NIGERIAN AGRICULTURAL JOURNAL
ISSN: 0300-368X
Volume 55 Number 1, April 2024 Pg. 125-132
Available online at: http://www.ajol.info/index.php/naj
https://www.naj.asn.org.ng

Analysis of Efficiency between Traditional and Modern Maize Storage Techniques among Farmers in Savanna Nigeria

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Abstract

The survey was carried out to compare the efficiency of traditional and modern maize storage techniques among farmers in guinea and derived savanna, Nigeria. A multistage sampling procedure was used in the selection of 400 active maize farmers, consisting of 200 respondents for each of the storage techniques in the off season of 2022 planting season. Copies of a well-structured questionnaire and Focus Group Discussion (FGD) were used to collect the cross-sectional data used for the study. The average socio-economic variable results revealed age (47 years), farming experience (25 years), years of education (6 years) and household size (12 members). Silos and rhombus were identified as more prominent modern and traditional storage equipments respectively. Traditional storage facility was found to be more efficient than the modern type with the efficiency ratios of 0.72 (72%) and 0.64 (64%) respectively. The quantity of maize stored annually was significantly influenced by the quantity of maize harvested and years of experience. It is recommended that more awareness be created for farmers to adopt modern storage technique, despite its relative inefficiency.

Keywords: Farmers, Maize, Multiple Regression, Storage Techniques, Savanna Nigeria

Introduction

Storage of farm produce, most especially cereals, remains a major challenge confronted by farmers at all levels of farm production in the sub-Sahara Africa. The inability of farmers to sell at a later date with fair price is not unconnected with their inability to store farm outputs and retain the quality and quantity that can enhance better pricing and subsequent increased revenue generation. Smallholder farm households throughout the developing world often sell substantial portions of their staple crop output immediately after harvest, a time when prices are low, only to repurchase the same staples later in the year at higher prices (Tsegab & Emana, 2023).

Post-harvest losses are high in developing countries due to insufficient and ineffective storage structures and poor handling practices. As a result, identifying post-harvest grain management and handling practices is critical for a variety of reasons, including food security (Befi-Kadu, 2019). Smallholder farm households throughout the developing world often sell substantial portions of their staple crop output immediately after harvest, a time when prices are low, only to repurchase the same staples later in the year at higher prices. Among the key constraints to improving food security in Africa are losses resulting from poor post-harvest management of grains, estimated at 20-30%, amounting to more than US$4 billion annually (FAO, 2010). Some of these losses are caused by insects and fungi, with the speed at which these multiply being influenced by prevailing environmental conditions (Nukenine *et al*., 2010).

Cereal crops play a major role in smallholder farmers' livelihoods in sub-Saharan Africa (SSA), with maize, *Zea mays L*., being the most important food and cash crop for millions of rural farm families in the region. In spite of the importance of maize in the region, grain yields are generally <1.0 t/ha, representing some of the lowest in the world (Cairns *et al*., 2013). This, combined with the high human population growth rates, results in a widening gap between food supply and demand, consequently aggravating the chronic food insecurity in SSA, with one in every four people estimated to be undernourished (FAO, 2013). Cereals and legumes mainly known as grains constitute the most vital diet component for the majority of people in the world (Duranti, 2006; Rajashekar *et al*., 2016) providing the calories and proteins consumed by the resource-poor and provide the rural folks with employment and sustainable source of income.

Post-harvest losses due to lack of efficient storage facilities has made it difficult for many farmers in the sub-Sahara Africa to survive in their farm profession. Diverse challenges are faced from one stage to another in the process of keeping their farm products intact both in quality and quantity terms. Pests, diseases, and some other biotic organisms are deterrents to keeping farm produce shelf life long and even out the materials for sale when the market ruling price favourable to earn good return on investment(ROI). In this connection, Entomology literature focuses on quantity losses in storage due to mold, insects, and other pests as the reason smallholders do not store more grain at harvest. Insects such as the larger grain borer (LGB) are prevalent across much of Africa and Asia and can reportedly cause losses of up to 30% in maize after six months of storage (Affognon *et al*., 2015; Boxall, 2002; Golob, 2002). Faced with high rates of potential losses, selling maize at harvest may be an optimal strategy to avoid losses due to pest damage. Although some empirical evidence from Kenya, South America, and Ethiopia indicates that modern storage technologies such as hermetic (airtight) bags, metal silos, and/or chemical protectants may reduce losses from insect damage and thereby improve households' food and income security. However, access to these technologies is severely limited, particularly in sub-Saharan Africa (Bokusheva *et al*., 2012; Gitonga *et al*., 2013, Tesfaye and Tirivavi), 2018). Lack of access to effective storage technologies may prevent smallholder households from storing grain at harvest for consumption or sale later in the year. Yet, Kaminski and Christiaensen (2014) use nationally representative data from smallholder households in three countries in SSA (Malawi, Uganda, and Tanzania) and find that many smallholder farmers believe their postharvest losses (PHLs) are small (between 1.4% and 5.9% of self-reported quantity produced is reportedly lost in storage).

To reduce post-harvest losses, common types of grains storage structures found in Africa include mud rhombus, thatched rhombus, in-hut storage (such as earthen pot) and warehouse storage which are prominently found in the Sudan savanna region of Nigeria include (Adejumo *et al*., 2007). These grain storage methods are also common in Cameroon and many rural areas of most African countries. Nigerian Stored Products Research Institute (1982), in line with her recommended procedures for grain storage, has also developed an inert atmosphere silo for grain storage. Other notable indigenous grain storage techniques practices include the open stack method, Kihenge, Kichanga, reli and Dari commonly found in Kenya, Zimbabwe, and Tanzania(Nwaigwe, 2019; Schmidt *et al*., 2019). These traditional storage structures which are commonly used in Nigeria and some other parts of West Africa are rhombus, cribs, women basket or open lid, communal warehouse, farm stores with rodent guards. The modern storage technology for grain is the silos, which have a large capacity to contain a high quantity of farm produce (Okoruwa *et al*., 2011; Adejumo and Raji), 2007).

Arising from the foregoing, literature has evidently established that farmers lose much of their farm produce both in quality and quantity terms due to biotic and abiotic organisms. Farmers may be referred to as being conservative but with their traditional knowledge, from the time immemorial, they had been reducing post-harvest losses in terms of building traditional storage facilities. However, modern technologies are also available which in many cases may be centrally installed for many farmers' use, but some may be built by farmers with large farms who have more yields. This study seeks to investigate the efficiency differential between the use of modern and traditional technology in the storage of maize in the guinea and derived savanna vegetation belts of Nigeria.

Numerous studies had been done on method of storage of farm produce, most the cereals, but scanty information is available on the comparing different storage techniques and by extension relating them in terms of individual farm efficiency. However, empirical information will be provided through this study and such will have potent policy formulation and economic planning. The specific objectives for the study are to describe the socio-economic characteristics of the farmers; identify different types of storage technologies commonly used by the farmers, estimate the efficiency differentials of modern and traditional storage facilities used by the farmers. Identify factors influencing quantity of products stored by the respondents, and also examine the perceived challenges militating against grain storage in the study area.

Materials and Methods

Study Area

Nigeria is a country in West Africa which occupies 923,768 km^2 of land. It comprises the major regions; South South and the North, and this is disaggregated into six distinct zones, namely; South West, South East, South South, North West, North Central and North East. Nigeria is located between latitude 4^{0}N and 14^{0}N of the equator and between longitude 3^{0}E and 15^{0}E of the Greenwich meridian. The country is bordered in the North by Niger Republic and Chad Republic, in the East by Cameroon, in the West by Benin Republic; and in the entire South by the Atlantic Ocean. According to the National Population Commission (2006), it has a population of about 140million. The land of Nigeria covers an area of 910,768km^2 while the remaining is dominated by water, the total land boundary is 4,047km and the coastline is about 853km. In the area of land use, arable land is 31.29%, irrigated land is 2,330km^2 and permanent crop occupy an area of 2.96% of the national land area. The average annual temperature and rainfall are 24^{0}C and 1,165.0 mm respectively, according to NiMET (2018). The entire land space of the country is disaggregated into vegetation belts from the South to the North in the order of Mangrove Swamp, Rainforest, Guinea Savanna, Derived Savanna, Sahel Savanna, Sudan Savanna and Montane. Nigeria is an agrarian nation, with about 65% of its population engaging in farming. The rainfall regime in Nigeria is modal in the North and bimodal in the South. Notable crops that survive all vegetation zones in Nigeria are maize, cassava, and yam, amongst others, while many others are specifically adapted to one zone or the other.

Source and Type of Data

Data used in this study was from a primary source and was cross-sectional in nature, given that it was collected at a point in time. The data included the type of storage facilities used by farmers, type of crop grown, length of time crops are stored, and the quantity of agrochemicals used in storing crops. It also included the number of labour used, age of farmer, years of experience, marital status, cooperative membership, number of seasonal extension contacts and farm size, amongst others.

Instruments of Data Collection

Data used for the survey were collected using well-structured copies of questionnaires, which were collected by trained enumerators under the supervision of the author for quality assurance. Excess copies of the questionnaire were made available in order to ensure that the targeted sample was obtained. In the event of any non-cooperating respondents reaching for interview, another available respondent was interviewed to make up for the targeted number designed for the survey.

Sampling Technique

A multistage sampling procedure was used in the selection of respondents for the survey. In the first stage, Guinea and Derived Savanna vegetation zones were purposively sampled due to the weather conditions in the two belts, which favor the production of grains and pulses, which can easily be stored due to their low moisture contents. In the second stage, there was the random selection of two states, one from each of the zones forming two states. Random selection of two local government areas from each of the states comprised the third sampling stage, while random selection of two communities from each of the local government areas amounting to 8 communities comprised the fourth sampling stage. In the fifth stage, 50 farmers were selected from each of the 8 communities, comprising a total sampling size of 200 farmers for each state, which was aggregated to comprise a total sample size of 400 respondents.

Analytical Tools

Descriptive Statistics

The socio-economic and input characteristics and different types of maize storage methods of the respondents were analyzed using descriptive statistics comprising mean, percentages and frequency counts.

Stochastic Frontier Production Function (SPFS)

The stochastic efficiency frontier independently proposed by Aigner, Lovell and Schmidt (1997) and Meeusen and van den Broek (1977) was used for the data analysis. The approach has the advantage that it accounts for the presence of measurement error in the specification and estimation of the frontier production function. The stochastic frontier function differs from the traditional function in that the former approach consists of two error terms. The first error term consists of the existence of Technical Efficiency (TE) and the second accounts for factors such as measurement error in the output variable, weather and the combined effort of unobserved inputs in production. The model is based on the stochastic efficiency model by Parikh and Shar (1994), which in turn was derived from the composed error model of Aigner, Lovell and Schmidt (1977), Meeusen and van den Broeck (1977), and Forsund *et al.* (1980).The frontier production model begins by considering a stochastic production function with multiplicative disturbance term of the form:

$Y=f(X_{ai}\beta)e^{\varepsilon}$ ...1

Where

Y = Quantity of maize stored (in kg)

X_a = Vector of input quantities (in kg and litres)

β = Vector of parameter and

ε = is error term

where $\varepsilon = \nu_i - \upsilon_i$ ...2

The symmetric component, ν, accounts for random variation in output due to factors outside the farm control, such as weather and diseases. It is assumed to be independently and identically distributed as: $N\sim(0,\sigma^2 \nu)$.A one sided component $\nu \leq 0$ reflects technical in-efficiency relative to stochastic frontier, $f(X_{ai}\beta)e^{\varepsilon}$.Thus, $\nu=0$ for a farm output which lies on the frontier and $\nu>0$ for those whose input is below the frontier as $|N\sim(0,\sigma^2 \upsilon|$ i.e. the distribution of ν is half normal.

The frontier of the farm is given by combining equations 1 and 2.

$Y= f(X_{ai}\beta)e^{\nu-\upsilon}$ 3

Measure of production efficiency for each farm can be calculated as:

$TE=\exp.[E\{\nu|\varepsilon\}]$ 4

The Battese and Coelli(1995) single stage model was applied in the efficiency analysis in this study. In this regard, υ in equation 4 is a non-negative random variable which is the efficiency associated with technical efficiency factors in production by the sample farmers. It is assumed that the efficiency factors are independently distributed and that ν arises by the truncation (at zero) of the normal distribution with means μ and variance σ^2, where ν in equation 4 is defined as:

$\nu=f(Z_{bi}\delta)$ 5

Where

Z_b=is a vector of farmer specific factors, and

δ=is a vector of parameters

The β and δ co-efficient in equation 1 and 5 respectively are known parameters to be simultaneously estimated together with the variance parameters which are expressed in terms of:

$\sigma^2 = \sigma \nu^2 + \sigma^2$ and 6

$\Upsilon=\sigma^2/\sigma^2_s$ 7

Where Υ-parameter has a value between zero and one

Model Specification

The empirical stochastic frontier production function was applied in the technical efficiency estimation and the selection of variables of interest were followed Ajibefun and Daramola (1998), Amaza and Olayemi(1998), Thruchelvam (2004), Ogundari and Ojo (2006) and Okoruwa and Ogundele (2008) thus:

$$\text{In}\, Y_{ij=}\ \beta_0 + \beta_1\, \text{In}X_{1ij} + \beta_2\, \text{In}X_{2ij} + \beta_3\, \text{In}X_{3ij} + \beta_4\, \text{In}X_{4ij} + \beta_5 X_{5ij} + V_i\text{-}U_i \quad \ldots\ldots\ 8$$

Where: subscript *ij* refer to the *ith* observation in the *jth* farmer;

In =denotes logarithm to base *e*;

Y = Quantity of maize stored (in tonnes)

X_1= Storage capacity (in m^3)

X_2= Quantity of labour (in man-days)

X_3= Quantity of agrochemicals (in litres)

X_4= Quantity of fuel (in litre)

ε_i = error term

It is assumed that the economic efficiency effects are independently distributed and vij arises by truncation (at zero) of the normal distribution with mean, vij and variance, 0, where vij is defined by equation (9).

The in-efficiency model specified by Battese and Coelli (1993) is as follows:

$$\upsilon_i = \delta_0 + \delta_1 Z_{1ij} + \ \delta_2 Z_{2ij} + \ \delta_3 Z_{3i} \ldots\ldots..\ 9$$

Where

υ_{ij} = In-efficiency model of the *ith* farmer

Z_1=Education (in years)

Z_2= Farming Experience (in Years)

Z_3= Extension contacts (No.)

The β and δ co-efficients are unknown parameters to be estimated, together with the variance parameters (Sigma and Gamma). The parameters of the stochastic frontier function were estimated using the Maximum Likelihood Estimation (MLE) method.

Likert Scale Rating

The five point Likert type scale was used to examine perceived challenges militating against maize processing among the farmers in the study area. These are defined as: 5= Very severe 4= Severe, 3 = Undecided, 2= mild and 1= very mild. The scores were then calculated as follows:

Weighed Score (WS) = 5n + 4n + 3n + 2n + 1n = Total Score for each constraint ….. 10

where n = Frequency of each constraint for each rating.

$$\text{Mean Score (MS)} = \frac{\text{TotalScoreofEachConstraint}}{\text{TotalNumberofRespondents}} \ \ldots\ldots\ 11$$

Rank = Value of the MS was then used to rank the severity of the limitations faced by the respondents.

Results and Discussion

Socio-economic and Input Characteristics of the Maize Farmers

Socioeconomic and input characteristics of the respondents are presented in Table 2. Result of farm size for modern storage revealed a mean of 2.42 hectares, while the mean farm size for traditional storage is 2.7 hectares. It is suggested by this result that farmers using traditional technology have more farmland earmarked for maize production than their counterpart, who uses modern storage technique. Age of the farmers using modern storage facilities was about 46 years, while the age of farmers employing traditional facilities to store their maize was about 49years. The result indicates that farmers using modern method of storing their maize are younger than their traditional storage facilities users. Both ages are still classified as active and productively efficient when their mental and physical efforts are optimally harnessed. Household size of users of modern processors was an average of 6 members, while the size of the traditional storage facilities users is also 6 members. The result shows that both groups of maize farmers are well updated with family planning knowledge, which is advocated from time to time by the Nigerian government for families to procreate the number of members they can adequately cater for. Labour use of the users of modern storage facilities and traditional storage facilities were found to be an average of 231 man-days and 80.9 man-days, respectively. The higher number of labour used under the modern storage technology could be traceable to the high quantity of maize stored per unit time, owing to the fact that modern storage facility can cater for many people, whereas in many cases, traditional facilities cater for a household. Experience of the users of modern facilities outweighs the experience of their traditional user's counterparts with an average of 9.3 years and 15.9 years respectively. The storage capacity of the two groups, modern and traditional technology user under comparison had average of 25132.5m^2 and 2967.5m^2 respectively. It could be inferred from the result that, in many cases, modern facilities are commercial in use, thus, attracting services from many farmers, contrary to the sole use of traditional storage facilities by a household or individual. The quantity of maize stored by the users of modern technology and traditional technology averaged 3598.0kg and 2101.7kg. The size of modern storage facility is bigger than the traditional type both in dimension and capacity, which makes it store more. Quantities of agrochemicals used by the two groups were 10.2lites and 4.2litres with a difference of 6litres. The difference in the average use of fuel between modern and traditional storage users may probably be due to more products stored in the modern storage facility. Average fuel consumption by the modern and traditional storage facilities, users were 123.2litres and 35.3litres respectively, with a difference of 87.9litres. The discrepancy in the consumption of fuel might be due to more activities due to large storage capacity of the modern facilities. Modern facility users were found to be more educated by their traditional user counterpart with the respective age of 8.8 years and 5.3 years. The difference in the years of education might be due to the level of expertise needed in the handling of modern technology. Extension contact was found to be about 5 years for the two categories of users of modern and traditional storage facilities. This result suggests that both groups enjoy extension activities equally.

Different Types of Storage Technologies Used by the Farmers

Table 3 presents the type of storage facilities used by the maize farmers in the study area. The users of silos formed 50.0% of the entire number of farmers. Silo is an example of a modern storage facility with high capacity. It is made of galvanized or metal material which is made air-tight for the efficient performance of any preservative used by the farmers. This, in most cases, can be used on a commercial scale as it contains a large quantity of grains stored therein per unit time. Crib was used by 18.8% of the maize farmers. The facility is fairly big in terms of capacity and more quantity of maize can be stored in it. Rhombus is used by 16.3% of the maize farmers. It is a cylindrical structure that is made of clay and covered with thatched or corrugated iron sheet. It is placed on a raised platform for aeration underneath. However, rhombus is a traditional storage facility. Granary is a modern storage facility which is has a relatively large chamber for storage of fairly large quantity of maize and it was used by 8.8% of the farmers. Basket was used by 6.3% of the maize farmers in the study area. It is a traditional storage facility which can store small quantity of maize as it has a small capacity.

Efficiency Determination of Maize Farmers under Modern and Traditional Storage Facilities (Technologies)

Results from Table 4 revealed the efficiency under the modern storage facility and traditional facility. Gamma (0.9983) indicates that (1-98.83= 0.0117) of the activities of the storage facility is out of the control of the farmers. Sigma (0.4540***) revealed that the modeled variables were fit and appropriate. Similarly, the result for the traditional storage expressed that gamma (0.9570) indicates that (1-0.9570= 0.043) of the activities relating to traditional storage were outside the control of farmers. Sigma (0.1419***) indicated that variables included in the model were suitable for the analysis. Result from the modern facility indicates that the efficiency variables such as storage capacity, quantity of agrochemicals and quantity of fuel were found to be significant at the conventional levels of 1% and 5%. The inefficiency variables under the use of modern storage facility also revealed that education, farming experience and extension contacts were also found to be significant at 1% and 10% levels. Storage capacity is negatively signed indicating that it decreases the quantity of maize stored. A percentage increase in the carrying storage capacity for maize will lead on the average to 19.97% decrease in the quantity of maize stored. Based on this, it suggests that additional capacity to modern storage capacity will not improve on the efficiency of farmers. Agrochemicals also increases the quantity of maize stored. A percentage increase in the quantity of agrochemicals uses leads on the average to 10.21% increase in the quantity of maize stored using modern technology. It could be inferred from this result that with additional use of agrochemicals and preservatives, there is a tendency that efficiency will increase. The use of fuel also influence the quantity of maize stored positively. Therefore, a percentage increase in the use of fuel leads on the average to 41.49% increase in the quantity of maize stored. The result suggests that with increase in the use of fuel, efficiency in the storage of maize increases. Education is positively signed; this indicates that the continuous use of the variable will reduce the efficiency of farmer. Both the farming experience and extension contacts were found to be negative and increase the efficiency of the modern storage facilities. A percentage increase in farming experience and extension contacts increase the efficiency of maize storage under the modern technology efficiently by 17.29% and 45.85% respectively. This indicates that, with more years experience and extension contacts, efficiency increases in the use of modern storage facilities. Result in the use of traditional technology indicates that storage capacity, agrochemicals and fuel were significant but only storage capacity and fuel were found to positively influence the quantity of maize stored by the farmers. A percentage increase in the use of the storage capacity leads on the average to 72.09% increase in the efficiency of the use of traditional storage facility. This infers that the farmers in the category can go ahead in increasing their size of storage equipment for better performance. Similarly, a percent increase in the quantity of fuel use leads on the average to 10.21% increase in efficiency of farmers under traditional storage arrangement. Education and extension contacts were found to be significant among the modeled inefficiency variable. A percentage increase in the years of education leads on the average to 74.34% increase in the efficiency of traditional storage among farmers. With an additional increase the years of education of farmers, more efficiency is achievable. Similarly, a percentage increase extension contacts leads on the average to 65.34% increase traditional storage efficiency. Therefore, increase in annual extension contacts among farmers will increase the efficiency.

Determinants of the Quantity of Maize Stored by the Farmers

Table 5 presents the Ordinary Least Square (OLS) multiple regression estimates of factors influencing the quantity of maize stored by farmers under modern and traditional storage methods. Result from the modern storage technology showed labour, agrochemicals and fuel as being significant at 1% level. Labour and fuel were found to positively influence the quantity of maize processed. A percentage increase in labour use will on the average leads to 11.36% increase in the quantity of maize processed. Also, a percentage increase in the quantity of fuel used leads on the average to 6.78% increase in the quantity of maize stored, while agrochemicals was found to reduce the quantity of maize stored by 19.99% when it is increased by 1%. Similarly, result from the traditional storage technology revealed labour and agrochemicals were significant at 5% and 10% respectively. Labour increased the quantity of maize stored while agrochemicals also reduce the quantity of maize stored. A percentage increase in labour use leads on the average to 13.16% increase in the quantity of maize stored. With additional labour, more of maize will be stored. Also, a percentage increase in agrochemicals leads on the average to 97.79% decrease in the quantity of maize stored. An attempt to add more of the input will reduce the quantity of maize stored.

Elasticity/Rate of Technical Substitution for Modern and Traditional Storage Methods

Elasticity/Rate of Technical Substitution for modern and traditional storage technology is presented in Table 6. Modern storage technology has elasticity of 0.68 while traditional storage technology has elasticity of 0.83. It could be suggested from this result that both the storage methods operate at the second stage on the production surface. Both methods are at the stage of increasing returns which is where a rational farmer should operate for an optimal performance.

Frequency Distribution of Technical Efficiency among Farmers

Frequency distribution of technical efficiency between modern and traditional storage technology is presented in Table 7. The revealed that 48% of the modern users of modern processing technology fell within the range of 61-70 while there is a cluster of 55.5% within the range of 71-80. The mean efficiency for modern storage technology and traditional storage technology were 0.6432 and 0.7211 respectively. This result suggests that many of the farmers are technically efficient in the performances.

Conclusion

The technical efficiency of the two groups of farmers, that is, under the modern and traditional storage techniques revealed that the latter is technically efficient than the former. Also, the rate of technical transformation revealed that both farmers operated at the optimal level that a rational farmer should operate which is the stage II on the production surface, still farmers using the traditional storage technology were also found to outperform their counterpart in the use of modern storage facilities. Government, non-governmental organizations and individuals who are stakeholders in agriculture should as a matter of importance and urgency ensure availability of more extension agent and encourage more coverage of farms through comprehensive itinerary. With increase in more areas of land cultivation for cereal crops to enhance food security by the government, to avert waste, farmers should be encouraged to make use of modern storage technique due to its larger capacity, although, it is nor as efficient as the traditional technique. Storage chemicals and preservatives should be made available, accessible and affordable to farmers in quality and quantity terms.

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Table 1: Sample Design for the Selection of Maize Farmers in the Study Area

Purposive	**Random**	**Random**	**Random**	**Random**	**Random**
Vegetation Zones	**State**	**LGA**	**Communities**	**(Modern Technology User)**	**(Traditional Technology Users)**
Guinea Savanna	Kwara	Baruten	Okuta	25	25
			Ilesa-Ibaruba	25	25
		Asa	Eyenkorin	25	25
			Olowookere	25	25
Derived Savanna	Niger	Chanchaga	Bako	25	25
			Babeji	25	25
		Bida	Babeko	25	25
			Daruda	25	25
Total	-	-	-	200	200

Source: Field Survey, 2023

Table 2: Socio-economic and Input Characteristics of the Respondents

Variables	**Modern Storage(n=200)**			**Traditional Storage(n=200)**		
	Min.	**Max.**	**Mean**	**Min.**	**Max.**	**Mean**
Farm size(in hectares)	0.34	4.6	2.42	45.00	112.0	2.70
Age(in years)	22.0	84.	45.6	23.00	84.0	48.5
Household Size(No.)	1.0	13.0	6.0	2.00	11.0	6
Labour(in man-days)	65.0	231.0	140.4	25.0	215.0	80.9
Experience(in years)	2.0	27.0	9.3	7.00	32.0	15.9
Storage Capacity(in m^3)	1200.0	65,000	25132.5	650	17500.0	2967.5
Maize Quantity Stored(in kgs)	1200.0	7500.0	3598.0	650	6500.0	2101.7
Preservatives(in ltrs)	2.0	17.0	10.3	1.0	16.0	4.2
Monthly Fuel consumed(in ltrs)	90.0	170.0	123.2	2.0	150.0	35.3
Education(in years)	2.0	13.0	8.8	2.0	10.0	5.3
Extension Contacts(No.)	2.0	13.0	4.8	1.0	10.0	5.3

Source: Field Survey, 2023

Table 3: Types of Storage Technologies Used by the Maize Farmers

Storage Technology	Number	Percentage
Silos	200	50.0
Crib	75	18.8
Rhombus	65	16.3
Granary	35	8.8
Basket	25	6.3
Total	400	100.0

Source: Field Survey, 2023

Table 4: Maximum Likelihood Estimate of the Efficiency of Farmers with Modern and Traditional Storage Technology

Variable	**Modern Storage Technology**		**Traditional Storage Technology**	
	Coefficient	**t-ratio**	**Coefficient**	**t-ratio**
Efficiency Variable				
Constant (β_0)	0.7773***	7.13	0.8350***	9.80
Storage Capacity	-0.1997***	-7.97	0.7209***	4.76
Quantity of Labour (β_2)	0.5824	1.39	0.1140	0.67
Quantity of Agrochemicals(β_3)	0.1021**	2.73	-0.1046***	-10.54
Quantity of Fuel (β_4)	0.4149***	2.00	0.1021***	3.79
Inefficiency Variables				
Constant (δ_0)	0.3177	2.13	-0.3817	-0.11
Education(in years) (δ_1)	0.4457***	3.07	-0.7434***	-7.65
Farming Exp. (in years) (δ_2)	-0.1729*	-1.82	0.1466	0.60
Ext. Contacts (in No.) (δ_3)	-0.4585*	-2.95	-0.6534***	-4.13
Sigma squared(σ^2)	0.4540***	3.95	0.1419***	11.95
Gamma(γ)	0.9883***	28.31	0.9570***	16.38
Mean Efficiency	0.6432(64%)		0.7211(72%)	
Sample Size	200		200	

Source: Field Survey, 2023

Table 5: Ordinary Least Square Multiple Regression Estimates of Factors Influencing Quantity of Maize Stored

Variable	**Modern Storage Technology**		**Traditional Storage Technology**	
	Coefficient	**t-ratio**	**Coefficient**	**t-ratio**
Constant	0.8987***	3.74	0.8282***	16.96
Storage capacity	-0.0662	-1.25	-0.7631	-1.31
Labour	0.1136***	6.37	0.1316*	1.76
Agrochemicals	-0.1999***	-4.46	-0.9779**	-2.61
Fuel	0.0678***	5.24	0.1090	1.59
Sigma Squared	4.6727		1.1413	
Log-likelihood function	-207.17		-85.56	

Source: Field Survey, 2023

Table 6: Elasticity/Rate of Technical Substitution (RTS)

Variable	Modern Tech.	Traditional Tech.
	Coefficient	Coefficient
Capacity	-0.19	0.72
Quantity of Labour	0.58	0.11
Quantity of Agrochemicals	0.10	-0.10
Quantity of Fuel	0.41	0.10
Total	0.68	0.83

Source: Field Survey, 2023

Table 7: Frequency Distribution of Technical Efficiency between Modern and Traditional Storage Technology

Eff. Range	**Modern Storage Tech.**		**Traditional Storage Tech.**	
	Frequency	**Percent**	**Frequency**	**Percent**
≤50	21	10.5	3	1.5
51-60	46	23.0	15	7.5
61-70	96	48.0	13	6.5
71-80	12	6.0	111	55.5
81-90	10	5.0	37	18.5
>90	15	7.5	21	10.5
Total	200	100.0	200	100.0
Mean Eff.	0.6432		0.7211	

Source: Field Survey, 2023