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Analysis of Sustainable Agricultural Practices and Profit Efficiency of Maize Farmers in Oyo and Ogun States, Nigeria

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ABSTRACT This study evaluates the adoption of Sustainable Agricultural Practices (SAP) and its effect on the profit efficiency of maize farmers in Oyo and Ogun State of Nigeria. The use of a multi-stage sampling technique was employed to select 174 and 196 maize farmers from Oyo and Ogun State respectively. Primary data were obtained through questionnaire administration. Analysis of data was done with descriptive statistics, Multivariate Probit Model and stochastic profit frontier model. The result of the study indicated that farmers' mean age was 40 years, and were operating on a small scale of 5.1 hectares on average. Sustainable practices were adopted by less than half of the farmers. However, improved seed utilization was adopted by more than two third of the farmers. Age, educational level, size of household, extension contact, association membership, and farm size were the determining variables influencing sustainable practices adoption. Multivariate probit results indicated that significant correlations exist between adoption options. Rent on land ($\beta = 0.9919$, $p<0.01$), price of seed ($\beta = -0.5583$, $p<0.10$), price of labour ($\beta = 1.1910$, $p<0.01$), and price of herbicide ($\beta = 0.1639$, $p<0.01$) were the significant variables in the profit efficiency model. SAP factors affecting profit efficiency were the use of organic manure, cover cropping, and zero tillage. This study proved that policy strategies geared towards farmers' adoption of sustainable agricultural practices should consider farmers' specific socioeconomic factors and emphasize the complementarities and substitutability between different SAPs to broaden farmers' options.

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Agricultural production is a sustainable livelihood option for most households, especially in rural areas. However, the sector is not growing fast enough to keep pace in meeting food adequacy. Much of the growth increase achieved in food production was through the increase in agricultural land area (Kaliba *et al*., 2018). With increasing population, arable land expansion has become difficult because agricultural land has reached its geographical limits hence resulting in declining soil degradation and poor fertility (Breisinger *et al*., 2011). Furthermore, managing agricultural systems to ensure the continuous supply of food products to feed the teeming population without irreversibly degrading the integrity of natural and agroecosystems is a huge challenge. Without the adoption of sustainable farm practices and efficient management of agricultural production, there would be increased yield loss and rising food prices due to environmental resource that is being degraded (Hamdy and Aly, 2014). Considering agricultural production from the perspective of a small-family farmer or large-scale agribusiness, sustainable food production and efficient resource utilization are needed to feed rising populations while considering environmental and socioeconomic impacts. Changes in agricultural

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practices, particularly the intensification, and concentration that have occurred over the last century as part of the green revolution to feed growing populations, have resulted in ecological damage with negative socioeconomic effects (Atkinson *et al.*, 2004). In modern agriculture, factors that limit production, specifically water and nutrients, are provided through synthetic chemicals and irrigation. The noticeable increase that was observed in crop output during the past years is associated with huge increases in nitrogen and phosphorus fertilization and in the quantity of farmland under irrigation system and total land under cultivation which affect biological diversity, water quality, water availability, and climate change (Lenka *et al*., 2017).Regardless of interventions or initiatives targeting supporting rural livelihood and also boost agricultural productivity, over-exploitation and degradation of land will lead to reduced fertility and availability of natural resources (Global Environment Facility, (GEF), 2010). According to Woodfine (2009), in sub-Saharan African countries, crop output would continue to decrease due to the degradation of land, while the revenue obtainable from crop production could fall up to ninety percent by 2100 and the most affected group of people would be smallholder farmers. This implies that the incidence of food insecurity would continue to increase. This indicates that there is a need to combat degradation and encourage commercial farming and ensure the food security of millions of people. More so, the need to ensure the resiliency and viability of farms and food systems, particularly maize production, the most valuable among cereal grain in the economy of African countries and one of the most important commodities used for food aid is a pressing and increasingly salient issue of concern (Olaniyan, 2015). Increased productivity and improved resource use depend on a sustainable environment, for example, if the quality of the soil is improved, this would in turn increase the resiliency of the land to environmental disturbances such as erosion and flooding (Osteen *et al.*, 2012). The productivity of land must be ascertained and enhanced for farmers to remain in the business of food production. Therefore, the environmental impacts of agricultural production can be reduced through the efficient utilization of productive resources and reduced production loss (Alem, 2021).Among arable crops that are widely grown by small-scale farm households in Nigeria, maize production is highly preferred among farmers (Olaniyan, 2015). The significance of maize production in developing economies cannot be underrated. Maize production has great potential to mitigate the food insecurity problem. Maize is a stable food that is consumed by most households in different forms (CIMMYT, IITA, 2010). In some developing countries of Africa, inadequate maize production invariably leads to food shortage and starvation. The demand for maize by a household would continue to increase and more than double in years to come (IITA, 2010) hence the need for strategic efforts to increase maize production. Maize has a positive response to production inputs; it is highly utilized for industrial purposes and it has better production potential compared to other major cereals. This made it a way forward to hunger and can reduce famine among the increasing population. Farmers' decisions concerning improved farm practices and efficient utilization of productive resources will influence the viability of their operations. Emphasis is expected to be placed on the need for farmers to intensify the use of agricultural practices that would address ecological problems, ensure the long-term sustainability of their operations, and use it as an adaptation strategy for coping with climate change (Walthall *et al*., 2013). Hence, the objective of this paper was to analyze sustainable agricultural practices and profit efficiency of maize farmers in Oyo and Ogun States, Nigeria

MATERIALS AND METHODS

Study area: The study was carried out among farmers who are participating in maize production in Oyo and Ogun State. These States were selected because the States were among the states producing large volumes of maize in Nigeria particularly, in the South-West. In Nigeria, maize is produced in the large Northern. The highest producer of maize in Northern Nigeria includes Kaduna, Niger, Taraba, and Borno States while in the Southwestern region, the highest maize producers include Ogun, Ondo, and Oyo States. Maize in Nigeria is mainly produced by small-scale farmers. These farmers cultivate an average of 0.65 hectares (Sahel Reports, 2014). Oyo State covers 27,107.93 square kilometers with latitudes 7ºN and 9ºN and longitudes 2.5ºE and 5ºE (Oladejo *et al.*, 2011). The State shows a typically tropical climate with two maxima rainfall regimes in March and October (Olaoye *et al*., 2013). Ogun State lies approximately between latitude 3º 30 N and 4º 30N and longitude 6º 30 E and 7º 30E (Ambali *et al*., 2012). The State is found within the humid tropical lowland region with two distinct seasons.

Sampling techniques: The study adopted a multistage sampling technique. This was used to select the sampled farmers for the study. In the first stage, the purposive selection of two ADP agricultural zones due to the agrarian nature of the zones. The second stage involves the random selection of one agricultural block from the selected zones out of which four cells were selected randomly. A simplified formula provided by Kabatesi and Mbabazi (2016) was used to determine the adequate sample size (n) for the population. This is given by equations 1 and 2.

$$n = \frac{N}{1 + N(e^2)} \qquad (1)$$

$$n = \frac{4810}{1 + 4810(0.055)^2} = 370 \qquad (2)$$

Where: n = is the sample size, N is the population i.e. total number of registered maize farmers and e =0.055 is the level of significance defined to determine the required sample size at 95% confidence level. The selection of 196 from Ogun and 173 Oyo States respondents is done in proportion to the number of registered farmers across the selected areas.

Data collection: Primary data were used for the study. The data were collected through the use of structured questionnaire. These were administered to the respondents by the trained enumerators. The data were collected on socio-economic as well as demographic characteristics of the respondents. Others were on sustainable practices adopted by the respondents, viz: organic manure, zero tillage, crop rotation, improved variety, organic pesticides etc.

Analytical techniques: Data collected were analyzed using descriptive statistics which were used to describe the socio-economic and demographic characteristics of the respondent maize farmers. Multivariate probit regression was used to identify factors influencing adoption of sustainable agricultural practices. Following Murendo *et al.* (2016) and Tey *et al.*(2017), the MVP model is specified as :

$$y_{im}^* = \beta_m + X_{im} + \varepsilon_{im} \qquad m= 1, 2, \ldots 5 (3)$$

$$y_{im} = \begin{cases} 1 \; if \; y_{im}^* > 0 \\ 0 \; otherwise \end{cases} \qquad (4)$$

Where y_{im}^* is a latent variable that captures the unobserved preferences associated with the choice of practice m.

This latent variable is assumed to be a linear combination of observed characteristics, Xim, and unobserved characteristics captured by the stochastic error term, εim. The vector of parameters to be estimated is denoted by β_m. Given the latent nature of y_{im}^* , estimation is based on observable binary variables y_{im}, which indicate whether or not a farmer used a particular practice. The error terms ε_{im}, m = 1,2 … … ,5 are distributed multivariate normal each with mean 0 and a variance-covariance matrix V, where V has 1 on the leading diagonal, and correlations $\rho jk = \rho kj$ as off diagonal elements (Cappellari and Jenkins, 2003).

The dependent variable (y_{im}) in the empirical estimation model is the choice of a practices.

The independent variables are: X_1 = Age (years), X_2 = Education (years), X_3 = Household size (number), X_4 = Farming experience (years), X_5 = Farm size (hectare), X_6 = Membership of association, X_7 = Extension contact (Number of contact)

Stochastic profit frontier function was also used to estimate profit efficiency of maize farmers in the area. The explicit Cobb-Douglas functional form for the farmers following Ogundari (2006) and Kaka *et al.* (2016) is therefore specified as follows:

$$In\Pi = ln\beta_0 + +\beta_1 In\, P_{1i} + \beta_2 In\, P_{2i} + \beta_3 In\, P_{3i} + \beta_4 In\, P_{4i} + \beta_5 In\, Z_{1i}\left(Vi - Ui\right) \quad (5)$$

Where: Πi represents normalized profit of i[th] farmer computed as total revenue less variable cost divided by farm specific maize price;P_1 = Average price per man day of labour ;P_2 = Average price per kg of fertilizer ;P_3 = Average price per kg of seed; P_4 = Average price per litre of herbicide; P_5 = Average price per litre of insecticide; Z_1 = Farm size (ha).

The variance of the random errors, $\sigma_v{}^2$ and that of the profit inefficiency effect $\sigma_u{}^2$ and overall variance of the model σ^2 are related thus: $\sigma^2 = \sigma_v{}^2 + \sigma_u{}^2$, measure the total variation of profit from the frontier which can be attributed to profit inefficiency (Battese and Corra, 1977). Battese and Coelli (1995) provided log likelihood function after replacing $\sigma_v{}^2$ and $\sigma_u{}^2$ with $\sigma^2 = \sigma_v{}^2 + \sigma_u{}^2$ and thus estimating gamma (γ) as: $\gamma = \frac{\sigma_u{}^2}{\sigma_v{}^2 + \sigma_u{}^2}$.The parameter γ represents the share of inefficiency in the overall residual variance with values in interval 0 and 1. A value of 1 suggests the existence of a deterministic frontier, whereas a value of 0 can be seen as evidence in the favour of OLS estimation.

The inefficiency model (Ui) is defined by:

$$U_i = \partial_0 + \partial_1 M_1 + \partial_2 M_2 + \cdots \ldots \ldots . \delta_{13} M_{13} + \varepsilon \quad (6)$$

Where U_i = Profit inefficiency M_1 = Age of the farmer (years), M_2 = Education (years), M_3 = Household size (number); M_4 = Farming Experience (years), M_5 = Membership of association (years), M_6 = Access to credit (yes=1, 0 otherwise), M_7 =Extension contact (number of contact during the production season), M_8 =Improved variety (dummy), M_9= Organic manure (dummy), M_{10} = Alley cropping (dummy), Z_{11}= Zero tillage (dummy), M_{12} = Cover cropping (dummy).

RESULTS AND DISCUSSION

Socioeconomic characteristics of the farmers: The results of socioeconomic and demographic characteristics of the farmers (Table 1) revealed that 68.92% of the respondents were males, while 31.08% were females.

Table 1: Socioeconomic characteristics

Variable	Frequency	Percent (%)
Sex		
Male	255	68.92
Female	115	31.08
Age		
21-30	87	23.51
31-40	99	26.76
41-50	123	33.24
51-60	52	14.05
>60	9	2.43
Mean	40	
Education		
No formal education	24	6.49
Primary education	17	4.59
Junior secondary education	106	28.65
Secondary education	120	32.43
Post-secondary education	103	27.83
Household size		
1-5	216	58.38
6-10	121	32.70
11-15	33	8.92
Mean	5	
Total	370	100
Farming experience		
1-10	118	31.89
11-20	162	43.78
21-30	80	21.62
>30	10	2.70
Mean	15	
Standard deviation	7.06	
Farm size		
1.1-5.0	255	68.92
5.1-10.0	45	12.16
10.1-15.0	70	18.92
Mean	5.10	
Extension contact		
Yes	58	15.68
No	312	84.32
Total	370	100

This implied that male farmers dominate maize production in the study area and could be attributed to the fact that there are more male headed households in rural communities of Nigeria. The average of the respondents was 40 years. It is a good indication that the farmers are young and still in their active period. Young people in farm business activities have a great importance for food production and adoption of innovation. Age is a variable that could influence farmer’s productivity in agricultural production (Amaza *et al*., 2009). Respondents in the study area had on form of education or the other. Those that had no formal education constitute 6.49%.

The mean size of household among the respondents was 5. Household size could determine the availability of family labour for farm operation especially in a situation where the members are over 18 years old, they could give helping hands in farming particularly during planting, weeding and harvesting of crops. The estimated mean farming experience was 15 years. This indicates that farmers in the area have be cultivating maize for a long period of time. The estimated mean farm size was 5.10 hectares. This indicates that the respondents could be classified as small scale farmers. Kadiri *et al.* (2014) classified small holder farmers as those who farm on marginal lands of between 0.1 – 6.0 hectares and highly dependent on rudimentary capital, rain-fed cropping, crude implements and the use of family labor. Only 15.68% had access to extension services. This could be a limitation to dissemination of improved farming methods and technologies.

Table 2: Rate of adoption of sustainable agricultural practices in the two States

SAP	Oyo	Ogun
Improved variety	153(88.44)	187(94.92)
Organic manure	44(25.43)	45(22.84)
Alley cropping	7(4.05)	142(72.08)
Zero tillage	25(14.45)	6(3.05)
Cover cropping	107(61.85)	180(91.32)
Improved variety and Organic manure	40(23.12)	37(18.88)
Improved variety and Alley cropping	7(4.05)	139(70.92)
Improved variety and zero tillage	24(13.87)	6(3.06)
Improved variety and Cover cropping	98(56.65)	171(87.27)
Organic manure and Alley cropping	7(4.05)	33(16.84)
Organic manure and Zero tillage	13(7.51)	6(3.06)
Organic manure and Cover cropping	36(20.81)	42(21.43)
Alley cropping and Zero tillage	7(4.05)	5(2.53)
Alley cropping and Cover cropping	7(4.05	141(71.94)
Zero tillage and Cover cropping	16(9.25)	6(3.06)

Rate of adoption of sustainable agricultural practices: The results presented in Table 2 showed the rate of adoption of SAPs among farmers in the two study locations. It was revealed that 25.43% and 22.84% were practicing organic manure in Oyo and Ogun respectively, those that adopted use of cover cropping were 61.85% in Oyo and 91.37% in Ogun. Adoption of improved seed was the highest with

88.44% and 94.92% in Oyo and Ogun States respectively. Generally, adoption of SAPs among farmers was generally low except the use of improved seed that was adopted by more than 50% of the farmers. The findings of this study were in line with previous reports in the literatures associated with adoption of SAP. It has been reported that adoption of SAP is low among smallholder farmers in sub-Sahara Africa (Giller *et al*., 2009; Mosers and Barret, 2006; Rockstrom *et al*., 2009; Usman *et al.*, 2021). Many studies conducted to find the reason for low adoption of SAPs concluded that there are manifold social, economic and ecological factors interacting which by nature vary from place to place (Sterve, 2010). According to Kaliba *et al.* (2018), low farm productivity, high incidence of food insecurity and poverty are in sub-Saharan countries is caused by low adoption of agricultural technology. The adoption of two different sustainable agricultural practices ranged between 4.05 and 71.94%. This implied that a range of about 4 and 71% of maize farmers in the study area have used combination of the two practices. The rate of adoption of improved variety and alley cropping in Ogun was 70.92%. This is an indication that the combination of these two practices was adopted to a large extent by the farmers. High rate of adoption of improved variety could be due to attributed characteristics such as high yielding and early maturity and multiple benefits from these practices (El-Tantawi, 2017; Mohammed *et al.*, 2020).

Table 3: Multivariate probit model of factors influencing adoption of SAPs

Variables	Improved variety	Organic manure	Alley cropping	Zero tillage	Cover cropping
Constant	-10.0155***	-1.8954***	-10.8516***	0.9090*	-0.2954
	(8.7756)	(0.7759)	(3.6040)	(0.4875)	(0.4802)
Age	-0.4137**	-0.1557***	0.1406	-0.0457**	0.0310
	(0.2097)	(0.0397)	(0.0935)	(0.0202)	(0.0194)
Education	1.3019	0.2804**	1.5874***	0.0315	0.1553*
	(0.6507)	(0.1137)	(0.5055)	(0.0865)	(0.0888)
Farm size	0.4657***	-0.1438**	-0.1920*	0.0428	0.0375
	(0.1204)	(0.0386)	(0.1087)	(0.0277)	(0.0293)
Farming	0.1525	0.0671**	0.1987**	0.0168	-0.0011**
experience	(0.1249)	(0.0278)	(0.0966)	(0.0202)	(0.0204)
Household size	1.0724	0.3235***	0.3614	-0.1938***	0.0268
	(1.2755)	(0.0956)	(0.3166)	(0.0646)	(0.0642)
Membership of	1.3448	0.2972***	-0.8387***	0.0291	0.0170
association	(0.7626)	(0.0747)	(0.2421)	(0.0425)	(0.0427)
Extension	3.9964	0.3862***	0.0752	0.0555	0.0858
contact	(3.5160)	(0.1279)	(0.2484)	(0.1084)	(0.1122)

Likelihood ratio test for the overall correlation of error terms chi2 (35) = 93.20; Prob > chi2 = 0.0000 *, **, *** *significant at 10%, 5%, and 1% levels, respectively. Figures in parentheses are standard errors*

Table 4: Correlation coefficients for MVP regression equations

	$\rho^{\text{improved variety}}$	$\rho^{\text{Organic manure}}$	$\rho^{\text{Alley cropping}}$	$\rho^{\text{Zero tillage}}$	$\rho^{\text{Cover cropping}}$
$\rho^{\text{Improved variety}}$	1				
$\rho^{\text{Organic manure}}$	-0.4358***	1			
	0.0305				
$\rho^{\text{Alley cropping}}$	-0.1987	-0.0271			
	0.2873	0.2494	1		
$\rho^{\text{Zero tillage}}$	0.6050***	0.1218***	-0.2360	1	
	0.1907	0.0439	0.1587		
$\rho^{\text{Cover cropping}}$	-0.0499	0.0030	0.4625**	0.1131	
	0.1837	0.1462	0.1999	0.1228	1

*Factors influencing adoption of sustainable agricultural practices among farmers***:** The results presented in Table 3 showed the estimates of factors influencing the adoption of sustainable agricultural practices among the respondents. The likelihood ratio test for the overall correlation of error terms is X^2 (35) = 93.20; p = 0.000. This value is significant at 1% level of probability. This indicates that the error terms across the adoption equations are correlated. The result therefore supported the application of the MVP model. Factors responsible for adoption of sustainable agricultural practices are age, farming experience, farm size, access to credit, membership of association and extension contact. The variables that were positively related to adoption of organic manure include that education, farm size, farming experience and contact with extension.. The significant variable associated with the adoption of cover cropping were education and contact with extension. Age and household size were negative. This implied that rate of adoption reduced as these variables increased. The result further showed that education farm size and farming experience were the factors influencing adoption of alley cropping. Adoption of zero tillage was influenced by age and household size. The implication of negative coefficient obtained for age is that young farmers are more likely to adopt SAP but as farmers become too old the likelihood to adopt falls. Older farmers are in most cases risk averse and less likely to adopt newer technologies compared to young farmers (Murendo *et al.,* 2016).The positive and significant sign offarm size indicated that as farm size increased, the likelihood of adopting alley cropping, improved variety and cover cropping. This result is consistent with the findings of Kassie *et al.* (2011) and Mariano *et al.* (2012). As indicated by the error correlation coefficients in Table 4, there were significant correlations between the use of improved variety and organic manure, improved variety and zero tillage, organic manure and zero tillage, alley cropping and cover cropping. The negative associations between adoption decisions, indicate that the SAP options were substitutes while the positive association showed that the options are complementary.

Table 5: Maximum likelihood estimate of stochastic frontier profit function

Variable	Coefficient	t-value
Constant	-42.1089**	-2.41
Farm size	0.9919***	3.07
Average of seed	-0.5583***	-2.31
Average price of fertilizer	0.8175	1.60
Average price of labour	1.1910***	3.17
Average price of herbicide	0.1639***	3.13
Average price of insecticide	1.1940***	3.47
Inefficiency model		
Constant	6.2651***	5.27
Age	-0.0207	-0.42
Education	-0.0805	-0.21
Household size	-0.8362****	-8.17
Farming experience	-0.0499	-0.89
Membership of association	-0.0836	-0.41
Extension contact	-0.0504***	-3.52
Access to credit	0.3460	0.81
Improved variety	0.9884	1.07
Organic manure	0.4479***	5.10
Alley cropping	-0.0147	-1.48
Zero tillage	-0.9962***	9.70
Cover cropping	-1.5010*	-1.76
Diagnostic statistics		
Sigma square	1.7972***	7.33
Gamma	0.8916***	56.34
Log-likelihood	-204.40	

*, **, *** *significant at 10%, 5%, and 1% levels, respectively*

Maximum Likelihood Estimates of the Stochastic Profit Frontier Function: The estimates of the parameters of the stochastic profit frontier model are presented in Table 5. The model showed that there was presence of profit inefficiency among the farmers. The generalized likelihood ratio test defined by the Chi-square ($\chi 2$) distribution was greater than critical chi-square values at 1% level of probability. These values maximize the joint densities in the estimated model. The implication is that the form of the model adopted in the estimation of this study is an adequate representation of the data. The estimated gamma parameter (γ) is 0.89 and significant at 1 percent level of probability. This implies that about 89 percent of the variation in actual profit from maximum profit (profit frontier) among farmers mainly arose from differences in farmers' practices rather than random variability. The estimated parameter obtained for farm size, price of labour and price of herbicide showed that there are significant effects of these variables on normalized profit of the farmers. Cost of seed was significant this implied that increase in the price of these variables, farmers' profit efficiency will decrease. Labour and herbicide exert positive relationship with profit which showed that these variables would increase profit efficiency of the farmers. The socio economic variables influencing profit inefficiency were household size and farming experience while SAP variables influencing profit inefficiency were the use of zero tillage and cover cropping. These variables were found reducing profit inefficiency among farmers.

Conclusion: The Adoption of different sustainable agricultural practices was generally low and interdependent. The adoption was significantly affected by socioeconomic and institutional factors. Variables such as education, membership of the association, farmers' accessibility to credit, and extension contact played a significant role in the adoption of SAPs. There is need for a policy that will support farmers' organization and extension as well as a service provider to accelerate adoption among farmers.

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