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Impact of sustainable soil management techniques on farm output of arable crop farmers in Imo State, NIGERIA

Emeka Emmanuel Osuji[1], Nnamdi Chukwuemeka Ehirim[2], Olubunmi Lawrence Balogun[3]
1 Department of Agricultural Economics, Michael Okpara University of Agriculture Umudike, Nigeria
2 Department of Agricultural Economics, Federal University of Technology Owerri, Nigeria
3 Department of Agricultural Economics and Extension, Babcock University Ilishan-Remo, Ogun State, Nigeria
osujiemeka2@yahoo.com, ehinadykus@yahoo.com, blarrybunmi@gmail.com

ABSTRACT
Farm output of farmers can be increased if farmers can be engaged in the use of sustainable soil practices that improve soil fertility. Hence, this study assessed the impact of sustainable soil management techniques on farm output 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 Table reveals that the major source of farmland for farm households in the area was inheritance which accounted for 95.0 percent. Cassava production dominated the roots and tuber crops with more than 97 percent of the farmers engaging in its production. The PSM and IPSW had values of 51353.76kg/ha and 49561.02kg/ha while the LATE estimates by WALD and IV had values of 55346.88kg/ha and 71036.01kg/ha. Hence, appropriate agric-policies should be channeled towards encouraging the farmers to adopting sustainable soil management techniques for effective food output and production.

Key words: Impact; sustainable soil; management techniques; farm output; LATE

INTRODUCTION
Over the years, farmers have engaged in the use of variant soil management techniques that are unsustainable which have degraded the fertility of the soils leading to poor yields and outputs of the farmers. Thus, considering the increase in Nigeria population and the need to supply the teeming population with basic foods require the practice of sustainable soil management techniques among farmers. Thus, this envisages increased farm outputs, food production, land productivity and income levels of the rural farmers [1]. Thus sustainability theory has been viewed as "a broad set of concepts which ensures that natural resources in this case land is effectively utilized both now and for future years ahead. It is seen as "the ability to maintain a given flow over time from the base upon which that flow depends," and as "primarily an issue of inter-generational equity" [2]. It involves calculation of the balance between present and future use of a resource or set of resources, as well as debate over the valuation of resources in relation to different uses. Intensification of sustainable soil management techniques encourages the growth of macro and micro nutrients in the soil and prepares the soil for maximum plant growth which engenders increased farm output. Sustianbale soil management techniques are for sustainable agriculture. Good soil management techniques such as organic manuring and mulching often improve the productivity of soils and the nutritional value of crops grown thereon. Plants and animal wastes are added to the

soil and upon decomposition, increase the nutrient content of the soil thus facilitating crop yields and outputs [3]. Empirical literature has reveal crop rotation as a formidable soil management technique. Crop rotation mitigates the build-up of pathogens and pests that often occurs when crop specie is continuously cropped and can also improve soil structure andfertility by alternating deep-rooted and shallow-rooted plants. Appropriate crop rotation increases organic matter in the soil, improves soil aeration, reduce soil degradation, and can result in higher yields and greater farm profitability in the long-term. Leguminous crops in the rotation fix atmospheric nitrogen and bind it in the soil thus, increasing fertility and reducing the need for synthetic fertilizers [4]. Furthermore, use of organic fertilizers, cover crops, multiple cropping, fallowing, strip and contour cropping and other agro-forestry practices ensures an increase on the output of the farmland while the latter help in erosion control, reduced run-off and water infiltration. Although, most empirical studies have examined the effect of land management practices on productivity and poverty levels of crop farmers in other States in Nigeria, none has provided an empirical evidence of the impact of sustainable soil management techniques (SSMT) on farm outputs of arable crop farmers in Imo state, Nigeria, hence the need for this study.

MATERIALS AND METHODS

This research was conducted in Imo State of Nigeria, which is located in the South Eastern part of Nigeria with a land area of 5,530 sqkm. The State lies between latitudes $4^{0}45^{\prime}$N and $7^{0}15^{\prime}$N and Longitudes $6^{0}50^{\prime}$E and $7^{0}25^{\prime}$E. The State shares boundaries with Abia and Cross Rivers State to the East, Delta State to the West, Rivers State to the South and Enugu and Anambra State to the North. The State has Owerri as its capital and made up of 27 (twenty-seven) Local Government Areas which are grouped into three agricultural zones namely Owerri, Orlu and Okigwe. Farming is the predominant occupation of the rural inhabitants. Multi-stage sampling technique was used for this study. In the first stage, two local government areas (LGAs) were purposively selected from each of the three agricultural zones of the State. The selection of these LGAs was based on their predominant agricultural activities and use of sustainable soil management techniques (SSMT). A total of six (6) local government areas were used for this study. The second stage involved a random sample selection of arable crop farmers from the list of registered arable crop farmers using SSMT, kept with the zonal ADP's in each of the selected LGAs from the various zones of the State. Owerri zone has 122 registered arable crop farmers while Orlu and Okigwe zones have 130 and 109 arable crop farmers. This shows that there are unequal numbers of arable crop farmers across the three zones, hence an equal representation of sample was made from a proportion of 70 percent of the total population from each zone. This gave a sample size of 85 for Owerri zone, 91 for Orlu zone and 76 for Okigwe zone giving a total of 252 arable crop farmers across the six LGAs. However, the study eventually used only 209 valid questionnaires for analysis. Data were analyzed using descriptive statistical tools, average treatment effect (ATE) and local average treatment effect (LATE) models following [5].

The ATE models were specified thus;

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

$$\mathbf{ATE1}=\frac{1}{n1}\sum_{i=1}^{n}-\frac{(d_i-p(X_i)y_i}{(1-p)(X_i)}$$

(Eqn.2)

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

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;

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

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

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

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

This is well known as the Wald and IV estimators, which can be estimated using two-stage least squares. The framework was designed by [6] and [7] in treating a set of heterogeneous population like the use of sustainable soil management techniques that has two possible outcomes denoted by y_1 and y_0 as high and low use of SSMT. High using status is denoted as d_1, otherwise d_0.

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

Table 2: Distribution of farmers based on source of farm land

Source of Farm Land	***Frequency**	**Percentage**
Inheritance	198	95.0
Gift	34	16.3
Lease/Rent	14	6.7
Outright Purchase	12	5.7
Pledge	28	13.4
Communal	36	17.2

Source: Field survey data, 2015

*Multiple responses

Table 3: Descriptive statistics of different output of crops produced in Imo State

Crop produced	No. of Farmers F	%	Unit	Mean Output	Standard Deviation	Minimum Output	Maximum Output
Maize (Zea mays)	204	97.6	Kg	2,299.71	80.76869	250.00	2,450.00
Melon (Cucumis spp)	141	67.5	Kg	2,298.58	88.6291	100.00	2,500.00
Yam (Dioscorea spp)	135	64.6	Kg	1,848.89	301.2082	300.00	1,950.00
Cassava (manihot spp)	206	98.6	Kg	4,624.10	166.4228	400.00	5,000.00
Okro(Abelmoscus esculentus)	125	59.8	Kg	1,293.28	87.95981	104.00	1,468.00
Vegetable (Fluted Pumpkin)	131	62.7	Kg	1,149.01	31.12011	81.00	1,216.00
Cowpea (Vigna unguiculata)	123	58.9	Kg	1,271.14	80.72625	100.00	1,450.00
Cocoyam (Colocasia spp)	151	72.2	Kg	1,399.60	120.8629	140.00	1,630.00
Pepper (Capsicum spp)	122	58.4	Kg	1,165.85	51.64391	80.00	1,360.00
Garden Egg (Solanum spp)	162	77.5	Kg	1,199.63	70.92056	88.00	1,396.00
SweetPotatoe(Ipomoea batatas)	114	54.5	Kg	1,164.91	76.98116	100.00	1,450.00
Plantain (Musa paradisiaca)	189	90.4	Kg	1,160.32	40.0221	75.00	1,365.00
Banana (Musa spp)	192	91.9	Kg	1,352.92	89.93211	110.00	1,495.00
Tomato (Lycopersicion esculentum)	120	57.4	Kg	1,323.81	66.53884	183.00	1,488.00

Source: Field Survey, 2015

Table 4: Impact of sustainable soil management techniques on farm output of arable crop farmers in Imo State

	LATE Estimators			
PARAMETER	LATE (WALD)	LATE (IV)	ATE (IPSW)	PSM
ATE	55346.88 (49.01)***	71036.01 (32.70)***	49561.02 (2.43)**	51353.76
ATE 1			22901.64 (2.46)**	
ATE 0			15546.22 (1.14)	

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

RESULTS AND DISCUSSION

Socio-economic characteristics of the respondents

The mean age of the farmers was 53 years as shown in Table 1. 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. This is in line with [8] who reported that the more a farmer advances in age, the more conservative he becomes in adopting new technologies. Also [9] noted that the risk bearing abilities and innovativeness of a farmer, his mental capacity to cope with the daily challenges and demands of farm production activities decrease with advancing age. Similarly, [1] posited that the above mean age signals declining productivity which may be a challenge for the agricultural sector performance in Nigeria. 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 [10] 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 [11]. Rural household farmers were characterized with low educational levels which retard their ability to understand and evaluate new production techniques. Education has an important implication particularly for farm management, participation in economic activities, dissemination and adoption of new technology and practice [12]. 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 [9] who reported that years of farming experience of a farmer increases his production efficiency and helps him overcome certain inherent farm production constraints. According to [11] the years of farming experience of a farmer enables him to acquire practical and relevant farming knowledge which drive his ability to efficiently utilize available resources with discretion. 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 [10] who reported that as change agents, extension workers serve as channels for diffusion of technical knowledge and innovations. Extension contacts enhance information dissemination amongst farm households. They further reported that extension contacts not only increase the land productivity of the farmers but also drives poverty reduction. 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 [10] 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. They further stated that rural farmers who cultivate arable crops operate on small scale bases probably due to the land tenure system available to them. However, the mean farm size in the area is typical subsistence farming where a farmer majorly provides for himself and his family.

Source of farm land of arable crop farmers in the area

The distribution of farmers based on sources of farmland is shown in Table 2. The Table reveals that the major source of farmland for farm households in the area was inheritance which accounted for 95.0 percent. This implies that majority of the farmers in the area obtained their land through inheritance. This could be true because the cultivation of most arable crops in Nigeria is carried out on inherited farm lands. Furthermore, land hereditary is a common practice in Nigeria agriculture where land is passed on from one generation to another. This finding is in conformity with [13] who reported that Nigeria agriculture is still practiced on inherited farm lands. Moreover, only 5.7 percent of the farmers purchased their farm lands. This could be probably due to the high costs of land in the area. This supports the findings of [10]. Similarly, 13.4 percent of the farmers obtained their land through pledge, while 16.3 percent of the farmers obtained their land through gift. This further implies that these farmers were given farm lands free of charge.

Descriptive statistics of different output of crops produced in Imo State

The descriptive statistics of different outputs of crops produced in the area is shown in Table 3. The Table shows that arable crop farmers in the area produced varieties of crops ranging from roots tubers, stem tubers, legumes, cereals to vegetables. Cassava production dominated the roots and tuber crops with more than 97 percent of the arable crop farmers engaging in its production. The mean output of cassava produced per farmers in the area is about 4,624.10kg which ranges from 400 to 5,000kg. Thus, this implies that there is a very high cassava production in Imo State with almost all the arable crop farmers engaging in its production. This is in line with the findings of [10] and [14] who reported a very high production of cassava amongst arable crop farmers in the State. The mean output of yam produced is 1,848.89kg which ranges from 300 to 1,950kg per cropping season. Other roots and tuber crops produced in the area are cocoyam and sweet potato with mean outputs of 1,399.60 and 1,164.91kg and ranges from 140 to 1,630 and 100 to 1,450kg per cropping season. Among the legumes cultivated, the result shows that melon dominated with over 60 percent of the farmers cultivating it and an average output of 2,298.58kg ranging from 100 to 2,500kg per cropping season. The result also showed that less than 60 percent of the arable crop farmers engaged in cowpea production with a mean output of 1,271.14kg ranging from 100 to 1,450kg. Furthermore, vegetable production in the area is dominated by garden egg with about 77.5 percent of the arable crop farmers followed by fluted pumpkin, 62.7 percent with mean outputs of 1,199.63 and 1,149.01kg ranging from 88 to 1,396 and 81 to 1,216kg respectively. Again, about 59.8 percent, 58.4 percent and 57.4 percent of the arable crop farmers engaged in the production of okro, pepper and tomatoes with mean outputs of 1,293.28kg, 1,165. 85kg and 1,323.81kg, respectively. This also agrees with [10]. The only cereal crop produced in the area is maize with about 97.6 percent of the farmers cultivating it and a mean output of 2,299.71kg ranging from 250 to 2,450kg per cropping season. Consequently, other crops produced in the area are plantain and banana with over 80 percent of the farmers engaging in its production and with a mean output of 1,160.32kg and 1,352.92kg which ranges from 75 to 1,365 and 110 to 1,495kg respectively. It therefore follows that among the various crops produced in the area, cassava recorded the highest mean output probably because of the high concentration of the arable crop farmers on cassava crops more than any other crops in the area.

Impact of sustainable soil management techniques on farm output of arable crop farmers in Imo State

Table 4: shows the impact of sustainable soil management techniques on farm output of arable crop farmers in Imo State. The output of farmers was measured in physical unit (kg/ha). The propensity score matching (PSM) had an estimated value of 51353.76kg/ha which was higher than the inverse propensity score weighing (IPSW) which recorded an estimate of 49561.02kg/ha. These estimates indicated the average treatment effect (ATE) on the use of sustainable soil management techniques (SSMT) on the farmer's output. Hence, 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' output. Since the PSM and IPSW are all positive and significantly different from zero at $P < 0.05$ critical level, the impact of SSMT on farm output is partly accounted for by the PSM and IPSW. The use of PSM can only removes overt bias in self selection problem thereby leaving the hidden bias. However, the use of these estimates are relevant but not sufficient hence, it is an inconclusive estimation procedure as it does not account for the unobservable covariates that affects a farmer self selection in the use of sustainable soil management techniques [6]. Again, due to the problem of non-compliance and endogenous treatment associated with the application of SSMT, ATE does not have any causal implication on the farm output of the arable crop farmers. In other to curb the limitations of the ATE, the LATE model was employed to cushion the inefficiencies introduced by the average treatment effect as it accommodates all the unobservable covariates that affect farmer's self-selection in the use of sustainable soil management techniques. The LATE estimates by WALD and (IV) were given as 55346.88kg/ha and 71036.01kg/ha respectively. These estimates showed that the use of sustainable soil management techniques had a positive relationship with the farmers' output 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 output by 55346.88kg/ha and 71036.01kg/ha. This further showed that the use of sustainable soil management techniques in the area had a significant impact on the output 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 farm output of the farmers. This finding is consistent with *a priori* expectations and supports the findings of [6] and [15].However extension contact cum effectiveness was used in this study as an instrumental variable which resulted in increase of output recorded in the area.

CONCLUSIONS

Farm output of farmers can be increased if farmers can engaged in the use of sustainable soil practices that improve soil fertility. Hence, the findings showed that output of farmers was intensively increased due to the adoption and use of sustainable soil management techniques which improves soil fertility, aeration, texture and structure of the soil without having any negative effect on the soil. The study further reveals that output of the farmers can be improved through actual land ownership via inheritance which allows farm owners to effectively carry out land improvement practices without having to seek the consent of land owners in the case of rent ownership. Hence, appropriate agric-policies should be channeled towards encouraging the farmers in general i.e. both farmers in the rural and urban centers in adopting sustainable soil management techniques for effective food output and production.

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