



SOCIO-ECONOMIC DETERMINANTS OF INTEGRATED SOIL FERTILITY MANAGEMENT (ISFM) PRACTICES CHOICE AMONG MAIZE FARMERS IN ADAMAWA STATE, NIGERIA

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ABSTRACT

This study was carried out to analyze socio-economic determinants of Integrated Soil Fertility Management (ISFM) practices choice among maize farmers in Adamawa State, Nigeria. Using a multi-stage sampling procedure, 206 maize farmers were selected and interviewed using a structured questionnaire. Descriptive statistics and multinomial logit regression models were used to analyze the data collected. Findings revealed that majority of the farmers (about 60%) fell within the 20-40 years and they were predominantly male (62.1%), married (82.0%), and had a secondary education (40.3%). Farmers operated on an average farm size of 1.70 hectares. Majority of the maize farmers in the study area used intercropping with legumes (94%), organic manure (87%) and improved maize seed (79%) ISFM practices, the least practiced ISFM among the farmers were minimum tillage, crop residue retention and use of crop rotation. Socio-economic factors that were significant ($P < 0.05$) and positively influenced ISFM practices used among maize farmers were annual income, education level, and household size. Meanwhile gender (sex) have negative and significant ($P < 0.05$) influence on minimum tillage practice by the maize farmers. The study concludes on moderate use of ISFM practices among maize farmers in the study area. It was therefore recommended that organized farmer's programmes should be targeted toward educating the farmers on ISFM

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INTRODUCTION

Rising demand for agricultural commodities coupled with on-going population growth, climate change, declining soil fertility, environmental degradation and rural poverty in the developing world emphasize the urge to sustainably intensify agricultural production in Sub-Saharan Africa (SSA) (Food and Agriculture Organization, FAO, 2020). Sustainable intensification refers to increasing agricultural production from the same area of land while reducing its negative environmental consequences (Godfrey *et al*, 2010). As one strategy to sustainably intensify smallholder agriculture, 'Integrated Soil Fertility Management' (ISFM) is increasingly promoted by governments and donors in SSA. ISFM is a system of technology

practices benefits and improving their income so as to facilitate adoption of ISFM practices for sustainable farm operation.

Keywords: Determinants, Fertility, Maize farmers, Management, Practices, Soil

consisting of a set of site-specific soil fertility practices which should be applied in combination. Its core is the integrated use of improved seeds with organic and inorganic fertilizers, which are supposed to bear important synergistic effects. Practices should be adapted to local conditions and, depending on the context, complemented by other technologies such as crop rotation, minimum tillage, or measures to correct soil acidity (Vanlauwe *et al.*, 2010).

Furthermore, ISFM includes an improvement of agronomic techniques, e.g. timely weeding or exact dosing and targeting of inputs. The general aim of ISFM is to improve soil fertility by replenishing its nutrient stocks and increasing soil organic matter levels, and thus, waterholding capacity and soil biota. On the one hand, healthier and more fertile soils can contribute to restoring and conserving natural resources by providing crucial ecosystem services, such as the storage of soil carbon, erosion control, and the prevention of further deforestation (Adhikari & Hartemink, 2016). Moreover, enhanced soil fertility is likely to improve food security, incomes, and ultimately, livelihoods of the rural population depending on small-scale agriculture (Barrett & Bevis, 2015). In Nigeria, the need to incorporate organic residues into soils is the panacea to sustainable crop production and has not been explored satisfactorily to increase yield by smallholder farmers. Farmer's practices for soil fertility regeneration and nutrient cycling within agricultural areas in the 20th century was predominantly traditional shifting cultivation system, where a few years of cultivation are followed by very long fallow periods.

It is envisioned that farming households could escape poverty traps by adopting agricultural technologies, which are in turn expected to boost productivity to the extent of producing a marketable surplus (Cunguara & Darnhofer, 2011). Nonetheless, the first barrier to be overcome is that of adoption. System innovation like ISFM, conservation agriculture, and agroforestry adoption have been subjects of intense discussion in recent years as its scale-out, as well as scale-up in SSA has remained limited (Vanlauwe *et al.*, 2014; Lambrecht, Vanlauwe & Maertens, 2015). A lot of emphasis has been placed on assessing socio-economic and contextual drivers of agricultural technology adoption with on adoption of ISFM (Ogwu *et al.*, 2018). Understanding the soil fertility management practices and their determinants in a particular agricultural system has received little attention in Nigeria. Similarly, smallholder farmers are quite different in their biophysical and socio-economic settings and their associated experience in managing soil fertility. Therefore it is important to understand the diverse indigenous soil fertility management and how they are affected by various determinant factors for designing appropriate intervention measures Thus, this study identified determinants of integrated soil fertility management practices choice by smallholder maize farmers in Adamawa State, Nigeria.

METHODOLOGY

Study Area

The study area for this study is Adamawa State, Nigeria. Adamawa State is located in the North-eastern part of Nigeria. It lies between latitude 7° and 11° N of the Equator and between

longitude 11° and 14° E of the Greenwich Meridian. It shared boundaries with Taraba in the South and West, Gombe State in the North-West, Borno State to the North and the Republic of Cameroun in the East. Adamawa State has a total land area of about 38,741km² with a population of 3,168,101 million according to 2006 national population commission report. Using the national annual population growth rate of 3.2%, the projected population of Adamawa State for 2024 is 4,914,876 people. The State is divided into 21 local government areas (LGA). There are two notable vegetation zones in the state: The Southern Guinea Savannah and the Northern Guinea Savannah. The topography is essentially picturesque mountainous land traversed by valleys of rivers Benue, Gongola and Yedzeram (Adamawa Agricultural Development Programme, AADP, 1996).

The state has a tropical climate marked by distinct dry and rainy seasons. The rainy season commences in April and ends in late October. The average rainfall in the North western part of the state is 700 mm and 1600 mm in the southern part. The wettest months are August and September while the driest months are January and February (Tashikalma *et al.*, 2014). Temperature varies from place to place with minimum recorded temperature 18°C and a maximum of 40°C. Mean monthly temperature in the state ranges from 26.7⁰ C in the south to 27.8⁰C in the northeast part of the state. The state has a large number of ethnic groups and most widely spoken languages are Hausa, Fulfulde, Kilba, Margi, Higgi, Bura and Bwatiye. The predominant occupations of the people in the State are farming and livestock herding. Some of the agricultural crops grown are maize, rice, sorghum, groundnut, cowpea, cotton and vegetables (Tashikalma *et al.*, 2014).

Sampling Technique and Sample Size

A multi-stage random sampling was employed for this study. In the first stage, three (3) local government areas namely Fufore, Gombi, and Guyuk were purposively selected due to the intervention of the ISFM project by FAO, International Institute for Tropical Agriculture (IITA) and other International developmental organizations in the LGAs in collaboration with the State Agricultural Development Programme (ADP). The second stage involved the selection of two communities from each local government area based on the maize production across the agricultural zones. A Raosoft sample size calculator was then used to determine the requisite sample size of 206 farmers from the sample frame of the selected communities. The third stage involves random sampling of maize farmers to give a total of 206 farmers.

Table 1: Sampling of Maize Farmers in the Study Area

LGA	Selected Communities	Sample Frame	Sample Size
Fufore	Parda	94	44
	Maraban cigari	62	29
Gombi	Parijo	71	33
	Gombi	92	43
Guyuk	Purokayo	63	29
	Bobini	60	28
Total		442	206

Source: Adamawa Agricultural Development Program (AADP), 2023

Data Collection

Primary data were collected through the use of a questionnaire to investigate the socioeconomic characteristics of the maize farmers, their farm size and adoption of integrated soil fertility management in maize production. Thus, the age of farmers, household size, educational status, farming experience, various cost items necessary for production were also collected, information on household dietary diversity was collected as well, also information on constraints faced by maize farmers in the study area was also captured.

Analytical Techniques

The tool of analysis for this study includes descriptive statistics and multinomial logit regression model, farm budgeting techniques, propensity score matching and household dietary diversity score.

Descriptive Statistics

The descriptive tools employed include mean (x), standard deviation, charts, frequency and percentages. These tools were used to describe socioeconomic characteristics and integrated soil fertility management (ISFM) practices used by the farmers

Multinomial Logit Regression Analysis

The multinomial logit regression model was used to determine socio-economic factors influencing maize farmer’s use of integrated soil fertility practices in the study area. MNL model is based on the utility theory of maximization. That is, the satisfaction derived as a result of profit accrued from a particular good instead of the others that could influence its production. The four (4) integrated soil fertility practices used were observed while the factor determining the need for a particular ISFM practices was determined by multinomial logit regression. The ISFM practices included in the model were 1= (Improved seeds + fertilizer), 2= Improved seeds +fertilizer + organic amendments, 3=Improved seeds + fertilizer + organic amendments + local adaptation (uses lime, manure, application of crop residues or mulch constructed terrace, tied ridges or ridging), while the alternative source of fertilizer serve as base out for any of these practices. The multinomial logit model is widely used as it builds on the choices where there are more than two categorical dependent variables. The independent variables were the socioeconomic characteristics of the maize farmers. The mathematical equations for the model are stated as:

$$P_{ij} = E(Y_i = j | x_i) = F(\alpha + \beta x_i) \quad j= 1,2,3 \dots\dots\dots (1)$$

$$= \frac{1}{1 + \sum_{j=1}^3 e^{-z_i}} \quad \text{where } z_i = \alpha + \beta x_i \dots\dots\dots (2)$$

$$= \frac{e^{z_i}}{1 + \sum_{j=1}^3 e^{z_i}} \dots\dots\dots (3)$$

For easy interpretation, Eq. (3) is differentiated in respect to the independent variables (X) to give the marginal effects (ME) of the variables (Eq.4) as it influences the choices made by the maize farmers. As a function of probability, marginal effect determines the expected change in

the maize preference of the farmer with respect to changes in the predictor variables. The ME equation is written as:

$$\delta Y_j = Y_j(\beta_{jk} - M) \dots\dots\dots(4)$$

The explicit function of the model is written in Eq. (5) below as;

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \epsilon_i \dots\dots\dots (5)$$

Where:

- Y=ISFM practice choice =1; otherwise=0
- X₁= Age of maize farmers (years)
- X₂=Sex of Maize farmers (1=male, 0=female)
- X₃=Educational level (1=educated; 0=otherwise)
- X₄=Farm Size (Hectares)
- X₅=Household size (hectares) X₆=
- Annual income (₦)

RESULTS AND DISCUSSION

Table 2: Quantitative Socio-economic Characteristics of Maize Farmers (n=206)

Variables	Frequency	Percentage	Mean	Minimum	Maximum	Standard Deviation
Age (Years)			39.00	20.00	70.00	11.54
20-30	50	24.3				
31-40	76	36.9				
41-50	52	25.2				
51-60	16	7.8				
61-70	12	5.8				
Household size (Persons)						
2-6	129	62.6	6.00	2.00	16.00	2.71
7-11	70	33.9				
12-16	7	3.4				
Farm Size(Hectare)			1.70	0.2	4.50	0.84
0.2-0.90	21	10.2				
1.0-1.90	93	45.1				
2.0-2.90	66	32.0				
3.0-3.90	20	9.7				
4.0-4.9.0	6	2.9				
Farming Experience(years)						
1-10	62	30.1	19.00	1.00	48.00	8.02
11-20	41	19.9				
21-30	75	36.4				
31-40	21	10.2				
41-50	7	3.4				
Annual Income						
100,000-200,000	74	35.9	30994.75	100,000	590000	14.8
201,000-300,000	36	17.5				
301,000-400,000	40	19.4				

401,000-500,000	30	14.6
501,000- 600,000	26	12.6

Source: Field Survey, 2023

Socio-economic Characteristics of the Maize Farmers

The socio-economic variables identified for this research were age, sex, level of education, farm size, annual income, primary occupation, household size, years of experience, membership of cooperatives, and contact with extension agents. The socio-economic variables were presented in Table 2 and 3. The results in Table 2 showed the age distribution of maize farmers in the study area. The result showed that 36.5% of the maize farmers were within the age bracket of 31-40years, 25.2% of them were between 41-50years, while 5.8% were between 61-70 years, with a mean of 39 years, and this implied that the maize farmers in the study area were in their active production age and this will enhance their adoption potential for ISFM. The results is in line with what was found by Zongoma *et al.* (2020) that the average age of farmers was above 38 years in Borno, State, Nigeria. The distribution for household size result showed that 62.2% of the maize farmers had household size between 2-6 persons, 33.9% of them had between 7-11 persons, while 3.4% had household size between 12-16 persons, with an average household size of 6 persons, and this implied a large household size in the study area. The findings from this study corroborated with the findings of Samuel *et al.* (2022) where they discovered that the average farming household was above 5 persons in Borno, State, Nigeria.

Moreover, the result for farm size showed that 45.1% of the maize farmers had farm size between 1.0-1.90 hectares, with an average farm size of 1.70 hectares. These results implied that most of the maize farmers in the study operates on a small scale. These findings agreed with Tahir *et al.* (2020) where they discovered that the average farm size of cowpea farmers in Borno State, Nigeria was above 1 hectare. In addition, the results showed that 36.4% of the maize farmers had farming experience between 21-30 years, 30.1% of them had experience between 1-10years, while 3.4% have farming experience between 41-50 years, with average farming experience of 19 years in the study area. This implied that most of the maize farmers in the study area have vast experience in maize production. The distribution of maize farmers based on annual income was also presented in Table 2. The result showed that 35.9% of the maize farmers had annual income between ₦100,000-₦200,000, 19.4% of the maize farmers had annual income between ₦301,000-₦400,000, while 12.6% of the maize farmers had between ₦501,000-₦600,000, with a mean annual income of ₦231,254.8 in the study area. These results showed that most of the maize farmers had income between ₦100,000-₦200,000 in the study area.

The sex distribution of maize farmers was presented in Table 3. The results showed that majority (62.1%) of them were males while (37.9%) were females. This showed that the maize production enterprise was dominated by the male, while the female counterparts focused on other aspects of the maize value chain in the study area. These findings agreed with Bashir, Ndaghu, Nakwe, Abdulazeez and Samuel (2018) where they discovered that farming of arable crop was male dominated in Taraba State, Nigeria. The marital status distribution of maize

farmers was also presented in Table 3. The results revealed that majority (82.0%) of the maize farmers were married, 10.2% were widow, 5.3% were single, while 2.5% were divorced. These results implied that most of the maize farmers in the study area were married with responsibility to cater for their families. The result from these findings agreed with Onuwa *et al.* (2022) where they observed that most farmers in Plateau State, Nigeria were married. Furthermore, level of education of maize farmers was presented in Table 3. The result showed that 40.3% of the maize farmers had secondary education, 21.4% had adult education, 19.9% had tertiary education, while 18.4% had primary education in the study area. This result implied that most of the maize farmers in the study area were formally educated giving them ability to adopt innovation on agricultural production such as the soil management practices. These findings corroborated with that of Kuzhkuzha *et al.* (2021) where they discovered that most of the farmers in Nassarawa State, Nigeria, had secondary education.

Table 3: Qualitative Socio-economic Characteristics of Maize Farmers (n=206)

Variable	Frequency	Percentage
Sex		
Male	128	62.1
Female	78	37.9
Marital Status		
Married	169	82.0
Divorced	5	2.4
Widowed	21	10.2
Single	11	5.3
Level of Education		
Adult Education	44	21.4
Primary Education	38	18.4
Secondary Education	83	40.3
Tertiary Education	41	19.9
Membership of Cooperative		
Member	186	90.3
Non-Member	20	9.7
Contact with Extension Agents		
Contact	165	80.1
No Contact	41	19.9
Primary Occupation Farming		
	104	50.49
Artisans	84	40.78
Business	18	8.73

Source: Field Survey, 2023

The distribution of maize farmers based on membership of cooperative was also presented in Table 3. The result showed that majority (90.3%) of the maize farmers were members of cooperative, while 9.7% do not belong to any cooperative society. This result implied that farmers who belonged to a co-operative were likely to adopt new technology easily than those not in any co-operative. The result from this findings was in line with Olatinwo *et al.* (2022),

who discovered that majority of farmers in Kwara state belonged to cooperative society. The distribution of maize farmers based on contact with extension agents was further presented in Table 3. The result showed that majority (80.1%) of the maize farmers had contact with extension agents, while 19.9% of them did not have contact with extension agents. In addition, the result showed that 50.49% of the maize farmers were into farming as the primary occupation, 40.8% were artisans, while 8.73% were into business in the study area. This result indicated that most of the maize farmers in the study area were into farming as a main source of occupation. The findings from this study agrees with Abubakar *et al.* (2020) where they discovered that farming was the main source of occupation among cowpea farmers in Sokoto State, Nigeria.

Table 4: ISFM Practices Adopted by Maize Farmers

ISFM Practices	Frequency	Adoption rate	Percentage (%)	Ranking
Use of organic manure	179	0.87	87.0	2 nd
Crop residue retention	74	0.36	36.0	6 th
Intercropping with legumes	194	0.94	94.0	1 st
Use of improved maize seed	163	0.79	79.0	3 rd
Minimum / Zero tillage	93	0.45	45.0	5 th
Crop rotation	38	0.18	18.0	7 th
Use of inorganic fertilizer	118	0.57	57.0	4 th

Source: Field survey, 2023

ISFM Adopted by Maize Farmers in the Study Area

The result in Table 4 showed the distribution of ISFM practices in the study area. The intercropping with legumes (94.0%) was the most common ISFM practices among maize farmers in the study area. This implied that maize farming was intercropped with certain legumes such as groundnut and cowpea to improve the fertility of the soil and to increase maize production in the study area. The result showed that 87.0% of the maize farmers adopted the use of organic manure in the study area, this implies that organic manure in the form of poultry droppings and cattle dung were adopted as an ISFM practices among the maize farmers. The use of improved maize seed (79.0%) was another ISFM practice adopted by maize farmers. This implied that they utilize different varieties of maize seed as a package of the ISFM practices in the study area. Other ISFM practices adopted by maize farmers in the study area included the use of inorganic fertilizer (57.0%), minimum or zero tillage (45.0%), crop residue retention (36.0%), and crop rotation (18.0%).

Table 5: Factors Influencing Adoption of ISFM Practices among Maize Farmers

Variables	Inorganic fertilizer	Zero/Minimum tillage	Crop Rotation
Constant	0.56(0.64)	0.47(0.74)	0.224(0.55)
Age	0.01(0.08)	-0.005(0.01)	0.001(0.007)
Annual Income	0.34(0.24)	7.733***(1.51)	0.55***(0.22)
Education Level	0.22(0.21)	0.39**(0.19)	0.97(0.02)
Farm Size	0.02(0.10)	-0.09(0.22)	0.59(0.09)
Sex	0.12(0.18)	-1.04*** (0.34)	0.007(0.16)

Household size	01.16***(0.27)	0.55*(0.3)	0.017(0.030)
N	206		
R-Square	0.457		
Loglikelihood	-123.94		

Source: Field Survey, 2023 * =10%, ** =5%, *** =1% SE=parenthesis

Factors Influencing the Use of ISFM Practices among Maize Farmers

The result in Table 5 showed multinomial logit regression results for the factors that influenced ISFM practices among maize farmers in the study area. The result revealed that the R square value of 45.7 shows that variables in the model are fit to explain the factors influencing the ISFM practices among maize farmers in the study area, also the value of probability with a lower log likelihood of -123.94 that is significant at 1% level of confidence, implied the overall fitness of the model. The result revealed that annual income, educational level, sex, and household were the only socioeconomic factors that influenced ISFM Practices among maize farmers in the study area. The coefficient of household have a positive and significant relationship with minimum/zero tillage (0.27, $P < 0.01$) and inorganic fertilize (0.3, $P < 0.01$). This implied that increase in household size would increase the probability of using ISFM practice of minimum/zero tillage and inorganic fertilizer application among maize farmers. The result therefore showed that farmers with high household size tends to adopt ISFM practices compared to their counterparts with less household size within the study area.

Furthermore, the coefficient of annual income, educational level, and household size showed a positive and significant ($P < 0.05$) relationship with ISFM practices while sex shows a negative relationship with minimum/ zero tillage. The results showed that increase in annual income would increase the probability of using minimum/zero tillage and crop rotation among maize farmers in the study area. This implied that annual income had effects on ISFM practices, because farmers with higher income annually practiced integrated soil fertility management to increase maize yield and income as well. There was a positive relationship between educational level and minimum/ zero tillage. The coefficient for educational level showed that maize farmer that were educated hence practiced ISFM more than the less educated ones in the study area. This result implied that education had positive effects on maize farmers because the understanding of the practices requires the knowledge through extension agents. The coefficient of sex showed a negative and significant ($P < 0.001$) relationship with minimum/zero tillage, which implied that female maize farmers utilize minimum/zero tillage compared to their male counterparts. The issue of sex was a factor that influenced ISFM among maize farmers in the study area. The result from these findings was in line with Ogwu *et al.* (2018) where they discovered that sex, household size and level of education were among the factors that influence soil fertility management among farmers in North central zone of Nigeria.

CONCLUSION AND RECOMMENDATION

The findings of the study revealed moderate use of ISFM practices among maize farmers given the fact that not all ISFM practices were adopted by most of the maize farmers in the study area. The findings further revealed socio-economic characteristics, such as annual income, educational status, household size, and sex to influence the use of ISFM practices among maize farmers in the study area. It was therefore recommended that farmers organized programmes should be targeted towards educating the farmers on ISFM practices and improving their

income so as to facilitate adoption of ISFM practices in order to ensure sustainable farm operations.

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