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IMPACT OF SUSTAINABLE SOIL MANAGEMENT TECHNIQUES ON NET INCOME OF ARABLE CROP FARMERS IN IMO STATE, NIGERIA

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Abstract

Effective land management techniques are sine qua-non for increased outputs and income of the farmers. Hence, this study evaluated the impact of sustainable soil management techniques on net income of arable crop farmers in Imo State, Nigeria. 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. The socio-economic features of the farmers reveals a mean age of 53 years, 6 persons per household, 6 years educational attainment, 17 years farming experience and 1.0 hectare of land. The LATE estimates by WALD and (IV) were given as ₦50, 186.91/ha and ₦61,456.02/ha. These estimates showed that the use of sustainable soil management techniques had a positive relationship with the farmers' net income and was highly significant at 1 percent statistical level. Hence, there is the need for corporate bodies through the extension agents and other agricultural officers to educate the rural farmers on the importance of using improved farming techniques for increased net income.

Key words**:** *impact, sustainable soil management, techniques, net income, crop farmers*

INTRODUCTION

The challenge for agriculture to meet the World's increasing demand for food in a sustainable way is still far-fetched. This could be credited to the declining soil management techniques among the household farmers. The World population
growth and its associated land fragmentation are forcing farmers to cultivate on small plots that are hardly suitable for soil improvement practices [4]. As long as agriculture remains a soil-based industry, major increases in productivity is likely to be attained through sustainable soil management techniques (SSMT) which ensure that plants have adequate supply of balanced of nutrients. According to the estimates of [2], only 12% of African soils is moderately fertile or well drained, compared to 33% in Asia, while about 88% is infertile covering an area of about 494 million hectares in the continent. Although soils in most developing African countries have inherently low fertility as a result of poor and inadequate soil management practices. In West-Africa and its suburbs, soil management technique such as alley cropping where farmers grow crops between rows of trees has been found to increase income and crop productivity. This practice is sustainable as it enables the same plot to be cultivated over and over, thus eliminating the need for the continual burning of the rain-forest to get fertile plots. Soil management techniques used in improving soil quality is becoming relevant in West-Africa, since it determines the level of food production, and to a great extent, the state of the global environment. Hence, soil management techniques are increasingly taking a central stage in agricultural policies and rural development among developing countries like Nigeria. It is an approach to managing agro-ecosystems for improved and sustained productivity, increased profits and food security while preserving and enhancing the resource base and the environment [14].
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 [15]. As a result, these reduce poverty amongst the arable crop farmers in Nigeria. Moreover, some soil management/ conservation practices have been proven to be sustainable among farmers in Nigeria and they include: conservation tillage practices, soil fertility improvement practices, and erosion control practices. Though, arable crop farmers still use soil management practices that are unsuitable with its attendant low income and productivity. [12] stated that soil management techniques practiced in most parts of Imo State is concomitant to soil erosion, soil nutrient depletion and decline income. Thus, the extent to which the use of sustainable soil management techniques (SSMT) by arable crop farmers to increase their income and reduce poverty especially in Imo State has not been documented, hence the
need for this study.

MATERIALS AND METHODS

This research work was carried out in Imo State, Nigeria located in the South Eastern part of Nigeria. The State has a land region of 5,530 sq km and lies 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. The State bound in the East by Abia and Cross Rivers, to West by Delta State, South by Rivers State, and North by Enugu and Anambra. The State has 27 Local Government Areas sorted into three agricultural zones; Owerri, Orlu and Okigwe. The occupants in the area are mostly associated with Farming. Multi-stage sampling technique was applied in this study. First stage has two local government areas (LGAs) purposively selected from each of the three agricultural zones. Selections were done based on use of sustainable soil management techniques (SSMT). Ngor-Okpala and Ohaji-Egbema was taken from Owerri zone, Nwangele and Isu from Orlu zone while Okigwe has Isi-ala Mbano and Obowo making six (6) local government areas used for the study. In the second stage, farmers were randomly selected from the list of filed crop farmers using SSMT, in custody of the zonal ADP's in each of the selected LGAs. Owerri zone has 122 filed arable crop farmers while Orlu and Okigwe zones have 130 and 109 arable crop farmers. This depicts that there are inadequate numbers of crop farmers across the zones. Adequate sample was attained from a ratio of 70 percent of the total population from each zone. This gave Owerri zone a sample size of 85, 91 for Orlu zone and 76 for Okigwe zone making a total of 252 crop farmers across the six LGAs. The study used only 209 valid questionnaires for data analysis.

Data were analyzed using descriptive statistical tools, average treatment effect (ATE) and local average treatment effect (LATE) models following [5].

Average Treatment Effect models were specified thus:

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

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

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

where n is the sample size, $n_i = \sum_{i=1}^{n} d_i$ is the number of treated (ie. 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:

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

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

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

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

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

.....(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 formulas represent the Wald and IV estimators, which is done using two-stage least squares. The model was designed by [9] and [8] in treating a set of heterogeneous sample that has two possible outcomes denoted by y_1 and y_0.

RESULTS AND DISCUSSIONS

Socio-Economic Characteristics of the Respondents

The mean age of the farmers was 53 years as shown in Table 1. This agrees with the findings of [1] who reported mean ages of 52 and 53. This implies that 25.8% of the farmers are over 60 years and thus, were ageing. This might have a tremendous influence on productivity and efficiency of resource utilization, since the strength of older farmers weakens by age. The mean household size was 6 persons. This implies that the household size in the area was relatively large and therefore could enhance production efficiency of the crop farmers since rural households rely more on members of their households than hired labourers who charge outrageous wages. This is in line with [13] who reported mean household sizes of 6 to 7 persons and therefore stated that large household size is a significant source of human power utilized in the farm operations. The mean years of formal education of the farm households were 6 years showing that majority of the farmers' had primary education which depicts a low educational background. Though these farmers can relatively read and write but may find it difficult to take critical decision. concerning their farming enterprises [3]. The mean farming experience of the farmers was 17 years. This means that most of the farmers were experienced in the farming enterprise which might considerably reduce inefficiency in production. This is consistent with [10] who reported that years of farming experience of a farmer increases his production efficiency and helps him overcome certain inherent farm production constraints. The mean extension contacts were 14 times, per cropping season. This implies that, on the average most of the household farmers were exposed to technical innovations from the extension agents, thus the utilization of these innovations tends to increase the land productivity and net income of the crop farmers. This is in line with [3] who reported that as change agents, extension workers serve as channels for diffusion of technical knowledge and innovations. However, the mean farm size was 1.0 hectares. This implies that majority of the farmers in the area operated on small-scale bases (cultivating less than 2.0 hectares). This supports the findings of [13] who reported that rural farm lands are characterized by small-sized holdings, fragmented and scattered which poses a great threat to land productivity and mechanization.

Table 1. Socio-economic characteristics of the respondents

Variable	Mean
Age (years)	53
Household size (No of persons)	6
Education (years)	6
Farming experience (years)	17
Extension contacts	14
Farm size	1.0

Source: Field Survey, 2015

Source of Funds of the Arable Crop Farmers in Imo State

The distribution of farmers based on their sources of funds for their farm work is shown in Table 2. According to this Table, the major sources of funds for farm households were from co-operative societies and local money lenders which accounted for 89.0 percent and 81.8 percent respectively. This implies that farm households in the study area relied more on co-operative societies and local money lenders for funds. This corroborates the findings of [11] who stated that rural farmers tends to source funds from co-operative societies and local money lenders due to the little or no interest charges placed on such funds. Personal savings was as low as 7.7 percent; this further implies the inability of the farm households to save money probably due to the need to meet day to day family

responsibilities. This further supports the findings from [16] who reported that over 60 percent of the rural farm households are generally resource poor and hence made use of borrowed capital to finance their farming businesses. However, only 6 percent of the farmers obtained their funds from banks. This may be as a result of the stringent conditions associated with bank lending. Also, most farmers lack suitable collateral to qualify them for bank lending. This is in line with [13].

Table 2. Distribution of farmers based on source of funds

Source of Funds	*Frequency	Percentage
Friends and Relatives	54	25.8
Local Money Lenders	171	81.8
Age Grade	49	23.4
Co-operative Societies	189	89.0
Banks	12	5.7
Personal savings	16	7.7

Source: Field survey data, 2015
*Multiple responses

Impact of Sustainable Soil Management Techniques on Net Income of Arable Crop Farmers in Imo State

The impact of sustainable soil management techniques on net income of arable crop farmers is shown in Table 3.

The result shows the estimates of propensity score matching (PSM) and inverse propensity score weighing (IPSW). The PSM shows an estimate of ₦49, 974.76/ha while IPSW has a lesser value of ₦40, 171.08/ha. These values are quite different from the values obtained by [7]. These estimates actually showed the average treatment effect (ATE) on the use of sustainable soil management techniques (SSMT) on the farmer's net income. It controls the observable covariate that is partly responsible for farmers self selection into the use of sustainable soil management techniques but cannot explain the total impact of the use of SSMT on farmers' net income. Since the PSM and IPSW are all positive and significantly different from zero at $P < 0.05$ critical level, the impact of SSMT on net income is partly accounted for by the PSM and IPSW as its net income can be increased by ₦49,974.76/ha and ₦40,171.08/ha respectively. [9] noted that the use of PSM only removes overt bias in self selection problem. However, the use of these estimates is relevant but not sufficient hence, it is an inconclusive estimation procedure as it does not account for the unobservable covariates in impact studies. Furthermore, as indicated earlier, the ATE estimates on the impact of sustainable soil management techniques on our outcome of interest do not have a causal interpretation due to the problem of non-compliance and endogenous treatment. Consequently, the use of local average treatment effect (LATE), either estimate by WALD or Instrumental Variable (IV) offers a conclusive result as it takes into consideration all the unobservable covariates that affect self-selection problems in an experiment. The LATE estimates by WALD and (IV) were givenas ₦50,186.91/ha and ₦61,456.02/ha respectively. These estimates showed that the use of sustainable soil management techniques had a positive relationship with the farmers' net income and was highly significant at 1 percent statistical level. This implies that the use of sustainable soil management techniques by the arable crop farmers increased farmers net income by ₦50,186.91 and ₦61,456.02 respectively. This further showed that the use of sustainable soil management techniques in the area had a significant impact on the net income of the crop farmers. Thus, a unit increases in the use levels of sustainable soil management techniques would lead to a unit increase in the net income of the farmers. This finding is consistent with *a priori* expectations and also supports the findings of [6] and [9]. The disparity between the LATE results was further explained by the use of Instrumental Variable. Moreover, since the use of SSMT is endogenous, farmers were faced with non-compliance which requires the use of an Instrumental Variable which is extension contacts. Extension contacts offers demonstration on the use of SSMT, farmer's diffusion, adoption and continual use of SSMT. Hence, the use of the Instrumental Variable helped in removing the hidden bias into self selection of a technique and this explains why the farmer's income further increased to ₦61,456.02/ha. This estimated

value of ₦61,456.02/ha is better than the LATE estimated using WALD. This is because the WALD estimate does not fully account for the impact of SSMT on net income of the arable crop farmers like the instrumental variable (extension contacts) that has completely removed the hidden bias into farmers self selection problem. Therefore, it is suggested that extension contacts should be built into any program that seeks to advance farmer's use of any technology in crop production.

Table 3. Impact of Sustainable Soil Management Techniques on Net Income of Arable Crop Farmers in Imo State
LATE Estimators

PARAMETER	LATE (WALD)	LATE (IV)	ATE (IPSW)	PSM
ATE	50186.91	61456.02	40171.08	49974.76
	(40.12)***	(76.90)***	(2.46)**	
ATE 1			38841.94	
			(2.39)**	
ATE 0			35640.21	
			(1.07)	

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

CONCLUSIONS

Sustainable land use patterns have proven to be primal towards increased output with its attendant benefits. Hence, this research work depicts that increased use levels of sustainable soil management techniques increased the net income of the arable crop farmers.

Findings from this study also established that extension contacts were perceived by the arable crop farmers to be instrumental towards increasing their net income. The mean extension contacts were 14 times, per cropping season.

This implies that, on the average most of the household farmers were exposed to technical innovations from the extension agents, thus the utilization of these innovations tends to increase the land productivity and net income of the crop farmers. T

his finding is further validated by other empirical results and therefore calls for strategic policy making. Hence, there is the need for corporate bodies through the extension agents and other agricultural officers to educate the rural farmers on the importance of using improved farming techniques for increased net income.

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