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Post-harvest Storage Losses in Rice: A Study of Ekiti State, Nigeria

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Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

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ABSTRACT

Aims: This study examined post-harvest storage losses in rice in Ekiti State, Nigeria.
Place and Duration of Study: The study was conducted in Ekiti State, Nigeria between May 2014 and August 2014.
Methodology: Multistage sampling procedure was used to select 150 rice farmers from Ekiti State. Descriptive statistics, Quantitative analytical techniques and Probit regression model were used to analyse the data.
Results: Over 50% of the respondents were using Warehouse as storage system, while the remaining respondents were using Bags. Some of the reasons for the use of warehouse as stated by the respondents include inheritance from parents and availability. Majority (52.3% and 48.4%) of the farmers recorded less than 10% intensity of post-harvest storage losses using Warehouse and Bag storage system respectively. The study further revealed that mean efficiency for Warehouse storage system and Bag storage system was 89.7% and 85.3% respectively, which shows that

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Warehouse is more efficient than Bag. The mean economic loss in Warehouse was ₦28,380, while that of Bag was ₦32,113 indicating that Warehouse storage system is more efficient economically than Bag storage system in the study area. The results of the probit model showed that cost, life-span and efficiency of the storage system were significant in determining the choice of storage systems in the study area.

Conclusion: It could be concluded that the intensity of post-harvest storage loss in the study area was high, which calls for urgent intervention so as to salvage the situation. Therefore, individuals, government and non-governmental organisations should introduce more affordable, efficient and sophisticated storage systems to the study area for effective storage.

Keywords: Losses; Nigeria; post-harvest; quantitative; rice; storage.

1. INTRODUCTION

Rice (*Oriza* spp) is one of the widely grown cereal crops throughout the world, which is seen as the most important food crop by virtually half of the population around the world [1]. In Africa, it has been calculated that rice maintains means of livelihood for about 100 million people with production processes providing job for over 20 million people [2].

According to [3], rice is known to be one of the staple foods in Nigeria and as a result of the large population it has, Nigeria is one of the largest consumers of rice in West Africa. The supply and demand gap of about 1.9 million tonnes of rice resulting from calculated 5.2 million tonnes demand and 3.3 million tonnes supply annually can only be covered by importation.

On yearly basis, some of farmers' productions aimed at boosting the economy are lost at post-harvest stage. The post-harvest technological situation in Nigeria on cereals, grain legumes, oilseeds, etc. gives bad experience and they are characterized by traditional techniques employed by growers, traders and the processors leading to considerable deterioration of physical and nutritional qualities of harvested crops [4]. It is estimated that as much as 15-20% grains are wasted after harvest and reducing post-harvest losses of agricultural produce to minimal level is very crucial to food security [5].

[6] stated that pre and post-harvest food loss among African countries is estimated to be about 10%, which is still in excess of the average global food loss. [7] had earlier explained that poor harvest and storage facilities claimed about 2.4 billion tonnes of food yearly in Nigeria. Therefore, households who rely greatly on storing excess agricultural commodities as a means of livelihood would experience limited income, exacerbated poverty condition and food insecurity as a result of crop losses [8].

As defined by [9], postharvest loss is said to be the degradation in both quantity and quality of a food production from harvest to consumption. Quality losses include those that affect the nutrient/caloric composition, the acceptability, and the edibility of a given product.

Significant losses of agricultural commodities produced on the field arise during various operations, such as harvesting, threshing, winnowing, bagging, transportation, storage, processing and exchange, before they reach the final consumers [10]. [11] explained that proper storage process starts with the condition of the harvested grains from the field such as moisture content, cleanness of the grains, injury during harvesting and transportation.

Seasonability of agricultural production makes storage very important in agriculture since demands for agricultural produce are not seasonal throughout the year. Therefore, this calls for the need to store during harvesting period when there is glut till the later days, when there will be scarcity, for stead release into the market [12].

It is generally believed that storing grain for long term is profitable [13] and storage structure can be said to be one of the major determinants of sale of grains. Increasing marketing flexibility to strengthen marketing position can be made possible by increasing sophisticated storage facilities. [14] enumerated the importance of storage structure in grain marketing where it is stated that appreciable quantity of grain is damaged during storage process and can subsequently result in reduced profits. This is the reason for having good storage management as one of the essential ways of preventing spoilage caused by mould growth and insect activities.

Reduction in food availability for human consumption is not only the consequence of food losses but also the related externalities which adversely affect the society in terms of the costs of managing waste and the production of Green House Gas (GHG). Food loss has been estimated to be producing about 6-10% of GHG generated by human [15]. Drudgery, stress, pains, and a whole lot of difficulties encounter during rice production process are not being rewarded neither compensated for because of poor storage facilities.

This is the motivation for this study which analysed post-harvest storage losses in rice in one of the major rice producing States in Southwestern Nigeria. The specific objectives are to; assess the intensity of post-harvest losses from the storage systems, estimate the efficiency of the storage systems, estimate the economic loss resulting from storage systems and determine factors influencing the choice of storage systems in the study area.

This study on post-harvest storage losses in rice would help assess the extent and magnitude of losses and identify the factors responsible for such losses. This in turn would help develop proper measures to reduce these losses. Formulating correct policies for minimizing post-harvest losses would crucially depend on reliable and objective estimates of such storage losses. Information that emanate from this study is important for scientists, technologists, policymakers, administrators and industrialists.

2. METHODOLOGY

2.1 Study Area

This study was carried out in Ekiti State, Nigeria, which is located between longitudes 40°51′ and 50°451′ East of the Greenwich meridian and latitudes 70°151′ and 80°51′ north of the Equator. The State has a climate marked by two major seasons: the rainy season which lasts between April to October, and the dry season lasting from November to March. The temperature ranges between 21°C to 28°C with high humidity. The State has topography of mainly an upland area, rising over 250 metres above sea level. The population of the State as at 2006 was 2,384,212 people. The south – westerly winds blow in the raining season, while the North East Trade winds blow dry (Harmattan) seasons. Tropical Forest exists in the south, while guinea savanna predominates in the northern peripheries. The main occupation of the people of the State is Agriculture which provides employment for about 75% of the population. Agricultural produce in the State include the following; cocoa, coffee, kola nut, cashew and oil palm, while arable crops grown include rice, yam, cassava, maize cowpea and cocoyam [16].

2.2 Data Collection and Sampling Procedure

Multi-stage sampling procedure was used to select the respondents. At the first stage, two Local Government Areas namely; Irepodun/Ifelodun and Ikole were purposively selected because of the dominance of rice production in the areas. In the second stage, simple random sampling technique was used to select three communities from each of the selected Local Government Areas. At the third stage, simple random sampling technique was used to select twenty five respondents from each of the selected communities. In all, a total number of 150 respondents were selected for the study. Primary data used for this study were collected directly from the rice farmers with the aid of a well-structured questionnaire. Data were collected on socioeconomic characteristics, storage facilities used, factor influencing their choice, storage facilities efficiency, economic losses incurred and intensity of the losses recorded overtime.

2.3 Data Analytical Procedure

Descriptive statistics were used to analyse the socio-economic characteristics of the respondents in the study area. Quantitative analytical technique was used to analyse the intensity of post-harvest storage losses, storage efficiency and economic loss due to storage. Probit regression model was used to analyse factors influencing the choice of storage facilities in the study area.

2.3.1 Quantitative analytical technique

Following authors [17], the quantitative analytical techniques used are as follows:

The Intensity of Post-harvest Storage Losses

$$= \frac{QLS}{IQ} * 100 \quad (1)$$

Storage Efficiency of the Facilities

$$= \frac{QAS}{QBS} * 100 \quad (2)$$

Economic Loss Due to Storage (EL)

$$= Ni(Pa - Pi) \quad (3)$$

Where;

QLS = Quantity Lost to Storage,
IQ = Initial Quantity
QAS = Quantity After Storage,
QBS = Quantity Before Storage
EL= Economic Loss
N_i = Quantity of infested grains
Pa = Price of good grain
P_i = Price of infested

2.3.2 Probit regression model

The Probit model is one of the widely used statistical models for studying data with binomial distributions. According to [18], probit model constrains the estimated probabilities to be between 0 and 1 and relaxes the constraint that predicted values of the dependent variable. This is normally experienced with the Linear Probability Model (LPM). The probit model assumes that while we only observe the values of 0 and 1 for the variable Y, there is a latent, unobserved continuous variable Y* that determines the value of Y. As part of the advantages of the probit model, it has credible error term distribution and realistic probabilities [19].

Following authors [20], the Probit model can be expressed in probability as follows;

$$\Pr ob(Y=1) = 1 - F\left[-\sum_{k=1}^{k} \beta_k b_k\right] = F\left[\sum_{k=1}^{k} \beta_k b_k\right] = \varphi\left[\sum_{k=1}^{k} \beta_k b_k\right] \quad (4)$$

The equation for probability of non-event is then written as follows;

$$\Pr ob(Y=0) = 1 - \varphi\left[\sum_{k=1}^{k} \beta_k b_k\right] \quad (5)$$

The farmer's decision on use of a particular storage system depends on the criterion function;

$$Y^* = \gamma Z_i + U_i \quad (6)$$

Where,

Y^* = Underlying index reflecting the difference between the use of Warehouse and Bag storage system.

γ =Vector of Parameters to be estimated

Z_i =Vector of Exogenous variables which explain use of storage system

U_i =Standard Normally Distributed Error Term

Considering the farmers' assessment, which crosses the threshold value, 0, it is observed that the farmer using the storage systems in question. In practice, Y_i^* is unobservable. Its counterpart is Y_i which is defined by;

$Y_i = 1$ If $Y_i^* > 0$ (Farmer *i* use Warehouse), and
$Y_i = 0$ If Otherwise (Farmer *i* use Bag).

In the case of normal distribution function, the model to estimate the probability of observing a farmer using a storage system can be stated as follows;

$$P\left(Y_i = \frac{1}{X}\right) = \varphi(X\beta) = \int_{-\alpha}^{X\beta} \frac{1}{\sqrt{2\Pi}} \exp\left(\frac{-z^2}{2}\right) dz \quad (7)$$

Where,

P = Probability that the ith farmer use Warehouse and 0 Bag.

X = *K* by 1 Vector of the explanatory variables.

Z = Standard Normal Variable (i.e Z ~$N(0,\delta^2)$ and

β = *K* by 1 Vector of the Coefficients estimated.

For a non-dichotomous variable, the marginal probability is defined by the partial derivative of the probability that $Y_i = 1$ with respect to that variable. For the jth explanatory variable, the marginal probability is defined by:

$$\frac{\partial p}{\partial X_{ij}} = \varphi(X_i \beta)\beta_j \quad (8)$$

Where,

φ(.) = Distribution Function for the Standard Normal Random Variable

β_j = Coefficient of jth explanatory Variable.

Therefore, the Probit model specification in this analysis can be written as:

$$Y_i* = X_i\beta + \varepsilon_i \quad (9)$$

$$Y_i = \begin{Bmatrix} 1 if Y_i* \geq 0 \\ 0 if Y_i* < 0 \end{Bmatrix}$$

Where,

Y_i = Observed Dichotomous Dependent Variable which takes Value 1 when the ith farmer uses Warehouse and 0, Bag as storage system.

Y_i* = Underlying Latent Variable that indexes the use of storage system.

X_i = Row Vector of Values of K Regressors for the ith Farmers.

β = Vector of Parameters to be estimated

ε_i = Error term which is assumed to have standard Normal Distribution.

2.3.3 Model specification

The probit model was used to analyze factor influencing the choice of a particular storage facility between the storage facilities available in the study area (warehouse and bags storage systems are dominantly in use). For this study, the model is specified explicitly as follows;

$$Y_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + \varepsilon_i \quad (10)$$

Where

Y_i = Storage System used (1=Warehouse, 0=Bags)
X_1 = Age of the respondent
X_2 = Household size
X_3 = Educational level
X_4 = Farming years of experience
X_5 = Farm size (Ha)
X_6 = Cost of storage system (₦)
X_7 = Life-span of system
X_8 = Efficiency of the system (%)
ε_i = Error term

3. RESULTS AND DISCUSSION

3.1 Socio-economic Characteristics of the Respondents

The results as shown in Table 1 indicate that majority of the respondents were between 30 and 49 years of age with mean age of 46 years. This implies that majority of the respondents were still in their active working age which is good for the labour-intensive and energy sapping farming activities being practiced in the study area. This study is in line with the study by [21-22] which stated that the average age of rice farmers was 46 years. Majority of the respondents (50%) had between 1 and 5 household size with mean household size of 6. It was observed that about 49% of the sampled farmers had at least household size of six, which is a pointer to access to family labour and adoption of new technologies on the farm. The result from this study is similar to the findings of [21] who reported mean household size of 7 persons. The reason for large household size could be attributed to polygamous nature of rural household farmers as stated by [23] citing [24]. Findings from this study revealed that about 80% of the sampled rice farmers were married indicating the dominance of married people in rice farming in the study area. This shows that majority of the respondents had stable family that is expected to strengthen the decision-making process in agricultural production. This result corroborates the findings of [25]. Majority (94%) of the respondents had one form of education or the other which is an indication that they were literate. This is expected to enhance the rate of adopting the disseminated innovations/ knowledge in agricultural production. The result is in conformity with the findings of [22] who explained that majority (91.2%) of the respondents had formal education ranging from primary to tertiary. The study further revealed that majority (68%) of the respondents were male farmers, while the remaining 32% were female farmers. This indicates that rice farming is dominated by male gender in the study area probably due to the intense nature of farming activities. This confirms the findings of [26] who reported that 87.3% of the respondents were men. Majority (53.3%) of the respondents cultivated 1-5 hectares of rice farm, which implies that majority of the sampled rice farmers were small scale farmers. Over 50% of the respondents were using Warehouse as storage system, while the remaining respondents were using Bags. Some of the reasons for the use of warehouse as stated by the respondents include inheritance from parents and availability.

Table 1. Distribution of respondents by socio-economic characteristics

Household characteristics	Frequency	Percentage of respondents
Age (years)	**Mean = 46 years**	
< 30	4	2.7
30-39	50	33.3
40-49	54	36.0
50-59	31	20.7
60-69	6	4.0
≥ 70	5	3.3
Household size	Mean = 6	
≤ 5	76	50.7
6-10	67	44.7
≥ 10	7	4.6
Marital status		
Single	20	13.3
Married	121	80.7
Divorced	03	2.0
Widowed	06	4.0
Educational level		
No formal education	09	6.0
Primary	38	25.3
Secondary	72	48.0
Tertiary	31	20.7
Gender		
Male	102	68.0
Female	48	32.0
Farm size (Ha)	Mean = 4 Ha	
≤ 5	80	53.3
5.1-10	54	36.0
10.1-15	6	4.0
15.1-20	4	2.7
>20	6	4.0
Storage system used		
Warehouse	88	58.7
Bags	62	41.3

Source: Field Survey, 2014; Number of Observation = 150

3.2 Intensity of Post-harvest Losses from the Storage Systems Used

Distribution of respondents by intensity of post-harvest storage losses in rice as shown in Table 2 revealed that majority (52.3% and 48.4%) of the farmers recorded less than 10% intensity of post-harvest storage losses using Warehouse and Bag storage system respectively. Some of the causes of the loss were attributable to mould resulting from inability to sun-dry rice grain to require moisture content and infestation of the storage system by rodents as well pest and diseases. This is in conformity with [27] who reported lower percentage post-harvest storage loss in the study carried out in Bangladesh.

3.3 Efficiency of the Storage Systems

Table 3 shows the distribution of respondents by efficiency of the storage systems used. Majority (48.9% and 59.7%) of the respondents recorded between 90.1% and 100% efficiency in Warehouse and Bag storage system respectively. There is significant difference between mean efficiency in Warehouse and Bag storage system at 5% significant level. The mean efficiency was 89.7% for Warehouse storage system and 85.3% for Bag storage system, which shows that Warehouse is more efficient than Bag.

3.4 Economic Losses Resulting from Storage Systems

As shown in Table 4, distribution of respondents by economic loss indicates that majority (85.2% and 88.7%) of the respondents recorded between ₦ 1 and ₦ 50,000 in Warehouse and Bag storage System respectively. There is significant difference between mean economic loss in Warehouse and Bag storage system at 5% significant level. The mean economic loss in Warehouse was ₦ 28,380, while that of Bag was ₦ 32,113 indicating that Warehouse storage system is more efficient economically than Bag storage system in the study area.

3.5 Factors Influencing the Choice of Storage Systems

The parameter estimates and marginal effects from probit model as shown in Table 5 revealed that cost of storage, life-span of the storage system and the efficiency of the storage system were significant in determining the choice of storage systems in the study area. R^2 value which measures the proportion of the variation in dependent variable that is explained by the independent variables was 0.58. This implies that the variables included in the model could explain 58% of the variation that occurs in the choice of storage system by the respondents in the study area. As cost of storage system increases, the tendency of the respondents to choose Warehouse storage system increases. As shown in Table 5, the marginal effect of the cost of storage system indicates that the probability of the respondents to use Warehouse storage system increases by 0.8%. The reason for the small percentage could be attributed to the fact that people are reluctant to use any system that is capital intensive. The tendency of the respondents to choose Warehouse storage

Table 2. Distribution of respondents by intensity of post-harvest storage losses

Intenstity (%)	Warehouse (Mean=6.85%)		Bags (Mean=7.79%)	
	Frequency	Percentage	Frequency	Percentage
≤ 10	46	52.3	30	48.4
10.1-20	26	29.6	20	32.3
20.1-30	15	17.0	10	16.1
30.1-40	01	1.1	02	3.2
Total	88	100	62	100

Source: Field Survey, 2014

Table 3. Distribution of respondents by efficiency of the storage systems used

Efficiency (%)	Warehouse (Mean = 89.7%)		Bag (Mean = 85.3%)	
	Frequency	Percentage	Frequency	Percentage
≤ 70	03	3.4	04	6.5
70.1-80	05	5.7	03	4.8
80.1-90	37	42.0	18	29.0
90.1-100	43	48.9	37	59.7
Total	88	100	62	100

Source: Field Survey, 2014

Table 4. Distribution of respondents by economic losses

Economic Loss (₦)	Warehouse (Mean= ₦28,380		Bags (Mean= ₦ 32,113)	
	Frequency	Percentage	Frequency	Percentage
1-50,000	75	85.2	55	88.7
50,001-100,000	10	11.4	06	9.7
100,001-150,000	03	3.4	01	1.6
Total	88	100	62	100

Source: Field Survey, 2014

Table 5. Parameter estimates and marginal effects from probit model

Variable	Estimates	t-Ratio	Marginal effects
Age	-0.002	-0.15	-6.43E-04
Household size	-0.072	-0.82	-0.015
Educational status	-0.153	-0.81	-0.031
Farming experience	0.018	0.66	0.004
farm size	0.005	0.40	9.35E-04
Cost of storage	1.86E-04**	2.00	0.006
Life-span of the system	0.362***	5.12	0.827
Efficiency of the system	0.048**	2.19	0.310

*** Significant at 5% level; *** Significant at 1% level*

*LR chi-square (8) = 79.17***; Log Likelihood = -42.773; Pseudo R^2 = 0.5806; Number of Observation = 150*

Source: Field Survey, 2014

system increases as the life-span of the storage system increases. According to marginal effects, increase in the life-span of storage system will bring about increase in the probability of choosing Warehouse storage system by 82.7%. This result shows the importance of life-span of storage system in determining the type of storage system to use in the study area. Efficiency of the storage system has a positive and significant relationship with the choice of storage system which implies that increase in the efficiency of the storage system increases the tendency of the respondents using Warehouse storage system. Therefore, a unit increase in the efficiency of the storage system increases the probability of using Warehouse storage system by 31% by the respondents. These results show that cost of storage system is not as important as life-span and efficiency of the storage system in increasing the likelihood of choosing Warehouse storage system in the study area as it is capital intensive.

4. CONCLUSION AND POLICY RECOMMENDATIONS

4.1 Conclusion

It could be concluded that the intensity of post-harvest storage loss in the study area was high, which calls for urgent intervention so as to salvage the situation. Warehouse storage system was the choice of the sampled farmers in the study area because of its efficiency and life-span.

However, the study revealed that increase in cost of storage system did not seriously increase the probability of the respondents using Warehouse storage system probably because law of demand was observed.

4.2 Policy Recommendations

Based on the findings of this study, it therefore suggests the following policy options that can drastically reduce post-harvest storage losses in rice enterprise in the study area;

1. More efforts should be intensified on creating awareness about importance of using storage system that gives room for ventilation and free from rodents as well as other pathogens.
2. There should be awareness creation on the need to sun-dry rice grains very well to minimum required moisture content before they are stored. This will help in preventing pathogens from gaining access to environment that promotes multiplication of the disease causing organisms.
3. Individuals, government and non-governmental organisations should introduce affordable, efficient and sophisticated storage systems to the study area for effective storage process.
4. Rice farmers are encouraged to participate in the cooperative societies where credits can be accessed to build warehouses that can be used for storage because of its efficiency. Cooperative societies can also provide benefits of economies of scale to rice farmers where cost of using efficient and sophisticated storage facilities will be shared by the participating cooperators, thereby reducing the cost of storage.
5. Competent extension agents should be sent to the study area for more enlightenment on the danger of post-harvest storage losses to the farmers and economy of the country at large.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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