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IMPACT OF SUSTAINABLE SOIL MANAGEMENT TECHNIQUES ON LAND PRODUCTIVITY OF ARABLE CROP FARMERS IN IMO STATE, NIGERIA

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Abstract

The study was designed to examine the impact of sustainable soil management techniques on land productivity of arable crop farmers in Imo State, Nigeria. Despite various efforts to produce basic foods for the increasing population in Nigeria, the track record of performance over the years has proved abortive. This stems from the use of variant unsustainable soil management techniques which are concomitant to soil erosion, nutrient depletion and decline in food production. Multi-stage random sampling technique was used to select 209 arable crop farmers. Objectives of this study were elicited from the sampled respondents through a well structured questionnaire. Data were analyzed using descriptive statistical tools, average treatment effect (ATE) and local average treatment effect (LATE) models. Results showed that farmers in the area have varied knowledge of sustainable soil management techniques (SSMT). The PSM and IPSW estimates were ₦141.14 and ₦97.06 respectively while the LATE by WALD and IV were ₦152.26 and ₦158.17. This implies that the use of SSMT has an impact on the productivity of land per unit increase in rent. Hence, farmers at all level should be encouraged to practice efficient soil management techniques in order to improve the productivity of the land.

Key words**:** *impact, Sustainable soil management technique, land productivity, Late Model, arable crop farmers*

INTRODUCTION

Agriculture remains a significant sector in the Nigerian economy despite the strategic importance of the crude oil sector. Apart from kick-starting economic growth, it has the ability to reduce poverty and hunger [12]. The sector provides employment for a large labour force and accounts for more than one-third of total Gross Domestic Product (GDP) in Nigeria [18]. The contribution of agriculture to GDP has been on decline since early 70's. Empirical studies showed that it dropped from 90% in 1960 to 56% in 1969 and has continued to be less than 40% since 1986 due to over dependence on oil and other environmental and socio-economic factors [1]. Land degradation has also contributed immensely to the declining state of agricultural productivity, food insecurity, malnutrition and further increased poverty among the farming households in Nigeria. Again, in spite of the soil management techniques and land use policies in Nigeria, agricultural productivity has continued to decline leading to a fall in agricultural growth, low performance of agricultural share on GDP and export earnings [17]. Majority of arable crop farmers in Nigeria are characterized with unsustainable farming practices which deplete soil fertility leading to low crop yields, low income and high poverty incidence of crop farmers. These farmers are often hindered by the small farm size holdings, which do not encourage soil improvement practices and farm mechanization [16]. The use of sustainable soil management techniques provide farmers with a means for optimizing their yields and profits while maintaining a balance between agricultural, economic and environmental benefits on a sustainable basis. As a result, these reduce poverty and aid land productivity. Moreover, some soil management/ conservation practices have proven to be sustainable among farmers in Nigeria and they include: conservation tillage practices, soil fertility improvement practices, and erosion control measures, etc. However, in some parts of Nigeria, for instance, in South-

West, the outputs of farmers are plagued with unsustainable soil management techniques coupled with prolonged interface between human induced and natural factors. Soil degradation in the area worsens as farmers cannot use modern technologies amidst inappropriate soil management practices such as continuous cropping, bush burning, deforestation, indiscriminate vegetation removal, over grazing and use of marginal lands for agricultural purposes which often precede eventual degradation of soil resources and environmental damages. These soil practices however cannot sustain the soil nor vegetative cover over a long period of time. Again in North-East Nigeria, sustainable soil management activities follow a flexible ecological pattern [14]. This is due to the prolong dry season and climatic condition in the area. This outcome forces farmers to adopt unsustainable soil management techniques which put significant pressures on soil health. Increased stock grazing on farmlands in the area increases the potential for soil compaction, pugging and erosion. Similarly, these incidences are the same in Imo State as crop farmers in the State use soil management techniques that do not conserve the soil, but rather exacerbate it. The need to overcome these challenges in the State have raised a concern when evaluation of a package like sustainable soil management technique (SSMT) is the issue.

MATERIALS AND METHODS

Research was done in Imo State of Nigeria, sited in the South-East of Nigeria with a land expanse of 5,530 sqkm. The State is situated between latitudes $4^0 45^I$N and $7^0 15^I$N and Longitudes $6^0 50^I$E and $7^0 25^I$E. It has boundaries in the East, West, South, and North with Abia and Cross Rivers State, Delta, Rivers, and Enugu and Anambra State. It is made up of 27 Local Government Areas classified into 3 agricultural zones; such as Owerri, Orlu and Okigwe. Farmers in these areas practice agriculture. Multi-stage sampling technique was employed for this study. A purposive selection of 2 local government areas (LGAs) was done in the first stage from each of the 3agricultural zones of the State. LGAs selected were based on their agricultural prowess and use of improved soil management techniques. The selected LGAs were Ohaji-Egbema and Ngor-Okpala, Isu and Nwangele, Obowo and Isi-ala Mbano respectively totaling 6 local government areas used for this study. Stage two, involved a random sample selection of farmers from the list of documented crop farmers using SSMT, with the zonal ADP's in each of the selected LGAs sampled. 122 farmers were recorded for Owerri zone while Orlu and Okigwe zones accounts for 130 and 109 crop farmers. This implies uneven distribution of the farmers in the area. Therefore, a rational representation of sample was taken from a proportion of 70% of the total population from each zone. Owerri zone had 85 sample size, Orlu 91 and Okigwe 76. This gave a total of 252 arable crop farmers but only 209 valid questionnaires were used for analysis. Descriptive statistical tools, average treatment effect (ATE) and local average treatment effect (LATE) models were used for data analyzes following [8].

Average Treatment Effect models were specified thus:

$$\textbf{ATE}=\frac{1}{n}\sum_{i=1}^{n}-\frac{(d_i-p(X_i)y_i}{p\,(X_i)(1-p(X_i)} \qquad \text{eqn.1}$$

$$\textbf{ATE1}=\frac{1}{n1}\sum_{i=1}^{n}-\frac{(d_i-p(X_i)y_i}{(1-p)(X_i)} \qquad \text{eqn.2}$$

$$\textbf{ATE0}=\frac{1}{1-n1}\sum_{i=1}^{n}-\frac{(d_i-p(X_i)y_i}{p(X_i)} \qquad \text{eqn.3}$$

where n is the sample size, $n_i = \sum_{i=1}^{n} d_i$ is the number of treated (i.e. number of SSMT users)
$P(X_i)$ represents the PSM evaluated at X_i
ATE = Average treatment effect
ATE0 = Average treatment effect on the untreated
ATE1 = Average treatment effect on the treated
Yi = Outcome variable,
di = Use status of the farmers.
The LATE Model is further expressed as follows;

$$\mathrm{E}(y_1-\frac{y_0}{d_1}=1)=LATE=\frac{cov(y,z)}{cov\,(d,z)} \qquad \text{eqn.4}$$

$$= \frac{E\left(\frac{y}{z}=1\right) - E(\frac{y}{z}=0)}{E\left(\frac{d}{z}=1\right) - E(\frac{d}{z}=0)} \quad \text{eqn.5}$$

$$= \frac{E(y_i*(z-E(z_i)}{E(d_i*(z-E(z_i)} \quad \text{eqn.6}$$

The right hand side of eqn. (6) can be estimated by its sample analogue:

$$\left(\frac{\sum_{i=1}^{n} y_i z_i}{\sum_{i=1}^{n} z_i} - \frac{\sum_{i=1}^{n} y_i(1-z_i)}{\sum_{i=1}^{n}(1-z_i)}\right) X \left(\frac{\sum_{i=1}^{n} d_i z_i}{\sum_{i=1}^{n} z_i} - \frac{\sum_{i=1}^{n} d_i(1-z_i)}{\sum_{i=1}^{n}(1-z_i)}\right) \quad \text{eqn.7}$$

where:
Z = binary outcome variable
y_1 = high users of SSMT
y_0 = low users of SSMT
d_i = use status of the farmers
E = mathematical function
These models are known as the Wald and IV calculated using two-stage least squares. The concept was designed by [10] and [9] in treating a set of dual population that has two possible outcomes.

RESULTS AND DISCUSSIONS

Types of Sustainable Soil Management Techniques among Farmers in Imo State

The various types of sustainable soil management techniques among farmers are shown in Table 1. It could be deduced from the Table that farmers in the area have varied knowledge of sustainable soil management techniques which ranges from contour cropping to shifting cultivation. The Table showed that all the arable crop farmers in the area have adequate knowledge of organic manure and multiple cropping. Organic manure is largely practiced by arable crop farmers to improve the fertility of the soil and productivity of the land. This could be due to its local accessibility and cheap source of the manure. This is in line with [14] who stated that organic manure is widely used by arable crop farmers to improve soil fertility and increase the productivity of the land. On the other hand, multiple cropping is mainly practiced to avert the risks of total crop failure. Multiple cropping is further practiced by arable crop farmers due to the ability of the farmland to accommodate one type of crop or the other per cropping season. This enhances better distribution of labour through-out the farming season, maintenance of organic matter, covering of the soil through-out the year, thus controlling run off cum erosion and producing different types of crops per cropping season [5] and [7]. Similarly about 99.0, 98.0 and 96.2 percent of the arable crop farmers are aware of shifting cultivation, bush fallowing and crop rotation. Shifting cultivation and bush fallowing are soil management techniques used to improve the fertility of the soil and enhance crop productivity of the farmers. However these soil management techniques are rarely practiced by crop farmers due to land scarcity and tenure systems available to the arable crop farmers. This conforms to the findings of [4]. On the other hand, good management of the soil through crop rotation ensures adequate nutrient availability through-out the cropping season and maintain balanced soil ecosystem [13]. Consequently, a cross section of the arable crop farmers are aware of mulching 95.2 percent, planting of leguminous/cover crops, 94.0 percent, erosion control measures using vetiver grass, 93.0 percent and minimum/zero tillage, 89.0 percent respectively. These soil management techniques are generally used to control soil erosion and reduce water run-off in most farmlands. This is consistent with the findings of [11]. Again, another section of the arable crop farmers in the area are aware of alley cropping 69.0 percent, crop residue recycling 68.0 percent and mixed farming, 49.0 percent respectively. These soil management techniques helps in increasing the farm productivity of the farmers, thus leading to an increase in income of the arable crop farmers. According to [4], these soil management techniques improve farm productivity of the farmers which in turn increases their farm income. Also [5] further stated that these soil management techniques increases soil fertility which enhances the productivity of the farmers. Furthermore, arable crop farmers in the area are aware of liming 42.1 percent, taungya farming 36.4 percent, contour cropping 32.1 percent and strip cropping 29.2 percent respectively. Liming is practiced by most arable crop farmers to reduce the acidity of the soil. Taungya farming improves soil fertility which enhances crop yields and

productivity of the farmers [6]. Contour and strip cropping on the other hand are used by crop farmers on slope farmlands to reduce the risks of water run-off and soil loss. Consequently contour and strip cropping techniques are sometimes difficult to practice due to its technical applications. This conforms to the findings of [4].

Table 1. Distribution of Farmers on Types of Sustainable Soil Management Techniques in Imo State

Types of SSMT	*Frequency	Percentage
Contour Cropping	67	32.1
Strip Cropping	61	29.2
Crop Rotation	201	96.2
Planting of leguminous/Cover crops	196	94.0
Crop Residue Recycling	142	68.0
Use of Organic Manure	209	100
Use of Mulching	199	95.2
Alley Cropping	144	69.0
Erosion Control Measures (Vetiver Grass)	194	93.0
Multiple Cropping	209	100
Minimum/Zero Tillage	186	89.0
Mixed Farming	102	49.0
Liming	88	42.1
Taungya Farming	76	36.4
Bush Fallowing	204	98.0
Shifting Cultivation	206	99.0

Source**:** Field survey data, 2015
*Multiple Responses

Impact of Sustainable Soil Management Techniques on Land Productivity of Arable Crop farmers in Imo State

The impact of sustainable soil management techniques on the land productivity of arable crop farmers is shown in Table 2. Land productivity here was shown as the proportion in naira of output returns per naira paid on rent. The PSM and IPSW estimates are ₦141.14 and ₦97.06 respectively. These estimates cannot identify the total casual effect of the use of SSMT on productivity as it does not accommodate the hidden bias [10]. Hence, they are declared inconclusive. However, they are positive but PSM is not significant even at P≤0.10 critical level while IPSW is evidently significant at that critical level. This implies that non-compliance still exists or at least accounted for in estimating the casual effect of the use of SSMT on land productivity. This non-compliance here means that there are farmers who will never use these technologies even when it is free for them to use or whereby a farmer had challenges in the use of a particular technique. The non-compliance effects strongly explain the hidden bias into self selection problem and can only be identified by an impact parameter called local average treatment effect (LATE).

The result shows that LATE from WALD and IV were estimated in this study and were highly significant at 1 percent statistical level. LATE estimated either way identifies the causal effect of use of SSMT in the presence of non-compliance. The LATE by WALD was ₦152.26 while that of IV was ₦158.17. Hence, this implies that the use of SSMT has an impact on the productivity of land by ₦152.26 percent per unit increase in rent. This further implies that the higher the use of the sustainable soil management techniques, the higher the land productivity of the arable crop farmers; that is, a unit increase in the use levels of the sustainable soil management techniques would lead to a unit increase in the land productivity of the arable crop farmers. This shows that with the removal of hidden bias of the crop farmers, the impact on productivity of land was increased by ₦152.26 per ₦1.00 increase in rent of land. It could be deduced from the result

that as the rent increases, the land productivity of the farmers also rises. In the same way, the LATE estimated using IV suggested an improved and consistent estimate of ₦158.17 with a unit increase in rent by ₦1.00. This implies that the IV (extension contacts) will lead to a further increase in productivity of land because it identifies the casual effects of use of SSMT in the presence of non-compliance as well as take care of hidden bias. This could be because of endogenous effects of use of SSMT shown to the farmers through extension contacts. Extension contact is persuasive to improve the performance of farmers who experience challenges in the application of a technique or who would have failed to comply even when they have identified with a particular technology. In this study, the IV improved the performance of the farmers as they were identified and included in the casual effect of the use of SSMT on the land productivity. This finding is consistent with *a priori* expectations and corroborates the findings from; [2] and [15]. The finding of impact parameter that identifies the casual effects of the use of SSMT on land productivity suggested that the identification made using IV (extension contacts) has the best performance in all the result. It is important to know that other IV like awareness level was unrealistic. Extension contacts were used because it gave realistic estimates consistent with *a priori* expectations and the findings from [3]. The finding suggests that the use of SSMT in arable crops production should be enforced with a stronger and monitored extension contacts at least to have a better impact on farmers' returns, poverty level and productivity. The use of only awareness or adoption as an instrumental variable (IV) may be misleading as the finding may be unrealistic in most cases [15]. Farmers perform better when they are convinced that a technology will improve their status quo and extension contacts has suggested that in the result; policy formulation on the use of environmental sustainable farming techniques should factor in extension contacts otherwise, farmers performance level will not be improved.

Table 2. Impact of Sustainable Soil Management Techniques on Land Productivity of Arable Crop Farmers

	LATE Estimators			
PARAMETER	**LATE (WALD)**	**LATE (IV)**	**ATE (IPSW)**	**PSM**
ATE	152.26	158.17	97.06	141.14
	(54.09)***	(66.14)***	(21.02)***	
ATE 1			90.16	
			(2.41)**	
ATE 0			71.51	
			(1.47)	

Source: **Source:** Field survey data, 2015 Computed from field survey data, 2015
***; ** indicates statistical significance at 1 percent, and 5 percent respectively

CONCLUSIONS

Despite variant use of unsustainable soil management techniques by the crop farmers, the impact of effective soil management systems cannot be undermined. The use of sustainable soil management techniques has become instrumental in improving land productivity and income of the farmers. Hence, findings from the result showed that increased use levels of sustainable soil management techniques increased the land productivity of the farmers in the area. The result also showed that all the arable crop farmers in the area have adequate knowledge of organic manure and multiple cropping which is very vital in improving the land productivity of the farmers with its attendant increase in income. However with these findings, it is expected that policy makers in Nigeria will find this study a good reference material in formulating food policies and adjusting existing ones to ensure self sufficiency in food crop production.

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