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EMPIRICAL ANALYSIS OF EROSION EFFECTS ON ARABLE CROP FARMERS' PRODUCTIVITY IN EGBEDA LOCAL GOVERNMENT AREA OF OYO STATE.

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Abstract
The study analyzed erosion effects on arable crop farmers' productivity in Egbeda Local Government Area of Oyo State. Erosion has become prevalent in the area to the extent that their effect on farmland is in terms of nutrients loss which eventually results in low output. Cross sectional data were collected through the use of structured questionnaire and interview guide in accessing and interviewing 150 arable crop farmers in ten spatially located communities. Analytical tools employed were Descriptive Statistics and Stochastic Frontier Production Function (SFPF). Results for the categories of farmers with erosion, without erosion and pooled data showed that farmers were of the average age of 48 years, males were about 70% and married farmers were the majority, while the erosion control method popularly adopted was ridging across the slope. The efficiency scores were 0.86 (farmers having farms without erosion effect), 0.72(farmers having farms with erosion effect) and 0.68 (the pooled data). Return to scale (RTS) showed that farmers without erosion and those with erosion on their farms were 0.83 and 0.62 respectively while the pooled data result was 0.68 indicating that all farmers operated at the stage II of the production surface which is rational. Efficiency distributions for arable crop farmers for the three categories clustered within 0.61-0.90(farmers without erosion), 0.41-0.90(farmers with erosion) while the pooled data showed that technical efficiency spread across the range uniformly. Hypothesis test showed that there was a significant difference between the technical efficiency of farmers without and with erosion experience on the farm (t=12.347, P<0.01). It was concluded that farmers without erosion on their farms were more technically efficient than their counterpart. Based on the result obtained, it was recommended that farmers should be given more training on erosion control methods in order to ensure availability of nutrients for crops on the farmland, in turn; lesser cost would be incurred on nutrient replenishment and land reclamation.

Keywords: Erosion, Arable Crop, Farmers, Productivity, Technical Efficiency

Introduction

Quality of soil, in terms of nutrient balance needed by crop to produce optimally given the available productive resources is of paramount importance regardless of farming practices or cropping system adopted by farmers to achieve the key purpose of technical transformation of inputs to output (Lal, 2001). Soil, however, remains the reticule of the crop basic needs and is an important ecosystem service that support crop production upon which humans and many animals depend for subsistence. Different types of soil are abound serving various purposes and are distinctly characterized by their texture, structure and consistency; all these among others ensure the capacity of soil for its primary productive purpose (Bouma and McBratney, 2013; Food and Agriculture Organization, 2015). The services provided by soil for crop survival in terms of nourishment are primarily determined by its properties (texture, mineralogy and organic matter) which together form the natural component of the soil (Palm et al, 2007). Soil texture and mineralogy are properties of soil that are inherited from the parent materials but change over time due to frequency of use or constant interaction with weather elements (McBratney *et al*, 2014; Steffen *et al,* 2015). Doran and Parkin (1994) described a healthy soil as the type with the capacity to function effectively and provide ecosystem services on a sustainable basis. Similarly, Abawi and Widmer (2000) described soil as being quality or healthy without laying premium on degradation or contamination only but also on overall fitness or effectiveness for supporting plant growth, managing water and responding to environmental stresses. However, soil quality, in recent times, focuses on the linkages among management practices and systems, observable soil characteristics, soil processes, and performance of soil functions.

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Palm (2007) stated that as at a natural state, soil organic matter reaches equilibrium with the environment in which the soil forms but soil organic matter responds quickly to human-induced changes and added that management of soil organic matter is central to sustainable soil quality because of its rapid response to change and the ability to manipulate it. Soil organic matter as the binding force for soil particles is associated with reduced erosion and runoff, improved infiltration, movement and retention of water in the soil coupled with soil aggregation and nutrient recycling (Greenland and Szabolcs, 1994; Woomer and Swift, 1994). An important ecosystem service that the soil provides is to support crop production upon which humans and many animals depend for subsistence. According to Idowu *et al* (2008), it was established that healthy soil will be able to support crop production on a sustained basis and be less prone to erosion, and expressed further that, soil is prone to many degrading factors among which are erosion, bush burning, desertification, deforestation to mention but a few. Lal *et al* (1990), Pimentel *et al*(1995) and Semhi (2013) in the empirical study of edaphic nature of the earth described erosion as the removal of the upper layer of the earth surface on which plant grows of which the resultant effect pronounces a negative effect in terms of it reducing the productivity of all natural ecosystems as well as agricultural, forest and pasture ecosystems. Pimentel (2006) expressed in the same vein that, with the growing human population, soil erosion, water availability, climate change due to fossil fuel consumption, eutrophication of inland and coastal marine bodies of water and loss of biodiversity rank as the prime environmental problems throughout the world.

Commission of the European Community-CEC(2006) based on the standard of the European Union(EU) recognizes seven soil functions that are synonymous to soil threats and these range from biomass production(including agriculture and forestry), storing, filtering and transforming nutrients (substances and water), biodiversity pool(such as habitats, species and genes), physical and cultural environment for humans and human activities; source of raw materials, carbon pool to achieving geological and archaeological heritage. Soil is adjudged to be healthy when it is productive despite the adverse biotic and abiotic effects in the immediate environment.

Nigeria has a total area of about 923,000 sq. km with 708,000 sq. km of agricultural land accounting for 76.7% while the arable land is 344,555.9 sq. km accounting for 37.33% (FAO, 2015). Land under cereal cultivation occupies 17,342,468ha while permanent crop land and forest areas are 659,022 sq. km (71.4%) and 69,930 sq. km (7.58%) respectively. This is evident that there is an ample prospect for agriculture in the country but there are some natural occurrences which militate against the productivity of land, it may be visible in terms of wide expanse but lack substance which can make it economically viable specifically in the area of food production. Among these are erosion, leaching, burning, flooding and other forms of land degradation which affect soil quality in any form. Cultivation of arable crops in the sub-Sahara Africa is prevalent based on the attributes of early maturity, survival rate and easy of processing into edible form, even with simple farm machines. Data in Table 1 shows the production of six selected arable crops frequently produced across the country, these are maize, millet, guinea corn, yam, cassava, and cocoyam. The total production for arable crops for the period under review; for 1980 was 14, 084,000 tons with the estimated population of 74.3 million and per capita output of 0.19 tons (190kg)., total production for 2000 was 80,424,999 with an estimated population of 149.5 million giving 0.53 tons (530kg) while the total production for 2016 was 12,512,616 tons with an estimated population of 174.3 million and 0.17 tons (170kg). The arable food crop population ratio increased steadily from 1980 to 2000 but followed a downward trend from 2000 to 2016 (FAO, 2018). This reflects the food availability per capita in the country which when critically looked at does not portend a good future for food sufficiency in the country. The information on crop output could have been better than presented by the Food and Agriculture Organization provided that some natural challenges were not frequently encountered. Fluctuation in productivity as reflected in the table is probably due, in part, to soil problem arising from land degradation due to delicate nature of tropical soil and unconventional farming practices commonly adopted by farmers.

Table1: Per Capita Selected Arable Crop Output and Population for Nigeria from 1980 to 2016 in Tons.

Crop / Year	Maize	Millet	G' Corn	Yam	Cassava	Cocoyam	Total Prod.	Popn (in m')	Percap Output
1980	612,000	2,824,000	3,690,000	5,250,000	1,500,000	208,000	14,084,000	74.3	0.19
2000	4,107,000	5,814,000	7,711,000	26,210,000	32,697,000	3,886,000	80,424,999	149.5	0.53
2016	764,678	1,468,668	6,939,335	44,109,615	57,134,478	3,175,842	12,592,616	174.	0.17

Source: Computed From FAO Data (2018)

Examining critically the food situation in the country, quality of land had impacted negatively on food production. Arable crops are surface feeders, based on this; sheet and rill erosion has been a serious menace in depleting soil nutrients thus denying crops from tapping the required nutrients which is necessary for their survival from the soil. Gully erosion is the most critical as it involves loss of soil and organic matter from the soil to a deep ground level (Kyawt *et al*., 2015).

Literature is awash with several works on erosion and its impact on the environment and crop productivity. Saliba (1985) worked on 'Soil productivity and farmers' erosion control incentives' of the United States using a dynamic modelling approach and based the work on the relationships between farm management, soil productivity, crop yields and other variables. The major finding was that erosion had significantly reduced farm output and it was suggested that with sufficient and effective farming practice, this perennial problem could be surmounted. From the foregone, this study will answer the following research questions in order to give an in-depth understanding of the spate of erosion effect on arable crop productivity and draw policies which are capable of addressing the menace. What are the socioeconomic characteristics of the arable crop farmers? What are the input and output characteristics of the respondents? What are the determinants of arable crop output among the respondents? What is the individual farm efficiency? The specific objectives of this study are to describe the socioeconomic characteristics of arable crop farmers; examine the input and output characteristics of the respondents; identify the determinants of arable crops produced among farmers; and determine the inter-farm efficiency in the study area.

Test of Hypothesis

H_0: There is no significant difference between the technical efficiency of farmers with erosion and the farmers without erosion on their farm.

Methodology

The Study Area

The study was carried out in Egbeda Local Government Area (LGA) of Oyo State because of the cluster of arable crop farmers who produce for their immediate families and convert the marketable surplus to cash. Its headquarters is located in Egbeda. It is located on latitude 7^0 21' to 8.0^0 N and longitude 4^0 02' to $4^0$28'E. It is bounded in the North by Lagelu LGA, in the West by Ibadan North East LGA, in the South by Ona Ara LGA and in the East by Ogun State. It has the population of 281,573(National Population Commission, 2006) and the estimated population of 398,500(National Bureau of Statistics, 2018) and the density of 2,086 per square kilometre. Lagelu LGA is situated in the rainforest vegetation belt with an average annual temperature and rainfall of ±27^{0}C and 1850mm. The rainfall in the area is always of high intensity and fair distribution which makes it torrential while the soil is highly weathered and fragile ranging from clay-loam to sandy loam (Oyo State Ministry of Information, 2018). The nature of the soil is erosion prone and at the same time as a high nutrient retention capacity to nourish especially the surface feeder crops which are mostly arable. Among these are: maize, guinea corn, melon, cowpea to mention but a few. The area is predominantly occupied by farmers who practise either on subsistence or commercial basis. The notable rural villages in the area are Erunmu, Alugbo, Osegere, Owo Baale, Kasumu/Ajia, Adeyadi, Ayede, Fayo, Koloko and Olorisa Oko among others. There is partially heavy vegetation in the area which further influences rainfall (Oyo State Ministry of Information, 2018).

Type of Data and Instrument the of Collection

Cross-sectional primary data were collected and used for this study. These were collected through the use of structured questionnaire and interview schedule. Among the variables included were age, gender, household size, farming system, cropping pattern, crop types cultivated, extension contact, method of cultivation and the host of other data that are germane to achieving the aims and the objectives of this study. The data used were collected in the month of September/October 2018 in order to assess for physical and pictorial details of the area.

Sampling Technique

Multistage sampling procedure was used in the selection of respondents for the study. The first stage was the purposive selection of Egbeda LGA (from 33 LGAs in the State) where the rainfall in the part of the year is torrential and in many cases result in erosion and relocation of surface soil. Random selection of ten rural villages where erosion was confirmed to be severe was selected and at the same time, farmers without erosion experience were also selected from the villages; the selection was proportional to the population of active farmers in each of the villages. These are: Erunmu, Efunwole, Ayede, Osegere, Owo Baale, Kasumu-Ajia, Adeyadi, Fayo, Idi-Omo and Alugbo, this constituted the second stage. The third stage was the purposive selection of eleven (11) respondents from Erunmu, Osegere and Owo Baale which are larger than the other seven(7) villages from which six(6) respondents were selected from each due to their relatively similar size of active farmers(see Table 2). The arable crops captured in the study were maize, groundnut and cassava and were all converted to equivalent weight using of conversion table(Kormawa, 2008). Figure 1 showed clearly the position of Egbeda LGA in Oyo State.

LGA	Village		Sampled Respondents	
1st Stage	2nd Stage		3rd Stage(with erosion	Without Erosion
Egbeda LGA	(i)	Erunmu	11	11
	(ii)	Efunwole	6	6
	(iii)	Ayede	6	6
	(iv)	Osegere	11	11
	(v)	Owo Baale	11	11
	(vi)	Kasumu/Ajia	6	6
	(vii)	Adeyadi	6	6
	(viii)	Fayo	6	6
	(ix)	Idi-Omo	6	6
	(x)	Alugbo	6	6
-		-	75	75
Total Sample:			150	

Source: Field Survey, 2018.

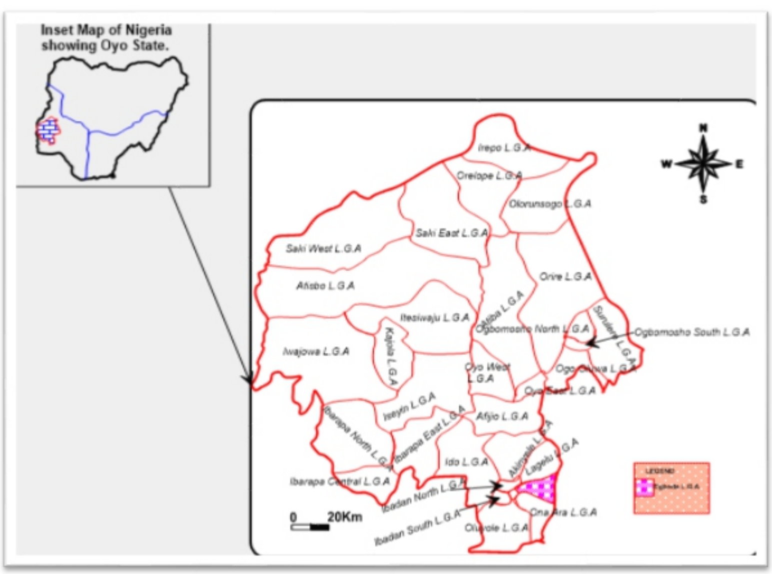

Figure 1: Map of Oyo State Showing Egbeda Local Government Area.

Source: Survey Division, Oyo State. s

Analytical Tools

Both descriptive and inferential analytical tools were used in analysing the data used for the survey study as presented in Table 3 below.

Table 3: Analysis of Objectives and Statement of Variable detail

	Objective	Analytical Tool	Variables	Rationale for Choice
1.	Socioeconomic characteristics of the arable crop farmers	Descriptive Statistics	Age, gender, experience, household size, marital status e.t.c.	Ease of analysis
2.	Input and output characteristics of the respondents	Descriptive statistics	Farm size, seed, fertilizer, agrochemicals and the quantities of output from farm among others	Ease of analysis
3.	Inter-farm efficiency/determinants of output.	Stochastic Frontier Production Function	Farm output, farm size, labour use, farming experience, Agrochemicals, fertilizer use, age e.t.c.	Amenable to identifying individual farme r's performance

Source: Author's Initiative, 2018.

Stochastic Frontier Production Function

The stochastic frontier model was used as the inferential statistics for the analysis of technical efficiency. Cobb-Douglas Stochastic Frontier Production Function was used with inefficiency variables to determine the technical efficiency effects of most important variables to the returns of the quantity of arable crops produced. The technical efficiency of individual farmer is defined in terms of the ratio of the observed output to the corresponding frontier output given the available technology (Olayemi, 2004; Onyeanwaku and Effiong, 2006).

Model Specification

Stochastic frontier production function can be estimated using either the Maximum Likelihood Method (MLM) or using a variant of the Corrected Ordinary Least Square (COLS) method suggested by Richmond (1974). The MLM was applied, using the FRONTIER computer programme developed by Coelli (1994). The following model specifications were used in the analysis:

$$\ln Y = \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + ... + \beta_4 \ln X_4 + V_i - U_i$$

where ln denotes logarithms to base e

Y_i = Quantity of crop produced (in kg)
X_1 = Farm size (in ha)
X_2 = Quantity of fertilizer (in kg)
X_3 = Quantity of agrochemicals (in litres)
X_4 = Quantity of labour (in Man-days)
X_5 = Quantity of seed (in kg)

V_i = Random error assumed to be independent of U_i identical and normally distributed with zero mean and constant variance N $(0, \delta^2 v)$
U_i = Technical inefficiency effects which are assumed to be independent of V_i, they are non-negative truncation at zero or half normal distribution with $N(\mu;\delta^2 u)$

If $U_i = 0$, no allocative inefficiency occurs, the production lies on the stochastic frontier. If $U_i > 0$, production lies below the frontier and it is inefficient. The inefficiency model based on Battese and Coelli(1995) specification was

$$U_i = \delta_0 + \delta_1 X_1 + \delta_2 X_2 + \delta_3 X_3 + \delta_4 X_4$$

Where
Z_1 = Education level (in years)
Z_2 = Farming experience (in years)
Z_3 = Extension contacts (No.)
Z_4 = Household size (No.)

Test of Hypothesis

Paired T-Test

The hypothesis formulated was tested using pair-test based on the fact that two independent groups were compared, that is, farmers with and without erosion experience in relation to their output quantities. The samples used in the study have unequal variances and equal number of observations $(n_1 + n_2)$, the test statistics is the same, that is,

Results and Discussion

Socioeconomic Characteristics of Arable Crop Farmers

The socioeconomic characteristics of arable crop farmers are presented in Table 3. Age of respondents showed that farmers in the two categories had an average age of about 48 years inferring that respondents were young and active. Gender distribution of respondents revealed the dominance of male farmers across the three categories as majority with over 70 percent showing that a high premium is placed on marital relationship among arable crop farmers in the area. Years of experience of the respondents revealed that farmers without erosion and those with erosion on their farms were in the respective of 23years and 8 years while the pooled result was about 15 years. The result showed that farmers with more years of experience had little or no erosion on their farms. This advantage may be due to application of erosion controlling strategies, modern or indigenous which were either gained from their elders or extension agents.

Household size was 7 members among farming households with no erosion experience while their mates with harrowing experience of erosion was 6 members and the pool data was 7 members. It could be inferred from this result that family labour might not have anything to do with the size of household when it comes to eradicating erosion. Married farmers were the majority in the two reference categories while there was similar result for the pooled data meaning that all farmers in the study area were more cultured and traditional in their ways of life.

Secondary school education was highest (54.7%) among farmers without erosion experience while primary education was highest (66.7%) among farmers with erosion problem but generally, primary school education was dominant in the entire area when pooled result was placed under consideration. Based on this result, it shows that education played a significant role in the management of farms most especially in averting erosion effects on the farmland as some farmers are believed to acquire some knowledge from formal and informal sources through exposure from education. Impact of erosion on the farms in the study area also reflected in the monthly income of arable crop farmers in the area. The result showed the average monthly income of farmers who are not affected by erosion as N39, 298.67k while their counterpart with erosion affected farms realized N32, 330.67k on monthly basis and the average monthly income in the entire area was N25, 362.67k($69.487/month) which translates to $2.32day. It could be inferred from this result that the margin of income realized by farmers who are not affected by erosion could be attributed to the efficient management of farmland which helped to a larger extent in increasing farm output given the more population of crops the available land permitted them to plant.

Erosion control was the management of farm using different methods which might be modern or traditional or both. Farmers in the area who are not affected by erosion adopted ridging across the slope (49.3%) as the common strategy while the same method was mostly (36%) used by the farmers who are affected by erosion; generally, the method was adopted mainly in the area by all farmers. It could be inferred from this that the method seemed to work well for farmers without erosion probably because of the level of adoption of the method or difference in the terrain of farmland.

Table 3: Socioeconomic Characteristics of Arable Crop Farmers

Variable	Data of Farms Without Erosion(n=75)			Data of Farms With Erosion(n=75)			Pooled Data(n=150)		
	Freq.	%age	Mean	Freq.	%age	Mean	Freq.	%age	Mean
Age(in years)									
≤20	1	1.3		-	-		1	0.67	
21-40	18	23.4	48.11years	21	28.0	48.40 years	39	26.0	48.3 years
41-60	42	54.6		46	61.3		88	58.7	
>60	14	18.2		8	10.7		22	14.7	
Gender									
Male	56	74.7		55	73.3		111	74.00	-
Female	19	25.3		20	26.7		39	26.00	
Farm. Exp.									
≤10	6	8		-	-		6	4.0	
11-20	17	22.7	22.9 years	64	85.3	8 years	81	54.0	15.3 years
21-30	12	16		10	13.3		22	14.7	
>30	40	53.3		1	1.3		41	27.3	
Household Size									
≤6	37	49.3		42	56.0		79	52.7	
7-10	20	26.7	7 members	32	42.7	6 members	52	34.7	7 members
>10	18	24.0		1	1.3		19	12.6	
Marital Status									
Single	5	6.7		15	20.0		20	13.3	-
Married	64	85.3	-	54	72.0	-	118	78.7	
Widowed	6	8		5	6.7		11	7.3	
Separated	-	-		1	1.3		1	0.7	
Educ. Level									
No formal	-	-		-	-		-	-	
Primary	21	28.0	-	50	66.7	-	71	47.3	-

Input and output Characteristics of the Arable Crop Farmers

Inputs and output characteristics of the respondents are presented in Table 4. The mean farm size of arable crop farmers was 1.84ha and 1.87ha for farmers without erosion and erosion respectively with a difference of 0.03ha. This result showed that farmers with erosion on their farms made use of additional land area in order to meet up with the target output. Quantity of labour used by farmers with eroded farms was about 181mandays per cropping season while their counterparts without erosion used 57.5mandays with a difference of 124.3ha. More labour was found to be used on the eroded farms for routine operations and reclamation of farmland from erosion. These reclamation efforts could range from erection of barrier, terracing to bounds making. Seed planted by farmers with erosion and their counterparts who are otherwise was an average of 32kg and 29.1kg respectively with a difference of 2.9ha. This result showed that farmers whose farms were devoid of erosion had more land areas to cultivate and therefore planted more seeds while their counterparts with erosion-ravaged farms could not attain the maximum plant population due to loss of substantial farm land to erosion. Farmers with erosion experience used more fertilizer (147.8kg) than their counterparts without erosion experience. The result showed that farmers with erosion experience use more fertilizer in order to balance the nutrient loss arising from leaching and run-off. More litres of agrochemicals

(0.31ha) were found to be used by farmers with erosion scourge and the reason for this was that more agrochemicals were wasted on erosion-prone farms in the area due to perceived reduction in its effectiveness most especially where land is heavily degraded. Average output quantity of arable crops produced by the farmers between farmers without erosion and their counterparts with erosion were 3,939.3kg (3.94tons) and 2,525.4kg(2.53tons) respectively and a difference of 1,412(1.41ha). It could be inferred from this result that, with more land available for arable crop farmers and other basic inputs, there is likelihood that farmers who are not affected by erosion will optimize the use of available farmland and produce more efficiently.

Variable	Without Erosion	With Erosion	Mean Difference
	Mean Value	Mean Value	
Farm size(in hectares)	1.84	1.87	0.03
Labour(in man-days)	57.5	181.8	124.3
Seed(in kilogram)	32.0	29.1	2.9
Fertilizer(in Kilogram)	139.2	287.0	147.8
Agrochemicals(in litres)	4.40	4.71	0.31
Output(in kilogram)	3,937.3	2,525.4	1,412
Sample size	75	75	

Source: Field Survey, 2018.

Estimate of Technical Efficiency among Arable Crop Farmers

(A) Farmers Without Erosion Experience

The maximum likelihood estimates of the stochastic production parameters for the crops (in aggregate) are presented in Table 5. The gamma (ʹϒ) value, 0.0399 (1-0.9601) was positively significant at 1% meaning that, about 0.0399 variation in the aggregate output of arable crop is due to technical inefficiency and other factors which were off the control of arable crop farmers. Sigma (σ) was 1.1884 and found to be significant at 1% level and valued greater than 1, which indicated a good fit for the model (Tadesse and Krishnamoorthy, 1997).

All modelled efficiency variables were found to be statistically significant with signs of interest which are also in agreement with *a priori* expectation except labour which is not significantly different from zero even at 10%. Farm size is positively signed and found to be very significant at 1% level. A percentage increase in farm size of arable crop farmers there is an increase in farm output by 34.79%. This implies that as farmer increases the area of land under cultivation there is a readily available opportunity to achieve optimum plant population and proportional crop output *ceteris paribus*. Fertilizer is positively signed and found to be significant at 1%, therefore, a percentage increase in the quantity of fertilizer used increases farm output by 74.35%. The more the quantity of fertilizer added to the farm land, all things being equal; there is an increase in the output harvested by farmers at more than proportional quantity. A percentage increase in the quantity of agrochemicals used by farmer decreases the quantity of arable crop produced by 20.17%. It could be implied from this outcome that, the use of agrochemicals is prevalent by farmers most especially for weed control and dusting of seeds. When much chemical is used on the farmland, there may be some micro and macro-elements inhibiting the required quantity of nutrients needed by crops and consequent low output. Seed is negatively significant at 10% and decreased the quantity of output by 6.73%. This implies that there was sufficient use of seed on the farm. The result also suggests further that, the quantity of seed used by farmers is not affected by erosion either in terms of run-off or leaching which less negative effect on arable crop output.

The inefficiency variables for farmers with no erosion showed that education and number of extension contacts positively influenced technical efficiency of arable crop farmers. A percentage increase in the years of education and number of extension contacts increased the quantity of arable crops produced by farmers by 155.08% and 114.60% respectively. It could be inferred from this result that education helps immensely to use both the western and traditional knowledge in proffering solution to erosion problem. More so, advice from the extension agents goes a long way in the use of effective erosion control method that enhanced maximum land area that was available for crop cultivation.

(B) Farmers with Erosion Experience

Diagnostic parameters, sigma (σ) and gamma (ʹϒ) were 1.0901 and 0.9730(0.027) respectively. Sigma showed good fit for the model while sigma showed that about 0.027 percent of the variation in the quantity of crop output was due to technical inefficiency while others were due to factors which were outside control of farmers. Efficiency variables for farmers whose farms are to prone to erosion were found to be significant at 1% and 5% respectively except labour which was not found significantly different from zero even at 10% level. Farm size negatively influenced the quantity of arable crops produced at 1%. A percentage increase in the quantity of farm size was found to reduce arable crop output by 118.78%. It could be inferred from this result that with an increase in the size of farmland, additional output cannot be realized because of nutrients shortage caused by erosion. Fertilizer was found to positively influence the quantity of output at 1% percent level of significant. Therefore, a percentage increase in the quantity of fertilizer used leads on the average to 95.38% increase in crop output. It could be inferred from this result that application of more fertilizer (organic and inorganic) could replenish lost nutrients caused by erosion. Quantity of agrochemicals used by farmers positively and significantly influenced the amount of crop produced. A unit increase in the quantity of agrochemicals leads to 19.07% increase in crop output among arable crop farmers. This means that farmers could only resort to the use of agrochemicals in the control of weeds and dusting of seeds in the face of severe erosion effect in order to maintain the soil structure. Seed was positive and significantly influenced the quantity of farm output. A percentage increase in the quantity of seed used by arable crop farmers resulted in 16.76% increase in crop output. The use of additional seed is inevitable in area with erosion as most likely, some seeds would be needed to compensate for the lost ones through run-off or leaching. This helps to increase the plant population within the available area and subsequent increase in output.

Years of education and farming experience were found to be significant at 1% and 5% respectively. A unit increase in years of education of the respondents increased the quantity of arable crops by 62.59% while a percentage increase in the farming experience of the respondents decreased the quantity of farm output by 378.78%. The implication of this result was that farmers with more years of education had opportunity of increasing farm output and the reason might be due to their level of erosion control method acquired from formal or informal source such as extension contacts, information from trainings, internet source and traditional knowledge. Conversely, years of farming experience reduced farm output of arable crop farmers.

The variables modelled for the combined data were found to be significantly different from zero except agrochemicals and seeds which were not significant at the three conventional levels of 1%, 5% and 10%. Farm size is significant at 5% and found to positively influence the farm output. It could be inferred from this result that with increase farm land by one percent brought about an increase of 27.79% increase in the quantity of arable crops produced. Fertilizer was negatively signed and found to be significant at 5%. A percentage increase in the quantity of fertilizer used decreased the quantity of farm yield by 28.87%. Also, labour was found to be statistically significant at 10% and also positively influence farm yield by margin of 24.67% relative to 1% increase in the quantity of labour used. The inefficiency variables, years of experience and the number of extension contacts were found to be significant at 5% but negatively influenced farm output by margin of 61.96% and 62.18% relative to 1% increase in both inputs respectively. The mean technical efficiency for farmers without erosion, with erosion and combined data were 0.86, 0.72 and 0.68.

Table 5: Maximum Likelihood Estimate (MLE) of Technical Efficiency of Arable Crop Farmers

Variable	Production Function Estimates					
	Without Erosion		With Erosion		Combined Data	
	Coeff.	T-ratio	Coeff.	T-ratio	Coeff.	T-ratio
Constant	3.4382***	3.8	0.5660	1.7	0.1169***	14.5
Farm size(in Ha)	0.3479***	5.8	-1.1878***	-10.2	0.2797**	2.17
Fertilizer(in km)	0.7435***	3.1	0.9538***	16.6	-0.2887**	-2.70
Agrochem.(in ltrs)	-0.2017***	-3.6	0.1907**	2.6	0.2006	1.12
Labour(in Mds)	0.0145	0.40	0.5076	0.8	0.2467*	2.3
Seed(in kg)	-0.0673*	-1.9	0.1676***	3.3	0.2542	2.0
Inefficiency model						
Constant	2.1811	1.5	13.751***	-3.6	0.4466***	11.3
Education(in yrs)	-1.5508***	-5.6	-0.6259*	-1.8	-0.5465	-0.45
Farm. exp.(in yrs)	0.1369	1.07	3.7878***	3.9	-0.6195***	-4.9
Ext. cont.(No.)	-1.1460***	-3.3	0.1532	0.7	-0.6218***	-4.9
Sigma(σ^2)	1.1884***	6.2	1.0911***	7.3	0.4901***	6.9
Gamma(γ)	0.9601***	106.5	0.9730***	149.4	0.9283***	8.2
Log. Lik. Fxn(llf)	19.7		-31.69		145.04	
Likelihood Ratio	299.9		73.91		91.26	
Mean TE	0.86		0.72		0.68	
Sample size(n)	75		75		150	

Elasticity and Return to Scale (RTS) of Categories of Arable Crop Farmers

Elasticity arable crop and return to scale of farmers with, without experience and combined data that represents the whole sampled population is presented in Table 6 .The RTS for farmers without erosion, with erosion experience and the combined farmers were 0.83, 0.62 and 0.68 respectively. The three groups operated in the stage II of the production possibility surface. This shows that, the three categories performed optimally despite the intra-farm problem that affected them. Farmers without erosion experience can be adjudged the best in terms of performance and this is followed by the combined sampled farmers and lastly, farmers whose farms are erosion-prone. Farms that are not prone to erosion are most efficient in term of input used and this is traceable to achievement of full land area for maximum crop population and optimal yield while farmers with erosion experience case are otherwise.

Variable	Without Erosion	With Erosion	Combined Data
Farm size(in Ha)	0.34	-1.18	0.27
Fertilizer(in kg)	0.74	0.95	-0.28
Agrochem.(in ltrs)	-0.20	0.19	0.20
Labour(in man-days)	0.01	0.50	0.24
Seed(in kg)	-0.06	0.16	0.25
RTS	0.83	0.62	0.68

Source: Field Survey, 2018

Frequency Distribution of Technical Efficiency of Arable Crop Farmers

Frequency distribution of arable crop farmers is presented in Table 7. The result showed farmers whose farms are not prone to erosion have the majority (69.3%) within the efficiency range of 0.81-0.90 with a mean efficiency score of 0.86. Farmers whose farms are prone to erosion was highest (57.3%) within the efficiency range of 0.71-0.80 with the mean efficiency score of 0.72 while the efficiency for the combined data was highest (49.6%) within the bracket of 0.61-0.70 and the mean efficiency value of 0.68. Farmers without erosion experience are most efficient because of their ability to make optimal transformation of inputs to output. This is the full utilization of basic production inputs such as land, labour, fertilizer, agrochemical and seed among others without being lost to surface run-off whereas, farmers with erosion experience has reduction in the available land surface which could have been used for more crop establishment per unit area, non-loss of seeds, agrochemical and fertilizer among others to surface run-off and leaching. Conversely, farmers with erosion experience are liable to losing these basic inputs to these natural hazards which definitely reduce target yield.

Table 7: **Frequency Distribution of Technical Efficiency among Farmers**

Range	Without Erosion		With Erosion		Combined Data	
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
≤0.10	-	-	1	1.3	5	3.4
0.11-0.20	-	-	-	-	7	4.7
0.21-0.30	-	-	2	2.7	3	1.8
0.31-0.40	-	-	-	-	7	4.7
0.41-0.50	-	-	1	1.3	8	5.4
0.51-0.60	-	-	2	2.7	20	13.4
0.61-0.70	4	5.3	2	2.7	74	49.6
0.71-0.80	8	10.7	43	57.3	16	10.6
0.81-0.90	52	69.3	24	31.9	9	6.0
≥0.90	11	14.7	-	-	1	0.6
Total	75	100.0	75	100.0	150	100.0
Mean	0.86		0.72		0.68	
Maximum	0.96		0.83		0.74	
Minimum	0.60		0.07		0.07	

Source: Field Survey, 2018

Test of Hypothesis

Table 8 presents result on test of hypothesis between the technical efficiency of arable crop farmers with and without erosion on their farm. The t-value in the pair t-test score was 12.347 and this was found to be significant at 1 percent level. Therefore, the null hypothesis was rejected for the alternative hypothesis which was accepted. Therefore, there is a significant difference between the technical efficiency of farmers with erosion on their farms relative to their counterparts with erosion-free farms.

Variable	Mean	Std Deviation	Standard Error Mean	t-value	Df	Sig.(2-tailed)
Farmers without erosion and farmers with erosion	0.38219	0.269	0.031	12.347	75	0.000

Conclusion and Recommendations

Based on the empirical findings of the study, it could be concluded that arable crop farmers without erosion performed better than their counterparts with erosion experience and this was better determined based on the difference in their efficiency scores. It is therefore recommended that: farmers in the area should be given a multifaceted erosion control method so that more of the nutrients would not be lost through any kind of surface runoff. More so, more extension education should be given to farmers which must strictly address land reclamation and nutrient replenishment.

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