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DETERMINANTS OF SUSTAINABLE LAND MANAGEMENT PRACTICES FOR CLIMATE CHANGE MITIGATION AND ADAPTATION AMONG MAIZE FARMERS OF THE WORLD BANK INTERVENTION PROJECTS IN NORTHWEST NIGERIA.

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ABSTRACT

Socioeconomic and institutional factors influence the interests and willingness of farmers to adopt sustainable land management for climate change mitigation and adaptation. This paper analyzes the determinants of sustainable land management practices for climate change mitigation and adaptation among maize farmers in the World Bank intervention projects in Northwest Nigeria. Results showed that a majority (60.56%) of farmers adopted unsustainable land-based practices, while the remaining 39.44% adopted sustainable land-based practices for climate change mitigation and adaptation. The estimated Tobit regression showed that an increase in the farmer's level of education, household size, the proximity of the farm to rivers/streams, and land acquisition by inheritance by one percent is likely to increase sustainable land-based practices for climate change mitigation and adaptation by 0.0057%, 0.0075%, 0.057%, and 0.094%, respectively. Conversely, an increase in extension contacts, labour requirement of sustainable land management, farming experience, membership of cooperative associations, and income level by one percent is likely to decrease sustainable land-based practices for climate change mitigation and adaptation by 0.0151%, 0.271%, 0.0049%, 0.148%, and 1.2e-07%, respectively. The World Bank should partner with stakeholders to support farmers in sustainable land management and provide tools that reduce labour and costs while aiding climate change adaptation

***Keywords**: sustainable land management, climate change, maize production, mitigation and adaptation, World Bank Intervention projects*

INTRODUCTION

Maize is a major cereal and one of the most important food crops in Nigeria (Kamara, Kamai, Omoigui, Togola, & Onyibe, 2020), and a major commercial crop for livestock feed (Olasehinde, Qiao, & Mao, 2023). Nigeria produced an estimated 28.1 million MT in 2023 (FAOSTAT, 2023). Despite the favourable ecology for maize production, the country has one of the lowest maize yields in Sub-Saharan Africa (SSA) (Olasehinde et al., 2023). Climatic factors are one of the main agents affecting yield (Wheeler & von Braun, 2013). Changes in rainfall and temperature enhance the probability of crop failures and the proliferation of weeds and insects, eventually reducing crop yields (Liniger *et al*., 2011). Climate change affects plant phenology and the timing of flowering; the interactions between plants and pollinators may be disturbed, with detrimental consequences for crop productivity (Shrestha, Garcia, Bulkovac, Dorin, & Dyer, 2018). In maize production, shorter crop growing cycles, determined by warmer temperatures, have negative effects on grain filling and consequently on crop productivity due to the reduced time for biomass accumulation and yield formation (Ciscar, Ruiz, Ramirez, & Dosio, 2018). High CO2 concentrations may, in some cases, affect the quality of crop production by reducing the protein content of C3 cereal grains (Zhou, Zhai, Chen, & Rong Yu, 2018), affecting the timing of flowering (Shrestha, Garcia, Bulkovac, Dorin, & Dyer, 2018), and slowing the development of maize crops by hindering seed and leaf development. During flowering and/or grain-filling phases, high temperatures can have large negative impacts on cereal grain yields (Eyshi, Webber, Gaiser, Naab, & Ewert, 2015). According to the Intergovernmental Panel on Climate Change (IPCC) (2014), adopting sustainable land management practices (SLM) that increase soil organic matter, erosion control, improved fertilizer management, and improved crop management contribute to climate change adaptation and mitigation in cropland.

SLM practices are structural, agronomic, vegetative, and management measures used to control soil erosion, reduce nutrient depletion, improve soil conservation, and enhance productivity (Adimassu *et al*., 2016). In cereal production such as maize, modifying crop calendars can help farmers take advantage of better early-season moisture conditions and a prolonged growing season, and help minimize drought risk periods during grain filling (Yegbemey, Kabir, Awoye, Yabi, & Paraiso, 2014). The use of cover crops improves soil properties (physical, chemical, and biological), soil organic carbon sequestration, nitrogen retention (reduction of nitrate leaching), above-ground biomass nitrogen, and nutrient cycling (European Environment Agency, EEA, 2019). A combination of cover cropping and minimum tillage effectively suppresses weed growth and reduces crop-weed nutrient competition (Price and Norsworthy, 2013). Mulching, which involves retaining crop residues on the field, conserves and enhances soil moisture, reduces surface runoff and erosion, provides soil organic matter and acts as a carbon sink, and increases soil fertility (Verhulst, Nelissen, Jespers, Haven, Sayre, Raes, Deckers, & Govaerts, 2011).

Farmers' adaptive response to climate change through sustainable land management is influenced by a number of socio-economic and institutional factors (Nyanga, Johnsen, Aune, and Kalinda, 2011; Derr, 2018). Factors such as farmers' interest and willingness (Moges and Taye, 2017), government support, farm size, farm location, and the availability of extension agents are often overlooked by developers of sustainable land management practices. These and other factors determine the success or failure of these practices. Farmers' socio-economic variables such as age, income, education, and extension contacts (Ebojei *et al*., 2012), farm size, farming experience, better yields, and the availability of improved seeds have a significant impact on the adoption of improved practices (Idrisa *et al*., 2012). Education, farm size, fertilizer usage, and access to extension services exert significant influence on adoption decisions by maize farmers (Fadare, Akerele, and Toritseju, 2014), influencing farmers' decisions to adopt sustainable land management practices for climate change mitigation and adaptation. Farmers in the Northwest States in Nigeria have benefited from several World Bank intervention programs, such as the National Fadama Development Projects, Commercial Agricultural Development Project (CADP), and the ongoing APPEALS (Agro Processing, Productivity Enhancement, and Livelihood Support) projects. These intervention projects support small and medium-scale commercial maize farmers in increasing productivity through the introduction of improved and sustainable technologies for climate change mitigation and adaptation. Nevertheless, the full adoption of these practices has yet to be realized among maize farmers in the area. Therefore, this study assessed the determinants of sustainable land management practices for climate change mitigation and adaptation among maize farmers in the World Bank intervention projects in Northwest Nigeria. The specific objectives were to:

1. examine the socioeconomic characteristics of maize farmers of World Bank intervention projects in the study area,
2. examine the level of climate change perception, sustainable land management practices for climate change mitigation and adaptation among maize farmers of World Bank intervention projects in the area,
3. identify and categorize farmers based on the level of sustainable land management practices adopted for climate change mitigation and adaptation in the area,
4. ascertain the socioeconomic and institutional determinants of sustainable land management practices for climate change mitigation and adaptation among maize farmers of the World Bank intervention projects in the area.

2.0 METHODOLOGY

2.1 Study Area

The North West is one of the six geopolitical zones, comprising seven (7) states, namely, Kaduna, Katsina, Sokoto, Zamfara, Kano, Jigawa, and Kebbi States (NARSP, 1997). It lies between latitudes 20 and 14° N and longitudes 7 and 6° E, covering an area of 216,065 sq km. The major ethnic groups are the Hausa and Fulani. The projected population of the zone was about 41.8 million, representing 25.56% of the total national population in 2014.

About 80 percent of the population are farmers, pastoralists, agro-pastoralists, or small-scale entrepreneurs. The mean annual rainfall ranges from 500mm to nearly 1200mm, characterized by rainfall variability, especially late onset and early cessation of rains, often resulting in a shorter growing season. The mean annual temperature ranges between 17 and 38°C, although high temperatures of up to 42°C occur during April/May. The North-West zone of Nigeria is the leading producer of cereals (sorghum, millet, maize), legumes, and vegetables, such as tomato, onion, and pepper (NARSP, 1997).

2.2 Analytical Techniques

The study was carried out using a well-structured questionnaire administered to maize farmers participating in World Bank intervention projects. Multi-stage and purposive sampling techniques were employed, and five hundred and forty (540) maize farmers were randomly selected. Data collected were analyzed using descriptive statistical tools (such as percentages and means), Land Management Index (LMI), Decision Index (DI), and Tobit Model. Maize farmers were classified based on the sustainable land management decision options for climate change mitigation and adaptation. The land-based mitigation and adaptation options available to the farmers were first identified, and farmers were then categorized based on their adoption decisions: sustainable land-based options (practices that do not involve the use of agrochemicals and do not contribute to climate change) and unsustainable land-based options (farmers that rely on agrochemicals). Sustainable options are those that ensure the long-term productivity potential of land, water, biodiversity, and the environment while maintaining ecosystem functions. In this case, land-based management options such as the use of synthetic fertilizer, pesticides, and other agrochemicals are considered unsustainable practices. The Land Management Index (LMI) was constructed from the total number of sustainable land management options (such as contour bunding, mulching, use of cover crops, incorporation of crop residues, use of compost/farm manure, minimum tillage, terracing, etc.) available for each farm operation in the area. Following Kassie (2016) and Eririogu *et al*. (2019), the Land Management Index (LMI) was estimated using the following:

$$L_i = \left(\sum_{i=1}^{n_j} \frac{S_i}{N} \right) \tag{1}$$

Where,

L_i = Index of land management for the i^{th} farmer.

S_i = Sustainable land management practices for climate mitigation and adaptation adopted by the i^{th} farmer.

n_j = Level of sustainable land management adopted for the jth farm operation.

N = Total number of sustainable land management practices adopted for all farm operations

However, farmers' decision options were categorized based on the level of sustainable land management practices adopted, derived as:

$$D_i = \begin{cases} 0, & L_i < 0.5 \\ 1, & L_i \geq 0.5 \end{cases} \qquad (2)$$

In this case, $L_i < 0.50 \rightarrow 0$, is an indication that farmers in this category are mitigating and adapting to climate change by adopting unsustainable practices, while $L_i \geq 0.50 \rightarrow 1$, is an indication that farmers in this category are mitigating and adapting to climate change using sustainable land management practices. The socioeconomic and institutional determinants of sustainable land-based decision options for climate change mitigation and adaptation among maize farmers were analyzed using the Tobit Model. The censored adoption decision options as derived in equation (2) was used as a dependent variable (In this case, $D_i \rightarrow 0$, is an indication that farmers in this category are mitigating and adapting to climate change by adopting unsustainable practices, while $D_i \rightarrow 1$ is an indication that farmers in this category are mitigating and adapting to climate change using sustainable land management practices). Tobit or censored normal regression model assumes that the observed dependent variables for observations j = 1…, n satisfy:

$$\boldsymbol{Y_j = \max(Y_j^*, 0)} \qquad \mathbf{(3)}$$

Where,

$$\boldsymbol{Y_j^* = \beta' X_j + U_j} \qquad \mathbf{(4)}$$

and,

$$\boldsymbol{Y_j = \begin{cases} Y_j^* \ if \ Y_j^* > 0 \\ 0 \ if \ Y_j^* \leq 0 \end{cases}} \qquad \mathbf{(5)}$$

Where,

Y_j = Observed variables

Y_j^* = Latent variables representing the land-based decision options (In this case, $D_i \rightarrow 0$, is an indication that farmers in this category are mitigating and adapting to climate change by adopting unsustainable practices, while $D_i \rightarrow 1$, is an indication that farmers in this category are mitigating and adapting to climate change using sustainable land management practices)

β' = Vector of parameters

X_j = Vector of independent variables

Where,

X_1 = level of education (years)

X_2= Household size (number)

X_3 = Farm location (Dummy variable 1 = near river/stream/lake; otherwise = 0)

X_4 = Number of Extension contact (number)

X_5 = Farm Size (hectares)

X_6 = Land tenure type (1 = inherited or purchased; otherwise = 0)

X_7 = Age (years)

X_8 = High labour requirement (Dummy variable 1=yes; otherwise = 0)
X_9 = years of farming experience (years)
X_{10} = Membership in farmers' organization (dummy variable 1= yes; otherwise = 0)
X_{11} = Gender (dummy variable 1 = male, otherwise = 0)
X_{12} = Knowledge of SLM (dummy variable 1 =yes; otherwise = 0)
X_{13} = level of income (naira)
U_j = error term

2.3 Test of Hypothesis

2.3.1 Hypothesis:

The null hypothesis that socioeconomic and institutional factors have no influence on the sustainable land management decision options among maize farmers of the World Bank intervention projects in the area was realized from the results of equation (5) using the chi-square statistics. The null is stated as:

$$Ho: \gamma = \delta = \theta \qquad (6)$$

The alternate hypothesis is stated as:

$$H_1: \gamma \neq \delta \neq \theta \qquad (7)$$

3. RESULTS AND DISCUSSION

3.1 Socioeconomic characteristics of maize farmers of World Bank intervention projects in the study area

Table 1 highlights the socioeconomic characteristics of maize farmers participating in World Bank intervention projects. The average age of the farmers is 49 years, indicating that younger, more venturesome individuals dominate maize farming, aligning with research by Nnadi and Akwiwu (2005). A significant 56.85% of the farmers have completed secondary education, a key factor in adopting sustainable land management practices for climate change mitigation, as suggested by Assoumana et al. (2016).

The majority of respondents (91.93%) are married, which implies higher production pressure, access to family labor, and more resources like land, as noted by Onubuogu et al. (2013). Household size averages 19 people, facilitating the labor needed for climate change mitigation and adaptation. Farmers have a mean farming experience of 38 years, enhancing their technical know-how. Male farmers and those with access to credit (90%) are major beneficiaries, with credit being crucial for investment in land-based climate change practices.

Most respondents (73.70%) had contact with extension workers, improving their awareness of climate change adaptation. Additionally, 71.30% of farmers inherited their land, which increases their likelihood of adopting sustainable practices. The mean annual income is N592,407.90k, allowing for investment in land-based mitigation practices, while the average farm size is 2.37 hectares, influencing adaptation decisions. Lastly, 70.56% of farms are not near water bodies, affecting farmers' conservation decisions, consistent with Willy and Holm-Muller's (2013) findings.

Table 1: Distribution of farmers by socioeconomic characteristics

	Variables	Frequency	% Distribution	Mean
	Age (years)			**49**
a)	18 – 28	7	1.30	
b)	29– 39	28	5.19	
c)	40– 50	320	59.26	
d)	51– 61	136	25.19	
e)	62 – 72	49	9.07	
	Education			
a)	No formal education	42	7.78	
b)	Primary	171	31.67	
c)	Secondary	307	56.85	
d)	Tertiary	20	3.70	
	Marital Status			
a)	Single	49	9.07	
b)	Married	491	90.93	
	Household Size			19
a)	0 – 10	60	11.11	
b)	11 – 20	288	53.33	
c)	21 – 30	152	28.15	
d)	31 – 40	40	7.41	
	Farming Experience			38
a)	0 – 10	8	1.48	
b)	11 – 20	42	7.78	
c)	21 – 30	65	12.04	
d)	31 – 40	125	23.15	
e)	41 – 50	300	55.56	
	Gender			
a)	Male	393	72.78	
b)	Female	147	27.22	
	Cooperative Membership			
a)	Yes	419	77.59	
b)	No	121	22.41	
	Credit Access			
a)	Yes	54	10.00	
b)	No	486	90.00	
	Extension Contact			
a)	Contact	398	73.70	
b)	No Contact	142	26.30	
	Mode of Land Acquisition			
a)	Inherited	385	71.30	

b)	Purchased	89	16.48	
c)	Rented	39	7.22	
d)	Communal land	27	5.00	
	Annual Income (Naira)			592,407.9
a)	0 – 100,000	2	0.37	
b)	100,001– 200,000	8	1.48	
c)	200,001– 300,000	3	0.56	
d)	300,001– 400,000	18	3.33	
e)	400,001 – 500,000	39	7.22	
f)	500,001 – 600,000	301	55.74	
g)	600,001 – 700,000	82	15.19	
h)	700,001 – 800,000	37	6.85	
i)	800,001 – 900,000	1	0.19	
j)	900,001 and above	49	9.07	
	Farm Size (Hectares)			2.37
a)	0 – 1	90	16.67	
b)	1.1 – 2	72	13.33	
c)	2.1 – 3	310	57.41	
d)	3.1 – 4	20	3.70	
e)	4.1 – 5	48	8.89	
	Nearness to river/stream/lake			
a)	Yes	159	29.44	
b)	No	381	70.56	

Source: Field Survey data, 2022

3.2 Level of climate change perception, land-based mitigation and adaptation among maize farmers of World Bank intervention projects in the area

The results from Table 2 reveal high levels of climate change awareness among maize farmers, with 99.44% recognizing climate shifts and 99.26% observing changing weather patterns. A substantial 94.07% are familiar with climate change, while 98.52% are aware of specific farmland practices that aid in mitigation and adaptation. This widespread awareness highlights the farmers general understanding of climate dynamics.

Regarding climate change perception, the primary concerns are soil degradation (93.15%), cessation of rainfall before crop maturity (90.37%), and high temperatures (80.56%). These reflect direct impacts on agricultural productivity. Other notable perceptions include poor yields due to crop failure (76.67%), inconsistent rainfall (75.56%), and frequent hot weather (74.26%). These insights indicate that farmers perceive various risks related to climate variability and its adverse effects on maize farming. Eyshi Rezaei, Webber, Gaiser, Naab, and Ewert (2015) reported that high temperatures experienced during flowering and/or grain filling phases can have large negative impacts on cereal grain yields. Interestingly, only a small percentage of farmers recognize certain impacts like low temperatures (4.26%) and reduced river levels (7.96%), which suggests that these are either less common or less impactful in their experience. Meanwhile, issues such as pollution and high rainfall also have lower recognition, pointing to their relatively minor perceived impact on maize farming compared to other climate-related challenges.

In conclusion, farmers in this study are highly aware of climate change and perceive its effects, particularly on soil health, temperature, and rainfall patterns, which directly affect their farming practices and yields. This awareness is crucial as it may influence their openness to adopting land-based mitigation and adaptation strategies.

3.3 Identify and categorize maize farmers based on land-based practices for climate change mitigation and adaptation in the area

Table 3 shows the multiple responses and percentage distribution of maize farmers participating in World Bank intervention projects by land-based decision options for climate change mitigation and adaptation. Results showed that the majority of the respondents adopted minimum tillage (56.48%), mulching (89.44%), soil/stone bunds (74.81%), use of organic manure (93.70%), crop residue/green grass incorporation (76.30%), intercropping with nitrogen-fixing crops (55.74%), and early maturing maize (94.07%) for climate change land-based mitigation and adaptation. This implies that farmers participating in World Bank intervention projects mostly adopt minimum tillage, mulching, soil/stone bunds, use of organic manure, crop residue/green grass incorporation, intercropping with nitrogen-fixing crops, and early maturing maize for climate change land-based mitigation and adaptation.

Table 2: Farmers' level of climate change awareness and perception

Climate Change Awareness	**Frequency**	**%**	**Ranking**
Aware of the changes in climate	537	99.44**	1
Pattern of weather generally changing	536	99.26**	2
Aware of practices on farmland that help in mitigating and adapting to climate change	532	98.52**	3
Knows about climate change	508	94.07**	4
Climate Change Perception			
Intensify soil degradation	503	93.15**	1
Cessations of rainfall before crop life cycle.	488	90.37**	2
Mostly high temperature	435	80.56**	3
Poor yield and crop failure	414	76.67**	4
Inconsistency in rainfall/shortage of rainfall	408	75.56**	5
Mostly hot weather	401	74.26**	6
Drought	381	70.56**	7
High wind velocity	378	70.00**	8
Soil erosion	352	65.19**	9
Flooding	147	27.22	10
Pollution of rivers/streams	87	16.11	11
Mostly high rainfall	74	13.70	12
Pest incidence	53	9.81	13
Weed incidence	48	8.89	14
Reduced river level	43	7.96	15
Mostly low temperature	23	4.26	16
Number of Observation	**540**		

Source: Field Survey data, 2022 **major perception and Awareness

Farmers were further categorized based on their land-based decision options as shown in Table 3. Results showed that the adoption decisions of the majority (60.56%) were classified as unsustainable land-based options, while the adoption decisions of the remaining 39.44% were classified as sustainable land-based options. This implies that most farmers participating in World Bank intervention projects adopted unsustainable land-based practices for climate change mitigation and adaptation. This could be linked to the need to improve soil fertility and suppress weeds using inorganic fertilizer and herbicides. This decision option increases agricultural emissions and hence contributes to climate change. According to Mengistu *et al*. (2015), integrating sustainable land management practices such as minimum tillage, mulching, soil/stone bunds, use of organic manure, nitrogen-fixing crops, etc., into the broader farm management system is important for smallholding farmers to ensure the long-term productivity potential of the farmland, as reported by Nedessa *et al*. (2015). According to Khanal, Clevo, Boon, and Viet-Ngu (2018), sustainable land management practices contribute to enhanced productivity and efficiency, as well as carbon sequestration.

Table 3: Distribution of farmers by land-based decision options for climate change

Land-Based Category	Sustainable Land Management	Freq.	% Distribution
Minimum Soil Disturbance	Minimum tillage	305	56.48**
	Mulching	483	89.44**
Soil Erosion Control	Terraces	162	30.00
	Soil/stone bunds	404	74.81**
Soil fertility management	Use of organic manure	506	93.70**
	Crop residue/green grass incorporation	412	76.30**
	Cover crops	198	36.67
	Crop rotation with nitrogen-fixing crops	5	0.93
	Intercropping with nitrogen-fixing crops	301	55.74**
Crop Variety Options	Drought-tolerant	10	1.85
	Flood-tolerant	0	0.00
	Early maturing maize	508	94.07**
Decision Options for Climate Change Mitigation and Adaptation			
Sustainable Land-based Option		213	39.44 ($LMI_i \geq 0.5$)
Unsustainable Land-based Option		327	60.56 ($LMI_i < 0.5$)
Total		**540**	**100.00**

**Major Practices (multiple response, ≥ 50%), LMI (Land Management Index for the ith farmer)

Source: Field Survey data, 2022

3.4 Determinants of Sustainable Land-based Decision

Table 4 presents the Tobit regression results, highlighting the socioeconomic and institutional determinants influencing maize farmers' sustainable land management decisions for climate change mitigation and adaptation in World Bank intervention projects. The model has a high pseudo-R-squared of 0.8766, indicating that it explains a substantial portion of the variance in the dependent variable. Additionally, the LR Chi-square value of 276.88 is highly significant, confirming the model's overall goodness of fit. While a pseudo-R-squared of 87.66% suggests that the explanatory variables account for a significant portion of the variation in adoption decisions for sustainable land management practices. As shown in Table 4, a 1% increase in a farmer’s level of education, household size, proximity to rivers or streams, and land acquired by inheritance is likely to increase sustainable land-based decision-making for climate change mitigation and adaptation by 0.0057%, 0.0075%, 0.057%, and 0.094%, respectively.

Conversely, a 1% increase in extension contacts, labour requirements, farming experience, cooperative membership, and income level is likely to decrease sustainable decision-making by 0.0151%, 0.271%, 0.0049%, 0.148%, and 0.00000012% (1.2e-07), respectively. These results suggest that education, household size, and access to water sources positively influence sustainable land management decisions, while labour intensity, cooperative membership, and reliance on extension services may present barriers to adopting sustainable practices

The observed decrease in sustainable land-based decision-making due to the increase in the number of extension contacts and membership of cooperatives could be linked to the knowledge of herbicide use in weed control and inorganic fertilizer use and awareness created by extension agents and gained from farmer's associations and/or organizations, which increases the adoption of unsustainable land-based decision-making for climate change mitigation and adaptation in the area. This is in line with the findings of Gebreegziabher and Mezgebo (2020), who affirmed that the frequency of extension workers' contact with farmers has a positive influence on the use of herbicide and inorganic fertilizer.

The decrease in sustainable land-based decision-making due to labour requirements could also be linked to the drudgery and high labour costs associated with sustainable land management, such as manual weeding and the lack of agrochemical use in sustainable land management for climate change mitigation and adaptation. Agrochemicals increase greenhouse gas emissions and contribute to climate change, as reported by the United Nations Environment Programme (2016).

The decrease in sustainable land-based decision-making for climate change mitigation and adaptation due to an increase in years of experience in farming could result from farmers' experience in agrochemical use and the corresponding increase in soil fertility and farm output, as well as the drudgery associated with sustainable land-based practices. Additionally, an increase in farm income increases farmers' likelihood to afford these agrochemicals and hence decreases the sustainable land-based decision-making for climate change mitigation and adaptation. Eririogu, Mevayekuku, Echebiri, Atama, Amanze, and Olumba (2019) also confirmed that an increase in farm income empowers farmers to adapt unsustainable labour-saving practices such as the use of agrochemicals (herbicides, inorganic fertilizers, and insecticides).

Table 4: Results of the socio-economic and institutional determinants of sustainable land-based decision options for climate change mitigation and adaptation among maize farmers of the World Bank projects

Variables	Coefficients	t-values	SE
Education	0.0057**	2.30	0.00248
Household Size	0.0075***	4.34	0.00173
Farm Location	0.0574**	2.13	0.0269
Number of extension visits	-0.0151**	-2.50	-0.00604
Farm Size	0.0177	1.29	0.0137
Land acquisition	0.0942**	2.18	0.0432
Age	0.00096	0.74	0.00130
Labour requirement	-0.271*	-1.82	-0.149
Years of Experience in farming	-0.0049***	-3.95	-0.00124
Membership of cooperative Association	-0.1476***	-3.92	-0.0377
Gender	-.0175	-0.33	-0.0530
Knowledge of Sustainable Land Management	-0.0092	-0.09	-0.102
Income Level	-1.21e-07***	-8.43	-1.43534994e-8
Constant	0.917***	4.75	0.193
Number of Observations	426		
LR Chi-square	276.88***		
Log Likelihood	-19.497		
Pseudo R-Square	0.8766		

***p<0.01, **p<0.05 and *p<0.10

Source: Field Survey data, 2022.

4.0 Conclusion and Recommendations

This study reveals several key conclusions about the factors influencing sustainable practices among maize farmers in the region. The typical farmer involved in the intervention is around 49 years old, predominantly male, married, and educated to a secondary school level. With extensive farming experience averaging 38 years and large household sizes, most farmers possess inherited land and have access to credit, cooperative networks, and extension services, all of which shape their farming practices and adaptation responses to climate change.

The findings indicate a high level of climate change awareness, as 99.44% of farmers recognize shifts in climate patterns and have experienced extreme weather events such as droughts, heat waves, soil erosion, and irregular rainfall. These experiences align with their reports of reduced crop yields and soil degradation, underscoring the urgency for adaptive measures. Many farmers adopt sustainable practices, including mulching, minimum tillage, organic manure use, intercropping with nitrogen-fixing crops, and planting early-maturing maize varieties.

However, the study also highlights that 60.56% of farmers favour unsustainable land management methods. This preference is often due to the labour-intensive nature and higher costs associated with sustainable practices, driving them to rely on agrochemicals for pest and weed control, which are perceived as more accessible and easier to use. Education, household size, proximity to water sources, and land inheritance positively influence sustainable practice adoption, while frequent extension visits, cooperative membership, and higher income correlate with less sustainable practices. These findings suggest that extension workers and cooperatives may unintentionally promote agrochemical use over sustainable alternatives, indicating a need for more targeted training and awareness programs to encourage sustainable practices among maize farmers.

Based on findings from the study, the following recommendations are made to enhance sustainable land management practices for climate change mitigation and adaptation among maize farmers involved in World Bank intervention projects in Northwest Nigeria:

1) The government should incentivize sustainable land management by offering financial support, such as subsidies for sustainable inputs like organic manure, cover crops, and mulching materials. Establish grants or low-interest loans to assist low-income farmers in adopting these practices.
2) Extension services should prioritize education on sustainable practices, including organic fertilizers and integrated pest management, instead of chemical inputs. This shift can encourage farmers to adopt environmentally friendly methods.
3) To make sustainable practices more accessible, especially for older farmers, the government should introduce labor-saving technologies like mechanical weeders and no-till farming equipment. These tools can reduce both the physical demands and costs associated with sustainable farming.
4) The government should support and re-orient farmer networks and cooperatives towards sustainable land management and climate-smart agriculture. These groups can facilitate knowledge sharing, bulk purchasing of sustainable inputs, and support for farmers transitioning to more sustainable methods.
5) Establish credit facilities specifically designed for sustainable farming practices, providing lower interest rates or grants for farmers committed to climate-smart agriculture. This financial support can help farmers adopt sustainable methods more readily.
6) Collaborate with agricultural research institutes to develop and distribute early-maturing and drought-resistant maize varieties. Government should ensure these resilient crops are easily accessible to farmers.
7) Government should implement awareness programs that highlight the long-term benefits of sustainable land management for climate resilience. Tailor these programs to farmers with varying educational backgrounds to make sustainability concepts accessible and practical for all.

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