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Smart Agroforestry Management Practices for Smallholder Farmers: Enhancing Soil Fertility, Livelihood Sustainability and Climate Change Mitigation to Boost Farm Productivity in Northeast Nigeria

Dr. Longshal Wakili Markus

Department of Agricultural Education, School of Vocational And Technical Education, Federal Capital Territory College of Education, Zuba, P.M.B. 61 Garki, Abuja, Nigeria
Email: dayitniapyil@gmail.com

ABSTRACT

This paper identified Smart-Agro-Forestry (SAF) management practices required by small-holder farmers for soil fertility and livelihood sustainability and for mitigating the impact of climate change on farm productivity in North East Nigeria. Four research questions were raised for the study, while one null hypothesis was formulated to guide the study. The study employed a survey research design. The Population of the study was 440, out of which a sample of 204 was purposively obtained. The instrument used for the study was a 46 structured questionnaire titled '*Smart-Agro-forestry Management Practice Questionnaire (SAFMPQ).* The instrument was validated by three experts from the Federal College of Forestry, Jos. Weighted mean (X) and Requisite Mgnt Practice Index (RMPI) were used to answer the research questions, while the Cronbach Alpha Reliability test was used to determine the internal consistency of the instrument, which yielded a coefficient of 0.86, indicating that the instrument was highly reliable. Results showed that all 76 SAF management practices were required by small-holder farmers for soil fertility and livelihood sustainability, and for mitigating the impact of climate change on farm productivity in North East Nigeria. It was recommended that the management practices and skills identified in SAF systems should be packaged into training modules for a workshop training programme for farmers (foresters).

Key Words: Smart-Agroforestry, Climate Change, Soil Fertility, Livelihood

I. INTRODUCTION

During the Climate Change Summit of November 7th, 2024 (COP29 SUMMIT) held in Baku, Azerbaijan, the president of the summit, Muthar Babayev, and the Secretary of the United Nations Framework Convention on Climate Change (UNFCCC) on behalf of member countries, pledged a whooping sum of 300 Billion USD to poorer nations for combating and mitigating the effects of climate change within the poorer nations. This gesture is a testament to the fact that there is enough scientific evidence to conclude that climate change is happening and to link climate change with the observed changes in the Earth's physical systems.

Agriculture is one of the high-priority sectors where the impacts of climate change exceed tolerance limits, which has implications for the livelihoods of millions of smallholder farmers dependent on this sector (Food and Agriculture Organization (FAO), 2021). (Rao, Louis, and Jan, 2007; IPCC reports, 2021). explained that the major processes of agriculture that are directly influenced by climate change are soil water, carbon and nitrogen cycles, crop growth and development, and incidence of weeds, pests, and diseases which are manifested in terms of increased heat stress, increased evapotranspiration, shortened seasons and increase photosynthesis and reduced water use due to higher CO_2 in the atmosphere. The results of various assessments of the impacts of climate change on agricultural production (Neufeldt, (2013; Owombo, Idumah, and Ighodaro, (2014); Ekele and Sawuri, (2022); FAO, 2022) are generally in agreement and have identified the following as major challenges that agroforestry and agricultural systems will face from climate change:

i. An increase in crop water requirements to meet the increased evapotranspiration demands

ii. Increased degradation of land resources from erosion due to the projected increase in extreme events

iii. New management challenges such as dealing with changes in the new pest and disease complexes

iv. Competition for land by emerging initiatives like biofuel production, which may further lead to an increase in food prices with adverse impacts on accessibility by poor

v. Reduction in the amount of plant-available water in most places due to the predicted shortages in water supplies

vi. Spatial and temporal changes in the land available for agriculture, with tropical countries being more disadvantaged

vii. Increased cost of inputs due to steep increases in energy and other input costs, including taxation

viii. A northwards shift in the domain of crops due to the increase in average annual temperature in the northern hemisphere

ix. Decrease in biodiversity and extinction of some species

x. Erosion of communities' capacity to invest in agriculture due to losses from the increased frequency and intensity of extreme weather (drought, floods, thunderstorms, etc.) conditions

Because of their ability to provide economic and environmental benefits, agroforestry interventions are considered to be the best measures in making communities adapt and become resilient to the impacts of climate change. The important elements of agroforestry systems (AFS) that can play a significant role in mitigating and adapting to climate change impact include changes in the microclimate, protection through the provision of permanent cover, opportunities for diversification of the agricultural systems, improving the efficiency of use of soil, water, and climatic resources, contribution to soil fertility improvement, reducing carbon emissions and increasing sequestration, sustainability of small-holder farmers' livelihood and promoting gender equity (Apata,2024)

Agroforestry is a planting technique that combines long-lived tree crops with seasonal crops, livestock, or fisheries within or outside forest areas through spatial and temporal arrangements, either simultaneously or alternately. It is the purposeful integration of trees or shrubs with crops and/or livestock at the plot, farm, and/or landscape scale (F.A.O., 2021; United Nations (UN), 2021). Iyang, (2000) cited in Ekele and Suwari (2015) opined that Agro-forestry is a sustainable land management system that increases the yield of the land, combines the production of crops and forest plants and/or animals simultaneously or sequentially on the same unit of land, and applies management practices that are compatible with cultural practices of local population.

Agro-forestry is one potential climate change mitigation and adaptation strategy to increase the resilience of farmers and agricultural systems against climate risk, providing a range of biophysical and socioeconomic benefits. It is an alternative solution to address the challenges of sustainable forest management (Rao, Louis, & Jan, 2007; IPCC reports, 2022).

Smart Agro-forestry is the integration of economic trees with annual crop production F.A.O., 2022). Smart agroforestry systems could be used to mitigate or adapt to the impacts of climate change on agriculture F.A.O., 2013). Alao and Shuaibu (2013); Buttoud, Ajay, Detlefsen, Place, & Torquebiau (2013); Berihu, Ashenafi, Manaye, Yirga, Musse, Adefires, and Agena (2023) agree that increased water and heat stresses, increased evapotranspiration, and generally reduced average rainfall amounts accompanied by an increase in inter-annual variability would negatively impact on agricultural productivity, especially on tropical agrarian systems in general and on sub-Saharan Africa in particular, where many of the world's poorest countries are located. However, the United States Department of Agriculture (USDA) (2022) asserts that agroforestry remains the best option for mitigation and/or adapting to these negative impacts on farm productivity and the livelihoods of millions of smallholder farmers. USDA outlined the benefits of SAF to include:

i. Diversification of agricultural enterprises

ii. Reduce/spread the risks associated with sole cropping

iii. Complement different farm enterprises

iv. Reduce income variability by reducing risk,

v. Exploit new market opportunities and existing market niches

vi. Increase diversification in on-farm processing and other farm-based,

vii. Increase in farm-based income-generating activities

viii. Encourages multiple production activities that are complementary in economic and/or ecological dimensions involving crops, trees, livestock, and post-harvest processing.

ix. Integrated agroforestry systems are a suitable pathway for sustainable diversification of agricultural systems

x. Contribute significantly to food security by providing products year-round

xi. Contribution to food and nutrition of households

xii. Meeting the subsistence needs of households

xiii. Generating additional cash income for households

xiv. Expanding market opportunities for smallholders

xv. Provides Medicinal plants

xvi. Reduction in carbon emissions and sequestering carbon

xvii. Improve soil health

xviii. Discourage deforestation.

Anyoha, Chikaire and Atoma, (2018) outlined three major categories of agroforestry systems (AFS) namely: Agri silvicultural, Silvipastoral, and Agro silvipastoral systems. In the context of this study, Smart-Agroforestry (SAF) also known as Agri-silviculture is the practice of agroforestry with a set of good agriculture and silvicultural knowledge and practices that are aimed not only at improving environmental parameters, including climate change mitigation and adaptation, biodiversity enhancement, and soil and water conservation but also increasing profits, resilience for farmers, sustainable soil fertility and livelihoods.

Agroforestry management practices in the view of Ekele (2015); Rice, (2018); United Nations Framework Convention for Climate Change (UNFCCC), (2021) is the science, art, and practice of managing and using for human benefit the natural resources that occur on, and in association with forest lands. They further noted that it concerns acquiring, preserving, developing, and utilizing forests and forest-related values. It is instructive to note that the management of forests is limited because forests as biological resources may be controlled by extraneous factors beyond man's control. However, when management is effective, it produces good results. In their submissions, Ekele, (2015); and Cheikh, Pete, David, Lalisa, and Mercedes, (2014) outlined the challenges confronting smallholder farmers in agroforestry management practices including failure of extension services in poor African countries, insecurity, limited investment in agroforestry, inadequate knowledge of Agri-silviculture, inadequate finance and poor timing of their release, low resource base that cannot meet future demands for forest products, acute shortage of technicians and poor management techniques, inadequate skilled human resources, crop diversification, long rotation systems for soil conservation, etc. The authors remarked that, unlike the olden days, the current approach to forest management is based on sustainable management practices that balance the competing interests of land use to yield the greatest possible long-term benefits to society.

Small-holder farmer's also known as small-scale farmers, pastoralists, foresters, and fishers manage areas varying from less than one hectare to 10 hectares (FAO, 2022; Apata, 2024). They are producers who rear livestock, raise fish, or cultivate crops on a limited scale and usually have limited access to land, financial capital, farm inputs, high levels of vulnerability, and low market participation.

Livelihood refers to the job or other source of income that gives you the money to buy things you need (USDA, 2011). It relates to occupation, work, and employment. Livelihood is a means of earning money to live, it is a source or means of living (Oke, 2017). Livelihood is a means of supporting one's existence especially financially or vocationally. A person's livelihood refers to their means of securing the necessities of life, it embraces a person's capabilities, assets, and income (Oxford Learners' dictionaries, Cambridge dictionary, Collins Dictionary, Merriam-webster).

Agriculture is the major source of livelihood for the inhabitants of North-East Nigeria; thus, the need to identify SAF agroforestry management practices required by small-holder farmers for training and retraining farmers for sustainable soil fertility and livelihood as well as mitigating and adapting to climate change impacts on agriculture cannot be overemphasized.

Climate change encompasses all forms of climatic inconsistency regardless of their statistical nature or physical causes. Climate change refers to: (i) long-term changes in average weather conditions, (ii) all changes in the climate system, including the drivers of change, the changes themselves, and their effects, (iii) only human-induced changes in the climate system (World Meteorological Organization (WMO 2009), IPCC, 2007). It is widely recognized that the increased heat stress, shift in monsoons, and drier soils pose a much bigger threat to the tropics than the temperate latitudes. With most developing countries located in the tropics and most of them being heavily dependent on agriculture for food and income, the relatively poor countries with limited resources face the costly and formidable task of adapting to climate change (World Bank, 2008; Worthington, 2011)

Climate change is real and happening. This acceptance is based on the overwhelming evidence presented by the scientific community through intensive monitoring of global climatic systems, extensive observations on changes in terrestrial and aquatic systems, and predictive modeling; climate change presents severe global risks, and it demands an urgent global response" (IPCC, 2007; F.A.O, 2020). Declining soil fertility, water shortages, widespread degradation of the resource base, and poor institutional and policy support already constrain agriculture. These changes in the climate from what the communities are adapted to will have significant adverse impacts on food, nutritional, and income securities of millions of those dependent on agriculture and to a large extent on the economies of those countries if mitigation and adaptation measures are not implemented urgently (Neupane, & Thapa, 2001; Idris, Ogunbameru, Ibrahim, & Bawa, 2012; Longshal, 2023)

Soil is one of the most valuable and dependable natural resources, but it is not renewable and must be managed to maximize its productivity. Adepetu, cited in Longshal (2023), defined soil as a natural body of loose, unconsolidated materials, which constitutes a thin layer several meters deep on the Earth's surface. Soil fertility refers to the ability of soil to sustain agricultural plant growth, providing plant habitat and nutrients on a sustainable level. It is the ability to sustain plant growth by providing essential plant nutrients and favorable chemical, physical, and biological characteristics (Ekele & Sawuri, 2022). Therefore, soil fertility must be maintained and sustained through smart agroforestry management practices to sustain the livelihood of smallholder farmers.

Objective of the Study

The objective of this study is to identify smart agroforestry management practices required by small-holder farmers for effective soil fertility and livelihood sustainability and for mitigating and/or adapting to climate change's impact on farm productivity in North-East Nigeria. Specifically, the study sought to:

1. Identify the management practices in smart agroforestry required by small-holder farmers in North-East Nigeria
2. Identify management practices in the shelter belt forest.
3. Identify management practices in plantation forests.

4. Identify the challenges in smart-agro-forestry management practice in North-East, Nigeria

Research Questions

The following research questions guided the study

1. What are the management practices in SAF required by small-holder farmers in North-East Nigeria?
2. What are the management practices in the shelter belt forest?
3. What are the management practices in the Savanna forest?
4. What are the challenges of smart-agro-forestry management practice in North-East, Nigeria?

Research Hypothesis

There is no significant difference between smallholder farmers' and agricultural Extension agents' mean ratings of responses on smart agroforestry management practices required for soil fertility, livelihood sustainability, and climate change adaptation in Northeast Nigeria.

II. Methodology

The design for the study is a descriptive survey research design. A descriptive survey according to Emmaikwu, (2015) aims at collecting data and describing systematically the characteristics, features, or facts about a given population. The main objectives of a descriptive survey are to identify the present condition and point to the present needs, to study the immediate status of a phenomenon, and fact-finding. A descriptive survey research design is suitable for this study because data will be collected from a sampled population of small-holder farmers on SAF management practices required for enhancing soil fertility, livelihood sustainability, and climate change mitigation to boost farm productivity in northeast Nigeria using a structured questionnaire.

The study was conducted in the North-East States of Nigeria, consisting of Adamawa, Bauchi, Borno, Gombe, Taraba, and Yobe states. This is because the researcher observes that the impact of climate change in the region in recent years can only be imagined as floods, erosion, and storms ravaging the farmlands. Furthermore, the majority of the inhabitants are smallholder farmers who practice agroforestry as an additional source of livelihood.

The population of the study was 446, consisting of 320 registered farmers/foresters and 126 agricultural extension agents from the 6 states' Ministry of Agriculture. The study's sample was 204 respondents, purposively sampled to obtain 178 farmers and 26 agricultural extension agents.

The instrument for data collection is a 28-item questionnaire titled ‘Smart-Agro-forestry Management Practices Questionnaire (SAFMPQ) developed from the literature review and used for data collection. The instrument has a 4-point response scale of highly required (HR), average required (AR), slightly required (SR), and not required (NR), with corresponding values of 4, 3, 2, and 1, respectively

The instrument for data collection was subjected to content and face validation by three experts from the Department of Forestry and Agronomy, Federal University of Agriculture, Makurdi, and Federal School of Forestry, Jos. Corrections and suggestions from the validates were used to produce the final version of the questionnaire

The instrument was trial-tested on thirty agricultural extension agents from North-Central Nigeria. Cronbach Alpha method was used to determine the internal consistency of the items of the questionnaire which yielded a coefficient value of 0. 96 indicating that the instrument is reliable.

Data were personally be collected by the principal researcher and 6 research assistants. A total of 204 copies of the questionnaire will be administered to the respondents. The questionnaire will be divided into two categories- required and performance. The required categories has a 4-point response scale of highly required (4), averagely required (3), slightly required (2), and not required (1). Similarly, the performance category also has a 4points response scale of high performance (4), average performance (3), low performance (2), and no performance (1) respectively.

Weighted Mean (x) and Requisite Mgnt practice Index (RMPI) will be used in analyzing the data from the questionnaire items to answer the research questions. To determine the requisite SAF management practices needed by farmers, the following steps will be taken: the mean (Xr) of the required category will be determined for each item, the mean (Xp) of the performance category will also be determined for each item, the performance gap (PG) will be determined by finding the difference between Xr and Xp for each item, i.e., PG = Xr – Xp. The inference drawn from the calculation is given as:

Key: RSR = Requisite Skill Required

Xr = Mean required

Xp = Mean performance

PG = Performance Gap

N = Number of respondents

Where the value of PG is positive (+) for each item, it indicates that the farmer needs requisite management practice because the level at which the farmer performs is lower than what is required. In other words, the level at which the Mgnt practice item is required is higher than the level at which the farmers could perform the requisite Mgnt practice item.

Where the performance gap (PG) is negative (-) for each item, it shows that the Mgnt practice item is not needed by the farmers. This is because the level at which the farmer performs is lower than what is required. In other words, the level at which the requisite Mgnt practice item is required is lower than the level at which the farmer performs the skill item. Where the performance gap (PG) is (0) for each item, it indicates that the farmers require no Mgnt skill because (the level at which the farmers perform the operations of items is equal to the level at which the farmers could perform the requisite skills).

III. RESULTS

Research Question 1

What are the management practices in SAF required by small-holder farmers in North-East Nigeria?

Hypothesis:

There is no significant difference in farmers' and agricultural Extension agents' mean ratings of responses on management practices required in SAF in Northeast Nigeria.

Table 1: Mean ratings, Standard Deviation, and t-test analysis of small-holder farmers and Agric Extension Agents on SAF management practices required in Northeast N_1=333 (farmers), N_2=110 (Agric. Extension Agents)

S/N	Item Practice	$\bar{X}_1$	SD_1	$\bar{X}_2$	SD_2	XG	t-cal	t-Cri	Rmks	HO
1	Mechanical soil Preparation	3.06	0.64	2.68	0.48	2.64	0.30	1.97	R	NS
2	Planting pits	3.48	0.62	2.62	0.46	2.82	0.43	1.97	R	NS
3	Planting and Replanting	3.04	0.62	2.48	0.64	2.40	0.42	1.97	R	NS
4	Thinning	3.06	0.24	2.64	0.68	2.86	0.32	1.97	R	NS
5	Fire prevention	3.04	0.42	2.82	0.43	2.64	0.34	1.97	R	NS
6	Building and Maintaining roads	3.02	0.24	2.62	0.52	3.06	0.36	1.97	R	NS
7	Timber harvesting	2.96	0.04	2.86	0.34	2.94	0.32	1.97	R	NS
8	Carbon sequestration	2.62	0.44	2.92	0.54	3.04	0.24	1.97	R	NS
9	Minimizing soil Disturbance	2.66	0.26	2.88	0.46	3.08	0.26	1.97	R	NS
10	Restoring degraded Land	2.82	0.34	2.94	0.48	3.62	0.34	1.97	R	NS
11	Improved fallow	3.04	0.14	2.68	0.20	2.96	0.34	1.97	R	NS
12	Taungya system	3.68	0.26	3.12	0.42	2.89	0.26	1.97	R	NS
13	Selective exploration	2.96	0.40	2.86	0.34	2.94	0.32	1.97	R	NS
14	Alley cropping	2.86	0.32	2.64	0.42	3.06	0.24	1.97	R	NS
15	Deforestation	2.58	0.83	2.86	0.17	3.01	0.46	1.97	R	NS
16	Regeneration	2.62	0.44	2.92	0.52	2.84	0.16	1.97	R	NS
17	Afforestation	2.82	0.41	2.90	0.53	2.86	0.17	1.97	R	NS
18	Tree gardens	2.98	0.82	2.80	0.26	3.04	0.42	1.97	R	NS

19	Reforestation	3.02	0.16	3.04	0.20	2.96	0.28	1.97	R	NS
20	Forest mensuration	2.98	0.74	3.21	0.41	3.04	0.56	1.97	R	NS
21	Estate crop Combination	3.25	0.64	3.04	0.62	3.14	-	1.97	R	NS
22	Aquaforestry	2.86	0.32	2.86	0.26	2.64	0.16	1.97	R	NS
23	Fuelwood Production	2.67	0.42`	2.92	0.32	3.46	0.18	1.97	R	NS
24	Agro-silvipastoral System	2.60	0.36	2.88	0.52	3.14	0.16	1.97	R	NS
25	Silvipastoral system	2.62	0.16	2.66	0.61	2.64	0.16	1.97	R	NS
26	Shelterbelts, windbreaks Live hedges	2.61	0.15	2.60	0.51	2.55	0.17	1.97	R	NS
27	Fuelwood production	2.92	0.53	3.02	0.55	2.51	0.54	1.97	R	NS

Key: $\bar{X}_1$= Mean of farmers, $\bar{X}_2$= Mean of Extension agents, SD = standard deviation

XG = Grand mean, t-cal = t-calculated, t-crit = t-tabulated. HO=Null hypothesis, NS = Not Sufficient.

Table 1 revealed that all 27 items on plantation forest management practices had their mean values ranging from 2.58 to 3.48, which is above the cutoff point of 2.50. This implies that farmers required all 27 skills and competency items for SAF management practices in Plantation forests. The standard deviation ranged from 0.14 to 0, 83 which means that the respondents were not too far from the mean and one another in their response.

Results of the hypothesis tested further revealed that there is no significant difference in farmers' and agricultural Extension agents' mean ratings of responses on all 27 items on SAF management practices in plantation forests required by smallholder farmers in Northeast Nigeria. This is because the t-calculated values are less than the t-critical values of 1.97 at a .05 level of significance with 434 degrees of freedom, therefore, the null hypothesis was accepted for all 27 items.

Research Question 2:

What are the SAF management practices required by smallholder farmers in Shelter belts?

Table 2: Mean and Standard Deviation of small-holder farmers and Agric Extension Agents on SAF management practices required in Shelter Belts N_1=333 (farmers), N_2=110 (Agric. Extension Agents)

S/N	Item Practice	$\bar{X}_1$	SD_1	$\bar{X}_2$	SD_2	XG	Remarks
1	Appropriate initial decision for establishment	3.06	0.32	3.02	0.86	2.98	Required
2	Site Preparation	3.04	0.64	3.16	0.18	3.2	Required
3	Make a layout for the trees	2.96	0.31	3.90	0.86	2.80	Required
4	Select the Planting position	2.84	0.60	3.04	0.68	2.68	Required
5	Space rows between two to four meters apart	2.67	0.32	2.66	0.38	2.60	Required
6	Choose species that have the right height, growth and density for the shelterbelt goals	2.68	0.62	2.64	0.36	2.68	Required
7	Space rows between two	2.66	0.43	2.61	0.42	2.62	Required

	to four meters apart							
8	Keep weeds and grass out of the shelterbelt	2.82	0.61	2.82	0.34	2.68		Required
9	Thin the shelterbelt within 4–10 years	3.23	0.82	2.42	0.28	2.80		Required
10	Apply the right thinning Operation	2.88	0.81	2.56	0.34	2.72		Required
11	Release cutting to avoid Undesirable competition	2.84	0.72	2.64	0.32	2.74		Required
12	Carryout careful pruning	2.67	0.61	2.72	0.26	2.76		Required
13	Protect trees from fire	2.82	0.53	2.92	0.32	2.84		Required
14	Use appropriate structural Mgnt.		2.62	0.31	2.57	0.52	2.62	Required
15	Protect trees from Indiscriminate falling, Grazing or harvesting	2.66	0.13	2.60	0.29	2.61		Required
16	Avoid interrupting the growth Pattern of forest	2.56	0.31	2.98	0.38	2.73		Required
17	Use triangular spacing in belts to reduce the effects of wind between the stems	2.64	0.33	2.58	0.37	2.28		Required
18	Put in place proper shelter belt composition of desirable species, e.g. fast and slow-growing spp.	2.77	0.60	2.71	0.40	2.74		Required
19	Selective exploitation	2.80	0.42	2.66	0.38	2.71		Required

Key: X_1= Mean of farmers, X_2= Mean of Extension agents, SD = standard deviation

XG = Grand mean

Data presented in Table 2 suggest that all the 19 items had their mean values ranging from 2.62 to 3.90 which is clearly above the cutoff point of 2.50. This means that farmers required all the 19 items use in SAF management practices in shelter belts. Table 2 further revealed that the standard deviation ranged from 0.13 to 0.18 an indication that respondents are close to one another in their responses.

Research Question 3: What are the SAF management practices required by smallholder farmers in Shelter belts?

Table 3: Mean ratings and standard deviation of small-holder farmers and Agric Extension Agents on SAF management practices required in Savannah Plantations N_1=333 (farmers), N_2=110 (Agric. Extension Agents)

S/N	Item Practice	X_1	SD_1	X_2	SD_2	XG	Remarks
1	Site reconnaissance	3.06	1.08	3.87	0.23	3.06	Required
2	Selection of the planting site	2.85	0.17	2.89	0.14	2.87	Required
3	Practice normality in even-Aged stands in Savannah Plantation	3.08	0.18	3.03	0.12	3.05	Required
4	Tree species selection	2.58	0.18	3.57	0.12	3.05	Required
5	Preparation of the planting site	3.08	0.14	3.26	0.15	3.06	Required
6	Planting holes 0.4 m x 0.4 m x 0.4 m at a density of 3 m x 3 m.	3.06	0.17	3.42	0.17	3.08	Required
7	Choice of appropriate planting time	3.08	0.16	3.62	0.15	3.07	Required
8	Planting of containerized Stock	2.68	0.18	3.03	0.17	3.08	Required
9	Carry out silvicultural rotation	3.28	0.13	3.01	0.16	3.14	Required
10	Carry out silvicultural Treatments on tree stands	3.22	0.12	3.18	0.19	3.19	Required
11	prepare a written working Plan for Savannah plantation	2.70	0.16	2.66	0.15	2.68	Required
12	State the objectives of Savannah plantation to include Timber for sale, farm use and Firewood	2.64	0.14	2.70	0.51	2.67	Required
13	Practice nature conservation By having a variety of crop Types	3.0	0.17	3.22	0.47	3.12	Required
14	Establish systems to manage Fire	3.07	0.16	3.07	0.49	3.24	Required
15	Ensure sustainable farming and grazing	3.05	0.15	3.09	0.52	3.65	Required
16	Design policies/regulations for managing savannah Ecosystems	2.80	0.13	3.03	0.45	3.55	Required
17	Ensure community coordination to enhance						

	networks and coordination for collective community actions.	3.05	0.14	3.09	0.55	3.71	Required
18	Minimize fire and pest Danger	3.08	0.16	3.09	0.52	3.86	Required

Key: X_1= Mean of farmers, X_2= Mean of Extension agents, SD = standard deviation

XG = Grand mean

Table 3 shows that all 18 items had mean values ranging from 2.64 to 3.87, which is clearly above the cutoff point of 2.50. This means that farmers required all 18 items used in SAF management practices in the Savannah plantation. It further revealed that the standard deviation ranged from 0.12 to 0.19, an indication that respondents were close to one another in their responses.

Research Question 4:

What challenges do farmers face in SAF management practice in North-East, Nigeria?

Table 4: Mean ratings and Standard Deviation of small-holder farmers and Agric Extension Agents on Challenges confronting farmers in SAF management practices in North-East Nigeria N_1=333 (farmers), N_2=110 (Agric. Extension Agents)

S/N	Item Practice	X_1	SD_1	X_2	SD_2	XG	Remarks
1	High level of Insecurity	2.68	0.38	3.20	0.53	2.94	Agreed
2	small land holdings	2.89	0.36	3.42	0.72	2.86	
3	limited farmer's, access to funding and resource availability	2.85	0.27	2.89	0.34	2.87	Agreed
4	Younger generation seems less interested in activities in the agricultural sector	3.08	0.42	3.14	0.84	3.78	Agreed
5	Limited skilled labor	3.06	0.91	3.18	0.28	3.12	Agreed
6	shortage of technical know how for post-harvest processing	2.60	0.64	2.89	0.82	2.78	Agreed
7	Poor knowledge of sustainable land management practices	3.07	0.73	3.86	0.71	3.66	Agreed
8	Poor conservation practices and well-planned fire mgmt.	2.84	0.53	3.06	0.78	2.94	Agreed
9	Regular drought	2.98	0.82	2.98	0.46	2.75	Agreed
10	Climate change challenge	2.65	0.62	2.53	0.31	2.62	Agreed
11	Lack of Government Commitment to Agric dvpt	3.7	0.73	3.69	0.82	3.58	Agreed
12	High maintenance costs	2.55	0.61	2.64	0.52	3.66	Agreed

Key: X_1= Mean of farmers, X_2= Mean of Extension agents, SD = standard deviation

XG = Grand mean

Data presented in Table 4 revealed that all the 12 items had their mean values ranging from 2.55 to 3.80 which is clearly above the cutoff point of 2.50. This shows respondents agree that all 12 items are challenges confronting farmers in SAF management practices in Northeast, Nigeria. Similarly, the standard deviation ranged from 0.35 to 0.91, further indicating that respondents are not far from the mean and from one another in their responses.

IV. DISCUSSION OF FINDINGS

Based on the research questions answered and the hypothesis tested, the following findings emerged from the study. Findings from Table 1 revealed that 27 management practices in SAF are required for small-holder farmers in North-East Nigeria. The findings are in agreement with Alao and Shuaibu (2013), who found that reforestation, the Taungya system, forest mensuration, and selective exploration were among the best practices identified in SAF management and non-timber forest products. The findings are also in agreement with Ekele (2015), who affirmed that forest regulation and afforestation were part of forest management techniques. The null hypothesis tested in Table 1 revealed that there was no significant difference in farmers' and agricultural Extension agents' mean ratings of responses on management practices required in SAF in Northeast Nigeria. The hypothesis was therefore accepted.

Findings from Table 2 revealed that all 19 SAF management practices in Shelter Belts are required by small-holder farmers in Northeast Nigeria. The findings are in agreement with those of Rice (2018), who affirmed that site preparation, layout for trees, selection of planting position, and species selection are all critical SAF management practices required for shelter belts.

Findings from Table 3 suggest that all 18 SAF management practices on Savannah plantations are required by small-holder farmers in the Northeast. The findings buttress those of Ekele (2015) who found out that site reconnaissance, selection of planting site, choice of appropriate planting time, silvicultural treatment of trees, and establishment system of managing fires are part of savannah plantation management practices required by farmers.

Findings from Table 4 that 12 item statements on Challenges confronting farmers in SAF management practices in North-East Nigeria were all agreed to by respondents in the study area. The challenges include but are not limited to insecurity, small land holdings, limited access to funding, regular drought, climate change challenges, and lack of technical know-how. The findings aligned with those of USDA (2011), and the study of Ekele, (2015) who found that poverty, insecurity, and lack of technical knowledge especially in the area of lumbering are major challenges faced by farmers in the study area

V. CONCLUSION

The growing and compelling evidence about climate change and its impact on soil fertility, agricultural activities, food security and livelihood sustainability are of greatest concern to most developing countries, particularly in Northeast Nigeria because of higher dependency on agriculture for livelihood, subsistence level of operation, low adaptive capacity and limited institutional support. SAF system offer a win-win opportunity by helping to attain food security, increase farm income for livelihood sustainability, and improve soil health and discouraging deforestation. While SAF systems offer economic and ecological advantages, the management practice of these systems is grossly inadequate or absent. In addition to an in-depth understanding of the benefits from SAF systems and farmer requirements, mainstreaming of SAF agroforestry better management practices seed selection, preparation, test for seed viability, site selection, Taungya system, forest mensuration, re-afforestation are all important forest management practices therefore, the identified SAF management practices should be used for capacity building of farmers for soil fertility and livelihood sustainability and for mitigating the impact of climate change on farm productivity for food security and sustainable development in North east Nigeria and the country at large

VI.RECOMMENDATIONS

1. The management practices and skills identified in SAF systems should be packaged into training modules for a workshop training programme for farmers (foresters)

2. Extension agents should use the identified management practices in Savannah plantation and Shelter Belts for capacity building to enhance performance

3. Periodic follow-up of trainees (T and V) by extension agents should be encouraged for practical demonstration of acquired knowledge.

4. The three tiers of government (Federal, States, and Local Government) should ensure the provision of adequate funding and land for SAF.

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