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RESEARCH ARTICLE

DETERMINANTS OF POST-HARVEST GRAIN LOSSES IN NIGERIA

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ABSTRACT

Food-grains play significant roles in food supply and utilization in the Nigerian economy. The major grains include maize, rice and cowpea. Nigeria is a major producer of the grains but still depends on food imports in order to meet domestic demand for food. In spite of growing food imports a large number of people are undernourished in the country. This is aggravated by postharvest food grains losses attributable to a host of factors. The study therefore investigates factors determining food-grain losses at various nodes of food-grain supply chain using primary data which were collected in a survey by means of well-structured questionnaires. The data included factors affecting post-harvest food-grain losses and extent of the losses. The data were analyzed using regression technique. The results showed length of stay on the field after harvesting significantly and positively affected post-harvest loss for maize. In the case of rice, use of traditional technique of storage positively and significantly affected the loss in rice. For cowpea, the long distance of farm to store positively and significantly affected post- harvest loss at farm-level. At processing level, the scale of operation was a significant factor. At marketing level, the longer the length of storage, the higher the losses incurred. Creating market opportunities for small scale actors and agri-business development is an important strategy for reducing post -harvest losses of food-grains in the country. This can be achieved through investment in rural infrastructure and improved processing technology.

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INTRODUCTION

Maize, rice, and cowpea are major food-grains in Nigeria. In the country, maize is a very important food-grain due largely to its commercial viability. It is a crucial input in food and feed production. Demand for maize in the country hovers around 20. 5 million metric tonnes while local production lingers around 15. 9 million metric tonnes (CBN, 2016). The country is also a major producer and consumer of rice with an annual production of about 5. 9 million tonnes. Similarly, cowpeas play a key role in food supply in the country. It is an important source of plant protein for people in both rural and urban areas. Nonetheless, the country continues to depend on imports to meet domestic demand for food to feed its increasing population. Over the period 1990 to 2015, food trade deficit grew by an average rate of 17. 5 per cents per annum. This is mostly attributed to growing food imports (Nicolas Depetris Chauvin *et al.* 2015). In spite of the large production and huge imports of food-grains into the country every year, a large number of people are undernourished (Deepak Kumar and Prasanta Kalita, 2017).

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Food and nutrition security remained a major challenge that was intensified by high postharvest food grains losses. It is observed that post-harvest losses due to inefficient harvesting, processing and storage techniques ranged between 20 and 40 per cent of the total food production in the country. Total national average percentage postharvest grain losses in the country as at 1993 were 13 per cent for maize, 9 per cent for rice, and 14 per cent for sorghum (Oni, 1997). This avoidable level of waste substantially reduces the incomes of various actors in food-grain supply chain and contributes to food insecurity for Nigerian households. In recent time, extent of food-grain losses in the country could not be ascertained since there is no precise record of the quantity of losses. The problem has been exacerbated bypoor and unimpressive state of infrastructure in the rural areas. The rural areas are typical of poor transportation, poor source of energy and poor marketing facilities and ineffective market linkage. Rural infrastructure deficit coupled with predominance of poor farm implements and rudimentary post-harvest technology, aggravates the problem of post-harvest foodgrain losses as the food move from farm to consumerunder several operations. It is important to identify the nature and characterize the factors responsible for the losses in the food supply chain so as to design policy intervention to reduce the loss.

Most studies in Nigeria such as Olayemi *et al.* (2010), Joseph (1991), Adewumi *et al*., (2009), Folayan (2013) and Babalola *et al.* (2010) either focused mainly on a single crop and a particular actor along the food supply chain and in a specific location. They failed to adopt integrated approach in which growers, processors and marketers along the food supply chain are adequately captured for grains. Similarly, the effect of individual factor on the extents of food-grain loss were not precisely determined. These are the major lacuna the study investigates. This study, therefore, aimed at providing answers to the following questions. What are the extents of food-grainslosses in the country? What are the factors that are responsible for the losses?Which policy measures will reduce the food-grain losses? Thus the objective of the study is to estimate determinants of post-harvest food-grain losses with a view to propose policy measures for minimizing food-grain losses in the country. The paper is organised into five sections. This introductory section is followed by section two which concentrates on conceptual framework and review of relevant literature. Section three discusses the methodology adopted by the study. Section four focuses on results and discussions while the paper is concluded in section five with policy implications and recommendations.

Conceptual Framework

Food crops travel along the food supply chain from harvest to consumption (Kitinoja, Lisa. 2016). Losses occur at each stage along the chain and contribute to total Postharvest Losses (PHLs). The loss at each stage is driven by different factors as shown by Table2. 1. Relative importance of a particular stage or factor towards contributing to total PHLs will vary across countries and commodities. For instance, estimating losses for a sophisticated, vertically integrated supply chain will likely require consideration of fewer factors than for a less integrated supply chain. Among the existing conceptual frameworks for evaluating PHL, the one by Aulakh *et al.* (2013) is considered more relevant and therefore provided the conceptual anchor for the study.

According to Aulakh *et al.* (2013), food losses in developed countries occur primarily at the consumer level, although some losses occur on the fields after harvest or at other stages of the supply chain. In contrast, losses in developing countries like Nigeria occur mostly during the harvest to market stages, with the smallest share of losses occurring at the consumer level. Thus, this paper focused on evaluating determinants of post-harvest food losses between harvesting and sales levels. In evaluating the factors affecting PHLs, Aulakh *et al.* (2013) adopted a functional approach by identifying critical factors responsible for PHL at each stage of food supply chain. These factors as illustrated by Aulakh *et al.* (2013) are summarized by Table 2. 1. With the use of Aulakh *et al.* 2013 conceptual framework, thelosses at different stages of Food Supply Chain can be determined by different factors as variables. The estimated parameters can then be used to obtain losses or to project future losses. For empirical estimation total PHL at any post-harvest stage for a given commodity and region is the sum total of food losses occurring at each stage of the food supply chain (Table 2.1).

Total PHL = Sum of PHL at each stage of the food supply chain

Mathematically expressed as:

$$\text{Total PHL} = \sum S_i = \sum f(X_j) \quad \ldots\ldots (1)$$

Where ‘Si’ stands for the losses in each critical stage of FSC (Food Supply Chain).

‘Xj’ stands forthe factors affecting losses at each stage and ‘i’ represents critical stages from harvesting to sales.

$$S_i = \sum f(X_j) \quad \ldots\ldots (2)$$

The equation (2) on the right hand side represents post-harvest losses at particular stage in the food supply chainand on the left hand side represents all the measurable factors which contribute to these losses.

Review of Relevant Literature

Postharvest Losses (PHLs) are losses that occur at the time of harvest, through various post-harvest operations on farm to the first level of market. Atanda *et al.* (2011) examined the various concepts of postharvest food losses, the importance of perishable crops, causes of food losses, environmental consideration and its influence on food losses. The authors also sought solutions to some of the identified problems. They identified factors contributing to food losses. These include the initial quality of the crop, mechanical injury, temperature, storage atmosphere, genetic factors and environmental influence. In order to minimize the problems, the appropriate agricultural techniques such as extending shelf-life of crops must be put in place. There should be proper management of temperature, humidity and effective methods for preventing the losses. They concluded that management of postharvest losses require a commitment to an integrated approach, involving numerous organizations, including local communities and groups.

Folayan J.A. (2013) in his study estimated factors that were responsible for post- harvest losses of maize in Akure North Local Government Area of On do State. The results of the study indicated that majority of the farmers in the study area had access to and obtained extension messages from extension agents. Major problems faced by them were inadequate finance, insect pest attack, high cost of transportation and price instability, among others. Results of the study showed that gender, source of information and type of storage facilities were some of the determinants of postharvest losses in the study area. The author recommended that efforts to reduce postharvest losses in maize should therefore be directed at providing appropriate information on postharvest handling of maize and to facilitate access to appropriate storage facilities for maize.

According to estimates provided by the African Postharvest Losses Information System (APHLIS), physical grain losses (prior to processing) can range from 10 to 20 percent. However, they are still too high to be ignored. For instance in Eastern and Southern Africa alone, based on APHLIS estimates, they are valued at US$1.6 billion per year, or about 13.5 percent of the total value of grain production (US$11 billion). There are no similar regional weight loss estimates available for grains in Central or West Africa except for anecdotal estimates. However, assuming losses of a similar magnitude, the value of PHL losses in SSA could potentially reach nearly US$4 billion a year out of an estimated annual value of grain production of US$27 billion (estimated average annual value of production for 2005–07) (World Bank, 2011).

In terms of PHL estimate, World Bank (2011) in its report titled the "Missing Food" estimated that currently, 1 out of every 5 kilos of grain produced in Sub Saharan Africa (SSA) is lost to pests and decay. This loss in food crops is enough to feed 48 million people for 12 months and is valued at around $4 billion or half annual grain imports to Africa. This means that a reduction in grain losses could have an immediate and significant impact on people's livelihoods. Additionally, due to the fact that grains form a major part of the staple food of the sub-Saharan region, it is important to address food security concerns and one of such is appropriate control steps to prevent post-harvest food-grain losses. Nevertheless, while government is strategizing on how to reduce post- harvest losses particularly for food-grains in Nigeria, little is known about the extent of the losses and factors that characterize the losses. It is necessary to understand the factors that determine the losses so as to create opportunity to increase investments for reducing the losses at each node along the food-grain supply chain.

METHODOLOGY

Nature, and Sources of Data.

The study has utilized cross-sectional data obtained from the survey of sample of growers, processors and marketers of rice, maize and cowpea through separate interview conducted with pre-tested and structured questionnaires. The data collected from the actors at various stages of the grain supply chain included causes of post-harvest food losses, factors affecting post-harvest food crop losses, extent of post-harvest food crop losses by farmers, marketers and processors as well as socio-economic variables of farmers, processors and marketers. These included age, sex, household size, educational background and man days of lab our.

The selected crops for the study were from the basic food crops that are strategic to meeting the food security objective of the country. The crops were chosen based on their characteristics as staples and the fact that they are cultivated across the geo-political zones in Nigeria. States were equally selected to capture geo-political representation. Sampling approach followed a multi-stage sampling technique. The first stage is the selection of states. The second stage was the selection of locations noted for the production of particular crops in the selected states while third stage involved the selection of respondents. Marketers and processors were identified and selected through their association. In terms of sampling size, 100 farmers were selected from each state and additional 25 selected from FCT making a total of 625. In addition, a total of 525 marketers and175 processors were selected across the states for the study.

Method of Analysis

The data were analyzed using econometric methods of analysis. Descriptive and inferential statistics such as means, frequency counts, as well as percentages were also used. Estimation of food-grain losses at each stage of the supply chain was done. Estimate of food losses at the farm level, losses in transit through marketing and losses at processing level were obtained.

The empirical model is stated as follows:

Total PHL=$\sum S_i = \sum f(X_j)$; i = 1…. . n …………………….. (1)

Where 'S_i' stands for the losses in each critical stage of food supply chain (FSC); 'X_j' stands for the factors affecting losses for each activity, and 'i' represents critical stages along the food supply chain. For this study, these stages have been grouped into farm, processing and marketing.

An econometric analysis was carried out to examine the factors affecting post-harvest food-grain losses at each node of the food supply chain for each of the selected crops. The functional model follows a multiple linear regression procedure, implicitly stated as follows:

$Y = \infty + \infty_i X_i + ei$

Where 'Y' represents the dependent variable (proportion of food crop losses), 'X_i' stands for the independent variables ranging from 1 to n, '∞_i' stands for parameter estimates and ei represents random error term. The model is explicitly stated in equations 2, 3 and 4 for farm, processing and marketing levels. The farm level model is as follows:

$Y_F = \alpha_0 + \alpha_1 X_1 + \alpha_2 X_2 + \alpha_3 X_3 + \ldots + \alpha_{15} X_{15} + e_1$-------------(2)

Where

Y_F = Proportion of on-farm food crop losses (%)
X_1= Age of respondents in years
X2 = Sex of the respondents
X_3 = Household size
X_4 = Educational status of the respondents (Dummy'1' for educated, '0' for not educated)
X_5 = Farm size (ha)
X_6 = Total quantity of the crop harvested (kg)
X_7 = Level of operation (Dummy '1' for large scale commercial, '0' otherwise)
X_8 = Harvesting done by children (Dummy '1' for Yes, '0' otherwise)
X_9 = Harvesting done by hired labour (Dummy '1' for Yes, '0' otherwise)
X_{10} = Method of harvesting (Dummy '1' for mechanized, '0' otherwise)
X_{11} = Length of stay on the field after harvesting (weeks)
X_{12} = Distance from farm to store (km)
X_{13} = Length of time of storage before sales (weeks)
X_{14} = Technique of harvesting, which takes the value '1' if modern and the value '0' otherwise.
X_{15} = Labour dummy, which takes value '1' if harvesting was done by hired labour and value '0' otherwise
e_1 = Random error term

At the processing level, the explicit regression model is:

$Y_P = \partial_0 + \partial_1 P_1 + \partial_2 P_2 + \partial_3 P_3 + \ldots\ldots + \partial_9 P_9 + e_3$…
……………. (3)

Where

Y_p= Proportion of food crop losses (%) at processing level
P_1= Sex of the respondents
P_2= Educational status of the respondents (Dummy'1' for educated, '0' for not educated)
P_3= Source of supply of crop (Dummy '1' for self-produced, '0' otherwise)
P_4 = Quantity of crop purchased (kg)
P_5 = Scale of operation of the business (Dummy '1' for wholesale, '0' for retail)
P_6 = Length of storage before marketing (weeks)
P_7 = Distance from source of supply to market (km)
P_8 = Distance from store to market (km)

P_9 = repackaging (Dummy '1' for Yes, '0' for No)
P_{10} = Traditional post harvest management technique (Dummy '1' for Yes, '0' for No)
P_{11} = Chemical post harvest management technique (Dummy '1' for Yes, '0' for No)
e_2= Random error term

The explicit equation at the marketing level is as follows:

$$Y_M = \beta_0 + \beta_1K_1 + \beta_2K_2 + \beta_3K_3 + \ldots \beta_{11}K_{11} + e_2 \ldots\ldots\ldots\ldots\ldots (4)$$

Where

Y_M= Proportion of food crop losses (%) at marketing level
K_1= Sex of the respondents
K_2= Educational status of the respondents (Dummy'1' for educated, '0' for not educated)
K_3= Source of supply of crop (Dummy '1' for self-produced, '0' otherwise)
K_4 = Quantity of crop purchased (kg)
K_5 = Scale of operation of the business (Dummy '1' for wholesale, '0' for retail)
K_6 = Length of storage before marketing (weeks)
K_7 = Distance from source of supply to market (km)
K_8 = Distance from store to market (km)
K_9 = repackaging (Dummy '1' for Yes, '0' for No)
K_{10} = Traditional post-harvest management technique (Dummy '1' for Yes, '0' for No)
K_{11} = Chemical post-harvest management technique (Dummy '1' for Yes, '0' for No)
e_2= Random error term

Different variants of the model were estimated and double-log functional form was selected as lead equations for interpretation. This was based on the sign, size and significance of estimated parameters.

RESULTS AND DISCUSSION

Post-Harvest Grain Losses at Different Levels

The proportion and quantity of food-grain losses were shown for farmers, processors and marketers in Table 4. 1. Losses at farm level were highest for cowpea (30. 7%) and lowest for rice (21. 6%). In the processor category, cowpea processors had the highest share of loss (39%), while maize processors had the minimal share of 20 percent. Among the marketers, rice marketers had the highest share of losses (13. 4%) than other marketers. In terms of quantity, rice farmers recorded the highest magnitude of losses (1,696kg) among the farmers at the farm level. Although cowpea farmers had a higher proportion of losses than other farmers, the magnitude of loss in kilogram was relatively small (258kg), this could be explained by the fact that cowpea farmers had the least output.
At processing level, rice processors recorded the highest quantity of losses with average loss of 25,837kg underscoring the challenges of processing that have been attributed to the crop. At each level, the proportion of loss incurred was accounted for by different activities. Table 4. 2 presented the food-grain losses at the farm-level. Maize, rice and cowpea suffered higher proportion of loss during harvesting and on-farm storage than any other level of farm activities. Maize and cowpea incurred more loss at the point of storage. Losses at the point of harvesting can be explained by the preponderance of traditional harvesting methods.

About 95 percent of farmers used traditional hand tools such as hoes, knives, cutlasses, sickles, and hand forks. Only about 4. 5 percent of farmers used mechanized or combined methods of harvest. Most farmers (55%) equally utilized open fields as their on-farm storage facility underscoring the susceptibility of crops to further losses during storage. Winnowing and transportation also represented a crucial node where losses were recorded especially for cowpea. Transport as an activity accounted for about 3 percent of losses incurred by cowpea farmers. Other technical activities sequel to harvesting, cleaning, drying, threshing and winnowing together accounted for a total of 8. 7, 9. 7 and 14. 9 percent in maize, rice and cowpea respectively. Food-grain losses at processing level were mainly at the points of storage, transportation and packaging. Storage was the most problematic and accounted for the highest proportion of loss (6. 63%) for all selected grains as shown in Table4. 3. Transportation ranked second (4. 4%) and is closely followed by packaging (3. 8%). In the case of rice, processors lose more at the point of processing than at any other stages of the activities. The loss at this point was as high as eight percent of the quantity of the commodity processed.

Cowpea processors suffered the highest proportion of loss at storage than at any other processing activities (transportation, packaging and processing). The problem of losses from storage experienced by processors is closely linked with the challenge of insufficient processing capacities for crops, specifically rice and the inefficient packaging methods used for cowpea. Timely and efficient processing of crops can reduce potential losses from storage. Conversely, insufficient processing facilities will mean more storage time in raw form and increased potential losses. In addition, inefficient processing methods will also aggravate losses at the processing point. Losses at the marketing stage arise from storage (2. 17%), transport (2. 07%) and packaging (1. 5%). Cumulatively, losses from storage and transport as well as packaging and repackaging form about 5. 7 percent of the losses experienced at the marketing stage. The distribution of losses across marketing activities is as shown in Table 4. 4

Determinants of Post-Harvest Grain Losses at the Farm Level

On the aggregate, six variables were statistically significant factors that affected Post-harvest food-grain losses at the farm level. These included sex of the farmer, level of commercialization, harvesting by hired labour, length of stay on the field after harvesting, distance from farm to the store, as well as the use of traditional post- harvest management techniques. The positive sign on the coefficient of the length of stay on the field after harvesting shows increasing length of stay on the field after harvest will lead to an increase in postharvest losses at the farm level. Three variables, sex of respondents, the use of children for harvesting as well as length of stay on the field after harvesting significantly and positively affected post- harvest loss for maize. The results imply that the longer maize stays on the field after harvesting, the more the postharvest food loss in maize. In the case of rice, the use of traditional and chemical post-harvest management techniques positively and significantly affected post- harvest loss in rice. While traditional post- harvest management techniques may not be effective in curbing farm-level loss, wrong application or the use of adulterated chemical may equally render the techniques ineffective.

Table 2. 1. Factors Affecting Post-Harvest Losses at Critical Stages of the Food Supply Chain.

Critical Stages of Food Supply Chain(S_i)	Factors Affecting Post-Harvest Losses(X_i)								
	Moisture	Weather	Pest/ diseases	Infrastructure	Size of Operation	Level of Mechanization	Quality of Management	Operator Characteristics	Access to Capital
Harvesting	X	X	X		X	X	X	X	X
Food Storage	X	X	X	X	X	X	X	X	X
Processing	X	X	X	X	X	X	X	X	X
Packaging				X	X	X	X	X	X
Sales				X	X		X	X	X

Source: Aulakh *et al.* (2013)

Table 4.1. Proportion and Quantity of Post-Harvest Losses of Food-Grains

	Average Loss (%)				Average Quantity of Loss(Kg)		
Crop	Farmers	Processors	Marketers	Total Loss	Farmers	Processors	Marketers
Maize	23.1	19.7	8.8	32.3	752	6,040	8,799
Rice	21.6	23.7	13.4	38.8	1,696	25,837	8,381
Cowpea	30.7	38.5	6.8	36.2	258	797	4,447

Source: Field Survey 2014.

Table 4.2: Proportion of Food-grain Losses Due to Farm Level Activities

	Proportion of Loss (%)			
Farm Activities	Maize	Rice	Cowpea	Average For All Crops
Harvesting	5.7	6.9	5.9	6.17
On-Farm Storage	6.9	3.4	7.2	5.83
Transportation	1.8	1.6	2.7	2.03
Drying	3.1	3.1	4.5	3.57
Threshing	3.3	3.8	4.2	3.77
Winnowing	2.3	2.8	6.2	3.77
Total	23.1	21.6	30.7	25.13

Source: Field Survey, 2014.

Table4.3. Proportion of Food-Grain Losses Due to Processing Activities

	Average Loss (%)			
Processing Activities	Maize	Rice	Cowpea	Average for All Crops
Transportation	3.2	3.5	6.5	4.40
Processing point	3.7	8.0	1.5	4.40
Packaging	2.5	2.1	6.8	3.80
Storage	5.0	4.5	10.4	6.63
Total	14.4	18.1	25.2	19.23

Source: Field Survey, 2014.

Table 4.4: Proportion of Food grain Losses Due to Marketing Activities

	Average Loss (%)			
Activities	Maize	Rice	Cowpea	Average for All Crops
Transportation	2.0	3.0	1.2	2.07
Packaging/Re-packaging	1.5	1.4	1.6	1.50
Storage	2.2	2.9	1.4	2.17
Total	5.7	7.3	4.2	5.73

Source: Field Survey, 2014.

For cowpea, the use of children for harvesting, the long distance of farm to store as well as the use of traditional management techniques positively and significantly affected post- harvest loss at farm-level.

Determinants of Post-Harvest Grain losses at processing level

The results presented in Table 5. 2 show that only the scale of operation was significant on the aggregate. This means that the losses incurred by the large scale processors were very significant when compared to the small scale and the higher the scale of operation, the higher the losses. This assertion was particularly true for rice as the variable positively and significantly affected post- harvest loss in rice at the processing level.

For cowpea, quantity purchased and the use of traditional management techniques positively and significantly affected post- harvest losses. The influence of the quantity processed is similar to that of the scale of operation as large processors are likely to handle larger quantity than the small scale.

Determinants of Post-Harvest Food-grain Losses at Marketing Level

At marketing level, two variables were found to have significant effects on post- harvest losses as indicated in the result of the aggregate data. They included length of storage before marketing and quantity of food-grains purchased. The longer the length of storage and the higher the quantity of food-grain purchased by the marketers, the higher the losses incurred.

Table 5.1. Factors Affecting Post- Harvest Food Grain Losses at Farm Level

Variables	Aggregate	Maize	Rice	Cowpea
Constant	-3.37	24.64	14.31	-16.12
	(-0.52)	(3.24)	(1.12)	(-1.30)
Sex	9.91**	6.31**	2.76	3.44
	(5.18)	(2.94)	(0.66)	(0.83)
Household size	-0.46	0.40	0.88	-0.42
	(0.46)	(0.18)	(0.48)	(0.21)
Educational status	1.76	2.11	6.07	1.94
	(0.89)	(0.76)	(1.49)	(0.47)
Farm size	1.45	0.30	-2.94	4.27
	(1.08)	(0.15)	(0.96)	(1.48)
Quantity harvested	0.00	0.00	0.00	-0.00
	(0.64)	(0.09)	(0.36)	(0.54)
Level of commercialization	3.43*	-0.60	1.19	3.88
	(1.76)	(0.23)	(0.27)	(0.94)
Harvesting by children	2.28	10.10**	1.93	12.68**
	(1.23)	(4.42)	(0.44)	(3.20)
Harvesting by hired labour	6.12**	0.97	0.00	4.65
	(3.55)	(0.35)		(1.03)
Length of stay on the field after harvesting	1.77*	4.30**	-2.64	-0.87
	(2.30)	(3.94)	(1.18)	(0.56)
Distance from farm to store	0.41*	-0.43	-0.25	0.83*
	(1.93)	(1.13)	(0.50)	(2.01)
Use of traditional post-harvest management technique	6.62**	1.45	16.24**	10.17**
	(4.22)	(0.80)	(4.93)	(2.66)
Use of Chemical post-harvest management technique	4.12	3.34	18.67**	3.57
	(0.67)	(1.40)	(6.04)	(0.87)
Adjusted R^2	0.51	0.48	0.46	0.40

Source: Field Survey, 2014. Figures in parenthesis are the t-values. * Significant at 10%, ** significant at 5%

Table 5.2 Factors Affecting Post-Harvest Food Grain Losses at Processing Level

Variables	Aggregate	Rice	Cowpea
Constant	16.02	6.43	11.24
	(2.86)	(0.36)	(1.08)
Sex	-0.16	2.85	-2.25
	(0.07)	(0.46)	(0.50)
Educational status	-4.19	-8.71	3.40
	(1.49)	(0.99)	(0.65)
Source of raw materials	-1.35	5.02	-7.27
	(0.66)	(0.63)	(1.49)
Scale of operation	8.35 **	28.92 *	3.95
	(2.67)	(2.45)	(0.54)
Distance from raw material source to factory	0.49	2.11	1.05
	(0.33)	(0.39)	(0.38)
Distance from factory to store	-1.05	0.25	-2.80
	(-0.57)	(0.03)	(1.15)
Length of stay of crop in store before processing	-1.33	-0.48	0.77
	(1.15)	(0.14)	(0.32)
Quantity purchased	-0.001	0.001	0.001*
	(0.15)	(0.10)	(2.11)
Traditional management technique	-0.13	-21.62	8.73 *
	(0.92)	(1.64)	(1.76)
Chemical management technique	-1.62	6.82	-
	(0.41)	(0.34)	
Adjusted R^2	0.29	0.37	0.31

Source: Field Survey, 2014. Figures in parenthesis are the t-values. * Significant at 10%, ** significant at 5%

Meanwhile in the maize equation, sex of respondents, distance from supply source to the store, distance from the store to the market, quantity purchased and the use of chemical post-harvest management techniques were found to make positive and significant contribution to Post-harvest loss. The positive contribution of chemical post- harvest management techniques may be due to inappropriate or inadequate use of chemical for pest control. The positive effect of the source of supply may be explained by the difficulty encountered by marketers arising from distance to the source, poor rural and feeder road as well as inadequate means of transportation to the sources of supply of food products. In the rice equation, inappropriate packaging and re-packaging contributed positively and significantly to Post-harvest loss, while appropriate and adequate application of chemical management techniques to PHL reduced losses significantly among the marketers. Quantity purchased as well as the use of traditional post- harvest management techniques contributed positively to Post-harvest loss among the cowpea marketers.

Policy Implications

Length of stay of food-grains on the field after harvesting is an important factor that should be managed properly by the actors at the various stages of the food supply chain. This variable, if not properly controlled and reduced at the farm level, it may expose food-grains to invasion and destruction by the cattle of migrating Fulani herdsmen that move their animals indiscriminately for free grazing land.

Table 5.3. Factors Affecting Post- Harvest Food Grain Losses at Marketing Level

Variables	Aggregate	Maize	Rice	Cowpea
Constant	10.07	4.65	26.27	-0.99
	(0.31)	(1.03)	(3.01)	(0.19)
Sex	0.37	6.88**	-2.07	0.24
	(0.31)	(3.85)	(0.53)	(0.14)
Educational status	1.81	-3.43	-3.50	1.55
	(1.28)	(1.41)	(0.68)	(0.71)
Source of supply	-1.86	5.34*	-1.56	-0.55
	(1.06)	(1.88)	(0.26)	(0.16)
Level of operation	0.59	2.82	-5.84	-0.86
	(0.48)	(1.44)	(1.52)	(0.43)
Length of storage before marketing	0.94	0.52	0.77	0.21
	(2.22)*	(0.80)	(0.52)	(0.25)
Distance from source of supply to store	-0.40	3.39**	0.11	0.94
	(0.74)	(4.08)	(0.07)	(0.94)
Distance from store to market	0.06	3.02**	0.11	0.94
	(0.09)	(3.05)	(0.07)	(0.94)
Repackaging	1.55	0.69	10.08**	3.16
	(1.25)	(0.39)	(2.75)	(1.31)
Quantity Purchased	0.001*	0.001**	-0.00	0.001*
	(2.14)	(3.33)	(1.12)	(1.63)
Use of traditional post-harvest management technique	-0.03	2.72	3.52	5.81*
	(-0.02)	(1.21)	(0.79)	(2.40)
Use of Chemical post-harvest management technique	-0.46	4.78*	-10.84*	-1.46
	(0.27)	(2.32)	(1.76)	(0.55)
Adjusted R^2	0.44	0.59	0.68	0.43

Source: Field Survey, 2014. Figures in parenthesis are the t-values. * Significant at 10%, ** significant at 5%

In the Northern part of the country, the animals have caused massive destruction of farms and farm products particularly food-grains that stayed on the farms for a long time. Enactment of anti-grazing law in some state such as Benue may be ineffective in reducing food-grain losses in the absence of alternative means of grazing for the animals of Fulani herdsmen. The current relocation of about ten million cows from Benue to Nasarawa State in the country arose from implementation of anti- grazing law in Benue State. This has resulted into improper harvesting of rice by the farmers under the fear of farm destruction in Nasarawa State thus aggravating the food-grain losses. Again, prolonged stay of grains on the field after harvesting as a form of traditional method of storage could expose the grains to the attack of rodents and insect pests which would ultimately contribute to more losses. At the processing node, increased losses was associated with expanded scale of operation particularly with respect to rice. The implication is that grain loss increases with the level of commercialization.

This may be connected with failure associated with adoption of improved technologies of processing. The failure is often ascribed to breakdown of machines, lack of spare parts and poor maintenance of processing machines. Other reasons included investments that are financially unsustainable; misidentified constraints such as focusing on improved storage while the economic incentives are missing; as well as lack of cultural acceptability. This imposes a constraint on capacity to develop the value chain of food-grains. This would necessitates training of actors at the processing node to achieve optimal efficiency and exploit fully the benefits of high processing technology. At the marketing node, an observation with significant policy relevance is the positive effect of the source of supply and distance of the source of supply to the market and store onfood-grains losses. The effect is due to the difficulty encountered by marketers arising from difficult terrain covered to reach the source of supply.

This is implicated by poor rural and feeder road as well as inadequate means of transportation available for the use of marketers to reach the sources of supply of food products. Most of the rural roads that lead to villages from the urban centres in Nigeria are terribly bad while bridges on the roads have collapsed thus constraining access to the villages and communities by the marketers. The only means of accessing the villages and rural communities that are very far away to all-weather road is by motorcycle or bicycle and the cost is exorbitant. This means that rural roads that connect villages to villages and villages to urban centres will facilitate movement of farm products especially food-grains from source of supply to the market, thereby ensuring effective market linkage which in turn would create effective demand and reduce post-harvest losses of food-grains. Additional benefits of good network of rural roads is the linkage of source of supply to agro-industry for value addition and transformation of primary products to high-valued final and semi-final products. Hence, effective network of rural roads will bring about efficient diversification of farm produce to emerging agro-based manufacturing and processing factories in the country which in turn would create potentials for generating diversified income and employment.

Policy Recommendations

Market opportunities to enhance access to markets and agri-business development

Creating market opportunities for small scale actors and agri-business development is an important government intervention for reducing post -harvest losses of food-grains in the country. This can be achieved through investment in rural infrastructure and processing infrastructure. Hence, domestic manufacture of processing machines with high technology should be encouraged. This is expected to facilitate linkage of production of food-grains to meet market demand through efficient postharvest processing and value addition largely in use by key stakeholders.

Effective network of rural road, efficient and affordable drying and storage facilities will help to reduce severe imperfections associated with the markets which would in turn bring about reductions in food-grain losses by creating appropriate opportunities to improve access to existing input and output markets and create new market linkages for domestic grain production and trade. Also it is necessary to promote warehouse receipt systems and build capacity of stakeholders in grading, branding, labelling and packaging. Marketing cooperatives should be encouraged among small scale actors in the food-grain production areas. Such organizations are especially needed in the country because of the relatively small farm size. This will allow the actors to exploit fully the advantages of marketing cooperatives. These include providing central accumulation points for the harvested commodity, purchasing harvesting and packing supplies and materials in quantity, providing for proper preparation for market and storage when needed, facilitating transportation to the markets, and acting as a common selling unit for the members, coordinating the marketing program, and distributing profits equitable.

Intervention in the area of storage facilities is very important. Government may choose to invest in, or facilitate ownership and management of these facilities by individual private investor. The manufacturing industry is equally expected to be responsive to the right type of technology for packaging food crops beyond the traditional approach of bags.With increasing level of commercialization government will have to strengthen the measures to mop up surplus production by farmers. Alternatively, average size silos and improved storage bags for grains and access to ventilated storage facilities should be provided at subsidized rate. While an effective monitoring framework should be put in place for effective implementation. Transportation is a crucial node where urgent intervention is required. Poor road conditions are issues for government attention while appropriate vehicles in use for transporting agricultural produce are issues for private transport operators. Development of rural and feeder roads should be priority attention of government. Regarding the long period of stay on the farm after harvesting of food-grains, the farmers should be trained on how to prevent the overstay of the food-grain through the useof the modern and simple storage technologies such as triple bagging storage technology while provision of alternative grazing land for the migrating Fulani herdsmen will reduce destruction of crops that stayed on the farm after harvesting.

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