Journal of Sustainable Development in Africa (Volume 22, No.3, 2020)
ISSN: 1520-5509
Clarion University of Pennsylvania, Clarion, Pennsylvania

ECONOMETRICS EVALUATION OF ON-FARM MAIZE (*Zea mays*) PRODUCTION, STORAGE SYSTEMS, MARKETABLE SURPLUS AND POSTHARVEST LOSSES AMONG SMALLHOLDER RURAL FARMERS, ABUJA, NIGERIA.

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ABSTRACT

Improving agricultural productivity through sustainable technologies and practices can go some ways towards increasing local food available, increasing food security and reducing poverty. This study evaluated econometrics of on-farm maize (Zea mays) production, storage systems, marketable surplus and postharvest losses among smallholder rural farmers, Abuja, Nigeria. This study was designed specifically to achieve the following objectives: identify the socio-economic profiles of smallholder rural maize farmers, determine the costs and returns of maize production among smallholder rural farmers, evaluate factors influencing on-farm maize storage technologies of smallholder rural farmers, evaluate factors influencing marketable surplus of maize grain among smallholder rural farmers, evaluate factors influencing postharvest losses of maize grain among smallholder rural farmers, and identify constraints facing smallholder rural maize farmers. Data used were of primary sources. Multi-stage sampling technique was adopted and used. Total sample sizes of one hundred (100) smallholder rural maize farmers were employed. Statistical and econometrics tools employed in analyzing data were: descriptive statistics, gross margin analysis, financial analysis, Probit model analysis, Logit model analysis, multiple regression analysis and t-Test analysis. The results show that the mean age of smallholder rural maize farmers was 45.4years.About 80% of smallholder rural maize farmers had formal education and were literate. The means of on-farm storage of maize grains were traditional and modern technologies. The average farm sizes were 2.62 hectares of farm land. About 51% of smallholder rural farmers had between 101 and 300 kg per hectares of farm land. The gross margin and net farm income were 909,780 Naira and 886,930 Naira respectively. The gross margin ratio of 0.927 implies that for every one Naira invested in maize production 92Kobo covered expenses, taxes, interest, profits and depreciation .About 26% of maize produced per hectare of farm land were postharvest losses at the farm, processing and marketing levels along the supply chain respectively. Age ($P < 0.05$), level of education ($P < 0.01$), access to credit ($P < 0.10$), quantity of maize stored ($P < 0.05$), experience in farming ($P < 0.10$),extension contact ($P < 0.05$),and transportation cost ($P < 0.10$). Factors influencing marketable surpluses of smallholder rural maize farmers were: price of maize ($P < 0.01$), extension contact ($P < 0.10$),access to credit ($P < 0.05$),distant to nearby market ($P < 0.05$), experience in farming ($P < 0.10$), farm size ($P < 0.01$), level of education ($P < 0.01$),and cost of transportation ($P < 0.05$). Age, educational level, and extension services were statistically and significant factors influencing postharvest losses of smallholder rural farmers at farm, processing and market levels respectively. Lack of transport facilities, bad road infrastructures, lack of storage facilities, lack of credit facilities and lack of improved seeds were the major constraints facing smallholder rural maize farmers. Improved seeds, fertilizers, chemicals and production inputs should be made available at the right time to smallholder rural maize farmers. Also, modern storage technologies should be provided for smallholder rural maize farmers.

Keywords: Smallholder Maize Farmers, On-Farm Storage Systems, Marketable Surplus, Postharvest Losses, Probit Model, Logit Model, Nigeria.

INTRODUCTION

The sustainable production of food is the first pillar of food security. Sustainable agricultural maize production system that conserves resources such as land and water are environmentally non-degrading, technically appropriate, economically and socially acceptable. Maize (*Zea mays*) is an important cereal food grain crop in Nigeria. Maize as a staple food crop, it comes second after rice. Maize is a good source of vitamins, protein (low-level) and carbohydrate. Maize is used for livestock feed, for production of starch, ethanol, fructose, maize flour and can be eaten boiled, roasted or processed into pap. Farming households cultivate maize extensively, any losses of maize grain can cause food insecurity and hence income coming to farmers will be low. Agricultural production sustainability as a concept considers the economic, environmental, and social aspects of farming, while also promoting the resilience and persistence of productive farming landscapes. The local production of maize in Nigeria was 15.9 metric tonnes (CBN, 2006). Agricultural development in Nigeria is faced with the problem of lack of modern storage technologies for grain (Sekumade and Oluwatayo, 2009). Storage can be defined as the process by which agricultural produce are kept for future use (Thamaga-Chitja *et al*, 2004). On-farm grain storage can be defined as a management, and risk techniques used by farmers to reduce the effects of negative weather situations and changes in market conditions. Grain storage and drying can reduce damage to crops by weather at harvest. On farm storage of grains also provide farmers with greater marketing options (Strahan and Page, 2003).The benefits of on-farm storage and drying include: it allows the grain to be harvested at earlier at high moisture content, the loss in quality of grain as a result of weather damage are prevented, the losses from lodging and shedding are avoided, and the grain yield are optimized. On-farm grain storage and drying provide benefits of postharvest in marketing and management of grain include the producers have more control of grain marketing, the marketing opportunity to hold grains and sell at higher prices in the future, or forward contract delivered at designated time in the future, and reducing the downgrading of losses due to low protein, high moisture content (Strahan and Page, 2003).Storage structures can be defined to be containers, medium or physical environment where by agricultural produce can be preserved against diseases, pest and theft for a good period of time. In addition storage performed other functions such as quality improvement, market price stabilization, seed preservations (Sekumade and Oluwatayo, 2009). Storage structures will minimize wastage and spoilage of grains. Some of the traditional storage techniques are described as crude, local, harzadous and outdated (Thamaga-Chitja *et al*, 2004).The new improved storage structures are expensive for smallscale farmers (Agboola, 2001).Grains can be stored in various forms such as cribs, barns, rhumbu, open fields, jute bags, polythene, tree, bin and hematics for household food security and self-sustenance (Adekunle and Nabinta, 2006, Meikle *et al*, 2004).Marketable surplus can be defined as the quantity of output that is either publicly owned or privately owned that is in excess of what the domestic requires (Osugiri, Ben-Chendo, Nwaihu, Okwara, and Utazi, 2018). Marketable surplus can in other ways be defined as the amount of output that is available for sale in the market after meeting that for consumption, seed requirements and feed. After meeting the requirements for households and the requirements of farms for the future, what is left is called marketable surplus. Marketable surplus is different from agricultural commercialization of agricultural produce (Pradhan, Dewina and Minsten, 2010). Agricultural commercialization intends to maximize both sales and profits (Sokoni, 2008, Yoon-Dom and Yoon, 2009, FAO, 2010). Marketable surplus is also different from scale of operations and farming system adopted. Provisions of markets for agricultural produce allows surplus of agricultural produce to dispose and the economic activity is hereby stimulated. An increase in marketable surplus provides raw materials for industries and food for the entire population (Osugiri, Ben-Chendo, Nwaihu, Okwara, and Utazi, 2018).Postharvest losses can be defined as losses that occur at harvest through postharvest operations such as threshing, winnowing, drying, bagging, transportation, storage, processing, marketing and exchange at market. In developing countries food are losses primarily at consumer level, some losses also occur on the field after harvest, others occur at stages of the supply chain. The causes of postharvest can be due to many causes such as poor handling, poor transportation, physical damage, physiological decay, loss of water, poor storage or simply because there are no buyers of surpluses of agricultural produce in the market. The losses can be due to total spoilage or loss in quality of agricultural produce. The World Bank (2011) reported that one (1) out of every 5kg of grains produced in sub-Saharan Africa was lost due to diseases and pest infestations. According to Africa Postharvest Losses Information System (APHLIS), 10% - 20% of physical grain could be loosed prior to processing (World Bank, 2011)

Objectives of the Study

The study was broadly evaluated econometrics of on-farm maize (*Zea mays*) production, storage systems, marketable surplus and postharvest losses among smallholder rural farmers, Abuja, Nigeria. The study was designed specifically to achieve the following:

(i) identify the socio-economic profiles of smallholder rural maize farmers,
(ii) determine the costs and returns of maize production among smallholder rural farmers,
(iii) evaluate factors influencing on-farm maize storage technologies of smallholder rural farmers,
(iv) evaluate factors influencing marketable surplus of maize grain among smallholder rural farmers,
(v) evaluate factors influencing postharvest losses of maize grains among smallholder rural farmers, and
(vi) identify constraints facing smallholder rural maize farmers.

METHODOLOGY

The Study Area

The study was conducted in Gwagwalada, Abuja, Nigeria. Gwagwalada is an area council located at Latitudes 80 55^{I} 59^{II} North of the Equator and Longitudes 70 5^{I} 59^{II} East of the meridian. The study area was characterized by high humidity, which has a heat trap effect. There are notably two main seasons; the wet and dry. Annual rainfall, ranges from 1100mm to1700mm. The climatic conditions of the study area permit agricultural activities such as cultivation of crops, grazing of animals and fishery production. Gwagwalada Area Council has a total land mass of about 1,043 Square Kilometer and with a population of 157,770 people (NPC, 2006). Average annual rainfall ranges from 800 to 1,500mm and temperature ranges between 21^{0}C - 35^{0}C.

Sampling Techniques and Sample Size

Purposive sampling technique was adopted and employed in choosing Abuja, Nigeria. This is because of predominant smallholder maize farmers in the area. Multi-stage was adopted and employed in choosing the smallholder maize farmers. First stage involves the selection of Gwagwalada out of six (6) area councils using simple random sampling technique employing ballot-box raffle draw method. Second stage involves the selection five (5) wards out of ten (10) wards using simple random selection technique employing ballot-box raffle draw method. Third stage involves the selection of two (2) villages per ward using simple random sampling technique employing ballot-box raffle draw method. Fourth and final stage involves the selection of five (5) smallholder maize farmers they are the target respondents, the smallholder farmers were selected using simple random sampling technique employing ballot-box raffle draw method. The total sample size was 100 smallholder maize farmers in the area.

Method of Data Collection

Data used were of primary sources. The target respondents were smallholder maize farmers. Data were collected through the use of well-structured and well-designed questionnaire. The questionnaire was subjected to validity and reliability tests. The questionnaire was validated through the team of experts. All corrections and observations made were incorporated in the questionnaire design. Reliability test was conducted on the questionnaires using simple correlation method which give a Crobach Alpha of 78%. Questionnaire was designed to collect information such as age, sex, marital status, educational level, household sizes which are socio-economic profiles or characteristics of smallholder maize farmers. Information's were also collected on costs and returns on maize production, marketable surplus, methods of on-farm storage system, and postharvest losses. Trained enumerators were used in collecting the data.

Method of Data Analysis

Data collected were coded and subjected to analysis through the use of the following statistical and econometrics tools:

(i) Descriptive Statistics,
(ii) Gross Margin Analysis
(iii) Financial Analysis
(iv) Probit Model Analysis
(v) Logit Model Analysis
(vi) Multiple Regression Model
(vii) Postharvest Loss Model, and
(viii) t-Test Analysis.

Descriptive Statistics

This involves the use of frequency distributions, mean, and percentages. It is used to have a summary statistics of socio-economics profiles or characteristics of smallholder maize farmers, and also summarize the constraints or problems facing smallholder maize farmers. This was used to achieve specific objectives one (i) and six (vi).

Gross Margin Analysis

The Gross Margin according to Olukosi and Erhabor (2005) is the difference between the gross farm income (GFI) and total variable cost (TVC):

Gross margin model (GM) is expressed as follows:

$$GM = TR - TVC \dots\dots\dots\dots\dots\dots\dots\dots (1)$$

Where,

GM = Gross Margin (₦),

TR = Total Value of Output or Total Revenue from the Smallholder Maize Farmers (₦),

TVC = Total Variable Cost (₦), and

TR = P.Q (₦).

Where: -P = Price of Maize Produced in Naira per Kilogram, Q = Output of Maize Produced in Kilogram.

Net Farm Income (NFI) is stated thus:

$$NFI = \sum_{i=1}^{n} P_1 Y_i - \sum_{j=i}^{m} P_j X_j - \sum_{k=1}^{k} GK \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (2)$$

NFI = Net Farm Income (Naira Per annum)

P_i = Unit Price of Product (Naira/Unit)

P_j = Price per Unit Variable Input (Naira/Unit)

GK = Cost of all Fixed Inputs (where k = 1,2,3, ……………. k fixed input)

∑ = Summation or Addition signs.

This was used to achieve part of specific objective two (ii)

Financial Analysis

Gross Margin Ratio (GMR) according to Ben-Chendo *et al* (2015) is defined as:

$$Gross\ Margin\ Ratio = \frac{Gross\ Margin}{Total\ Revenue} \dots\dots\dots\dots\dots\dots\dots (3)$$

This was used to determine the profitability of smallholder maize production. Gross Margin Ratio was used to achieve part of specific objective two (ii)

Probit Model Analysis

A Probit model following Alabi, Oladele and Oladele (2020) was used. Probit model is stated as:

$$Z_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + U_i \ldots\ldots\ldots (4)$$

$$Y_i = b_0 + \sum_{i=1}^{7} b_i X_i + U_i \ldots\ldots\ldots\ldots (5)$$

Where,

Z_i= Dichotomous Response Variable (1, if Modern; 0, Traditional),

i = Number of Independent Variables,

β_0= Constant Term,

$\beta_1 - \beta_7$= Regression Coefficients,

X_1= Age (Years),

X_2= Level of Education (0, Non-Formal; 1, Primary; 2, Secondary; 3, Tertiary),

X_3 = Access to Credit (1, Access; 0, Otherwise),

X_4 =Quantity of Maize Stored (Kg),

X_5 = Experience in Farming (Years),

X_6= Contact with Extension Agent (1, Contact; 0, Otherwise),

X_7= Transport (Naira),

U_i= Error Term.

This was used to achieve specific objective three (iii).

Logit Model Analysis

The Logit Model is defined as:

$$Z_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + U_i \ldots\ldots\ldots (6)$$

$$Y_i = b_0 + \sum_{i=1}^{8} b_i X_i + U_i \ldots\ldots\ldots\ldots (7)$$

Where,

Z_i =Dichotomous Response Variable for Marketable Surplus

(1, Quantity Sold Per Households; 0, Otherwise)

X_1 = Price of Maize (Naira/Kg)

X_2 = Contact with Extension Agents (1, Contact; 0, Otherwise)

X_3 = Access to Credit (1, Access; 0, Otherwise)

X_4 = Distant to Nearby Market (Km)

X_5 = Educational Level (0, Non-Formal; 1, Primary; 2, Secondary; 3, Tertiary)

X_6 = Farm Size (Hectares)

X_7 = Cost of Transport (Naira)

X_8 = Farming Experience (Years)

β_1- β_8 = Regression Coefficients

β_0 = Constant Term

U_i = Error Term

This was used to achieve specific objective four (iv)

Multiple Regression Model

The Ordinary Least Square Regression model is stated thus:

$$Y_{ij} = b_0 + \sum_{i=1}^{13} b_i X_{i\,j} + \varepsilon_i \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (8)$$

The explicit function is stated:

$$Y_{i_j} = \beta_0 + \beta_1 X_{1_j} + \beta_2 X_{2_j} + \beta_3 X_{3_j} + \beta_4 X_{4_j} + \beta_5 X_{5_j} + \beta_6 X_{6_j} + \beta_7 X_{7_j} + \beta_8 X_{8\,j} + \beta_9 X_{9_j} + \beta_{10} X_{10_j} + \beta_{11} X_{11_j} + \beta_{12} X_{12_j} + \beta_{13} X_{13_j} + \varepsilon_i \ldots\ldots\ldots (9)$$

Where,

Y_i= Postharvest Losses at (Farm, Processing, and Marketing Levels)

$X_{1\,j}$ = Age of Farmers (Years)

$X_{2\,j}$ = Sex (1, Male; 0, Female)

$X_{3\,j}$ = Educational Level (0, Non-Formal; 1, Primary; 2, Secondary; 3, Tertiary)

$X_{4\,j}$ = Farm Size (Hectares)

$X_{5\,j}$ = Distant from Farm to Store (Km)

$X_{6\,j}$ = Quantity Purchased (Kg)

$X_{7\,j}$ = Distant from Processing Units to Store (Km)

$X_{8\,j}$ = Distant from Raw Material to Processing Units (Km)

$X_{9\,j}$ = Distant from Store to Nearby Market (Km)

$X_{10\,j}$ = Length of Storage before Marketing (Days)

X_{11_j} = Extension Services Dummy (Number of Extension Contact in a Month)

$X_{12\,j}$ = Length of Stay in Store before Processing (Days)

$X_{13\,j}$ = Distant from Source to Store (Km)

β_1- β_{13} = Regression Coefficients

β_0 = Constant Term

ε_i = Error Term

This was used to achieve specific objective five (v)

Postharvest Losses (PHL)

Postharvest Losses Model (PHL) is defined as:

$$PHL = \sum_i^n S_i \quad \text{……………………….(10)}$$

Where,

S_i = Postharvest Losses at Each Stage of the Supply Chain (Farm, Processing and Marketing Stages)

RESULTS AND DISCUSSION

Socio-Economic Profiles of Smallholder Rural Maize Producers.

Table 1 shows the socio-economic profiles of smallholder maize producers. About 69% of smallholder rural maize producers had their ages less than 50 years. This means that the smallholder rural maize producers were active, resourceful, energetic and in their youthful age. Also, 29% of them were single, while 42% were married. Furthermore, smallholder rural maize farmers were literate and can read and write as revealed that 80% of them had formal education. The methods used by smallholder rural farmers for on-farm storage techniques were traditional (87%) and modern (13%) means of storing system of maize grain produce. The traditional methods of storing maize used by smallholder rural farmers include: open field (17%), jute bags (11%), tree (11%), polythene (07%), rhumbu (14%), cribs (15%), barns (11%). The modern methods of storing maize used by smallholder rural farmers include: bin (9%) and hematic (5%) respectively. The mean years of experience for smallholder maize farmers were 14.30 years. In addition, 34% of smallholder rural maize farmers had less than 11 years' experience in maize farming. The mean marketable surplus for smallholder rural farmers was 242.50Kg of maize per hectare. The results show that 51% of smallholder rural farmers had between 101 to 300 Kg/ha marketable surplus of maize produce. The mean size of farm was 2.62 hectare of land. The farm sizes for rural maize farmers were of smallscale in nature. About 61% of smallholder rural farmers had less than 3 hectare of maize farm land. The results is in line with findings of Alabi and Ibraheem (2018), Alabi, Oladele and Oladele (2020), Osugiri, Ben-Chendo, Nwaihu, Okwara and Utazi (2017), Falola, Fakayode and Ajayi (2013), Sekumade and Oluwatayo (2009), Strahan and Page (2003).

Table 1: Socio-Economic Profiles of Smallholder Rural Maize Producers

Socio-Economic Characteristics	Frequency	Percentage	Mean
Age (Years)			
31 – 40	32	32.00	
41 – 50	37	37.00	**45.4**
51 – 60	31	31.00	
Marital Status			
Single	29	29.00	
Married	42	42.00	
Widowed	19	19.00	
Divorced	10	10.00	
Educational Status (Years)			
Primary	42	42.00	
Secondary	17	17.00	
Tertiary	21	21.00	
Non-Formal	20	20.00	
Storage Technologies			
Open Field	17	17.00	
Jute Bag	11	11.00	
Polythene	07	07.00	
Tree	11	11.00	
Rhumbu	14	14.00	
Cribs	15	15.00	
Barns	11	11.00	
Bin	09	09.00	
Hematic	05	05.00	
Experience in Maize Farming (Years)			
1 – 10	34	34.00	
11 – 20	44	44.00	**14.30**
21 – 30	22	22.00	
Marketable Surplus (Kg/Ha)			
< 100	10	10.00	
101 – 200	27	27.00	**242.50**
201 – 300	24	24.00	
>300	39	39.00	
Farm Size (Hectares)			
1 – 2	27	27.00	
2 – 3	34	34.00	**2.62**
3 - 4	39	39.00	
Total	**100**	**100.00**	

Source: Field Survey (2019), Computed from STATA Version 14

Costs and Returns of Smallholder Rural Maize Farmers

Sustainable agricultural maize production uses fewer of external inputs such as purchased chemicals, fertilizers and more locally available natural resources. The costs involved and revenue obtained in smallholder maize production and storage was presented in Table 2. The prevailing market prices for maize as the time of this research were used in the computations of the various costs and returns analysis involved. The total variable cost was calculated to be 70, 860 Naira and this accounted for 75.62% of the total cost of production of maize and storage by the smallholder rural farmers. The various total variable costs were: cost of land preparation (2.88%), labour cost (7.25%), seed input (4.91%), fertilizer input (37.34%), chemical cost (7.36%), storage cost (6.36%), transportation cost (3.63%) and harvesting cost (5.87%). The fixed cost accounted for 24.38% of the total cost of production. The gross margin and net farm income were 909,780 Naira and 886,930 Naira respectively. This means that maize production by smallholder rural farmers is profitable enterprise in the area.

Table 2: Costs and Returns of Smallholder Rural Maize Production

Variable	**Value (₦)**	**Percentage**
(a) Variable Cost		
Cost of Land Preparation	2,700.00	02.88
Labour Cost	6,800.00	07.25
Seed Input	4,600.00	04.91
Fertilizer Input	35,000.00	37.34
Chemical Cost	6,900.00	07.36
Storage Cost	5,960.00	06.36
Transportation Cost	3,400.00	03.63
Harvesting Cost	5,500.00	05.87
Total Variable Cost	**70,860.00**	**75.62**
(b) Fixed Cost		
Depreciation of Farm Assets	3,460.00	03.69
Cost Incurred on Fixed Assets	6,590.00	07.03
Expenses Spent on Administrative Procedures	5,100.00	05.44
Taxes	4,500.00	04.80
Interest	3,200.00	03.41
Total Fixed Cost	**22,850.00**	**24.38**
Total Cost of Production	**93,710.00**	**100.00**
Price Naira (50Kg Bag)	**15,000**	
Quantity(Number 50Kg Bag)	**65.376**	
Total Returns	**980, 640.00**	
Gross Margin	**909,780.00**	
Net Farm Income	**886,930.00**	
Gross Margin Ratio	**0.927**	

Source: Field Survey (2019), Computed using STATA Version 14

The gross margin ratio of 0.927 implies that for every one Naira invested in rice production and its storage, 92 Kobo covered expenses, taxes, depreciation, interest and profits.

Postharvest Losses of Maize by Smallholder Rural Farmers.

The postharvest losses of maize grain produce by smallholder rural farmers were presented in Table 3.The postharvest losses of maize grains were identified in three (3) levels along the supply chain analysis. The levels were: farm, processing and marketing respectively. The total postharvest losses for the supply chain of maize grain were 26%. The percentage postharvest losses at each stage of the supply chain of maize grain were farm level (10%), processing level (12%) and marketing level (04%) respectively. Table 4 presented the average quantity of postharvest of maize grain per hectare of produce lost along the supply chain of maize grain. At the farm level about 300Kg of maize grain were lost, and at processing and marketing levels, 360Kg and 120 Kg of maize grain harvested in one hectare farm were lost respectively. The total postharvest of 780Kg were lost from 3,000 Kg of produce harvested from one hectare of maize farms. This results is in line with findings of Oni (2017), Umar, Liu, Khalid and Mohammed (2015), Begum, Hossain and Papanagiotou (2012)

Table 3: Postharvest Losses of Smallholder Rural Maize Grain Producers at Farm, Processing and Marketing Levels

Levels	Postharvest Losses (%)	% Share in Total Losses
Farm	10.00	38.46
Processing	12.00	46.15
Marketing	04.00	15.38
Total	**26.00**	**100.00**

Source: Field Survey (2019), Computed using STATA Version 14

Table 4: Average Quantity of Postharvest Losses per Hectare of Smallholder Rural Maize Grain Producers at Farm, Processing and Marketing Levels

Levels	Quantity Losses (Kg)	% Quantity Losses
Farm	300.00	38.46
Processing	360.00	46.15
Marketing	120.00	15.39
Total	***780.00**	**100.00**

**3,000Kg Produce of Maize per Hectare*.

Source: Field Survey (2019), Computed using STATA Version 14

Factors Influencing On-Farm Storage Technologies of Smallholder Rural Maize Farmers

The various exogenous variables influencing on-farm maize storage system of maize grain by smallholder rural farmers were presented in Table 5. The exogenous variables included in the Probit model that were statistically significant in influencing on-farm maize storage system were: age ($P < 0.05$), level of education ($P < 0.01$) , access to credit ($P < 0.10$), quantity of maize stored ($P < 0.05$), experience in farming ($P < 0.10$), extension contact ($P < 0.05$) and transport cost ($P < 0.05$). The Wald Chi Square and Log-Likelihood value were 64.69 and -106.091 respectively and they were significant ($P < 0.01$). The pseudo R^2 value was 0.871, this means 87.1% variations in on-farm storage system of maize grain by smallholder rural farmers were explained by exogenous variables included in the Probit model. The result is in line with findings of Sekumade and Oluwatayo (2009), Oni (2017).The results of the marginal effects of the Probit model were also presented in Table 5.The marginal effects shows that as smallholder rural maize farmers get educated will lead to 0.2610 increase likelihood or probability of using modern method of storing maize grain. Also, as smallholder rural farmers acquired more experiences in maize farming will lead to 0.3173 increase probability or likelihood or propensity to make use of modern storage system for maize.

Table 5: Factors Influencing or Affecting On-Farm Storage Technologies of Smallholder Rural Maize Producers

Variable	Regression Coefficient	t-Statistics	Marginal Effect
Age (X_1)	0.0163**	2.56	0.1139
Level of Education (X_2)	0.1032***	3.12	0.2610
Access to Credit (X_3)	0.1304*	2.01	0.1982
Quantity of Maize Stored (X_4)	0.2018**	2.67	0.3173
Experience in Farming (X_5)	0.1989*	2.20	0.1102
Extension Contact (X_6)	0.1032**	2.87	0.1307
Transport Cost (X_7)	0.2451*	1.98	0.1557
Wald Chi Square	64.89***		
Log-Likelihood	-106.091		
Pseudo R^2	0.871		

Source: Field Survey (2019), Computed using STATA Version 14
*****-Significant at P <0.01, **-Significant at P <0.05, **-Significant at P <0.10**

Factors Influencing Marketable Surplus of Smallholder Rural Maize Farmers

The statistically and significant explanatory variables influencing marketable surplus of smallholder maize grain were price of maize ($P < 0.01$), extension contact ($P < 0.10$), access to credit ($P < 0.05$), distant to nearby market ($P < 0.05$), experience in farming ($P < 0.05$), farm size ($P < 0.01$), level of education ($P < 0.01$) and cost of transport ($P < 0.05$). The Log-Likelihood and Wald Chi Square values were -128.96 and 76.21 and they were significant at ($P < 0.05$).The Pseudo-R^2 value of 0.759 implies that 75.9% of variations in dependent variable which is the marketable surpluses were explained by explanatory variables included in the model. The marginal effects of the Logit model were presented in Table 6. A unit increase in hectares of maize farms will lead to 0.2109 likelihoods or probability increase in marketable surplus for smallholder rural maize farmers. This results is in line with findings of Osugiri, Ben-Chendo, Nwaihu,Okwara and Utazi (2017), Falola, Fakayode and Ajayi (2013).

Table 6: Factors Influencing or Affecting Marketable Surplus of Smallholder Rural Maize Producers

Variable	Regression Coefficient	t-Statistics	Marginal Effect
Price of Maize (X_1)	0.2189***	3.49	0.1039
Extension Contact (X_2)	0.1001*	2.11	0.2190
Access to Credit (X_3)	0.2452**	2.92	0.1760
Distant to Nearby Market (X_4)	0.5412**	2.82	0.1672
Experience in Farming (X_5)	0.1671*	1.97	0.2167
Farm Size (X_6)	0.5620***	3.69	0.2109
Level of Education (X_7)	0.897***	3.89	0.1309
Cost of Transport (X_8)	0.5921**	2.28	0.1469
Wald Chi Square	76.21***		
Log-Likelihood	-128.96		
Pseudo R^2	0.759		

Source: Field Survey (2019), Computed using STATA Version 14
*****-Significant at P <0.01, **-Significant at P <0.05, **-Significant at P <0.10**

Factors Influencing or Affecting Postharvest Losses at the Farm, Processing and Marketing Levels of Smallholder Rural Maize Farmers

Evidence shows strengthening economic, environmental sustainable agriculture with social concerns and other employment sources such as smallscale enterprises, cottage industries and smallscale processing units in rural areas can help reducing poverty and unemployment problems. Factors influencing postharvest losses at the farm, processing and market levels were presented in Table 7. The statistical and significant exogenous variables influencing postharvest losses at the farm level include: age ($P < 0.05$), educational status ($P < 0.01$), farm size ($P < 0.05$), distant from farm to store ($P < 0.05$), and extension services ($P < 0.05$). The coefficient of multiple determinations(R^2) was 0.672.This means that 67.2 % of variations in the postharvest losses at the farm level were explained by explanatory variables included in the multiple regression models. The F-value was significant at ($P < 0.01$). The statistical and significant explanatory variables influencing the postharvest losses at processing levels were age ($P < 0.10$), educational status ($P < 0.05$), quantity purchased ($P < 0.05$), distant from processing unit to store ($P < 0.05$), distant of raw materials to processing unit ($P < 0.05$), extension services ($P < 0.10$), and length of maize stay in store before processing ($P < 0.05$). The coefficient of multiple determinations(R^2) was 0.613. This means that 61.3% of variations in the postharvest losses at processing level were explained by the exogenous variables included in the models. In addition, the statistical and significant predictor variables included in the model influencing postharvest losses at market level were age ($P < 0.05$), educational status ($P < 0.05$), quantity purchased ($P < 0.05$), distant from store to nearby market ($P < 0.01$), length of storage before marketing ($P < 0.10$), extension services ($P < 0.05$), and distant from source to store ($P < 0.05$). The coefficient of multiple determinations(R^2) was 0.628. This means that 62.8% of variations in postharvest losses at market level were explained by predictor variables included in the model. This result is in line with findings of Oni (2017), Begum, Hossain and Papanagiotou (2012)

Table 7: Factors Influencing or Affecting Postharvest Losses at Each Level of Smallholder Rural Maize Farmers

Variables	Farm Level		Processing Level		Market Level	
	Coeff.	t-Value	Coeff.	t-Value	Coeff.	t-Value
Age (X_1)	0.1691**	2.73	0.1051*	2.59	0.0416**	2.68
Sex (X_2)	0.0314	1.21	0.0601	1.09	0.0047	1.14
Educational Status (X_3)	0.1701***	3.46	0.1091**	2.87	0.2109**	2.91
Farm Size (X_4)	0.1264**	2.81	----------	-------	---------	--------
Distant from Farm to Store (X_5)	0.6047**	2.65	--------	-------	---------	---------
Quantity Purchased (X_6)	----------	--------	0.4360**	2.84	0.1730**	2.90
Distant from Processing Unit to Store (X_7)	----------	--------	0.4019***	3.21	--------	---------
Distant from Raw Material to Processing Unit (X_8)	---------	-------	0.1789**	2.96	-------	--------
Distant from Store to Nearby Market (X_9)	--------	-------	--------	------	0.1229***	3.12
Length of Storage before Marketing (X_{10})	---------	-------	------	------	0.1649*	1.91
Extension Services (X_{11})	0.1179**	2.59	0.1209*	1.96	0.1489**	2.81
Length of Stay in Store before Processing (X_{12})	--------	------	0.1805**	2.89	--------	------
Distant from Source to Store (X_{13})	--------	-------	-------	-------	0.1439**	2.60
R^2 -Value	0.672	------	0.613	-------	0.628	------
Adjusted R^2	0.60	------	0.55	------	0.57	-----
F-Value	121.69***	-------	162.89***	-----	189.95***	------

Source: Field Survey (2019), Computed Using STATA Version 14

Constraints or Problems Facing Smallholder Rural Maize Farmers

The constraints or problems facing smallholder rural maize farmers are presented in Table 8. Lack of transport facilities had 17.98% and was ranked 1st , bad road infrastructures had 16.65% and was ranked 2nd .Lack of storage facilities, lack of credit facilities and lack of improved seeds had 14.95%, 12.64%, 11.06% and were ranked 3rd , 4th and 5th respectively.

Table 8: Constraints or Problems Facing Smallholder Rural Maize Producers

Constraints	Frequency	Percentage	Rank
Lack of Storage Facilities	123	14.95	3rd
Lack of Credit Facilities	104	12.64	4th
Lack of Transport Facilities	148	17.98	1st
Bad Road Infrastructures	137	16.65	2nd
High Cost of Fertilizers	89	10.81	6th
Lack of Improved Seeds	91	11.06	5th
Inadequate Production Inputs	56	06.80	8th
Lack of Labour Input	75	09.11	7th
Total	***823**	**100.00**	

***Multiple Responses**

Source: Field Survey (2019), Computed Using STATA Version 14

CONCLUSION

The concept of sustainable agricultural development integrates economic, ecological and social aspects. There is the need for promoting sustainable agriculture and resource conserving technologies and practices for increasing food security and reducing poverty especially in sub-Saharan Africa. Smallholder rural maize production was profitable in the study area. The gross margin and net farm income were 909,780 Naira and 886,930 Naira respectively. The gross margin ratio was 0.927. This means for every one Naira invested in maize production in the area 92 Kobo covered interest, taxes, profits, depreciation and expenses. The smallholder rural maize farmers were young, energetic, resourceful and of youthful age. The mean age was 45.4years. They had formal education and were literate. The smallholder rural maize farmers stored their produce in modern and traditional methods. The traditional methods of on-farm storage of maize grain were open field, jute bag, rhumbu, cribs, barns, tree and polythene. The modern methods of storage for maize grain by smallholder rural farmers were hematic and bins. The average maize farms were 2.62 hectares of land. They had considerable experiences in maize farming with an average of 14.30 years. Majority (52%) of smallholder rural maize farmers fell between 101 to 300 Kg per hectare marketable surplus of maize grain. About 26% of postharvest losses of maize grain were observed along the three (3) levels of the supply chain. The three levels are: farm level with 10% postharvest losses, processing level with 12% postharvest losses and marketing level with 4% postharvest losses out of 3,000kg of maize produce harvested per hectare of land. An average quantity of 300Kg of maize grain were lost at the farm level, about 360Kg were lost at the processing level while 120Kg were lost from the marketing level for every 3,000 kg maize produced per hectare of farm land. Factors statistically and significantly influencing on farm-storage technologies were age, level of education, access to credit, quantity of maize stored, experience in farming, extension contact and transportation cost. Factors statistically and significantly influencing marketable surplus of maize by smallholder rural farmers were: price of maize, extension contact, access to credit, distant to nearby market, experience in farming, farm size, level of education, and cost of transportation. Factors influencing postharvest losses of maize by smallholder rural farmers at the farm level were: age, educational status, farm size, distant from farm to store and extension services. Factors influencing postharvest losses of maize grain at the processing level were: age, educational status, quantity purchased, distant from processing unit to store, distant from raw material to processing unit, extension services and length of stay in store before processing. Factors that influence postharvest losses of maize grain at the market level were age, educational status, quantity purchased, distant from store to nearby market, length of storage before marketing, extension services and distant from source of maize grain to store. The constraints or problems facing smallholder rural maize farmers were: lack of transport facilities and was ranked 1st, bad road infrastructures and was ranked 2nd, lack of storage facilities and lack of credit facilities and were ranked 3rd and 4th respectively.

RECOMMENDATIONS

The following policy recommendations were made based on the findings of this research study:

(i) Inputs like fertilizers, improved seeds, chemicals and other production inputs should be made available to smallholder rural farmers at appropriate time in sufficient quantity to increase maize production.

(ii) Extension Officers should be employed to disseminate research findings and improved technologies to smallholder rural maize farmers

(iii) Storage facilities with modern technologies should be made available to smallholder rural maize farmers to adequately store their farm produce including maize grains.

(iv) Feeder roads infrastructures should be constructed to convey farm produce like maize from farm to market centers.

(v) Transport facilities should be provided as means of conveying farm produce from farm to market centers. The means of transport will reduce spoilage and bruises to farm produce in transit. It makes it possible for easy movement of farm produce to nearby market centers.

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