MITIGATION TO ARABLE LAND DEGRADATION AND EFFICIENCY OF FOOD CROP PRODUCTION IN NORTH-CENTRAL NIGERIA

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ABSTRACT

Efficient land utilization and management practices ensure achievement of farm level objectives in terms of economic viability, food security and environmental sustainability, amounting to risk aversion. The study analysed the effects of mitigation to land degradation on efficiency of food crop production among small-scale farmers in North-Central Nigeria. A Multistage sampling technique was used to select 360 respondents for the study. Data for the study were obtained from primary sources with the aid of a well-structured questionnaire and analysed using descriptive and inferential statistics. It was found that, farmers have been using strategies to adapt to land degradation such like; mixed-cropping (67.4%), use of modern technologies (fertilizer (95.2%), herbicides (92.4%) and tractor (16.6%)), minimum or zero tillage (16.9%), manure usage (41.3%), improved/resistant varieties (82.3%). Fallow Rotation Intensity was 0.89 indicating continuous cropping. Crop diversification (0.31) and tractorization (0.99) increased farmers' economic inefficiency of land use. Alternately, Improved varieties (-0.01), crop rotation (-0.53) and clean clearing (-0.33) reduced economic inefficiency. The study identified continued cropping, crop diversification and tractorization as key factors that increased farmers' inefficiency in the North central region of Nigeria. This calls for a review of land holding especially for farming interests with more access to land for farming and strategies to reduce farm inefficiencies.

Keywords: Mitigation, Land degradation, Efficiency, Food crop production

INTRODUCTION

With the continued growth of the human population, competition for limited land resources has steadily increased over recent years and most countries in sub-Saharan Africa like Nigeria, have experienced an intensive use of the arable land. Although scholars like Boserup (1981), Buckles and Erenstein (1996), Erbaugh (1999) had earlier on affirmed the potential of achieving agricultural growth through intensification, Headey and Jayne (2014) submitted that in much of African Agriculture, intensification has reached the stage of permanent cropping.

However, commensurate use of modern inputs was identified as fundamental condition for sustainable growth through increased land-use intensity. In the absence of this, increased land-use intensity could lead to continuous depletion of soil fertility, decline in productivity, loss of soil structure, soil erosion and land degradation (Cassman 1999; Erbaugh 1999). The intensity of land use has been recognised as one of the most significant human alteration to the global environment (Matson, Parton, Power and Swift, 1997). Meanwhile, land degradation, the weakening of the structure, stability and productive potential of the soil, is one of the worst environmental problems facing many people world–wide, with over 40 million affected in Nigeria (Etuonovbe, 2009). However, commensurate use of modern inputs was identified as fundamental condition for sustainable growth through increased land-use intensity. In the absence of this, increased land-use intensity could lead to continuous depletion of soil fertility, decline in productivity, loss of soil structure, soil erosion and land degradation (Cassman 1999; Erbaugh 1999). The intensity of land use has been recognised as one of the most significant human alteration to the global environment (Matson, Parton, Power and Swift, 1997). Meanwhile, land degradation, the weakening of the structure, stability and productive potential of the soil, is one of the worst environmental problems facing many people world–wide, with over 40 million affected in Nigeria (Etuonovbe, 2009).

The persistent abuse of land resources for any reason usually leads to irreversible degradation, while if economically or properly used will lead to sustainable development and poverty reduction through provision of both food and wealth (Fakoya *et al*., 2007; Ezeaku & Davidson, 2008). Efficient land utilization and management practices ensure achievement of farm level objectives in terms of economic viability, food security and environmental sustainability, amounting to risk aversion (Udoh & Akintola, 2002). According to Fagbohun (2010), improper land utilisation coupled with natural disasters often lead to land degradation.

The widening degradation of agricultural land, coupled with the low adoption/use of environmentally friendly and socio-economically robust technologies among resource-poor rural households have created a serious gap in meeting the objective of food production to feed the ever-increasing population. Hence, there is every need to increase food crop production due to increase in human population so as not to cause hunger and starvation among the teeming population. Land use does not necessarily lead to degradation, not even intensive land use. Proper short term investments in inputs (water, fertilizer, seeds) and long term investments in structures and equipment (pumps, tractors, dams, terraces) can conserve soil and water, while allowing productive and sustainable agricultural land use. However, if conditions are such that farmers cannot invest in these inputs and structures, human activities will continue to degrade natural resources and peoples livelihoods, unless some adaptation strategies can help provide food and income without destroying the natural resource base.

Despite the perceived importance of land in rural food productivity and maintenance of environmental quality, little empirical evidence exists on the influence of land degradation mitigation efforts on efficiency of food crop production (Lubowski *et al.*, 2006). To reduce poverty via agriculture and rural development, there is need to understand the importance of adaptation to land degradation problems in the Nigerian economy. Hence, sustainable environmental-friendly agriculture and rural development should be the overriding issue in future planning and this, among other requirements demands adequate knowledge of sensitivity towards arable land utilisation and productivity through efficient management of farms (ECA, 2004).

The relationships between mitigating land degradation and efficiency of food crop production will provide ample evidence as a basis for the development of improved land policies in support of food and environmental security. Also, the effect of the current farming practices adopted by arable farmers to mitigate land degradation in the study area would provide an empirical guide for the identification of any gaps that may exist in the current farming practices employed and the interventions required towards more sustainable food production. This paper assessed the effect of mitigation to land degradation and efficiency of food crop production among small-scale farmers in North-central Nigeria. Specifically, the paper: described households' specific characteristics, determined the efficiency of food production and examined the influence of land degradation mitigation strategies on efficiency of food production.

METHODOLOGY

The study was carried out in North-central Nigeria. The zone has a land area of 296, 898 km^2 representing nearly 32 percent of the country's total land area (NBS, 2008). There are six states in the zone and the Federal Capital Territory, Abuja. The States include Benue, Kogi, Kwara, Nasarawa, Niger and Plateau. It is located in the central part of Nigeria and in the sub-humid region of the country, and bounded to Bauchi, Kaduna, Zamfara and Kebbi States to the north; Cross-River, Ebonyi, Enugu, Edo, Ondo, Ekiti, Osun and Oyo States to the south; Taraba State and Republic of Cameroon to the east and the Republic of Benin to the west. Situated between latitudes 6^o 30' - 11^o 20' N and longitude 7^o – 10^oE, the zone has 20.36 million people with the rural population constituting 77 percent (NPC, 2006).

Multi-stage random sampling technique was used to select a sample size of 360 respondents. In the first stage, a random selection of three States from North-central Nigeria was made. Hence, Benue State, Kogi State and Plateau State were selected. Secondly, two agricultural zones were randomly sampled from each State selected for the study making six agricultural zones. Thirdly, two local government areas were randomly selected from each agricultural zone, giving a total of twelve local government areas. In the fourth stage, three farming communities were randomly selected from each local government area making a total of thirty-six farming communities. Lastly, ten arable crop farmers were randomly selected from each farming community, giving a sample size of 360 arable crop farmers (i.e. 120 respondents from each state). Apart from Plateau State which returned all the 120 copies of the questionnaire, 117 and 119 were returned from Benue and Plateau States respectively giving a total of 356 respondents analysed for the study.

The use of descriptive statistics like percentage, frequency distribution and means were employed to analyse data for objective i. For objective ii, the Stochastic Production Frontier Model was used. The model was stated as:

$$lnY = \beta_0 + \beta_1 lnL + \beta_2 lnFL + \beta_3 lnHLC + \beta_4 lnFC + \beta_5 lnSC + \beta_6 lnTC + \beta_7 lnMC + \beta_8 lnAC + \beta_9 lnC + v_i - u_i$$

vi ~ $N(0,\sigma^2_v)$

Where:

ln = natural logarithm,

Y = total revenue from 5 major food crops per ha (₦), L= farm land area of ith farmers (ha), FL= family labor used by ith farmer (man-day), HLC = cost of hired labour by ith farmer (₦), FC= fertilizer cost by ith farmer (₦), SC = Seed cost by ith farmer (₦), TC = cost of mechanization, MC = the cost of manure (₦), AC = Cost of agrochemicals (₦), and C = other capital inputs (taxes, interest on loan in ₦), Vi= are random variables which are assumed to be independent of μ_i, identical and normally distributed with zero mean and constant variance.

μ_i= which are non-negative random variables which are assumed to account for technical inefficiency in production and are often assumed to be independent of Vi such that μ is the non-negative truncated (at zero) U of half normal distribution with $|N(0, \sigma^2_v))|$.

The inefficiency of production, μ_i is modeled in terms of the environmental degradation adaptation strategies that are assumed to affect the efficiency of land use (land value proxied by farm income) of arable farmers.

The inefficiency model is specified as follows:

$$\mu_i = \delta_0 + \delta_1 Z_1 + \delta_2 Z_2 + \cdots + \delta_{20} Z_{20}$$

where:

$|ui|$ = inefficiency of i*th* farmer, $\boldsymbol{\delta}_0$ = constant, $\boldsymbol{\delta}_1 - \boldsymbol{\delta}_{20}$= estimated parameters

The zi are the independent variables specified as:

Z_1 = household size (number of people in a household),

Z_2 = population density (household size per ha), Z_3 = farming experience (years),

Z_4 = education (years), Z_5 = off-farm income (₦), Z_6 = extension contact (number of contacts in a year), Z_7 = land fragmentation (number of plots under crops),

Z_8 = irrigation use (1= use, 0 otherwise), Z_9 = use of improved varieties (= use, 0 otherwise),

Z_{10} = mulching (use = 1, 0 otherwise), Z_{11} = cover cropping (use = 1, 0 otherwise),

Z_{12} = minimum/zero tillage (use = 1, 0 otherwise), Z_{13} = crop rotation (use = 1, 0 otherwise),

Z_{14} = crop diversification (number of crops grown), Z_{15} = tenure security (inheritance/purchase land = 1, otherwise 0), Z_{16} = changed planting time (1, 0), Z_{17} = increase farm size (1, 0), Z_{18} = tractorisation (use = 1, 0 otherwise), Z_{19} = bush fallow practice (yes = 1, no 0) and Z_{20} = clean clearing (yes = 1, 0 otherwise),

RESULTS AND DISCUSSION

Farmer-Specific Characteristics in North Central Nigeria

The farmer-specific characteristics of arable farmers in the study area are presented in table 1. Majority of the respondents (62.4%) were found to fall within the age group of 41-60 years. On the average, the age of the respondents was found to be 48 years. This implied that the farmers were still within the active and economic age bracket of between 21- 60 years. The result agreed with the findings of Ogunwale (2000), Ezedinma and Otti (2001) that the mean age of farmers in Nigeria was between 45-48 years. The result was also in agreement with the study by Adikwu, Tsue and Abu, (2020) who found that majority of the food secure farmers in Benue State fell within the age bracket of 41-60 years.

Analysis of sex of household head showed that, majority of the respondents (79.5%) in North central Nigeria were males. The result implied that arable crop production was still primarily male dominated. This could be due to the cultural and religious background of most African communities that still put women's enterprise under their husbands' care as a form of submission. This result on sex of household head agreed with the study of Bamire (2010) on the effects of tenure and land use factors on food security among rural households in the dry savannas of Nigeria, where majority (92.5%) of the respondents were males.

The result of marital status showed that majority (87.6%) of the respondents were married. This implied that a high proportion of respondents had family responsibilities and would likely use land more intensely. The result of this study corroborated the work of Oluwatayo (2009) in rural Nigeria that about 63% of farmers were married. The result also agreed with the findings of Okwu and Acheneje (2011) on the socio-economic analysis of fish farming in Makurdi Local Government Area of Benue State, Nigeria, that majority of the respondents (74.5%) were married.

Analysis of the size of the arable farmers' household showed that majority of the respondents (76.7%) had household size of more than six people with the average household size of nine people. Large family size is assumed to be the source of labour, skills and strong social capital to adapt to changing situations. This result agreed with Obamiro, Doppler and Kormawa (2003) who reported that the average number of people in a farm household was seven. In addition, a study by Tsue, Lawal and Ayuba (2013) found a mean household size of nine people in Benue State, Nigeria.

The result of level of education of arable farmers showed that, 82% of them had formal education at varying levels. On the average, years of educational attainment of the respondents were 8.74. The result implied that arable farmers in the study area attempted secondary education and or its equivalence. This result suggested that majority of the arable crop farmers in North Central Nigeria could read and write. The result was similar to Abu, Alumuku and Tsue (2011) that the average years of educational attainment of tomato farmers in Benue State Nigeria were 8.32. The result was however higher than the 43.1% of non-formal educated farm operators found by Ashaolu, Momoh, Ayinde and Ugalahi (2010) in Obi and Doma Local Government Areas of Nassarawa State, Nigeria.

Many of the respondents (56.4%) were found to have farming experience of 20 years and below. On the average, arable farmers in the study area had a farming experience of 20.47 years. This implied that, the respondents were experienced farmers, hence, they had over the years acquired enough farming experience needed to perceive and handle the effect of environmental degradation on farming activities in their areas. This conformed to Ashaolu *et al.* (2010), that the average experience of beniseed farmers in Obi and Doma LGA of Nasarawa State was 20.5 years.

The result further showed that many (74.2%) of the respondents had farming income of ₦300,000.00 and below. The average farm income was ₦370,000.00. Majority (51.7%) of the respondents had no non-farm employment, while the average income from non-farm jobs of ₦ 183000 per year. This showed that farm income was the most important source of income for the farm household income. The low engagement in off-farm employment could hinder farmers from owning and operating large farm size and investing in both farm and environmental protection. Though, increased non-farm work reduced financial constraints, particularly for resource poor farmers and, thus, enabled them to purchase productivity enhancing inputs, the situation might have negative implication on efficient supervision of farm activities.

Table 1: Descriptive Statistics of Farmer-specific Characteristics (n = 356)

Variable	Frequency	Percentage (%)	Mean
Age (years)			47.86 (10.65)
≤ 20	1	0.3	
21 – 40	94	26.4	
41 – 60	222	62.4	
>60	39	11.0	
Sex			
Female	73	20.5	
Male	283	79.5	
Marital Status			
Married	312	87.6	
Single	22	6.2	
Separated	5	1.4	
Widowed	17	4.8	
Household Size			8.52 (4.26)
≤5	83	23.3	
6 – 10	184	51.7	
11 – 15	66	18.5	
>15	23	6.5	
Education (years)			8.74 (5.51)
Non-Formal	64	18.0	
Primary	81	22.8	
Secondary	115	32.3	
Tertiary	96	27.0	
Farming Experience (years)			20.47 (11.29)
≤10	92	25.8	
11 – 20	109	30.6	
21 – 30	101	28.4	
>30	54	15.2	
Annual Farm Income (₦)			370000 (753619.67)
≤100000	78	21.9	
100001 – 200000	105	29.5	
200001 – 300000	81	22.8	
>300000	92	25.8	
Off-Farm Income (₦)			183000 (344256.52)
≤100000	230	64.6	
100001 – 200000	44	12.4	
200001 – 300000	15	4.2	
>300000	67	18.8	

Note: Values in parentheses represent standard deviation

Source: Computed from field survey data, 2015

Strategies to Mitigate Land Degradation by Farmers

The results on land-use management practices as strategies to mitigate land degradation are presented in table 2. The result showed that mixed-cropping was commonly practiced by 67.4% of the farmers in the study area. The need to create security against potential risk of monoculture had been identified as one of the driving forces behind mixed-cropping as a form of diversification among smallholder farmers (Muhammad, Muhammad, Asif & Rashid, 2003; Preston, 2003). Nevertheless, one of the basic challenges in multi-cropping systems is the inherent competition among the component crops for space, soil nutrients and moisture. When the cultural practices adopted by the farmer do not cater for such competitions adequately; reduction in soil fertility, land degradation and consequently, environmental degradation would result (Makinde, Saka & Makinde, 2007).

The distribution of arable farmers by their use of modern technologies (fertilizer, herbicides and tractor) showed that majority of the farmers used fertilizer (95.2%) and herbicide (92.4%), while a few (16.6) used tractor on their farm. Tractorisation encourages large-scale farming. However, if overused or not properly used on the farm land, it could affect the structure of the soil and hence, lead to soil erosion and water logging, thereby causing land degradation and making it unfit for agricultural production.

Majority (83.2%) of the farmers in the study area practiced complete tillage, while minimum or zero tillage was practiced by few (16.9%) farmers. Minimum or zero tillage is an appropriate soil conservation technology in Nigeria as it reduces erodibility. This form of conservation tillage results in long-term maintenance of the soil structure and an increase in water retention and hydraulic conductivity.

Manure usage was practiced minimally (41.3%) in the study area. Application of domestic wastes (including animal waste) is an age-long traditional practice on farmlands. It is a source of nutrient as well as an ameliorative material for degraded soils. Results from a study by Ahaneku *et al.* (2004) using animal wastes as soil amendments showed a reduction in soil strength parameters like compaction and bulk density, arising from increased pore spaces and enhanced infiltration capacity which ultimately minimised runoff and soil erosion. A good percentage (45.5%) of the respondents in the study area practiced slash and burn method of land clearing. While result on irrigation use showed that only a few (13.5%) farmers were engaged in this practice in North central Nigeria.

Majority of the farmers (82.3%) in the study area used improved and resistant varieties on their farms. In addition, the result showed that, 51.1% of the respondents used mulching on their farm. The advantages of mulching include keeping the soil cooler in the heat, preventing erosion of valuable topsoil, conserving nitrogen by preventing sun from heating the soil surface, allowing easy water penetration into the soil and preventing wind erosion.

Table 2: Percentage Distribution of Respondents by Land-use Management Practices (n= 356)

Land use practice	*Frequency	*Percentage (%)
Intercropping	240	67.4
Bush clearing	162	45.5
Complete tillage	296	83.2
Zero Tillage	60	16.9
Irrigation	48	13.5
Improved seed	293	82.3
Cover cropping	245	68.8
Mulching	182	51.1
Fertilizer application	339	95.2
Manure use	147	41.3
Herbicide application	329	92.4
Tractorization	59	16.6
Mining activity	72	20.2

*= multiple responses recorded

Source: Author's computations from field survey, 2015

Efficiency of Food Crop Production

The dependent variable here is total revenue from agricultural outputs per hectare. In this case, the economic efficiency levels of land use were computed as in Adikwu *et al*, (2020), Oyekale *et al* (2012). The analysis of data for the economic efficiency estimates was done through Maximum Likelihood Estimation (MLE) which involved the estimation of the conventional Cobb-Douglas model (model 1) without the inefficiency effects and Cobb-Douglas stochastic frontier model (model 2) with inefficiency effects. In order to choose the preferred model for the study, hypothesis was formulated and tested using the generalised log likelihood-ratio statistic (**λ**) as presented in Table 3.

The null hypothesis (H_0: γ = $\boldsymbol{\delta}_0$, $\boldsymbol{\delta}_1$,...$\boldsymbol{\delta}_{19}$ = 0) which states that inefficiency effects are absent from the frontier model is rejected. This implies that the Cobb-Douglas stochastic frontier production model (model 2) was the preferred model that fits the data of arable farmers in the study area better. This was because the value of Chi-square calculated was greater than the tabulated values at 5% level of significance (Table 3). This agrees with the reports of Rahman (2002), Tijan*et al.* (2006) and Ogundari (2006).

Table 3: Generalised log likelihood-ratio tests for model fit

Arable farmers	**N**	**Log likelihood function**		**λ**	***Critical value**	**Decision**
		Model 1	**Model 2**			
Full sample	356	-233.09	-216.80	32.58	30.1	Reject H0

Degree of freedom is the number of restricted parameters which were 19 in this case
*critical value is obtained from table of chi-square distribution

Source: Author's Computations, 2015

The maximum likelihood estimates of the frontier production function is presented in table 4. The elasticity parameters are contained in the upper segment of the table while the determinants of inefficiency are also contained in the lower segment of the table. The significance of the estimates of gamma (0.077) at 1% shows that the inefficiency effects jointly estimated with the production frontier function are not simply random errors. This implies that land degradation mitigation strategies as well as selected farmer-specific characteristics have significant influence on the efficiency of food crop production by arable farmers. The γ-parameter shows the relative magnitude of the variance in output associated with economic efficiency. The coefficients of the variables derived from maximum Likelihood Estimation are very important, as they represent percentage change in the dependent variable as a result of percentage change in the independent variables.

The elasticity coefficients presented in the upper segment of Table 4 showed that, the parameter of farm size was negative (-0.561) and statistically significant at 1%. This implies that a 100% increase in the area of land will reduce the value of land by 56.1%. This may be a reflection of the degrading nature of the arable land. Due to population pressure, poverty and food security concerns, farmers sometimes expand cultivation to marginal lands, a situation that leads to reduced yield and hence low value of the land. Also, when farm land become too large efficient supervision and management become too low especially when other engagements are always competing with farmers time and attention. This result is contrary to the findings of Amasa,Bila and Iheanacho (2006) which found a positive relationship between land size and output of crops in Borno State Nigeria. The parameter of family labour (-0.119) was also negative and statistically significant ($p = 0.01$) suggesting that a 100 percent increase in family labour reduces land value by 11.9 percent. This corroborates Stephen *et al*. (2004) and Tambo and Gbemu (2010). Meanwhile, the parameters of fertilizer (0.013), seed (0.574), manure (0.015) and mechanization (0.035) were found to be inelastic, positive and statistically significant ($p \leq 0.10$). This implies that increasing expenses on these variables will increase the value of arable land in the study area.

The significance of expenses on fertilizer variable derives from the fact that fertilizer is a major land fertilizing input and improves the productivity of existing land by increasing crop yields per hectare. Awotide and Agbola (2010) indicated that fertilizer was a significant factor in maize production in northern Nigeria. Previous studies by Amaza (2000), Adeoti (2001); Awotide (2004) also reported low elasticity for fertilizer in food crop production in Nigeria.

Table 4: Maximum likelihood Estimates of the Input parameters and determinants of economic efficiency of land use in North-central Nigeria

Independent variable	**Coefficient**	
	Model 1	**Model 2[b]**
Constant	7.007 (16.61)	7.257 (16.50)
LnFarm size	-0.533(-9.85)***	-0.561(-9.04)***
LnFLabour	-0.131(-3.81)***	-0.119 (-2.93)***
LnHired Labour cost	0.002 (0.37)	0.001 (0.22)
LnFertilizer cost	0.006 (0.710	0.013(1.54)***
LnSeed cost	0.586(15.19)***	0.574(14.39)***
LnManure cost	0.014(2.86) ***	0.015(2.98)***
LnMechanization cost	-0.004 (-0.60)	0.035(2.92)***
LnAgro-chemical cost	-0.0001 (-0.015)	-0.004 (-0.53)
Ln other Capital_inputs	0.005 (1.08)	0.006 (1.19)
Inefficiency Model		
Constant	-	0.24 (0.68)
Population_density	-	0.042 (0.54)
Farming experience	-	-0.142(-1.81)
Education	-	-0.035 (-1.31)
Off_farm_income	-	-0.003 (-0.43)
Extension contact	-	0.040(1.65)
Land Fragmentation	-	-0.144(-1.53)
Irrigation	-	-0.200 (-1.14)
Improved/resistant varieties	-	-0.010(-2.98)***
Mulching	-	-0.125 (-1.01)
Cover cropping	-	0.267(1.80)
Zero tillage	-	0.123 (1.22)
Crop rotation	-	-0.534(-3.76)***
Crop Diversification	-	0.31(2.09)**
Tenure security	-	0.058 (0.44)
Changed_plantingTime	-	0.042 (0.22)
Increase farm size	-	-0.026 (-0.20)
Tractorization	-	0.995(3.64)***
Fallow	-	0.282(1.89)
Clean clearing	-	-0.335(-2.59)***
Sigma squared	0.22	0.206(12.03)***
Gamma	0.05	0.077(3.27)***
Log likelihood function	-233.09	-216.80

Note: *, ** and *** denote t-test significant at 1%, 5% and 10% levels respectively
Values in parenthesis represent t-statistic; b represents preferred model

Source: Computed from field data, 2015

Distribution of Farmers' Economic Efficiency in North-central Nigeria

Table 5 presents the distribution of farmers' efficiency in the study area. The economic efficiency of the sampled farmers was less than one (or 100%) indicating that all the arable farmers sampled were operating below the frontier. The least efficient farmer in North central Nigeria was 77 percent inefficient (23.43% efficient), while the most efficient farmer was 2 percent inefficient (i.e. 98% efficient). On the average the farmers were 13.8 percent inefficient (i.e. 86.2 percent efficient) implying that 13.8 percent of the value of land (revenue from crop production) is lost due to inefficiency on the part of farmers. This can be recovered if farmers improve their efficiency in the use of land degradation mitigation strategies and other and farm-specific characteristics.

Table 5: Percentage distribution of efficiency estimates in North central Nigeria

Efficiency index	Frequency	Percentage (%)
≤ 0.30	2	0.6
0.31 -0 .60	39	11.0
0.61 -0 .90	91	25.6
>0.90	224	62.9
Total	356	100.0
Minimum efficiency	**0.23**	
Maximum efficiency	**0.98**	
Mean efficiency	**0.857**	

Source: Computed from field data, 2015

The Influence of Land Degradation Mitigation Strategies on the Efficiency of food Crop Production in North-central Nigeria

Land degradation mitigation strategies and farmer-specific variables influencing inefficiency of food crop production in North-central Nigeria are respectively contained in the inefficiency model of the lower section of table 4. Land degradation mitigation strategies and farmer-specific variables that had significant relationship with economic inefficiency and are discussed below:

Land fragmentation

A negative (-0.144) and statistically significant relationship was found between land fragmentation and inefficiency in food crop production. This implies that an increase in the number of plots used by farmers decreased their inefficiency in food crop production. Fragmentation allows farms with scattered plots to benefit from risk management through the use of multiple eco-zones and the practice of crop scheduling. Thus, fragmentation enables farmers to disperse and reduce risk by using a variety of soils and other microclimatic and micro-environmental variations. Fragmentation also makes it possible for farmers to grow a variety of crops that mature and ripen at different times, so that they can concentrate their labour on different plots at different times, thereby avoiding household labour bottlenecks.

Improved/resistant varieties

The use of improved/resistant varieties was found to have a negative (-0.010) and statistically significant ($p = 0.01$) relationship with farmers' inefficiency in the study area. This implies that increase use of improved/resistant varieties reduced farmers' economic inefficiency. This is expected as improved and resistant varieties can withstand adverse weather conditions to some extent thereby adding more value to arable land than the traditional varieties.

Cover cropping

A positive and significant relationship existed between cover cropping and inefficiency implying that a unit increase in the use of cover cropping will increase inefficiency of farmers by 0.267 percent. This is against the a priori expectation of this variable but may be as a result of overuse (cover cropping was used by 68.8% of respondents as shown in table 2) which led to competition of soil nutrients and sunlight by the cover crops and the main crops grown. According to Ahaneku (2010) the use of cover crops improves soil structure, increases nitrogen level, and acts as weed smotherers. They can be planted in pure stands on an uncultivated piece of degraded land or in association as a relay with an annual crop such as maize. Tarawali, Douthwaite, de Haan (2002) cited additional advantages of cover crops to include increased crop yield, the ability to suppress weeds such as spear grass (*Imperata cylindrica*), thus reducing the arduous task of weeding, provide livestock feed and additional income to farmers through the sale of some of the seeds.

Crop rotation

The coefficient of crop rotation was negative (-0.534) and statistically significant ($p = 0.01$) to inefficiency. This implies that increasing the practice of crop rotation as a measure of preventing land degradation will likely reduce inefficiency in food crop production by farmers in the study area. According to Akinnagbe and Umukoro (2011),crop rotation, mixed cropping and relay cropping provide a protective cover, reduce the rate of soil moisture loss through evaporation from soil surface, improve soil organic matter, total nitrogen, cation exchange capacity, infiltration and water retention capacity. This will improve the value of arable land by increasing yield of cultivated crops.

Crop diversification

A positive (0.31) and statistically significant relationship exists between crop diversification and inefficiency in food crop production. This implies that an increase in diversification of crops tends to increase farmers economic inefficiency in the study area. This suggests that lesser diversification is associated with higher economic efficiency. The result is in agreement with the findings of Amaza *et al.* (2000) that a positive relationship existed between crop diversification and technical inefficiency of food crop farmers in Borno State Northern Nigeria. According to Gutu (2013), smallholder commercialization is possible only when households do specialise in certain crops rather than diversifying.

Tractorisation

In Nigeria, two main groups of tillage methods are pronounced: tractor tillage and manual tillage. Mechanised farms use tractor equipment mainly for ploughing, harrowing and land area expansion. The variable was specified as a dummy variable, where one denotes tractor tillage and the other manual tillage. The coefficient (0.995) of tractorization was positive and statistically significant at one percent level suggesting that increase use of tractor tillage tends to increase farmers' inefficiency. The implication of the result is that, arable farmers using manual tillage are more economically efficient in the study area. As noted by Titilola and Jeje (2008), excessive use of heavy machinery involving the pulverization of otherwise fragile sandy soils and continuous cultivation which has replaced shifting cultivation in the study area subject the soil to annual cycles of water and wind erosion. Equally dangerous is the use of heavy machinery on heavy clayey soils. This causes compaction of the soil and reduces aeration and water infiltration to the great disadvantage of the growing plant crops.

Bush fallow

The coefficient (0.282) of bush fallow was positive and statistically significant at 10 % to economic inefficiency in Northern Nigeria. This implies that increasing bush fallow by farmers tends to increase their economic inefficiency in the study area. This is the case especially when population and economic pressures tend to push farmers to use a piece of farm land every year in order to curb the menace of hunger and poverty.

Clean clearing

The coefficient (-0.335) of clean clearing was found to have a statistically significant with inverse relationship with economic inefficiency of farmers in North central Nigeria suggesting that the more farmers practice clean clearing of land methods of land clearance the less they become economical inefficient.

CONCLUSION AND RECOMMENDATIONS

This study examined the effect of mitigation of land degradation on the efficiency of food crop production among small scale farmers in North Central Nigeria. This study identified continued cropping, crop diversification and tractorization as key factors that increased farmers inefficiency in the North central region of Nigeria.

Recommendations

To provide feasible policies and address the challenges highlighted from the findings of this research, the following recommendations are made for action:

1. Group associations like cooperatives should be encouraged among farmers as means to enjoy economy of scale in the use of key farming operation like tractorization. This will decrease their farming inefficiency with greater productivity for their different lands put together.
2. A more intense extension service support with relevant information to cover viable farm diversification and robust technologies for continued cropping activities should be provided for the farmers.

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