CONSTRAINTS ON ADOPTING SUSTAINABLE LAND MANAGEMENT FOR CLIMATE CHANGE MITIGATION AMONG MAIZE FARMERS IN WORLD BANK PROJECTS, NORTHWEST NIGERIA.

Echebiri, Raphael. N. and Atama, Alexander. A.
Corresponding author's email: abiscolisco@gmail.com

ABSTRACT

The study examined factors constraining the adoption of sustainable land management (SLM) practices for climate change mitigation and adaptation among maize farmers involved in World Bank projects in Northwest Nigeria. Data was collected through structured questionnaires administered to 540 maize farmers. The analysis, using descriptive statistics and Principal Component Analysis, revealed that the average farmer was 49 years old, mostly male, and had secondary education. Most had substantial farming experience (38 years), a household size of 19, and an annual income of N592,407.90. Findings indicated that most farmers were part of cooperatives, had access to credit, and maintained contact with extension workers. They primarily practiced on inherited land with an average farm size of 2.37 hectares, typically far from water sources. Almost all farmers (99.44%) were aware of climate change, recognizing issues like poor yield, soil degradation, erratic rainfall, and high temperatures. Common SLM practices adopted included minimum tillage, mulching, soil bunds, organic manure use, intercropping, and early maturing maize. Constraints to SLM adoption were identified as limited input availability, high labour demands, tedious processes, and inconsistent government support. The study recommends that stakeholders, including the World Bank, should enhance technical support, provide SLM training, and develop labour-saving tools to facilitate SLM adoption, reducing associated costs and effort.

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

INTRODUCTION

Climate change, a naturally occurring phenomenon affected by anthropogenic greenhouse gas emissions (Getz, Gilmer, Cassidy and Byers, 2018), is the most uttered environmental term of the present time (Rahman, 2013). Changes in rainfall amounts and patterns and an increase in temperature, seriously threaten agricultural productivity and food security (Gebrehiwot and van der Veen, 2013). Food crop such as maize is affected by climate-related factors such as temperature, humidity, and atmospheric CO_2 concentration. Shorter growing cycles due to high temperatures negatively affect grain filling and thus productivity because of the reduced time for biomass accumulation and yield formation (Ciscar *et al.,* 2018, Olesen, 2016). As a result of the effects of climate change on crop production, stakeholders in land management and climate change recommended sustainable land management practices that mitigate or help farmers to adapt to changing climate.

Sustainable land management (SLM) is simply about people looking after the land – for the present and the future. SLM practices maintain and improve a balanced SOM–nutrient cycle, eliminate net losses, and improve soil fertility (Liniger *et al*., 2011). SLM is the stewardship and use of land resources, including soils, water, animals and plants, to meet changing human needs while simultaneously assuring these resources' long-term productive potential and maintaining their environmental functions (Altieri and Nicholls, 2017). Practices such as cover cropping and minimum tillage help suppress weed growth (Price and Norsworthy, 2013) without contributing to greenhouse gas emissions through herbicides. In cereals 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. and Paraiso, 2014). Farmers practice tree planting, cultivation of early-maturing maize, mixed farming and use of improved maize varieties as adaptations to climate change (Anyola, Nnadi, Chikaire, Echetama, Utazi, and Iheanacho, 2013).

Unfortunately, SLM practices are developed and implemented without considering farmers' indigenous knowledge (Snyder, Ludi, Cullen, Tucker, Zeleke and Duncan, 2014) or farmers' needs and aspirations (Mulema *et al.*, 2017). This leads to a lack of ownership and maintenance of SLM practices. Knowledge of sustainable land management implies more than an understanding of SLM practices alone. This also involves knowing how to implement such practices and the related benefits to farmers when implemented in the field (Meijer, Catacutan, Ajayi, Sileshi and Nieuwenhuis, 2015). Poor coordination and integration are also constraints, and this stems from the 'disciplinary' approach followed by SLM implementers, whereas, the implementation and scaling-up of SLM requires a more interdisciplinary and integrated approach (Gete, Menale, Pender and Mahmud, 2006). The coordination between the government agencies for natural resource management does not exist. This makes it difficult to integrate different sources of knowledge and exchange information on the scaling up of SLM practices (Snyder *et al.*, 2014, Getenet and Tefera, 2017). Lack of coordination hinders the sharing of responsibilities, which in turn, causes duplication of efforts and conflicting approaches when implementing and scaling up SLM practices (Nedessa, Seyoum and Gebrehawariat, 2015).

Most natural resource conservation planning and implementation policies follow a top-bottom approach (Ariti, van-Vliet and Verburg, 2018). Regular communication between key stakeholders and common learning activities are important in sharing knowledge and building capacity to effectively implement and scale up sustainable land management (Carter and Currie-Alder, 2006), and social networks at the local level are crucial in sharing information between farmers and transfer knowledge on sustainable land management practices (Tukahirwa, Mowo, Tanui, Kamugisha and Masuki, 2013).

According to Abi, Kessler, Oosterveer and Tolossa (2018), farmers who spontaneously implement stone bunds on their farmlands learn this mainly from their neighbouring farmers (through their social networks). Limited capacity, in terms of skills, workforce, budget, equipment and facilities, of extension workers and officials to transfer knowledge on sustainable land management, on the other hand, is another constraining factor (Leta, Kelboro, Stellmacher, Assche and Hornidgem, 2018).

Farmers' investments in SLM practices remain limited, and SLM efforts have only been partially successful (Adimassu *et al.*, 2016). Many sustainable land management practices are not widely adopted due to insecure land tenure, lack of access to resources and agricultural advisory services, insufficient and unequal private and public incentives, and lack of knowledge and practical experience (IPCC, 2014); farmland size, social capital, access to information and sources of income (Abebe and Sewnet, 2014); nearness of farmland to a river/lake/stream (Lokonon and Mbaye, 2018) and other socioeconomic factors such as age, education and extension contact (Ebojei, Ayinde and Akogwu, 2012), lack of credit and climate change forecasting information (Oyerinde and Osanyande, 2010). As a result of these limiting factors, the World Bank, USAID, Food and Agriculture Organization, ICRISAT (International Crops Research Institute for the Semi-Arid Tropics) and other donor agencies have provided support and agricultural intervention projects that will scale up the adoption of sustainable land management practices, especially in the Northwest, Nigeria. Therefore, this study assesses the factors constraining the adoption of sustainable land management practices for climate change mitigation and adaptation among maize farmers of the World Bank intervention projects in the Northwest, Nigeria. The specific objectives were to;

i. examine the socioeconomic characteristics of maize farmers of World Bank intervention projects in Northwest, Nigeria;
ii. examine climate change perception and sustainable land management practices for climate change mitigation and adaptation among maize farmers in the area;
iii. ascertain the factors constraining the adoption 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

Northwest is one of the six geopolitical zones, comprising seven (7) states, namely, Kaduna, Katsina, Sokoto, Zamfara, Kano, Jigawa and Kebbi States (NARSP, 1997). The North-west zone lies between latitudes 2^0 and 14^0 N and longitudes 07^0 and 60^0 south of the Greenwich meridian. The zone covers an area of 216,065 sq km or 25.75 percent of the country's total land mass, and its major ethnic groups are the Hausa and Fulani, who historically share strong ties and are very much intermixed. The projected population of the zone was about 41.8 million representing 25.56% of the total national population in 2014. Most of the population (about 80 percent) are farmers, pastoralists, agro-pastoralists or small-scale entrepreneurs. The zone is characterized by rainfall variability, especially late onset and early cessation of rains, often resulting in a shorter growing season. This, in turn, leads to the death of seedlings, low yields or even crop failure. The mean annual rainfall ranges from 500mm to nearly 1200mm. The mean annual temperature ranges between 17^0 and 38^0C, although high temperatures of up to 42^0 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). The North-west zone has gained several agricultural intervention projects from World Bank and other donor agencies, such as FAO, USAID, etc, The intervention agricultural projects include, CADP (Commercial Agricultural Development Project), Fadama, MARKETS II (maximizing Agricultural Revenue and Key Enterprises in Targeted Sites II), Funtua, Community Based Agriculture and Rural Development project (CBARDP) and the current APPEALS (Agro-Processing, Productivity Enhancement and Livelihood Improvement Support) of World Bank, on various staple crops including maize. These projects promoted Draught Tolerant Maize (DTM) in the traditionally non-maize growing areas (Lukas, 2013).

2.2 Analytical Techniques

The study was carried out using a well-structured questionnaire, administered to maize farmers of World Bank intervention projects**.** Multi-stage and purposive sampling techniques were employed, and five hundred and forty (540) maize farmers were randomly selected. The data collected were analyzed using descriptive statistical tools (such as percentages and mean) and Principal Component Analysis (PCA) techniques.

The PCA identified the important factors constraining the adoption of sustainable land management practices for climate change mitigation and adaptation among maize farmers. The model is stated as:

$$
\begin{aligned}
Y_1 &= a_{11}X_1 + a_{l22}X_2 + \ldots + a_{1n}X_n \\
Y_2 &= a_{21}X_1 + a_{l22}X_2 + \ldots + a_{2n}X_n \qquad (1) \\
Y_3 &= a_{31}X_1 + a_{l32}X_2 + \ldots + a_{3n}X_n \\
Y_n &= a_{n1}X_1 + a_{n2}X_2 + \ldots + a_{nn}X_n
\end{aligned}
$$

Where,

$Y_1, Y_2, \ldots, Y_n$ = observed factors among the maize farmers; $a_l - a_n$ = factor loading or correlation coefficients. $X_1, X_2 \ldots, Xn$ = unobserved factors constraining the sustainable land management practices.

3. RESULTS AND DISCUSSION

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

The study explores the socioeconomic characteristics of maize farmers involved in World Bank intervention projects in Northwest Nigeria, focusing on their ability to adopt sustainable land management (SLM) practices for climate change mitigation and adaptation. Table 1 reveals key statistics: the average farmer is 49 years old, indicating a predominance of younger farmers under 50, which aligns with findings by Nnadi and Akwiwu (2005) that associate youth with resilience and adaptability. Most respondents (56.85%) have secondary education, which enhances their likelihood of adopting SLM practices, corroborating findings by Assoumana, Boubaca, Ndiaye, Puje, Diourte and Graiser (2016).

The majority (91.93%) are married, which potentially increases production pressure due to family demands, as noted by Opara (2010). The mean household size is 19, suggesting a substantial family labor force available for farming and SLM practices. With an average of 38 years of farming experience, these farmers possess valuable expertise, as noted by Silvestri, Bryan, Ringler, Herrero, Okoba (2012), which supports their adaptability to climate challenges. Male farmers predominantly benefit from the World Bank projects, with gender playing a crucial role in climate change adaptation, as reported by Okonya, Syndikus, and Kroschel (2013). Most farmers (90%) have access to credit, which is vital for investment in SLM, a sentiment echoed by Willy and Holm-Müller (2013). Additionally, 73.70% of respondents regularly interact with extension workers, which enhances their climate awareness and adaptive decisions. Land inheritance is common (71.30%), influencing a stronger commitment to sustainable practices. The average annual income is N592,407.90, supporting the financial capacity for SLM. The mean farm size is 2.37 hectares, with larger landholdings associated with increased conservation efforts, as supported by Nhemachena and Hassan (2007). Lastly, most farms are not located near water bodies, which may influence decisions on soil conservation strategies, aligning with findings by Willy and Holm-Muller (2013).

3.2 Climate change perception and SLM practices

Table 2 shows the multiple response and percentage distribution of farmers by climate change awareness, perception, and sustainable land management practices for climate change mitigation and adaptation. Results indicated that a vast majority of respondents were aware of climate change (99.44%) and shifting weather patterns (99.26%). Most also perceived various climate-related challenges, including poor yield and crop failure (76.67%), soil degradation (93.15%), inconsistent rainfall (75.56%), rainfall cessation before the crop lifecycle completes (90.37%), hot weather (74.26%), soil erosion (65.19%), high wind velocity (70.00%), drought (70.56%), and high temperatures (80.56%). These findings suggest that maize farmers benefiting from World Bank intervention projects are not only aware of climate change and its effects but also perceive significant risks, such as soil degradation, inconsistent rainfall, and extreme weather conditions. Eyshi Rezaei, Webber, Gaiser, Naab and Ewert (2015) noted that high temperatures during critical phases like flowering and grain filling can severely impact cereal grain yields.

Table 1: Distribution of farmers by socioeconomic characteristics

	Variables	Frequency	% Distribution	Mean
	Age (years)			**49**
f)	18 – 28	7	1.30	
g)	29– 39	28	5.19	
h)	40– 50	320	59.26	
i)	51– 61	136	25.19	
j)	62 – 72	49	9.07	
	Education			
e)	No formal education	42	7.78	
f)	Primary	171	31.67	
g)	Secondary	307	56.85	
h)	Tertiary	20	3.70	
	Marital Status			
c)	Single	49	9.07	
d)	Married	491	90.93	
	Household Size			19
e)	0 – 10	60	11.11	
f)	11 – 20	288	53.33	
g)	21 – 30	152	28.15	
h)	31 – 40	40	7.41	
	Farming Experience			38
f)	0 – 10	8	1.48	
g)	11 – 20	42	7.78	
h)	21 – 30	65	12.04	
i)	31 – 40	125	23.15	
j)	41 – 50	300	55.56	
	Gender			
c)	Male	393	72.78	
d)	Female	147	27.22	
	Cooperative Membership			
c)	Yes	419	77.59	
d)	No	121	22.41	
	Credit Access			
c)	Yes	54	10.00	
d)	No	486	90.00	
	Extension Contact			
c)	Contact	398	73.70	
d)	No Contact	142	26.30	
	Mode of Land Acquisition			
e)	Inherited	385	71.30	
f)	Purchased	89	16.48	
g)	Rented	39	7.22	
h)	Communal land	27	5.00	

	Annual Income (Naira)			592,407.9
k)	0 – 100,000	2	0.37	
l)	100,001– 200,000	8	1.48	
m)	200,001– 300,000	3	0.56	
n)	300,001– 400,000	18	3.33	
o)	400,001 – 500,000	39	7.22	
p)	500,001 – 600,000	301	55.74	
q)	600,001 – 700,000	82	15.19	
r)	700,001 – 800,000	37	6.85	
s)	800,001 – 900,000	1	0.19	
t)	900,001 and above	49	9.07	
	Farm Size (Hectares)			2.37
f)	0 – 1	90	16.67	
g)	1.1 – 2	72	13.33	
h)	2.1 – 3	310	57.41	
i)	3.1 – 4	20	3.70	
j)	4.1 – 5	48	8.89	
	Nearness to river/stream/lake			
c)	Yes	159	29.44	
d)	No	381	70.56	

Source: Field Survey data, 2022

3.3 Sustainable Land Management Practices for Climate Change Mitigation and Adaptation Adopted by Maize Farmers

Table 3 presents the percentage distribution of maize farmers from World Bank intervention projects by their adoption of sustainable land management (SLM) practices for climate change mitigation and adaptation. The data reveals that the majority of farmers adopted various SLM techniques, including 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 varieties (94.07%). These practices improve soil fertility, nutrient cycling, and organic matter content, as Lal (2004) highlighted. A notable adoption of early maturing maize aligns with findings by Lobell *et al*. (2014), which emphasize the importance of climate-resilient crop varieties to mitigate climate risks. However, further classification of farmers' land management practices shows that 60.56% adopted unsustainable land-based management options, while 39.44% engaged in sustainable practices. The prevalence of unsustainable practices may be linked to the reliance on inorganic fertilizers and herbicides for soil fertility and weed control, potentially increasing agricultural emissions and contributing to climate change. The study underscores the importance of integrating sustainable practices, such as minimum tillage, mulching, and the use of nitrogen-fixing crops, into farm management. This integration enhances long-term productivity and resilience of farmlands, as noted by Mengistu *et al*. (2015).

Moreover, Khanal *et al*. (2018) emphasize that sustainable land management supports enhanced productivity, efficiency, and carbon sequestration. For smallholder farmers, adopting SLM practices is crucial to ensuring the long-term viability of their land while mitigating climate-related impacts.

Table 2: multiple response and percentage distribution of farmers by climate change perception, sustainable land management practices for climate change mitigation and adaptation

Climate Change Awareness	Frequency	% Distribution	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**		

**Major perception and Awareness

Source: Field Survey data, 2022

Table 3: Distribution of farmers of World Bank intervention projects by sustainable land management practices adopted for climate change mitigation and adaptation

Land-Based Category	Sustainable Land Management	*Frequency	% 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 cropping	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
	Early maturing maize	508	94.07**
Adoption Decisions 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**

3.4 Limitations to Adoption of Sustainable Land Management practices for Climate Change Mitigation and Adaptation among Maize Farmers

Table 4 presents the principal component loadings for various limiting factors influencing the adoption of Sustainable Land Management (SLM) practices among maize farmers of the World Bank Intervention Projects. Principal component analysis (PCA) is a statistical technique used to reduce the dimensionality of data and identify underlying patterns or factors. Table 4 also shows the results of Kaiser-Meyer-Olkin (KMO) sampling adequacy (0.537) and significant results of Barrett's test of sphericity ($p<0.01$). The results of KMO greater than 0.5 indicate that the sample size is suitable for assessing the factors limiting the adoption of sustainable land-based management decision options for climate change mitigation and adaptation among maize farmers. Barett's test of the null hypothesis that the correlation matrix was an identity matrix was significant at 1% ($p<0.01$), indicating a relationship between the variables.

Results also showed that the Principal Component (PC) contributed about 64.20% to the variation in the dataset. The dominant PC loading (≥ 0.3) showed that unavailability of the required inputs for SLM technology (0.3902), tedious nature of sustainable land management practices (0.4662), high labour requirement of sustainable land management practices (0.4696) and Poor/inconsistent government support (0.3867) were the factors limiting the adoption of sustainable land management practices for climate change mitigation and adaptation among maize farmers. The dominant positive loading for unavailability of the Required Inputs for SLM Technology (PC loading: 0.3902) indicates that the unavailability of necessary inputs is a significant limiting factor for adopting SLM practices. Farmers may face challenges in accessing seeds, equipment, or materials required for sustainable practices (Sumberg, Philip, William and Joanes (2012). In line with Acquah-de Graft and Onumah (2011), who also reported that insufficient access to inputs, lack of knowledge about other adaptation options, no access to water, lack of credit, lack of information about climate change, high cost of adaptation and insecure property rights are the main factors constraining climate change adaptation and mitigation. The tedious nature of SLM practices also has a strong positive loading, which indicates that the laborious and time-consuming nature of SLM practices is a significant barrier. Farmers may be deterred by practices that require extensive effort, especially if they do not see immediate benefits (Bolliger, Uta and Robert (2006). Moreover, the strong positive loading for high Labour requirement of SLM Practices indicated that the labour-intensive nature of SLM practices is a significant limitation. Farmers with limited labour resources may find it challenging to implement practices that demand a substantial workforce (Doss, Carmen, Gale, and Jennifer, 2003)

Table 4: factors limiting the adoption of sustainable land management practices for climate change mitigation and adaptation among maize farmers

Limiting Factors	PC loading
Unavailability of the required inputs for SLM technology	0.3902*
Lack of credit	0.2030
Low prices of output	0.2150
Tedious nature of SLM practices	0.4662*
Lengthy procedures	0.1153
Complex nature	0.1765
Irregularity of extension services	0.2116
Lack of SLM knowledge	0.1821
High labour requirement of SLM practices	0.4696*
Poor/inconsistent government support	0.3867*
Eigenvalue	**6.419**
% Variance	**64.20**
Kaiser-Meyer-Olkin (KMO) test	**0.537**
Number of observations	**540**

Barllet's test ($p<0.01$) significant at 1%; *Dominant PC loading(≥ 0.3)

Source: Field Survey data, 2022

CONCLUSION AND RECOMMENDATIONS

The study underscores the need for targeted interventions to alleviate these constraints, particularly by improving access to necessary resources and providing more consistent governmental support. Addressing these limitations could facilitate broader adoption of SLM practices, ultimately enhancing the resilience of maize farmers to climate change in Northwest Nigeria.

Based on the findings of this study and the policy implications, the following recommendations were made:

1) The government should establish mechanisms to ensure that essential inputs for sustainable land management practices, such as seeds, organic fertilizers, and tools, are more accessible and affordable for farmers.
2) The government should increase access to credit and subsidies to enable farmers to invest in sustainable practices without being constrained by high costs.
3) The government should enhance extension services to provide farmers with consistent guidance on implementing SLM practices. Support programs should also be made more reliable to build farmer confidence in SLM.
4) In collaboration with the World Bank, stakeholders in sustainable land management should develop and promote labour-saving technologies and practices that reduce the physical burden of SLM, making it more feasible for farmers with limited labour resources.
5) The World Bank, donor agencies, and the government should facilitate the creation of cooperatives or groups that allow farmers to pool resources and labor for SLM practices. This would enable collective adoption and potentially reduce individual costs.
6) The government should establish incentive programs to reward farmers who successfully implement and maintain sustainable practices. This could motivate others to adopt similar measures by showcasing the benefits and successes of SLM practices.
7) Donor agencies should promote knowledge sharing and collaboration between stakeholders, including farmers, scientists, policymakers, and technology developers, to encourage the dissemination of best practices and success stories related to sustainable land-based management practices.

REFERENCES

Abebe, Z. D., & Sewnet, M. A. (2014). Adoption of soil conservation practices in North Achefer District, Northwest Ethiopia. *Chinese Journal of Population Resources and Environment, 12,* 261-268.

Abi, M., Kessler, A., Oosterveer, P., & Tolossa, D. (2018). How farmers' characteristics influence the spontaneous spreading of stone bunds in the highlands of Ethiopia: a case study in the Girar Jarso woreda. *Environment, Development and Sustainability*. https://doi.org/10.1007/s10668-018-0203-2

Acquah-de Graft, H., & Onumah, E. (2011). Farmers' perceptions and adaptations to climate change: An estimation of willingness to pay. *Agris, 3*(4), 31-39.

Adimassu, Z., Langan, S., & Johnston, R. (2016). Understanding determinants of farmers' investments in sustainable land management practices in Ethiopia: Review and synthesis. *Environment, Development and Sustainability*, *18*, 1005-1023.

Altieri, M. A., & Nicholls, C. I. (2017). The adaptation and mitigation potential of traditional agriculture in a changing climate. *Climatic Change*, *140*(1), 33-45.

Anyola, N. O., Nnadi, F. N., Chikaire, J., Echetama, J. A., Utazi, C. O., & Iheanacho, R. A. (2013). Socio-economic factors influencing climate change adaptation among crop farmers in Umuahia South Area of Abia State, Nigeria. *Net Journal of Agricultural Science*, *1*(2), 42-47.

Ariti, A. T., van Vliet, J., & Verburg, P. H. (2018). Farmers' participation in the development of land use policies for the Central Rift Valley of Ethiopia. *Land Use Policy*, *71*, 129-137.

Assoumana, B. T., Ndiaye, M., Puje, G., Diourte, M., & Graiser, T. (2016). Comparative assessment of local farmers' perceptions of meteorological events and adaptation strategies: Two case studies in the Niger Republic. *Journal of Sustainable Development*, *9*(3), 118–135. https://doi.org/10.5539/jsd.v9n3p118

Bolliger, A., Uta, J. D., & Robert, F. (2006). Diffusion of sustainable agricultural practices in the Swiss Plateau: A spatial econometric analysis of factors influencing adoption. *Agricultural Economics*, *34*(3), 261-270.

Burney, J., Davis, S. J., & Lobell, D. B. (2014). Greenhouse gas mitigation by agricultural intensification. *Proceedings of the National Academy of Sciences*, *107*, 12052–12057. https://doi.org/10.1073/pnas.0914216107

Carter, S. E., & Currie-Alder, B. (2006). Scaling-up natural resource management: Insights from research in Latin America. *Development in Practice*, *16*, 128-140.

Ciscar, J. C., Ruiz, D. I., Ramirez, A. S., & Dosio, A. (2018). Climate impacts in Europe: Final report of the JRC PESETA III project. *JRC Science for Policy Report*. Luxembourg: Publications Office of the European Union. http://doi.org/10.2760/93257

Doss, C. R., Carmen, D. D., Gale, S., & Jennifer, K. (2003). Gender and the distribution of wealth in developing countries. *World Development*, *31*(3), 577-602.

Ebojei, C. O., Ayinde, T. E., & Akogwu, G. O. (2012). Socio-economic factors influencing adoption of hybrid maize production technologies in Giwa Local Government Area of Kaduna State, Nigeria. *The Journal of Agricultural Science*, *7*(130), 23-32.

Eyshi Rezaei, E., Webber, H., Gaiser, T., Naab, J., & Ewert, F. (2015). Heat stress in cereals: Mechanisms and modelling. *European Journal of Agronomy*, *64*, 98-113. https://doi.org/10.1016/j.eja.2014.10.003

Gebrehiwot, S. G., & Van Der Veen, A. (2013). Assessing the evidence of climate change impacts on agriculture in Ethiopia. *Journal of Agricultural Science*, *5*(10), 74-87.

Gete, Z., Menale, K., Pender, J., & Mahmud, Y. (2006). Stakeholder analysis for sustainable land management (SLM) in Ethiopia: Assessment of opportunities, strategic constraints, information needs, and knowledge gaps. *Second Draft*. Environmental Economics Policy Forum for Ethiopia (EEPFE), International Food Policy Research Institute, Ethiopia.

Getenet, B., & Tefera, B. (2017). Institutional analysis of environmental resource management in Lake Tana Sub-basin. In K. Stave, G. Goshu, & S. Aynalem (Eds.), *Social and ecological system dynamics: Characteristics, trends, and integration in the Lake Tana Basin, Ethiopia*. Cham: Springer International Publishing.

Getz, J., Gilmer, A., Cassidy, J., & Byers, W. (2018). The use of peat-based biochar as an additive to manure management systems to reduce greenhouse gas emissions. In C. Heidecke, H. Montgomery, H. Stalb, & L. Wollenerg (Eds.), *International Conference on Agricultural GHG Emissions and Food Security – Connecting research to policy and practice*. September 10-13, 2018, Berlin, Germany.

Intergovernmental Panel on Climate Change (IPCC). (2014). Climate change 2014 — Synthesis report. *Summary for policymakers*. Geneva, Switzerland: Intergovernmental Panel on Climate Change. http://www.ipcc.ch/pdf/assessment-report/ar5/syr/AR5_SYR_FINAL_SPM.pdf

Khanal, U., Clevo, W., Boon, L., & Viet-Ngu, H. (2018). Do climate change adaptation practices improve technical efficiency of smallholder farmers? Evidence from Nepal. *Climatic Change, 147*(3–4), 507–521.

Lal, R. (2004). Soil carbon sequestration to mitigate climate change. *Geoderma, 123*(1-2), 1-22.

Leta, G., Kelboro, G., Stellmacher, T., Van Assche, K., & Hornidge, A. K. (2018). Nikinake: The mobilization of labour and skill development in rural Ethiopia. *Natural Resources Forum, 42*, 93-107.

Liniger, H. P., Gurtner, M., Studer, R. M., & Hauert, C. (2011). Sustainable land management in practice - Guidelines and best practices for Sub-Saharan Africa. TerrAfrica, World Overview of Conservation Approaches and Technologies (WOCAT) and Food and Agriculture Organization of the United Nations (FAO), Rome, Italy: FAO.

Lokonon, B. O. K., & Mbaye, A. A. (2018). Climate change and adoption of sustainable land management practices in the Niger basin of Benin. *Natural Resources Forum, 42*, 42–53.

Lukas, A. (2013). Press release at the opening ceremony of the 8th World Bank Project Implementation Mission Kano State. Available from https://www.worldbank.org/en/news/press-release/2013/07/12/world-assisted-commercial-agriculture-development-project-disburse-over-n209-million-to-3000-farmers-in-kano-state.

Meijer, S. S., Catacutan, D., Ajayi, O. C., Sileshi, G. W., & Nieuwenhuis, M. (2015). The role of knowledge, attitudes and perceptions in the uptake of agricultural and agroforestry innovations among smallholder farmers in sub-Saharan Africa. *International Journal of Agricultural Sustainability, 13*, 40-54.

Mengistu, D., Bewket, W., & Lal, R. (2015). Conservation effects on soil quality and climate change adaptability of Ethiopian watersheds. *Land Degradation and Development*. https://doi.org/10.1002/ldr.2376

Mulema, A. A., Lema, Z., Damtew, E., Adie, A., Ogutu, Z., & Duncan, A. J. (2017). Stakeholders' perceptions of integrated rainwater management approaches in the Blue Nile Basin of the Ethiopian highlands. *Natural Resources Forum, 41*, 244-254.

National Agricultural Research Strategy Plan (NARSP). (1997). Nigerian National Agricultural Research Strategy Plan: 1996-2010. Bukar, S., Adamu, A., & Bakshi, J.S. (Eds.). Department of Agricultural Sciences, Federal Ministry of Agriculture and Natural Resources. Abuja, Nigeria: African Intec Printers.

Nedessa, B., Yirga, A., Seyoum, L., & Gebrehawariat, G. (Eds.). (2015). A guideline on documentation of sustainable land management best practices in Ethiopia. Ministry of Agriculture, Natural Resource Sector. Addis Ababa, Ethiopia: Ministry of Agriculture, Natural Resource Sector.

Nhemachena, C., & Hassan, R. (2007). Micro-level analysis of farmers' adaptations to climate change in Southern Africa. IFPRI, Environment and Production Technology Division. Washington, DC: International Food Policy Research Institute.

Nnadi, F. N., & Akwiwu, C. D. (2005). Rural women's response to selected crop production technologies in Imo State, Nigeria. *Global Approaches to Extension Practice Journal, 1*(1), 47-55.

Okonya, S. J., Syndikus, K., & Kroschel, J. (2013). Farmers' perception of and coping strategies to climate change: Evidence from six agroecological zones of Uganda. *Journal of Agricultural Science, 5*(8), 252-263. http://dx.doi.org/10.5539/jas.v5n8p252

Olesen, J. E. (2016). Socio-economic impacts — Agricultural systems. In North Sea region climate change assessment. Regional Climate Studies. Springer, Cham.

Opara, U. N. (2010). Personal and socio-economic determinants of agricultural information use by farmers in the Agricultural Development Programme (ADP) zones of Imo State, Nigeria. *Library Philosophy and Practice*, 32.

Oyerinde, O. V., & Osanyande, O. V. (2010). Farmers adaptation strategies and Idare forest resources, Ondo State, Nigeria. In Climate change and forest resources management: The way forward. A proceeding of the 2nd Biennial National Conference of the Forest and Forest Product Society, Federal University of Technology, Akure, Nigeria, 233-237.

Price, A. J., & Norsworthy, J. K. (2013). Cover crops for weed management in southern reduced-tillage vegetable cropping systems. *Weed Technology, 27*(1), 212–217.

Silvestri, S., Bryan, E., Ringler, C., Herrero, M., & Okoba, B. (2012). Climate change perception and adaptation of agro-pastoral communities in Kenya. *Regional Environmental Change, 12*(4), 791–802. https://doi.org/10.1007/s10113-012-0293-6

Snyder, K. A., Ludi, E., Cullen, B., Tucker, J., Zeleke, A. B., & Duncan, A. (2014). Participation and performance: Decentralised planning and implementation in Ethiopia. *Public Administration and Development, 34*, 83-95.

Sumberg, J., Wells, P., Minter, W., & Awo, J. (2012). The political economy of sustainable intensification. *IDS Bulletin*, *43*(6), 9-19.

Tukahirwa, J., Mowo, J., Tanui, J., Kamugisha, R., & Masuki, K. (2013). Scaling sustainable land management innovations: The African Highland Initiative devolution model. *African Crop Science Journal*, *21*, 705-722.

Willy, D. K., & Holm-Müller, K. (2013). Social influence and collective action effects on farm level soil conservation effort in rural Kenya. *Ecological Economics*, *90*(June), 94–103.

Yegbemey, R. N., Kabir, H., Awoye, H. R., Yabi, J. A., & Paraiso, A. A. (2014). Managing the agricultural calendar as coping mechanism to climate variability: A case study of maize farming in northern Benin, West Africa. *Climate Risk Management*, *3*, 13-23.