FUDMA Journal of Agriculture and Agricultural Technology
ISSN: 2504-9496
Vol. 8 No. 1, June 2022: Pp.142-150

https://doi.org/10.33003/jaat.2022.0801.033

ANALYSIS OF POST-HARVEST LOSSES AND TECHNICAL EFFICIENCY OF RICE FARMERS IN MIDDLE RIMA VALLEY IRRIGATION SCHEME (MRVIS), SOKOTO STATE, NIGERIA

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ABSTRACT

Nigeria has been characterized with shortage quantity 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. This study was undertaken to examine the technical efficiency and post-harvest losses of rice farmers in MRVIS. Multi-stage sampling technique was used to sample 98 respondents. Data were collected using questionnaire and then analyzed using descriptive statistics, multiple regression model and Data Envelopment Analysis. The findings show that 73.4% of the farmers were within the age of 30-57. Similarly, farming was a male dominated enterprise with 93.0%. The farmers had a mean of 20 years in rice farming. The estimation of post-harvest losses confirmed that a total of 575kg/ha (8.44%) of total production was lost from harvesting to storage. There was ineffective utilization of production resources as the farmers could not achieve the optimal technical efficiency in rice farming. The regression analysis shows that harvesting, farm size, level of education and farming experience were the determinants of rice post-harvest losses in the area. It was recommended that Government should adequately install modern techniques for rice farming in MRVIS.

Key words: Post-harvest, Losses, farmers, Rice, Technical efficiency.

INTRODUCTION

Nigeria is the largest country in West Africa with a total land area of 923,770 km^2 and an estimated population of 195,875,237 people (United Nation, 2018). The country is also the largest producer of rice in the continent and was ranked 15^{th} in the world with a total production of 7.2 million tons of paddy equivalent to 4.5 million tons of milled rice as of 2018 (USDA, 2018). The yield was obtained from 3.2 million ha of land under rice cultivation with an average yield of 1.41 tons of milled rice/ha which was considerably low compared to the 2018 consumption rate of 7.5 million tons of milled rice per annum (USDA, 2018). The low quantity of rice production in Nigeria is attributed to post-harvest losses which have effects not only on social and economic scale but also represent a waste of resources used in the rice value chain which include land, labour, capital, water and other vital resources (Hodges, Buzby and Bennett, 2011). The production trend of milled rice in Nigeria from 2015 to 2021 is traced in Figure 1.

Post-harvest losses have been one of the key encumbrances to the income of rice farmers in Sub-Saharan Africa including Nigeria in particular (Gorny, 2011). The post-harvest technological situation in Nigeria is characterized by traditional techniques employed by growers, traders and processors leading to considerable losses in physical and nutritional qualities of the harvested crop. In Nigeria, it is estimated that about 20-25% of rice produced annually is lost along the value chain (Adeniyi, Lawrence and Abiola, 2016).Globally, about 30% of the food produced(rice recorded 3.7%) for human consumption is lost or wasted as a result of post-harvest losses along the value chains every year (Food and Agriculture Organization (FAO), 2016). This is a whopping 1.3 billion metric tons of food that does not ever reach the consumer. A report by IFAD in 2016 has estimated that this loss or wasted food could feed 1.6 billion people every year (Ambuko, 2017). In Africa, the losses are even higher between 12% and 15%. The losses at farm level can be attributed to poor harvest practices and poor handling such as poor storage or packaging, mode of transport, processing practices, poor access to market and poor coordination among the actors in the value chains (Japan International Cooperation Agency (JICA), 2015).

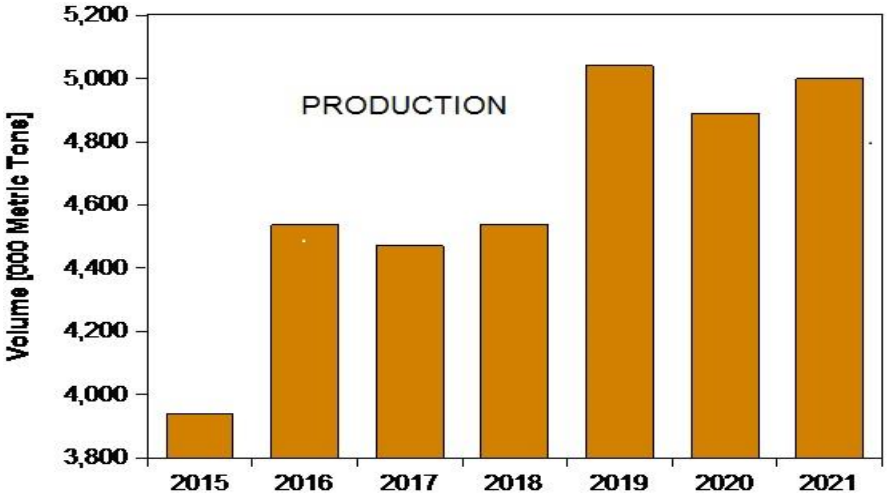

Figure 1:Rice Production trend in Nigeria (2015-2021)
Source: United State Department of Agriculture (USDA), 2021.

First International Congress on post-harvest loss prevention held in Rome, Italy in 2015, where researchers from sixty-two countries including Nigeria discussed post-harvest losses on a global level. The participants developed a roadmap towards post-harvest losses. The roadmap identified that food is lost in five major areas along a value chain; harvesting, processing, transportation, storage and retail. New approaches and technologies in each of these areas will increase the amount of food available for human consumption. However, implementing these solutions will require cooperation among nations and substantial financial support from public and private sectors (Volland, 2016).

The Middle Rima Valley Irrigation Scheme (MRVIS) was established in 1988 in Goronyo and Gada Local Government Areas of Sokoto State, Nigeria by the Department of Irrigation and Drainage, Federal Ministry of Water Resources under the jurisdiction of Sokoto Rima River Basin Development Authority (SRRBD) to provide irrigation facilities for all year round agricultural activities in the areas. Potentially, the scheme was expected to produce as much quantity of rice as 8tons/ha/annum. However, before this research was carried out, the scheme was only producing 5.6tons/ha/annum (SRRBDA, 2017).

In spite of various efforts put in place by researchers and policy makers to boost the rice production activities of the study area by expanding the land area under cultivation in the scheme, easy access to water resources and implementation of TRIMING project (Transforming Irrigation Management in Nigeria) by federal government, yet the farmers perform below expectations. Post-harvest practices along the rice farming segment are still rudimentary and hence contribute significantly to the existing gap between the current condition of farmers' technical efficiency and their potential performance.

It is therefore in the light of the above that the study attempted in analyzing the following research objectives:

i) Describe the socio-economic characteristics of rice farmers in MRVIS
ii) Examine the level of technical efficiency of the rice farmers in the study area,
iii) Estimate the post-harvest losses of rice farmers in the area
iv) Identify the factors influencing Post Harvest Losses in rice production in the study area

MATERIAL AND METHODS

Description of the study area

The Middle Rima Valley Irrigation Scheme (MRVIS) is an area which falls between Goronyo and Gada Local Government areas of Sokoto state. The area covers about 5,360 ha on the banks of Rima River between the towns of Goronyo and Keta on the left bank and Tuleske and Gidan-Alwali on the right bank. It lies between longitudes 5^0 39′ and 5^0 50′ East and latitudes 13^0 25′ and 13^0 33′ North (SRRBDA, 2017). The area falls within the Sudan savannah agro-ecological zone of the country with a land mass

of 1,704 km^2 and a projected population of 245,800 people in 2016 (National Population Commission (NPC), 2016). Most of the people in the area are Hausa/Fulani by tribe and the major crops grown are rice, maize, watermelon, vegetables, sweet potatoes, sorghum and wheat (SRRBDA, 2017).

Sampling Procedure

Multi-stage sampling technique was employed in the study. The first stage involved purposive selection of Middle Rima Valley Irrigation Scheme (MRVIS) in Sokoto state due to predominant rice production activities in the area. The second stage involved random selection of three villages from twelve villages identified in the area during reconnaissance survey. The third stage was the application of proportionate sampling in order to select appropriate number of farmers from their respective villages. To do that, Yamane sample size formula was used to determine the total sample size of the farmers (98) which was then proportionately allocated to the villages. This was shown in Table 1.

Table 1: Sampling size of the respondents

Village	Population of registered farmers	Farmers selected
Mai'iyali	76	43
Falaliya	53	30
Takakume	44	25
Total	**173**	**98**

Source: Computed by the authors

The proportionate sampling used is specified as follows:

$$n = \frac{X}{D} * N$$

Where:
n= Sample size of farmers selected per village
X = Number of the farmers per village
D = Total number of all farmers in the three villages
N=Recommended sample size by Yamane sample size formula

Data Collection

The data for the study were collected through primary source which was generated using questionnaire administered to the 98 selected rice farmers through face to face contact. A pilot test of the questionnaire was done so as to remove ambiguity and ensure accuracy. In a situation where the actors could not fill the questionnaires, interview schedule was arranged to acquire necessary information.

Data Analysis

Descriptive statistics was used to describe the socio-economic characteristics of the rice farmers and to determine the extent of post-harvest losses in the area while Data Envelopment Analysis was used to estimate the technical efficiency of the farmers. The analytical tools are specified as follows:

Descriptive statistics

This involves tabular presentation of mean, frequency distribution and percentages of the analyzed data on socio-economic variables of the farmers. To determine the post-harvest losses, relevant questions in a questionnaire were formulated and administered to the rice farmers to give estimates based on experience the quantities of rice they usually lost in the course of carrying out various post-harvest operations. The scores of the questions were then subjected to descriptive analysis. Thus, the losses during harvesting, drying, threshing, winnowing, packaging, transportation and storage were estimated in this study.

Data Envelopment Analysis

Data envelopment analysis (DEA) is a non-parametric model and a mathematical programming-based technique used to evaluate the relative efficiencies of a given firm. It is a comparative approach for identifying performance of the Decision Making Unit (DMU) specifically technical and scale efficiencies (Santos *et al.,* 2013). Considering the fact that stochastic frontier model has been widely in used despite its disadvantages such as; the efficiency cannot be determined without a functional form and that it requires some assumptions in the data to be collected (Hossain *et al.,* 2012). This study therefore used DEA

because it requires no functional forms for the efficiency to be determined and also the results are much easier to interpret and utilize (Hossain *et al.*, 2012).

In DEA, efficiency (Ef) of a specific decision-making unit (DMU) (farmer) under analysis is defined as the ratio between a weighted sum (µra) of its outputs (Yra) and a weighted sum (Via) of its inputs (Xia) (Santos *et al.*,2013). The DEA technique can be specified in the form of Charnes Cooper Rhodes (CCR) model which assumes constant return to scale specified as follows:

$$Ef_a = \frac{\sum_{r=1}^{s} \mu ra\ yra}{\sum_{i=1}^{m} via\ xia} \quad \ldots\ldots (1)$$

Where:

Ef_a = Efficiency of decision making unit (DMU_a)
∑ = Summation sign
µra yra = weight sum of output
via xia= weight sum of input

A decision making unit (DMU) is said to be technically efficient if the efficiency ratio is one.

Thus:

r = 1 (Technically efficient)
r < 1 ≥ 0.5 (Moderately technically efficient)
r < 0.5 (Technically inefficient) (Charnes *et al.,* 1978).

However, to evaluate efficiency using DEA, the following linear programming maximization problem has to be solved for each one of the decision-making unit (DMUa) under analysis:

$$\text{Max } Z_j = \frac{\sum_{r=1}^{s} \mu ra\ yra}{\sum_{i=1}^{m} via\ xia} \quad \ldots\ldots (2)$$

Subject to:

$$\sum_{i=1}^{m} Y_{rj} V_{ij} X_{ij} = 1 \ldots\ldots (3)$$

$$\sum_{r=1}^{n} U_{kj} Y_{rj} - U_0 \leq \sum_{i=1}^{m} Y\ V_{ij} X_{ij}\ ;\ j = 1,2,3....n \ldots (4)$$

$$U_{kj}^{k=1} \geq 0;\ k=1,2\ldots q \ldots\ldots (5)$$

$$V_{ij} \geq 0;\ i=1,2\ldots m \ldots\ldots (6)$$

Where:

Z_j represents technical efficiency of farmer under evaluation, X_{ij} is the amount of input *i* used by farmer j in the production of the output, Y_{rj} is the level of output r produced by farmer j (these measures of outputs and inputs are assumed to be ≥ 0) U_{kj} is the unit weight of output k produced by farmer j, V_{ij} is the unit weight of input i used by farmer j (Truong, 2009).

Regression analysis Multiple regression model was used to estimate the determinants of postharvest losses in the study area. The model was specified as follows:

$$\text{Log } Y = \log \alpha + \beta_1 \log X_1 + \beta_2 \log X_2 + \beta_3 \log X_3 + \beta_4 \log X_4 + \beta_5 \log X_5 + \beta_6 \log X_6 + \beta_7 \log X_7 + \mu \ldots\ldots (7)$$

Where:
Y = Physical Output of rice lost (kg/ha)
α = Intercept
β_1 to β_7 = Parameters to be estimated
X_1 = Harvesting (1=modern technique 2=traditional technique)
X_2 = Farm size (ha)
X_3 = Threshing (1=modern technique 2=traditional technique)
X_4 = Level of education (number of years schooling)
X_5 = Types of rice variety (1=improved, 2=Local, 3=Both)
X_6 = Age (years)
X_7 = Farming experience (years)
µ = Unobservable random Error term

RESULTS AND DISCUSSION

Socio-economics Characteristics

The result in Table 2 shows that 73.4% of the farmers were within the age of 30-57. The mean age for farmers was 50years. This implies that majority of the farmers were still within their productive age and can engage efficiently in rice production with high possibility of adopting new discoveries for developing the rice farming activities unlike the older age. The findings are in line with that of John *et al*. (2012), who revealed that majority of the farmers in Kwara State were between the age of 30 and 59. The distribution of the farmers by gender shows that 93.0% of the farmers were male, while only 7.0% were females. This indicates that male dominated the rice production in the study area and hence their productivity is expected to be higher because of their tendency to be more laboured efficient and their great influence in farm decision making. This is consistent to the findings of Faruk (2013) in Kebbi state who revealed that 86.7% of the sampled rice farmers were male against 13.3% of female. The result on household size reveals that 50%, 22.4% and 12.3% of the farmers had a family size of 8-15, 16-23 and 24-31 persons respectively.

This means that the farmers have a good opportunity to utilize family labour thereby reducing the cost of hired labour and at the same time reduce the total cost of production. The result is not in line with the findings of Abubakar *et al.* (2010) who found that 70% of the sampled rice farmers had a family size of 1-6 in their study area. In the case of educational level, it was found that 64.3% of the farmers had non-formal education which comprised both Qur'anic and adult education. However, only 18.4%, 11.2% and 6.1% of the respondents acquired primary, secondary and tertiary education respectively. This indicates that there is low level of western education in the study area and hence new discoveries are likely not to be easily accepted, because the level of education is the rate of exposure to knowledge which influences the decision making of a given farmer with regards to perception and adoption of technologies. The findings are not in line with that of John *et al*. (2012) who reported that about 54.6% of the respondents attended western education in Kwara state.

Table 2: Socio-economic characteristics of the rice farmers

Socio-economic characteristics	Frequency	Percentage
Age (years)		
16-29	6	6.1
30-43	36	36.7
44-57	36	36.7
58-71	16	16.3
72-85	4	4.2
Total	98	100
Mean	50	
Gender		
Male	91	93
Female	7	7
Total	98	100
Household size		
1-7	15	15.3
8-15	49	50
16-23	22	22.4
24-31	12	12.3
Total	98	100
Mean	14	
Level of education		
Primary	18	18.4
Secondary	11	11.2
Tertiary	6	6.1
Non-formal education	63	64.3
Total	98	100
Farm size(ha)		
0.5 – 3.5	72	73.5
4.0 – 7.0	26	26.5
Total	98	100
Farming Experience (Years)		
2-13	34	34.7
14-25	46	46.9
26-37	8	8.2
38-49	6	6.1
50-61	4	4.1
Total	98	100
Mean	20	
Membership of cooperatives		
Non-member	18	18.4
Member	80	81.6
Total	**98**	**100**

Source: Field survey, 2019.

The result further disclosed that 73.5% of the farmers had a farm size of 0.5 to 3.5 hectares of land. Only 26.5% of the farmers owned a farm size of between 4 and 7 hectares. This implies that majority of the farmers are small scale rice farmers. Thus, they were operating at subsistence level. This can lead to decreased productivity in the area. As for the farming experience, the farmers had a mean of 20 years of rice farming in the study area. This implies that the rice farmers may have the courage to mitigate postharvest losses and tackle other problems of rice farming activities in the area due to their level of experience in rice production. The findings on membership of cooperative societies show that 81.6% of the farmers were members of various cooperative societies which include Water Users association, Fadama III and Mai'iyali Right Association. This indicates that the farmers had opportunity to get benefits from their respective cooperatives in terms of training, credit from financial institutions, easy access to inputs and access to extension services among the others. The result corroborates the work of chidiebere (2017) who reported that 51.7% of the farmers were members of cooperative societies in Ebonyi state.

Post-harvest losses at farming stage

At farming stage, losses during harvesting, drying, threshing, winnowing, packaging, transportation and storage were estimated and discussed in Table 3. The Table shows that the farmers experienced higher losses of paddy during storage. About 2.34% of total production got lost. The losses in storage may be attributed to poor storage facilities because none of the farmers have modern storage facilities in the area. This resulted in rodents to penetrate into the store and damage the stored paddy. Other causes of losses at storage include storing the paddy with high moisture content and low marketing leading to long term storage. Losses during harvesting were also higher because up to 1.76% of total production got lost using traditional technique. The result further shows that only two post-harvest operations (threshing and transportation) were conducted using modern techniques by some farmers in the study area and the losses realized were minimal compared to that of traditional technique. On the average, about 8.44% of the total production was lost as a result of post-harvest losses from harvesting to storage. This is equivalent to 575kg of paddy equals to 7 bags of paddy valued at ₦70,000 that does not ever reach the final consumer. This implies that post-harvest losses contribute greatly to the reduction in total quantity of paddy produced thereby affecting the food security status and minimizes the income of the rice farmers in the study area. The findings are in accordance with that of Haruna and Tukur (2015) who realized that post-harvest losses from harvesting to storage in Kano State was about 8.2% of the total volume.

Table 3: Post-harvest losses of rice farmers in MRVIS

Point of losses	Average quantity lost/85kg of paddy (Traditional tech.)	Average quantity lost/85kg of paddy (Modern tech.)	Percentage loss to total production
Harvesting	120	NA	1.76
Drying	75	NA	1.10
Threshing	98	51	1.44
Winnowing	85	NA	1.25
Packaging	20	NA	0.29
Transportation	18	12	0.26
Storage	159	NA	2.34
Total	**575**	**63**	**8.44**
Total production (Average) 6800kg/ha			

*NA = Not Applicable

Source: Field survey, 2019.

Technical efficiency

The result of the technical efficiency of rice farmers was obtained using Data Envelopment Analysis and is presented in Table 4.

Table 4: Technical efficiency status of the rice farmers

Efficiency ratio	Frequency	Percentage
< 0.5	10	10.2
0.50-0.59	12	12.2
0.60-0.69	8	8.2
0.70-0.79	6	6.2
0.80-0.89	51	52.0
0.90-0.95	11	11.2
Total	**98**	**100**
Mean	**0.82**	
Minimum	**0.35**	
Maximum	**0.95**	

Source: Field survey, 2019.

Technical Efficiency

The result in Table 4 shows that none of the farmers in MRVIS could attain optimal technical efficiency (a ratio of one). However, majority of the farmers (77.6%) were moderately technically efficient with a ratio ranging from 0.51-0.95 and a mean of 0.82. Only 10.2% of the farmers were technically inefficient. This implies that the farmers were not able to produce maximum output using the available resources. It can be said that material and labour resources used were not effectively utilized during the production process. Hence, the final feasible revenue of the farmers is negatively affected. As it was earlier reported, post-harvest losses have drastically reduced the potential quantity of paddy produced by the farmers. This may possibly be among the reasons why that majority of the farmers could not attain the optimal technical efficiency. The result supports the findings of Fayose and Jebor (2016) in Nasarawa state where they disclosed that attaining technical efficiency in rice production is the most difficult task by many farmers due to post-harvest losses and high record of under-utilization of resources.

Factors affecting post-harvest losses

In order to identify the factors affecting post-harvest losses (harvesting, farm size, threshing, level of education, types of rice variety, age and farming experience were regressed against the dependent variable (quantity of rice lost by farmers) using multiple regression and the result is shown in Table 9.

Table 5: Factors of post-harvest losses

Variable	Coefficient	Standard Error	T-value	R-square	F-value
Constant	256.563	241.235	1.0635	0.6223	18.45
Harvesting	6.1178	3.0946	1.9769**		
Farm size	-9.1562	4.2318	-2.1637**		
Threshing	10.2136	9.9905	1.0223ns		
Level of education	3.7765	2.1875	1.7264***		
Types of rice variety	-1.2234	1.3386	-0.9139ns		
Age	11.1244	10.9814	1.0130ns		
Farming experience	12.2790	3.1278	3.9258*		

***Significant at 10%, **Significant at 5%, *Significant at 1%, ns = not significant
Source: Field survey, 2019.

The regression analysis in Table 5 shows that post-harvest losses in the area are affected by (harvesting, farm size, level of education and farming experience). Harvesting was positively significant at 5% level, which means it has a positive relationship with the dependent variable and hence any increase in the use

of traditional technique during harvesting can increase the quantity of rice lost by the farmers. Farming experience and level of education were also found positively significant at 1% and 10% respectively. This indicates that any increase in the units of these variables can increase the chances of saving the quantity of rice that get lost in the area. Similarly, farm size was significant at 5% but with a negative relationship. This implies that as the farm size decreases, the postharvest losses in rice production in the area decreases as well.

CONCLUSIONS

It is concluded that the farming segment in the area was a male dominating enterprise. The rice farmers were not optimally utilizing the scarce resources. Post-harvest losses contribute greatly to the reduction in total quantity of paddy produced by the farmers. Harvesting, farm size, level of education and farming experience were the determinants of rice post-harvest losses in the area. It is therefore recommended that government should adequately install modern techniques for rice farming and processing in the area, this will highly minimize the level of post-harvest losses along the rice sector in MRVIS.

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