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SUSTAINABLE LAND MANAGEMENT FOR ENHANCED ENVIRONMENTAL SUSTAINABILITY AND PRODUCTIVITY AMONGST RESOURCE-POOR FARMERS IN NIGERIA

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ABSTRACT: *Soil degradation is an epic phenomenon adversely affecting enhanced agricultural productivity and development in Nigeria, through progressive loss in the quality of land which manifests in the form of soil erosion, sedimentation, flooding, desertification, higher than normal temperature condition, poor crop yields, etc. It is estimated that over half of the world's grasslands are degraded, with nearly 1.5billion people directly affected worldwide. Most African soils are typically impoverished and deficient in plant nutrient materials like phosphates and other essential nutrients. These soils are also characterized with low organic matter content, low water retention capacity, and low CEC. They are also subjected to heavy leaching and siltation in addition to increasing demand for increased productivity by its rapidly growing population, with high need for good (efficient) management essential for enhanced and sustainable agriculture. As a result of the combination of these factors, both crop yields and quality do not appreciably increase as expected in this part of the world over a long period. This is in spite of the significant progress made in agricultural research, and hence the need for an all-round agricultural land management practices in this area, which is afforded by the SLM practice. In Nigeria in particular, soil erosion is the most widespread form of land degradation militating against environmental sustainability and rural prosperity, thereby making sustainable land management (SLM) a great imperative for enhanced agricultural productivity and profitability. This study shows the imperatives of sustainable land management amongst resource*-poor farmers in a growing economy with rapidly growing human population like Nigeria, majority of who live in rural areas and derive their livelihood directly from the land resources through agriculture and related primary activities.

KEYWORDS: Agricultural productivity, Crop yield, Resource-poor farmers, Soil degradation, Sustainable land management.

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INTRODUCTION

Human-induced soil degradation is a common phenomenon that adversely affects agricultural productivity and profitability, especially amongst poor farmers, who produce the bulk of the food in Nigeria (Imo, 2013). This could be in the form of soil erosion, sedimentation, flooding, desertification, and deforestation, among others, with far reaching implications on food security and the socio-economy of the country. Soil erosion is the most widespread type of soil degradation in the country that has been recognized for a long time as a serious problem militating against environmental sustainability, enhanced agricultural productivity and rural prosperity, thereby making sustainable land management (SLM) an indispensable issue in the country (Hans, 2000).

In response to these challenges, the Nigerian government has over the years, set out various strategies to deal with these challenges, as well as signed a number of international treaties and declarations on the protection of the ecosystem. Many of these strategies have been modified in order to achieve sustainable development in the country, and, in particular, to secure a quality environment adequate for the health and well-being and restoring, maintaining and enhancing the ecosystems and ecological processes in the country, essential in the proper functioning of the biosphere (World Health Organization, 2015). In spite of all the investments in different agricultural sectors (like crop, livestock, forestry, water resources, wild life, etc.), environmental degradation has continued at an alarming rate in Nigeria (Muhammed *et al.*, 2014).

Soil degradation and its attendant effects have been a source of concern, both locally and internationally. In Nigeria, in 1989, about 693,000 km^2 of soil was already characterized by runoff-induced soil losses in the south and 231,000 km^2 was degraded, mainly by wind erosion in the north. While sheet erosion dominates all over the country, rill and gully erosion are common in the eastern parts and along rivers in northern parts of the country. Nigeria has the world's highest deforestation rate of primary forests and Africa's highest rate of total forest loss. From 2000 to 2005, the country lost 55.7% of her primary forests. Nigeria's forest cover is now less than a third of what it was in the 1960s (Junge et al., 2009).

Nigeria is also losing about 3,510 km^2 of rangeland and cropland to desertification each year. And while Nigeria's human population grew from 33 million in 1950 to 132 million in 2005, its livestock population grew from roughly 6 million to 66 million. The forage needs of Nigeria's livestock population exceed the sustainable yield of Nigeria's grasslands (Ikhuoso *et al.*, 2020). Today, one out of every 3 people on the face of the earth is affected by land degradation of some sort, and hence good land management is of critical importance in overcoming the aforementioned challenges in Nigeria's development aspiration as it ensures long-term (sustained) agricultural productivity and sustainability of the natural resource base, which are generally threatened by inefficient and inappropriate or competing land uses across diverse landscapes of the country (Lal, 1995).

Sustainable land management (SLM) consists of the proper use of land resources, including soil, water, plants and animals, improve soil fertility and biological potential for the production of goods to meet changing human needs and climate variability and future changes, while simultaneously ensuring long-term productive potential of these resources and the maintenance of their environmental functions (Dahiru, 2017). This is indispensable in Nigeria now more

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than ever before because of its rapidly increasing population, 75% of which are into agriculture and related activities.

Agriculture is the mainstay of Nigeria's economy, with land (and its resources) as its key asset. Therefore, the need for upscaling and adopting SLM practices by farmers in the country in order to improve productivity, food security, and reduce poverty, which is highest among agricultural households cannot be over emphasized, especially that her agricultural growth is based on land- use intensification rather than land-use intensification, with lots of other unsustainable land-use practices (LUPs) like over-exploitation of natural resources in mining, bush burning, construction works and weak protected area management among others (Maimuna & Benedict, 2015).

This study examines the roles and benefits of SLM in addressing environmental degradation, as well as in monitoring and estimating environmental benefits from SLM practices through content reviews of relevant text materials.

CONCEPTUAL FRAMEWORK

SLM is an essential building block for sustainable agricultural development, as well as a key element in Agenda 21 of the UN-backed sustainable development goals (SDGs) (Dahiru & Emankhu, 2018). SLM combines techniques, policies, strategies and activities aimed at integrating sustainable economic principles with environmental concerns so as to simultaneously:

- maintain and enhance production (land productivity);
- reduce production risk level and enhance soil capacity to buffer against degradation processes (stability/resilience);
- protect population of natural resources and prevent degradation of soil and water quality (protection);
- be economically viable (viability); and to
- be socially acceptable and assure access to the benefits from improved land management (acceptability/equity) (Motavalli *et al.*, 2013).

According to the Food and Agricultural Organization (FAO) of the United Nations, SLM is a series of practices and technologies aimed at integrating the management of land, water, and other environmental resources, to meet the needs of man, while ensuring long term sustainability, ecosystem services, biodiversity and livelihoods. It is the use of land resources including soils, water, plants and animals, for the production of goods to meet changing human needs, while simultaneously ensuring the long term productive potential of these resources and the maintenance of their environmental functions. It encompasses established approaches such as soils and water conservation, natural resource management, and integrated land management (ILM). It involves holistic approaches to achieving a healthy and productive ecosystem by integrating social, economic, physical, and biological needs and values and contributes to sustainable rural development and poverty alleviation (WHO, 2005).

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Land is the key asset of the rural poor. How productive it is managed therefore, has important implications on poverty alleviation, economic growth and development. The ability of land to produce is finite in nature, and the important limits to production are set by soil; prevailing climatic conditions; available water resource, and land use type. Any land utilization beyond these limits results in its degradation with decreasing productivity (and profitability for farmers) (Anande-Kur, 1992). Unsustainable land-use practices in Nigeria in over-exploitation of natural resources, and on-going climate variability that pose threats to the maintenance of the productivity of agricultural lands and ecosystem functions.

In the past decades, agriculture has witnessed unprecedented changes in Africa in general, and its parts (like Nigeria) in particular due to large population increase; integration of rural areas into national and international agricultural practices and other markets, and the development of new technologies, among others. This work focuses on the impact of soil degradation on agriculture and the imperatives of SLM on improved agricultural productivity for resource-poor rural farmers in the country, most of whom are poor in terms of access to natural resources; unavailability of credit facilities; information/knowledge gap, and lack of external inputs for enhanced productivity and profitability, as a result of which their per capita food production has declined by about 1.3% in the recent years, with a corresponding estimated 5% reduction of agricultural GDP (UNEP, 1997).

This state of affairs is further aggravated by the increased human population and its multifarious activities which lead to several kinds of land degradation in the form of soil erosion and sedimentation; flooding; siltation and drying up of water bodies and loss of biodiversity; deforestation, and desertification, as exemplified by Nigeria’s scenario, by virtue of which the phenomenon of land degradation is recognized as a long time serious problems militating against environmental sustainability, enhanced agricultural productivity and rural prosperity, thereby making sustainable land management (SLM) an indispensable issue in the country (Dahiru, 2017).

Land-Use and Land Degradation in Nigeria

Land degradation is such an important issue globally for its spate and devastation owing to the rapidly increasing huge global population and its myriads of anthropogenic activities, with far reaching implications on both global, continental, regional, sub-regional and national socio-economy (United Nations Environment Programme, 1997). Land degradation is a function of the land use practice, climatic factors, as well as the nature of the country rocks of an area among others.

Human-induced land degradation is a common phenomenon in Nigeria that could result in soil erosion; flooding; sedimentation; desertification; siltation, etc., with soil erosion as the most widespread type of soil degradation that militate against environmental sustainability, enhanced agricultural productivity and rural prosperity, thereby making sustainable land management (SLM) an indispensable issue in the country (Dahiru, 2018). 76m rural Nigerians, mostly poor, rely on natural wealth, for their survival and wellbeing. The economic and ecological services provided by the country’s renewable natural resource base constitute the only safety net, while also serving as the foundation of the nation’s non-oil economic growth and food security. As such, sustainable agricultural development depends on efficient land management practices that conserve soil and water, soil fertility, and the biological potential for productivity, while allowing communities to adapt to climate variability and future change.

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Not only do such practices deliver important local benefits, they also help secure global environmental benefits such as carbon accumulation in soil and biomass, improved nitrogen cycling, higher water tables, in-situ biodiversity, and general ecosystem function.

Soil degradation is a widespread phenomenon in sub-Saharan Africa, including Nigeria, as a result of which the region suffers from poor annual productivity or huge losses of crop yields, ranging from modest levels (2 percent decline over several decades) to catastrophic levels (>50 percent), depending on crop, soil type, climate and production systems, with most studies reporting significant losses (Scherr, 1999).

In a study of 33 African countries, Drenge (1990) found compelling evidence of serious land degradation in 13 countries, including Nigeria. In another study, it was estimated that 73 percent of dry lands of the African-sub region were degraded, while 51 percent were severely degraded. They concluded that 18 percent of irrigated lands, 61 percent of rain-fed lands and 74 percent of rangelands are also degraded. The most widespread cause of land degradation in Africa, including Nigeria was due to water erosion, followed by wind erosion, chemical degradation, and physical degradation, with varying devastating effects on different parts of the country, such as loss of nutrients and productivity (17% loss). And according to Dregne and Chou (1992), more than half of rainfed land in Africa and Asia had experienced a 10 percent loss in productive potential,

Challenges of SLM Adoption in Nigeria

SLM practice is an important challenge amongst resource-poor farmers in Nigeria because of a number of factors affecting them on their strides, which includes but not limited to the following:

- Land tenure system, which is essentially communal in nature, leaving the poor farmers with little or no option of real investment on improving the quality of the land
- Fragmented/small land holding which allows for only subsistence farming with barely enough for the market
- Poor education and technological adoption on the part of the farmers
- Use of traditional agricultural practices and clinging unto cultural/traditional practices as against modern agricultural practices
- Lack of finance and government support amongst resource-poor farmers, and climate change-induced vagaries, among others.

The long term productivity and sustainability of agriculture and the renewable natural resource base, as well as the adoption and scaling up of SLM practices is also threatened by inefficient and inappropriate or competing land uses across diverse landscapes, which exacerbate the various adverse impacts of land degradation in the country. Because land is the prime asset of the rural poor, the maintenance of land quality is critical in reducing poverty and achieving food security. Land management throughout Nigeria is fragmented in terms of knowledge, data, projects, processes, sectors, institutions, and stakeholders. Other challenges to the adoption of SLM practices in the country include:

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- Inadequate knowledge and SLM technology transfer
- Knowledge gaps on specific land degradation and management issues
- Compartmentalized/ fragmented institutions, awareness, and approach of many SLM programs and knowledge management systems
- Poverty and general lack of resources and investment opportunities
- Poor attitude of farmers to technology/innovation.

Benefits of SLM Adoption in Nigeria

The adoption of good SLM practices allows land users to:

- minimize land degradation and rehabilitate degraded areas;
- improve soil management and resilience to erosion and other forms of degradation;
- optimize water cycling, storage and efficient use of water/water productivity;
- enhance above and below ground biodiversity;
- optimize the production of healthy food, animal feed, fiber and forest products;
- derive sustained livelihoods to land users;
- maintain the provisioning function of ecosystem services for future generations;
- enhance resilience to natural disasters like droughts, floods, storms and landslides; and to
- engender food security, enhance practice profitability and improve socio-economy.

SLM focuses on efficient functioning of land resources for the benefits of man. These functions are:

- production functions: These include production of food, fodder and fuel; construction materials; industrial goods, etc.
- Physiological functions: to ensure human health by minimizing the release of toxic substances-water, soil and plants. Or hazards like landslides, flash floods, etc.
- cultural functions: to preserve the integrity of landscape, and to maintain the historical and aesthetic value of the landscape
- ecological functions: to ensure the maintenance of ecosystem functions and global life support functions, including global geochemical (nutrient) cycles/sink capacity for greenhouse gases, filtering of water and pollutants, etc.

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For enhanced and sustained food production, and profitable operation, it is imperative that farming activities are well adapted to the changing farming environment from time to time, through the appropriate adaptation of effective and efficient land management practices (SLM) by farmers and environmental management stakeholders. SLM practices Monitoring Tool (SLM-MT) makes changes in land management apparent. Monitoring changes in land management is an essential process of learning about the man-environment relationship that requires minimum information about the general trend in land management, and shows specific benefits attached to particular SLM practices by farmers. Farmers based SLM practices include but not limited to the following:

SLM is exemplified by:

- Improved seed/planting materials, plant spacing and good fertilization (organic and inorganic)
- Planting of trees and shrubs along with vegetables and other crops in the homestead plot
- Temporary animal enclosure
- Conservation tillage
- Gully reclamation, stream bank stabilization/water channelization
- Watershed/catchment management
- Construction of cross slope barriers (fanya juu terraces, earth banks, stone lines, cutoff drains, hillside ditches)
- Processing crop residues and agro-industry by-products for livestock production, etc.

The above practices have the advantages of improving land quality and productivity, ensuring food security; reducing poverty; improving ecosystem integrity, and reducing resource use.

Table 1: Average Cumulative Loss of Productivity as a Result of Human-induced Soil Degradation, Worldwide and by Region

Region	Cropland	Pastureland	Crops and pastures (low estimates of impact)	Crops and pastures (high estimates of impact)
Africa	25.0	6.6	8.1	14.2
Asia	12.8	3.6	4.7	8.9
South America	13.9	2.2	4.1	6.7
Central America	36.8	3.3	8.7	14.5
North America	8.8	1.8	3.0	5.8
Europe	7.9	5.6	4.6	9.0
Oceania	3.2	1.1	1.2	3.2
World	12.7	3.8	4.8	8.9

Source: *Scherr (1999)*

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Policy Considerations to Arrest Soil Degradation and Promote Sustainable Rural Development

Leaders in the economic and agricultural development communities, as well as environmentalists, must draw the attention of policymakers to soil degradation concerns and work with them to set priorities for public investments, farmer services and provide supportive policies for broad-based agricultural development. Such considerations should include amongst others:

- Identification of priority soil degradation problems and adequate information dissemination about appropriate remediation techniques to be passed-on to farmers and the general public through appropriate channels at all levels in the country.
- A detailed survey and documentation of the soil resources at the country level, indicating the various soil types, their capability and suitability for different types of uses, their agronomic constraints, their distribution and extent is desirable and overdue in Nigeria. This information will form the basis for appropriate soil resource allocation which will guarantee enduring soil productivity and sustainable rural development.
- Provision of micro-credit to farmers to enable them to invest in appropriate land husbandry that will minimize soil degradation and ensure sustainable productivity of the soil. Such investment may go well beyond fertilizer application to replace chemical nutrients, and could involve restoring organic matter, improving soil structure and water holding capacity, among others.

Benefit Indices of Some On-Farm SLM Practices

Different agricultural practices have different effects on the soil. The evaluation of environmental sustainability is based on the kind of land-use to which the land is put to (at a given place and time), and the evaluation is always relative to the biophysical and economic context of the area concerned. A lot of information is required in the measurement of soil sustainability and the development of appropriate indices that constitute the essential parameters that determine whether a particular kind of land management system is sustainable or not. Environmental sustainability evaluation is also based on scientifically valid procedures, data, choice of criteria and indicators of sustainability, which reflect understanding of causes and symptoms (Ezeaku, 2015).

Certain on-farm practices are important in soil conservation, ecosystem integrity and function, productivity, and environmental sustainability (Motavalli *et al.*, 2013), based on which certain indicators (known as generic indicators) were set as standards for monitoring and evaluating SLM thus:

- Crop yield (trend and variability);
- Nutrient Balance;
- Maintenance of soil cover;
- Soil Quality/Quantity;
- Water Quality/Quantity;

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- Net Farm Profitability; and
- Use of Conservation Practices

Table 2: Model for Estimation of Benefit-Index for Specific SLM Practices

a. Benefit Index for Mulching	
MbI = $\frac{\sum_{i=1}^{n} Mb}{n}$ Where : MbI = Mulching Benefit Index Mb = $(x_1 + x_2 + x_3 + x_4 + x_5 + x_6)/K_I$ K_I = No. of mulching benefit indicators = 6 n = Sample size	**Benefit Indicators:** X_1 = Reduced run-off (0, 1) X_2 = Moisture retention (0, 1) X_3 = Reduced loss of soil (0, 1) X_4 = Regulation of soil temperature (0, 1) X_5 = Suppression of weeds (0, 1) X_6 = Increased yield (0, 1) K_I= 6
b. Benefit Index for Cover Cropping	
CbI = $\frac{\sum_{i=1}^{n} Cb}{n}$ Where : CbI = Cover Cropping Benefit Index Cb = $(x_1 + x_2 + x_3 + x_4 + x_5 + x_6)/K_2$ K_2 = No. of Cover Cropping Benefit Indicators = 6 n = Sample size	**Benefit Indicators:** X_1 = Reduced run-off (0, 1) X_2 = Add organic matter to soil (0,1) X_3 = Trap nutrients (0, 1) X_4 = Improve soil tilt (0,1) X_5 = Reduce weed competition (0, 1) X_6 = Increased yield (0, 1) K_2 = 6
c. Benefit Index for Improved fallow	
FbI = $\frac{\sum_{i=1}^{n} Fb}{n}$ Where : FbI = Improved Fallow Benefit Index Fb = $(x_1 + x_2 + x_3 + x_4 + x_5 + x_6)/K_3$ K_3 = No. of Improved Fallow benefit Indicators = 4 n = Sample size	**Benefit Indicators :** X_1 = Reduce leaching (0, 1) X_2 = Reduce soil runoff (0, 1) X_3 = Add organic matter to soil (0, 1) X_4 = Increased yield (0, 1) K_3 = 4
d. Benefit Index for Agroforestry(Alley cropping)	
AgbI = $\frac{\sum_{i=1}^{n} Agb}{n}$ Where : AgbI = Agro-forestry (Alley cropping) Benefit index Agb = $(x_1 + x_2 + x_3 + x_4 + x_5 + x_6)/K_4$ K_4 = No. of Agro-forestry (Alley cropping) Benefit Indicators = 6 n = Sample size	**Benefit Indicators:** X_1 = Reduce soil erosion (0, 1) X_2 = Moisture retention (0, 1) X_3 = Add organic matter to soil (0, 1) X_4 = Regulation of soil temperature (0, 1) X_5 = Increased yield (0, 1) K_4 = 5
e. Benefit Index for Contour farming	
CFbI = $\frac{\sum_{i=1}^{n} CFb}{n}$ Where: CFbI = Contour Farming Benefit Index	**Benefit Indicators:** X_1 = Conserve rainwater (0, 1)

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CFb = $(x_1 + x_2 + x_3 + x_4 + x_5 + x_6)/K_5$ K_5 = No. of Contour farming Benefit indicators = 4 n = Sample size	X_2 = Reduce soil losses from surface erosion (0, 1) X_3 = Increased infiltration and more uniform distribution of the water (0,1) X_4 = Increased yield (0, 1) K_5 = 4
f. Benefit Index for Intercropping/Strip cropping	
ICbI = $\frac{\sum_{i=1}^{n} ICb}{n}$ Where: ICbI = Intercropping/Strip cropping Benefit Index ICb = $(x_1 + x_2 + x_3 + x_4 + x_5 + x_6)/K_6$ K_6 = No. of Intercropping/Strip cropping benefit indicators = 5 n = Sample size	**Benefit Indicators:** X_1 = Reduce erosion (0, 1) X_2 = Lowers evaporation (0, 1) X_3 = Increases water infiltration (0, 1) X_4 = Add organic matter to soil (0, 1) X_5 = Increased yield (0, 1) K_6 = 5
g. Benefit Index for Zero tillage	
ZbI = $\frac{\sum_{i=1}^{n} Zb}{n}$ Where : ZbI = Zero tillage Benefit Index Zb = $(x_1 + x_2 + x_3 + x_4 + x_5 + x_6)/K_7$ K_7 = No. of Zero tillage Benefit Indicators = 4 n = Sample size	**Benefit Indicators:** X_1 = Reduce soil erosion (0, 1) X_2 = Reduce weed competition X_3 = Improved soil regeneration (0, 1) X_4 = Increased yield (0, 1) K_7 = 4
h. Benefit Index for Ridging/Ridge tying	
RbI = $\frac{\sum_{i=1}^{n} Rb}{n}$ Where: RbI = Ridging/Ridge Benefit index Rb = $(x_1 + x_2 + x_3 + x_4 + x_5 + x_6)/K_8$ K_8 = No. of Ridging/Ridge benefit indicators = 4 n = sample size	**Benefit Indicators:** X_1 = Moisture retention (0, 1) X_2 = Reduced loss of soil (0, 1) X_3 = Reduce weed competition (0, 1) X_4 = Increased yield (0, 1) K_8 = 4
i. Benefit Index for Composting	
CPbI = $\frac{\sum_{i=1}^{n} CPb}{n}$ Where: CPbI = Composting Benefit Index CPb = $(x_1 + x_2 + x_3 + x_4 + x_5 + x_6)/K_9$ K_9 = No. of composting benefit indicators = 5 n = Sample size	**Benefit indicators:** X_1 = Add organic matter to soil (0, 1) X_2 = Reduces soil runoff (0, 1) X_3 = Moisture retention (0, 1) X_4 = Reduce weed competition (0, 1) X_5 = Increased yield (0, 1) K_9 = 5
j. Benefit Index for Liming	
LbI = $\frac{\sum_{i=1}^{n} Lb}{n}$ Where: LbI = Liming Benefit Index	**Benefit Indicators:** X_1 = Reduces soil acidity (0, 1) X_2 = Add organic matter to soil (0, 1)

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Lb = $(x_1 + x_2 + x_3 + x_4 + x_5 + x_6)/K_{10}$ K_{10} = No. of Liming Benefit Indicators = 3 n= Sample size	X_3 = Increased yield (0, 1) K_{10} = 3
k. Benefit Index for Mixed Cropping	
MCbI = $\frac{\sum_{i=1}^{n} MCb}{n}$ Where: MCbI = Mixed Cropping Benefit Index MCb =$(x_1 + x_2 + x_3 + x_4 + x_5 + x_6)/K_{11}$ K_{11} = No. of Mixed cropping benefit Indicators = 3 n = Sample size	**Benefit indicators:** X_1 = Reduce weed competition X_2 = Reduce insect pests (0, 1) X_3 = Increased yield (0, 1) K_{11} = 3

The indicators identified and the benefit index estimation model above can be used to develop an SLM adoption monitoring tool in an area. It estimates the SLM benefit index once the required data is input into it. Results could be subject to further analysis such as graphical analysis, descriptive statistical analysis, etc.

CONCLUSION

In Nigeria, the majority of the population live in rural areas and derive their livelihood directly or indirectly from the land, with many socio- economic, cultural or religious affinities to the land on which they live and derive their livelihood. A decline in the quality of the land to satisfy their needs is bound to adversely affect their wellbeing. Therefore, the challenge for the scientists, land managers and policymakers alike is to find appropriate strategies for sustainable agricultural production to ensure rural development. The way out of which is to focus greater attention on SLM for land, essential in sustainable rural and agricultural development.

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