra State was 10.33, and 7.17 in Ebonyi State. Larger household sizes in Anambra could mean more labour is available for post-harvest activities, but it could also indicate a higher dependency ratio, which may strain resources and reduce the adoption of good practices. Smaller household sizes in Ebonyi might limit labour availability but could allow for better resource allocation per capita, potentially improving post-harvest management efficiency. This assertion corroborates the assumptions of Uchemba *et al* (2021) [44] who noted that larger household size supplies cheap labour on the farm.

In Farming Experience, the mean in Anambra State was 13.76, and 13.72 for Ebonyi State. Both states have farmers with significant experience, which could be beneficial for adopting post-harvest management practices, as experienced farmers are more likely to recognize the benefits of reducing losses. However, they may also be resistant to change, requiring targeted interventions to promote new practices. In both States, the result was not in agreement with Nmeregini, and Udoka (2021) [29] who found 11 years' experience for rice production in the study.

Consequently, the average annual income in Anambra State was ₦1,371,670, and ₦1,014,689 in Ebonyi State. The higher income in Anambra suggests that farmers there committed more resources to post-harvest management technologies. In contrast, lower incomes in Ebonyi could constrain the ability to adopt such practices, potentially leading to higher post-harvest losses. These findings are not in line with the result of Agyo and Ornan (2021) [1] who found that the average annual income of farmers was N595,667.04 in their study.

In rice output, Anambra State reported an average of 3.73 tons and 3.0179 tons in Ebonyi State. Higher output for Anambra indicates better overall productivity, which may be linked to better post-harvest management practices. In Ebonyi, lower output could result from or contribute to poor post-harvest practices, underscoring the need for targeted interventions to boost productivity and reduce losses. This average output is far below the 4.82 tons/ha reported in Obianefo *et al* (2022) [31].

Equally, Anambra State farmers recorded average of 3.11 extension contacts and 3.00 in Ebonyi State. The frequent extension contacts in both states suggest that farmers have relatively good access to agricultural information, which is crucial for adopting improved post-harvest management practices. Extension services should focus on post-harvest issues to help farmers reduce losses. This result corroborates the report of Uduji *et al* (2018) [45] who reported that accessibility of extension services increases farmers' access to agricultural information.

Lastly, Anambra State reported a mean farm size of 1.13 ha. and 1.6 ha. Larger farm sizes in Ebonyi may allow for more extensive production, but they also pose challenges in managing post-harvest losses due to the increased volume. Smaller farm sizes in Anambra could lead to more manageable post-harvest processes, but they may limit overall production capacity. At these average farm sizes, Obianefo *et al* (2022) [31] suggested that farmers in the Southeast are operating as smallholder farmers.

However, the demographic information of the study respondents in Anambra and Ebonyi States show both similarities and differences that affect post-harvest management practices. While Anambra farmers may have more financial resources and access to training, Ebonyi farmers could leverage their cooperative networks and educational levels to improve post-harvest outcomes. Understanding these dynamics is crucial for developing effective interventions that minimize post-harvest losses and enhance the economic viability of rice farming in both states.

Table 3: Socioeconomic characteristics of farmers in Anambra and Ebonyi State

Socioeconomic Variables	Frequency	Percentage (%)	Mean	Frequency	Percentage (%)	Mean
Age (Years):						
18 – 34	34	21.3		24	15	
35 – 54	100	62.5	44.28	89	55.6	47.69
55 and above	26	16.3		47	29.4	
Level of education:						
No formal education	7	4.4		15	9.4	
Primary school	29	18.1		43	26.9	
Secondary school	51	31.9		38	23.8	
Tertiary	48	30		60	37.5	
Postgraduate	25	15.6		4	2.5	
Household size:						
1 - 5 People	39	24.4		66	41.3	
6 - 10 people	59	36.9	10.33	56	35	7.17
11 and above	62	38.8		38	23.8	
Farming experience:						
1 - 5 years	26	16.3		11	6.9	
6 - 10 years	43	26.9		49	30.6	
11 - 15 years	27	16.9	13.76	43	26.9	13.72
16 and above	64	40		57	35.6	
Annual Income (N):						
100,001 - 500,000	18	11.3		37	23.1	
500,001 - 1,000,000	36	22.5	1371670	40	25	1014689
1,000,001 and above	106	66.3		83	51.9	
Rice output (ton):		160				
0 - 2.00	6	3.8		20	12.5	

2.01 - 3.00	32	20		65	40.6	
3.01 - 4.00	67	41.9	3.73	52	32.5	3.0179
4.01 an above	55	34.4		23	14.4	
Extension contacts:						
0 - 2 times	68	42.5		52	32.5	
3 - 4 times	42	26.3	3.11	53	33.1	
5 - 6 times	50	31.3		55	34.4	
Farm size:						
0 - 0.50 ha	40	25		15	9.4	
0.51 - 1.00 ha	37	23.1		28	17.5	
1.01 - 1.50 ha	60	37.5	1.13	64	40	1.6
1.51 - 2.00 ha	23	14.4		53	33.1	

Source: Field Survey, 2024.

4.2 Post-harvest losses suffered by rice farmers at different stages of post-harvest operation

The results in Table 4 showed the various post-harvest losses suffered by rice farmers at different stages of post-harvest operations in Anambra and Ebonyi States.

For the primary post-harvest losses:

Grain shattering during harvesting had 37.5% in Anambra and 52.5% in Ebonyi State. This indicates that Ebonyi State farmers experience higher losses due to grain shattering, possibly more mechanical harvesting or rough handling practices than Anambra. For the Damaged Grain Due to Improper Threshing and Winnowing, Anambra farmers had 69.4%, and Ebonyi farmers had 66.9%. Both states exhibit high losses due to poor threshing and winnowing techniques, with Anambra slightly higher. This suggests that both states need improved methods or equipment to minimize these losses. Again, for Quality Deterioration Due to Adverse Weather Conditions, Anambra farmers had 61.9%, and Ebonyi farmers had 70.6%. Thus, farmers in Ebonyi suffer more from weather-related quality deterioration. This was a result of less effective drying practices or inadequate storage facilities. For Mechanical Damage During Transport, Anambra farmers scored 83.8%, and Ebonyi farmers scored 40.0%. This, however, implied that Anambra farmers face significant challenges with transportation, leading to high mechanical damage. Ebonyi farmers seem to have better transportation methods or shorter distances to cover. These findings are similar Mba *et al* (2021) [25]; Danbaba, (2023) [15]; Egwuonwu (2020) [17] listed grain shattering, improper harvesting, threshing, and winnowing among others as the primary causes of post-harvest losses

Furthermore, Anambra farmers scored 82.5% in Spoilage Due to Fungi Infestation whereas Ebonyi farmers scored 79.4%. This implied that both states show similar, high levels of spoilage due to fungi, indicating widespread issues with storage conditions. Loss Due to Pests, Rodents, and Insects recorded 86.9% in Anambra, and 79.4% in Ebonyi. Suggestively, pest infestations are the major problem in both states, with Anambra slightly more affected. This suggests that both states need to improve pest control measures in storage facilities. Again, for Mold Growth Due to Improper Drying, Anambra farmers scored 56.3%, and Ebonyi farmers scored 35.0%. Thus, Anambra farmers face more issues with Mold growth, likely due to improper drying practices. Ebonyi seems to have better drying techniques. These findings are in line with the submission of Najmu *et al* (2020) [28] and Gezai *et al* (2020) [20] who classified post-harvest losses into biological losses that occur due to pests, pathogens, and general spoilage, which can be caused by microorganisms and nematodes.

For the secondary Post-Harvest Losses:

Loss of Quality Due to Improper Handling and Extended Storage was recorded at 70.0% in Anambra, and 80.6% in Ebonyi State. The implication was that Ebonyi farmers suffer more from quality loss due to handling and storage issues, indicating a need for better training and storage facilities. Physical Damage During Transportation to Milling results in 37.5% in Anambra State, and 71.3% in Ebonyi State; Unlike primary transportation, Ebonyi faces higher losses during transport to the milling center, suggesting inefficiencies. Again, Broken Grains Due to Inefficient Milling recorded 75.6% in Anambra, and 21.3% in Ebonyi State. Informatively, Anambra has a significantly higher loss due to inefficient milling, indicating a need for better milling equipment or practices. These findings corroborate the result of Omoniwa, and Aliy (2019) in their study from Kwara State.

Also, the Loss of Market Value Due to Mishandling scored 30.0% in Anambra and 58.8% in Ebonyi State. These affirmed that Ebonyi farmers suffer more from market value loss due to mishandling, possibly due to poor packaging or delays in transportation. Physical Damage Due to Substandard Packaging scored 46.3% in Anambra, and 69.4% in Ebonyi State. Substandard packaging is a bigger issue in Ebonyi, suggesting that farmers there need better access to quality packaging materials. Equally, farmers I Anambra scored 76.9% in Loss Due to Market Fluctuations, and their colleagues in Ebonyi scored 73.8%. Both states suffer significantly from market price fluctuations, indicating a broader economic issue affecting rice farmers (Al-Dairi *et al*, 2022) [2] in the region.

For Tertiary Post-Harvest Losses:

Farmers in Anambra scored 53.8% in Inability to Utilize Broken Rice, and those in Ebonyi scored 60.6%. Both states face challenges with broken rice utilization, with Ebonyi slightly more affected. This could be addressed through better processing or marketing strategies for broken rice. Low Skill in Soaking recorded 80.0% in Anambra and 43.1% in Ebonyi State. Anambra farmers have significantly lower skills in soaking, indicating a need for training in post-harvest processing techniques. Again, Inadequate Knowledge of Wet-Milling was picked by 31.9% of the respondents in Anambra State, and 55.6% of those in Ebonyi. Ebonyi farmers are more affected by inadequate wet-milling knowledge, suggesting a need for education and training in this area. These findings agreed with the study of John *et al* (2019) [23] in Uganda.

Lastly, Improper Rice Sedimentation Skills was identified by 63.1% of the respondents in Anambra State and 67.5% of farmers in Ebonyi. Both states face issues with rice sedimentation skills, though Ebonyi is slightly more affected, indicating a need for training. Lack of Good Drying Platform scored 83.8% in Anambra and 51.3% in Ebonyi. The lack of good drying platforms is a major issue in Anambra, which may contribute to other quality issues like Mold growth. And

Inability to Pulverize Rice scored 54.4% in Anambra and 71.3% in Ebonyi State. Ebonyi farmers face more challenges in pulverizing rice, indicating a need for better processing equipment or techniques.

The outcome of these findings has several economic implications which include that high losses reduce the amount of marketable rice, leading to lower income for farmers. This could exacerbate poverty in rural areas. And that farmers may need to spend more on improving post-harvest practices, such as better storage, drying platforms, or milling equipment, increasing their production costs (Danbaba, 2023) [15].

Table 4: Postharvest losses suffered by farmers

		Anambra State		Ebonyi State	
Sn.	**Losses at various stages**	**Frequency**	**Percentage**	**Frequency**	**Percentage**
A	**Primary post-harvest loss**				
1	Grian shattering during harvesting due to the mechanical action of threshing	60	37.5%	84	52.5%
2	Damaged grain due to improper threshing and winnowing techniques	111	69.4%	107	66.9%
3	Quality deterioration due to exposure to adverse weather conditions	99	61.9%	113	70.6%
4	Mechanical damage of grains from farm to storage center due to inefficient transportation methods	134	83.8%	64	40.0%
5	Spoilage of stored grain due to fungi infestation	132	82.5%	127	79.4%
6	Loss of quality and quantity caused by pests, rodents, and insects due to poor storage	139	86.9%	127	79.4%
7	Mold growth, discoloration, and reduced quality due to improper drying	90	56.3%	56	35.0%
B	**Secondary post-harvest loss:**				
8	Loss of quality due to improper handling, contaminants, and extended storage	112	70.0%	129	80.6%
9	Physical damage during transportation from the warehouse to the milling center	60	37.5%	114	71.3%
10	Broken grains, bran, and other by-products due to inefficient milling practice	121	75.6%	34	21.3%
11	Loss of market value due to mishandling, improper packaging, or delays in transportation	48	30.0%	94	58.8%
12	physical damage of grain due to substandard packaging	74	46.3%	111	69.4%
13	loss of lower prices of produce due to market fluctuations or unfair trade practices	123	76.9%	118	73.8%
	Tertiary Postharvest loss				
14	Unable to utilize broken rice	86	53.8%	97	60.6%
15	Low skill in soaking	128	80.0%	69	43.1%
16	Inadequate knowledge to conduct wet-milling	51	31.9%	89	55.6%
17	Improper rice sedimentation skills	101	63.1%	108	67.5%
18	Lack of good drying platform	134	83.8%	82	51.3%
19	Inability to pulverize rice	87	54.4%	114	71.3%

Source: Field Survey, 2024.

4.3 The causes of post-harvest losses in rice production

The results in Table 5 identified and compared the causes of post-harvest losses in rice production between the Anambra and Ebonyi State farmers. The mean threshold of 5 points Likert scale was used for this objective. A benchmark value of 3.0 was used for the decision-making unit. Items with a mean score of 3.0 and above were said to be a significant cause of postharvest loss in the study area, whereas those below the benchmark unit are not significant causes of postharvest loss. However, the grand mean scores in both states (Anambra: mean = 3.33, Std. Dev. = 1.205, and Ebonyi State: mean = 3.25, Std. Dev. = 1.559) are above the benchmark of 3.0, indicating that, on average, the listed causes are considered significant contributors to post-harvest losses. The standard deviation is slightly higher in Ebonyi, suggesting more variability in how different farmers perceive these issues. Moreso, the grand mean suggests that post-harvest losses are a pervasive issue in both states, with numerous factors contributing significantly. This highlights the need for comprehensive interventions across various stages of the post-harvest process. Addressing these issues could lead to significant economic benefits by reducing losses, improving rice quality, and increasing profitability for farmers (Carter *et al*, 2017) [12].

Furthermore, in Ebonyi State, poor harvesting techniques are recognized as a significant cause of post-harvest loss. The mean score of 3.06, though just above the benchmark, indicates a consensus among farmers, albeit with some variability (Std. Dev. = 1.499). This suggests that improvements in harvesting methods could reduce losses (Danbaba *et al*, 2019) significantly in Ebonyi. In contrast, Anambra farmers do not consider this a significant issue. Once more, the economic implication in Ebonyi State is that investing in better harvesting techniques and training could reduce losses, thereby increasing the overall yield and profitability for farmers (Kumar, and Kalita, 2017). Anambra farmers may not prioritize this, potentially overlooking a minor but impactful area of improvement. Again, both states acknowledge delay in harvesting as a significant cause of post-harvest loss ((Anambra State: Mean = 3.35, Std. Dev. = 1.156, Ebonyi State: Mean = 3.56, Std. Dev. = 1.175), with Ebonyi having a slightly higher mean score. The standard deviation indicates moderate agreement among respondents, suggesting that delays are a widespread issue. This delayed harvesting could lead to over-ripening and increased vulnerability to pests and weather, reducing grain quality and market value. Also, both states see lack of proper drying as a significant issue (Anambra State: Mean = 3.21, Std. Dev. = 1.375, and Ebonyi State: Mean = 3.50, Std. Dev. = 1.133), with Ebonyi again showing a higher mean, suggesting it might be a more pressing concern there. The standard deviation in both states is relatively high, indicating variability in the experiences of farmers, possibly due to differences in access to drying facilities. Arguably, improper drying can lead to Mold growth, discoloration, and spoilage, reducing both the quantity and quality of marketable rice. These observations corroborate the findings of Taiwo and Bart-Plange (2016) [41] who noted that when these causes are not addressed properly, they can lead to food insecurity, poverty, poor healthcare access, and inadequate food

availability which then leads to mistrust and hostility among people

Equally, Anambra farmers see inadequate storage facilities as a significant cause of loss (Anambra State: Mean = 3.42, Std. Dev. = 1.135), while those in Ebonyi do not, with a mean just below the benchmark (2.98, Std. Dev. = 1.36). The lower mean and higher standard deviation in Ebonyi might suggest that some farmers have access to better storage or that storage issues are less uniform across the State. For Anambra, inadequate storage leads to high post-harvest losses due to factors like pest infestation and spoilage, directly affecting farmers' incomes.

Anambra State (Mean = 3.55, Std. Dev. = 0.996), and Ebonyi State (Mean = 3.38, Std. Dev. = 1.063) farmers recognized fungal and bacterial infections as significant causes of post-harvest losses, with a strong agreement in Anambra (lower standard deviation) and slightly more variability in Ebonyi. Also, Anambra farmers considered physical damage during handling a significant cause of loss (Mean = 3.45, Std. Dev. = 1.143), unlike those in Ebonyi (Mean = 2.99, Std. Dev. = 1.471), where the mean falls just below the benchmark. The higher standard deviation in Ebonyi suggests varying experiences among farmers, possibly due to differences in handling practices or equipment. Economically, the above variables reduce the quality and marketability of rice, leading to economic losses.

Both states agree that inefficient transportation is a significant cause of post-harvest losses (Anambra State: Mean = 3.08, Std. Dev. = 1.434, Ebonyi State: Mean = 3.36, Std. Dev. = 1.366), with Ebonyi farmers reporting slightly higher concern. The similar standard deviations indicate moderate variability in responses. Both states recognized that the lack of post-harvest infrastructure was a significant cause of loss (Anambra State: Mean = 3.46, Std. Dev. = 1.104, and Ebonyi State: Mean = 3.06, Std. Dev. = 1.433), with Anambra showing stronger agreement. The higher standard deviation in Ebonyi suggests more variation in the availability and quality of infrastructure. The lack of infrastructure, such as drying facilities, storage, and processing equipment, hampers efficient post-harvest handling, leading to significant losses (Nwankwo, and Chiekezie, 2024) [30]. Investing in such infrastructure could substantially reduce these losses and improve economic outcomes for farmers.

In another response, both states consider lack of market access a significant issue (Anambra State: Mean = 3.58, Std. Dev. = 1.091, and Ebonyi State: Mean = 3.04, Std. Dev. = 1.431), with Anambra showing stronger consensus. Market access issues can lead to delays and increased losses due to prolonged storage. Again, both states agree that climate change is a significant cause of post-harvest loss (Anambra State: Mean = 3.14, Std. Dev. = 1.251, Ebonyi State: Mean = 3.44, Std. Dev. = 1.062), with Ebonyi showing slightly stronger concern. The variability in responses indicates differing levels of impact among farmers. Climate change leads to unpredictable weather patterns, affecting drying, storage, and transportation. However, Okon *et al* (2021) noted that mitigating climate-related risks through better practices and infrastructure could help reduce economic losses.

Both states see lack of information and education as significant issues (Anambra State: Mean = 3.58, Std. Dev. = 1.119, and Ebonyi State: Mean = 3.01, Std. Dev. = 1.360), though Anambra has a stronger consensus. Education on best practices in post-harvest handling is crucial for minimizing losses. Again, both states recognized inadequate post-harvest technologies as a significant cause of loss (Anambra State: Mean = 3.51, Std. Dev. = 1.105, and Ebonyi State: Mean = 3.03, Std. Dev. = 1.432), with stronger consensus in Anambra. The variability in Ebonyi suggests uneven access to technologies. However, Danbaba *et al* (2019) suggested that enhancing farmers' knowledge and skills through education could lead to better post-harvest practices, reducing losses and improving economic outcomes.

Equally, poor quality seed is considered a significant issue in both states Anambra State: Mean = 3.53, Std. Dev. = 1.104, and Ebonyi State: Mean = 4.00, Std. Dev. = 5.000), with Ebonyi showing a much higher mean, though with extreme variability (high standard deviation). This suggests that while some farmers may have access to good seeds, others are severely impacted by poor quality seeds. Again, both states recognized the lack of financial resources as a significant cause of post-harvest losses (Anambra State: Mean = 3.43, Std. Dev. = 1.091, and Ebonyi State: Mean = 3.46, Std. Dev. = 1.159), with similar means and standard deviations, indicating consistent concern across the board. Bisheko (2023) [10] noted that limited financial resources prevent farmers from investing in better post-harvest technologies, infrastructure, and practices, leading to higher losses and reduced profitability. Improving access to finance could empower farmers to reduce post-harvest losses.

Table 5: Causes of post-harvest losses in rice production

		Anambra State			Ebonyi State		
Sn	**Causes of post-harvest losses**	**Mean**	**Std. Dev.**	**Remarks**	**Mean**	**Std. Dev.**	**Remarks**
1	Poor Harvesting Techniques	2.77	1.468	Disagree	3.06	1.499	Agree
2	Delay in Harvesting	3.35	1.156	Agree	3.56	1.175	Agree
3	Lack of Proper Drying	3.21	1.375	Agree	3.50	1.133	Agree
4	Inadequate Storage Facilities	3.42	1.135	Agree	2.98	1.367	Disagree
5	Pests and Insects	2.91	1.510	Disagree	2.93	1.437	Disagree
6	Fungal and Bacterial Infections	3.55	0.996	Agree	3.38	1.063	Agree
7	Physical Damage During Handling	3.45	1.143	Agree	2.99	1.471	Disagree
8	Inefficient Transportation	3.08	1.434	Agree	3.36	1.366	Agree
9	Lack of Post-harvest Infrastructure	3.46	1.104	Agree	3.06	1.433	Agree
10	Lack of Access to Markets	3.58	1.091	Agree	3.04	1.431	Agree
11	Climate Change	3.14	1.251	Agree	3.44	1.062	Agree
12	Lack of Information and Education	3.58	1.119	Agree	3.01	1.360	Agree
13	Inadequate Post-harvest Technologies	3.51	1.105	Agree	3.03	1.432	Agree
14	Poor Quality Seed	3.53	1.104	Agree	4.00	5.000	Agree
15	Lack of Financial Resources	3.43	1.091	Agree	3.46	1.159	Agree
	Grand Mean	**3.33**	**1.205**	**Agree**	**3.25**	**1.559**	**Agree**

Source: Field Survey, 2024.

4.4 The causes of post-harvest loss do not differ in the two States of Anambra and Ebonyi

Table 6 presents the statistical analysis of whether the causes of post-harvest loss differ between Anambra and Ebonyi States. The results indicate that the differences in the causes of post-harvest loss between the two states are not statistically significant. All the significance values are greater than 0.05, indicating that there is no statistically significant difference in the causes of post-harvest loss between the Anambra and Ebonyi States. Since the analysis shows no significant difference in the causes of post-harvest loss between Anambra and Ebonyi States, it suggests that the underlying factors contributing to these losses are similar in both States. This implies that interventions aimed at reducing post-harvest losses can be uniformly applied across the two states. Equally, a uniform approach to addressing post-harvest losses can lead to more efficient allocation of resources (Ogundele, 2022) [34]. For instance, if both states face similar issues such as poor storage facilities, lack of access to technology, or inadequate transportation, then policies, and programs designed to mitigate these issues can be implemented simultaneously, potentially reducing costs and maximizing impact.

Table 6: The causes of post-harvest loss do not differ in the two States of Anambra and Ebonyi State

Chi-Square Tests	Value	Degree of freedom	Sig. value
Pearson Chi-Square	2.152[a]	2	**0.341**
Likelihood Ratio	1.892	2	0.388
Linear-by-Linear Association	0.221	1	0.638
N of Valid Cases	160		

Source: Field Survey, 2024.

5. Conclusion and Recommendations

This study uncovered critical information about the different stages of post-harvest loss suffered by rice farmers in Anambra and Ebonyi States, it educated the audience on an often-overlooked aspect of agricultural production. By distinguishing between primary, secondary, and tertiary losses, this research revealed the specific points where interventions can be most effective. The findings emphasize the urgent need for targeted support in post-harvest management, including improved storage facilities, better drying techniques, and enhanced transportation logistics. The researcher(s) are of the opinion that if these issues are properly addressed, farmers will experience a significant reduction in losses, thereby improving their income and overall productivity. Additionally, minimizing post-harvest losses contributes to the broader goal of food security by ensuring that more rice produced actually reaches consumers, reducing the pressure on food imports, and stabilizing local markets.

Furthermore, the study's findings provided a solid foundation for policymakers, agricultural extension workers, and financial institutions to develop tailored programs that address specific loss stages. For example, financial institutions can design credit facilities that support investments in post-harvest technologies, while extension services can focus on capacity-building programme that equip farmers with the necessary skills to reduce losses. Additionally, this research opens new pathways for future studies that can explore the economic implications of post-harvest losses, the role of climate change in exacerbating these losses, and the effectiveness of different intervention strategies. By leveraging the knowledge gained from this study, stakeholders can collaboratively work towards a more resilient and efficient rice value chain, ultimately benefiting both farmers and consumers.

The study therefore recommends that:

1. Policymakers needs to comprehensively interven or design programmes to address improved harvesting, drying, storage, transportation, and financial support.
2. The extension agents needs to train the farmers on better post-harvest technologies, and better market access to significantly reduce losses and boost farmers' income.

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