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Soil Loss Estimation and Nutrient Level Changes in Selected Farm Lands in Ilorin, Nigeria

Musa, J. J., Adeoye, P. A., Adams-Suberu, J. And Kuti, I. A.

Department of Agricultural and Bioresources Engineering, Federal University of Technology, P M B 65, Minna, Nigeria, Corresponding Author: johnmusa@futminna.edu.ng

Abstract: *Despite several governmental efforts, Nigeria's increasing population and decreasing land resources is an environmental problem and it has to be combated head on if she must overcome loss of natural resources due to sedimentation and nutrient loss. Urbanization, Intensified agricultural activities and deforestation are the key factors that influence soil erosion rate and sediment yield which subsequently leads to land degradation in the Southern and Northern parts of Nigeria respectively. This paper explores and reviews globally existing land management practices and various typologies, in relation to the various agricultural and urban activities in Nigeria. Over 50 publications were referred to, representing most continents and many countries. It was concluded that there is so much pressure on land and yet improper sustainable land management applied due to lack of awareness and socio-economic lifestyle of the people. Land degradation can be remedied through integrated approaches such as creation of awareness programmes, encouraging sustainable land management practices for both rural and urban zones, use of satellite remote sensing technology, planting of trees and shrub species and protection of marginal lands and the use of alternative energy sources.*

Key words: Land degradation, Land management typologies, Soil, Nigeria

1.0 Concept of Land Management Practices

"Biodiversity Conservation" and "Agricultural Sustainability" are two major driving forces behind a good Land management practice in the world today and as the intensity of agricultural activities increases over the years, so has the capability of farmers to increase yields per area covered and reduce labor expenses. Though, intensified agricultural activities has its far-reaching consequences which includes; potential soil degradation, reductions in reservoir storage, flooding due to reduced river channel capacities, water eutrophication which leads to deterioration of lake or river health due to increased turbidity and pollution with pesticides and fertilizers. (Zyl and Lorentz, 2003). In many developing countries in the world today, the main causes of land use change are extensive land use for agriculture and physical expansion of urban area (Musa *et al.,* 2014). Although erosion rates associated with urbanization are much higher than from agricultural sources, these activities only occupy a small percentage of the land attributed to agricultural activities. Recent researches have indicated that over 70% of most agricultural lands have been affected by different types of soil erosion which is in itself a natural process at varying intensities and accelerated by vegetation clearing or overgrazing indicates that. It is increasingly accepted worldwide that natural resource conservation initiatives to control erosion should be linked to both soil (on-site erosion) and water (off-site sedimentation). Several countries have incorporated "Clean Water Strategies" into legislation, health and water programmes and most importantly agricultural policies (John, 2007, Zyl and Lorentz, 2003).

The management of land resources is the actual practice of the use(s) of the land by local human population to a sustainable level (Diyer *et al.,* 2013). FAO (1995) defines the many components of land resources management and they include; "*Land-use planning, as agreed between stakeholders; legal, administrative and institutional oversight; clearly defining the land areas in question; inspection and control of compliance with the decisions; resolving land tenure issues; settling of water rights; issuing of concessions for plant and animal extraction (timber, fuel wood, charcoal and peat, non-wood products, hunting); promoting the role of women and (other) disadvantaged groups in agriculture and rural development; and safeguarding the traditional rights of indigenous peoples*"

The realities of land degradation are not being factored by the current land planning and land management policies and models instead they are based on 'on methods' and overexploitation of natural

resources making them unsustainable (Diyer *et al.,* 2013). Thus sustainable land use must encompass all proper management of land components and attributes. To maximize the economic and social benefits from the land, appropriate land management practices has to be adopted that would enable land users maintain or enhance the ecological support functions of the land resources (FAO, 2009).

FAO, (2010) recently estimated that nearly 2 billion hectares of land worldwide, are already seriously degraded, some irreversible. Degraded land in Africa represents 16% which is roughly 494.2 million hectares with an annual monetary value of low agricultural production to the time of an $65million (Ezeaku and Davidson, 2008). In many temperate countries, for example, the United States of America (USA), before the adoption of sustainable land management, it was stated that an extremely high rate of surface erosion took place in historical times and this was as a result of rapid expansion of cultivated areas (Di Silvo and Basson, 2008). Although many attempts have been made to define its complex concept, it is a branch of the broad discussion of sustainable agriculture. Sustainable land management (SLM) has the potential of making very significant and lasting differences in the near future in most comprehensive manner. Food, fibre, water, industrial products and all essential ecosystem services and functions are derived from a rich diversity of natural ecosystems resources such as vegetation, water, soils and genetic diversity (FAO, 2004). However, these resources are being threatened as a direct result of the ever increasing needs of a growing population a rate of two percent per year. This would require the food production to double by 2030 to keep up with the population demand (FAO, 2008). Thus there is the urgent need to introduce best management practices and governance of land resources in response to its general decline in productivity of natural resources, one that is able to respond in an integrated manner and in a very systematic way to these challenges.

The aim of the study is to explore and review existing land management practices, typologies, characteristics and adopted considerations and their respective relation to the various agricultural activities in Nigeria.

2.0 Existing Land Management literatures

Maisharou *et al.*, (2015) reviewed and recommended strategies to strengthen the capacities of all stakeholders in the various Sustainable Land Management (SLM) approaches, practices and technologies in the Sahelian countries. Musa *et al.,* (2011*)* recommended that there is need for general policy implementation in areas with rapid changes in land use especially where agricultural lands are lost due to urbanization in Anyigba, Nigeria. Baig *et al.*, (2013) suggested ways by which rainwater can be harvested to improve the productive potential of the ecosystems and realizing optimum and sustainable yield at the same time conserving both land and water resources in Pakistan. Ebenezer, (2015) discussed the, remedy to drought and desertification, awareness programmes, protection of marginal lands, tree planting, sustainable agricultural practices and use of alternative energy sources to be implemented through the integrated approaches. Taimi (2008) concluded that expert opinions, field measurements, field observations, land user's opinions, productivity changes, remote sensing and modeling methods can act as a backbone for many approaches to assess land degradation at different levels, worldwide.

Ajadi *et al.,* (2011), identified that climate has little impacts on crop productivity and so other factors such as soil or farm techniques could be the source of variation in crop yield in Ilorin. It was recommended that for agricultural yield to be improved in Ilorin, the use of fertilizers and modern agricultural techniques should be employed. Hernando *et al.,* (2015) emphasize difficulties in determining the rainfall erosivity factor (R-factor) of the Universal Soil Loss Equation in without good spatial and temporal data coverage and therefore stressed the need for continuous recording rain gauges. Firuza *et al.*, (2015) explored the reasons behind the increasing agricultural activities at hillslope areas over recent years at northern part of Taraba, Nigeria while flatland areas still exists. It also investigated farmers' local-knowledge and perception as well as their socioeconomic influence on soil erosion within the study region.

Abrol and Sharma (2012) gave an appraisal on "Conservation Tillage" in the Peninsular and Central India. They concluded that greater focus on soil conservation efforts is needed because of projected high runoff and soil losses in the above stated region associated with global climate change. They also stated that the removal of Carbon dioxide CO_2 from the atmosphere and fixing it as beneficial organic matter in the soil can be achieved effectively through organic agriculture and includes photosynthesis by plant and management techniques by the farmer and by 2050, the global cereal production must be increased by approximately 50%. It was also discovered that 1990s, crop yields in sub-Saharan Africa and South Asia have either stagnated or declined because of the widespread use of extractive farming practices, soil erosion and other environmental problems and due to the ever rising population as well as rising standards of living, there is need to develop existing agricultural practices that would maximize agricultural production and also enhance ecosystem services.

Aswathy and Sindhu (2013) linked the changes in the rate of soil loss to the most prominent parameter crop and management factor (C) and erosion practice factor (P) of the Universal Soil Loss Equation (USLE) in which both are functions of land cover change, the ultimate result of urbanization. They stated that as natural physical landscape are used to expand urban related area, the water holding capacity of the soil decreases which increases runoff and subsequently, soil erosion. Abdulazeez *et al.,(*2014) revealed that poor knowledge of improved agricultural practices, inadequate supply of fertilizer, poor transportation, inadequacy of labour and credit, low produce prices and high cost of production are the major constraints in achieving sustainable crop management in Kwara State. They suggested the need for training programme on the use of appropriate sustainable practices which would help the farmers in adopting the best cropping systems. Ogban *et al.,* (2008) demonstrated that residue mulch, mixed with tilled soil or applied on the surface of tilled and no-tilled soil could help improve soil properties and increase cow pea growth and yields. The studies showed great significant growth of cowpea yield in tilled soil when compared to that of no-tilled soil. Recent researches have also shown that the desirable mulch rate for soil and water conservation in western part of Nigeria is about 4Mg/ha/season in which this this is due to decreased runoff and lower sediment concentration (Lal, 1998). Montenegro *et al.,* (2011) did a performance evaluation on the impacts of mulching on hydrological processes such as reduce runoff, soil losses and soil moisture and how it may be able to mitigate land degradation and buffer soil temperature variations in semiarid regions. Barton *et al.,* (2004) investigated the effectiveness of five treatments: no-tillage, polythene mulching, straw mulching, intercropping and the conventional tillage (control) as potential soil conservation measures to solving the erosion problem on subtropical Ultisols in Yunnan Province, China. They stated that straw mulching maintained topsoil structure and enhancing infiltration, thus providing a very effective way of reducing runoff and controlling erosion rate. Khan *et al.*(2016) assessed the erosional processes in mulched and un-mulched purple soils in the hilly areas of the Sichuan basin, southwest, China. They studied the effects using different simulated rainfall intensities with different slopes and it was discovered that sediment and water losses increased as rainfall intensity and slope steepness increases, furthermore, mulched soil maintained a higher infiltration capacity compared to un-mulched soil. Abui *et al.,*(2014) examined the implication of bush burning on agricultural crops and the environment as a whole. They further stressed the need for public enlightenment campaign and the involvement of all stakeholders including the Federal Government, Traditonal rulers and the public at large.

2.0 Existing Land management typologies at a global scale

The question of "by what criteria do we ought to type" comes to mind which leads to number of possible criteria for classification as stated by Gerald (1965), it was observed that there is a growing realization of studies carried out in underdeveloped areas, of which some of the accepted generalizations of development literature are not valid, therefore, there is the need to establish meaningful typology to actualize different economic models designated for different types of underdeveloped economies especially in Africa. Thus it was observed that most

attention have been focused on two other types of criteria includes the character of the export industry with sub classification (peasant agriculture, mining and plantation) and factor endowment characteristics with sub classification (land and labor)

Silva and Acheampong (2015) discussed the "ideal typology" of spatial planning systems and four major traditions were identified based on fifteen EU Member States and they include; regional economic planning approach, comprehensive integrated approach, land-use management and urbanism.

Soule (2001) compared the farm management of small family farms with large family farms based on soil nutrient and resources usage. The criteria commonly used for this farm typology includes gross sales, operator's primary occupation and other characteristics which could be associated with two practices; rotation with legumes and conservation tillage.

Dunk *et al.,*(2011) presented a typology of land-use conflicts for a peri-urban area of Switzerland. The meaningful types of peri-urban land-use conflicts were identified, namely Visual blight, Noise pollution, Health hazards, Nature conservation, Preservation of the past and Changes to the neighborhood.

Bidogeza *et al.,*(2009) developed a typology of farm households for Umutara Province Rwanda, socio-economic factors was emphasized to influence the adoption of new technology. The typology to this study was based on the following categories: farm size, education, risk perception and risk attitude, income, land ownership, personal attributes of head of household, and technological attributes.

3.0 Characteristics and associated adopted considerations

The knowledge of land characteristics is very important because of the limitations they impose on the use of land (Department of Natural Resources and Environment, n.d.) Thus these features are important in improving the level of management to overcome these limitations. Soil and land characteristics, together with the criteria used to assess them influence crop production and soil management (Webb and Wilson, 1995) thus land characteristics are grouped into topographic, soil physical, soil chemical, environmental and climatic characteristics.

Table 1: Land characteristics and related land qualities. Wilson (1984), Wilson and Giltrap (1984)

Land characteristics	Related land qualities
Topographic characteristics:	
Slope angle	Trafficability, workability, erosion hazard, harvesting efficiency, irrigability
Soil physical characterisitics	
Effective rooting depth	Water and nutrient availability, root penetrability
Penetrability (penetration resistance, packing density)	Root penetrability
Profile available water	Water availability, doughtiness
Soil wetness (or evidence of reduction, drainage class)	Supply of oxygen to the root zone, risk of waterlogging, water availability
Air-filled porosity	Supply of oxygen to the root zone, risk of waterlogging, ease of drainage
Stoniness	Workability, root penetrability
Rock outcrop	Hindrance to machinery and related management constraints
Permeability profile	Easy drainage, waterlogging risk, effluent absorption potential, leaching & water loss hazards
Penetration resistance in topsoils	Soil trafficability
Days with water content below plastic limits	Soil workability
Clays content and mineralogy of topsoils	Topsoil structural stability, arable sustainability, susceptibility to compaction and crusting
Soil chemical characterisitics	
Nutrients (P,K and S)	Nutrient supply
pH	Aluminum toxicity, nutrient availability
Salinity	Crop growth, slaking
Cation-exchange capacity	Buffering capacity, effluent absorption capacity
Organic matter	Structural stability, workability
Phosphorus retention	Structural stability, P fertilizer requirement

Environmental characteristics	
Flood return interval	Flood hazard
Erosion severity	Erosion hazard
Climatic characteristics	
Soil temperature	Crop suitability, yield
Frost severity	Frost damage
Frost-free period	Frost hazard, crop suitability, frost protection
Growing degree days	Crop suitability, yield, ripening
Chill period	Vernalisation, crop suitability, yield
Sunshine hours	Crop suitability, yield, ripening
Soil water balance	Water deficit, irrigation requirement, effluent, absorption capacity

4.0 The Nigerian Case

Nigeria is a large country located approximately between latitudes 4° and 14° north of the equator and between longitudes 2° 2' and 14° 30' east of the Greenwich Meridan (Ebenezer, 2015). It was said that the dry lands of the Nigeria forms a substantial part of the total land mass extending into the Sudano-Sahel, together with the neighbouring northern Guinea savannah. The Nigerian climate is characterized with two seasons; the dry and wet season with the highest average annual rainfall above 2,500mm, experienced in the southern part of Nigeria to less than 400mm, at some parts of the extreme north (Federal Ministry of Environment of Nigeria, 1994).

Generally, land use and management practices contributes to local, regional, and global climate changes, thereby affecting fauna and flora as well as the human health directly and indirectly (Adetunji, 2012). Thus it can be said to be the primary source of soil, water and land degradation. In many African nations, including Nigeria, land use is usually being characterized by a significant amount of land degradation and they are clearly stated by Brabier (1999). When there is decline in productivity, poor farming households abandon the existing degraded pasture and cropland and migrate into new land for cultivation and grazing. Brabier (1999) did further state that, often, the pattern of land use will often result into depletion of soil nutrients. Thus there is need for appropriate management practices have to be adopted.

Nigeria, just like any country in the sub-Saharan Africa are besieged by serious environmental degradation leading to desert encroachment, drought and soil erosion either due to wind impact or runoff from very high intensive rainfall resulting to soil loss (Igwe, n.d.). It was further stated that in the northern part of Nigeria, desertification and aridity are the main environmental challenges while high torrential rainfall creates enabling environment for catastrophic soil erosion in the southern region of the Nigeria. Many land development programmes and projects have evolved without any appreciation of the value of land use and land cover information (Atser *et al.,* 2014). Thus lack of facts of "what covers where" and "possible changes that may occur" by planners thereby resulting in uncoordinated development.

In South-eastern part of the country like Akwa Ibom state, the forests at Uwet Odot, Obot Ndom have suffered from land mismanagement (Ekpo, 2001). Land cover change leads to subsequent change in land use, therefore affected by socio-economic indicators such as agricultural productivity, rural income and wealth and education (Muller and Zeller, 2002). Despite the threat of desertification in the northern part of Nigeria, there isn't much studies about factors that determine the choice of land management practices over there (Agboola *et al.,* 2015) thus it is important to note that Nigeria has witnessed land degradation in terms of soil erosion, deforestation, ecological imbalance, and climate change as the result of unsustainable agricultural practices, thus, combating land degradation has become an urgent priority in global efforts to encourage commercial farming and ensure food security of millions of people. It was further stated that, factors such as household size of family, farm size and age are important considerations that influence the choice of land management practices in the North central. Adetunji (2012) reported that some South-Western States of Nigeria predominantly practice a farming system of shifting cultivation with mixed cropping and crop rotation. It was emphasized that education level influences the choice of land management practices in which investment on land encourages fallowing coupled with incorporation of crop residues. Abdulazeez *et al.,* (2014) emphasize the constraints faced by farmers in the use of sustainable practices in crop production in Kwara state, North central of Nigeria and they include;

Table 2: Constraints faced in the adoption of sustainable agricultural practices (Abdulazeez *et al.*, 2014)

Constraints to Use of Sustainable Practices	Likert Mean Score	Rank
Inadequate Fertilizer Supply	3.57	1
Non-availability of Labour	3.4	2
Non-availability of Credit	3.4	2
Inadequate Knowledge of Modern Technique	3.38	3
High Labour Cost	3.32	4
Problems of accessibility (Transportation)	2.96	5
High Cost of Water (Irrigation)	2.95	6
Low Produce Price	2.93	7
High Cost of Soil Management	2.75	8
Inadequate Improved Variety of Seed/Planting Material	2.63	9
Insufficient Availability of Land	1.98	10
Insufficient Agricultural Extension Services	1.78	11

With the rapid urban development in Nigeria in recent times, it is very crucial for the country to tackle subsequent land use problems such as rising cost of land, overcrowding, flooding, congestion, accessibility for land housing, slum formation among others (Aribigbola, 2008). Thus the need for effective urban land control and management so as to achieve the purpose of sustainable city development, health and safety. Lagos, Port Harcourt, Onitsha, Aba, Kaduna as well as other cities in Nigeria have been developing with the conventional land use approach, thus creating complicated urban problems such as slums, epidemics, congestion, unsanitary condition and all forms of pollution deteriorating the cities (Jiboye, 2005). Thus, tagging Nigeria to have the dirtiest cities that are least aesthetically pleasing and unsafe for living (Agboola *et al.*, 2002).

Recent research shows that Nigeria is currently using 30 to 34 million hectares of the available 83 million hectares suitable for cultivation, out of which 90 percent of it is accounted for by the Nigerian small-scale farmers (Oni, 2011). It was further stated by Oni, (2011) that Nigeria possesses tremendous agricultural potentials and they include: diverse climate favorable for agriculture, stretching from the densely forested humid south to the savannah vegetation zones of north and naturally fertile and irrigable land.

5.0 Existing Land management typologies (Nigeria)

Foli (2012) conducted farm characteristics based on constructed farmer typology in the southern and northern Guinea savannah zones of Nigeria in which the roles of legumes grains to improve soil fertility and crop production was understood. It was stated that the major differences that influenced type creation were total crop land, number of livestock, farm income and remittances. Senjobi and Ogunkunle (2011) assessed the extent to which land use types influences soil nutrients and productivity in Ogun State. The land use types were classified as follows arable cropping, oil palm, secondary forest and building sites.

Uchua, (2011) mapped and analyzed the agricultural systems in a part of the Lower River Benue Basin, Nigeria, the classification of agricultural systems was specially oriented to (a) based on the use of a farm management and farm household perspective and (b) based on the use of a framework for analysis, not only in the Lower River Benue Basin but throughout other river basins to improve agricultural productions and tackle food security and poverty reduction in the country.

Jake, (2011) researched on the sustainability of *fadama* (floodplains) farming systems of North Nigeria in which strong emphasizes was placed on socio-economic, institutional and demographic factors and typology of improvement were classified into eight types and they include;

(a) Type 1: Improved Financial measures
(b) Type 2: Improved use of non-renewable inputs and technologies
(c) Type 3: Improved use of available renewable resources (natural capital)

(d) Type 4: Intensification of single sub-component of farm system
(e) Type 5: Diversify by adding new productive natural capital and regenerative components
(f) Type 6: Social and participatory process that lead to organized group action for making better use of existing resources and development of new skills
(g) Type 7: Add value by processing to reduce losses and increase returns
(h) Type 8: Add value by direct or organized marketing of produce to consumers

6.0 Conclusion and Recommendation

Researches have revealed that a great proportion of occupation in Nigeria is land based which implies there is so much pressure on land, and majority of land users do not apply proper sustainable practices due to lack of awareness, socio-economical lifestyle of the people and lack of commitment from Federal Government of Nigeria. At present, as the population grows rapidly, the demand for food and urban expansion increases which is turning land into a relatively scarce commodity.

The following remedies is suggested;

- The first step in solving this issue is the creation of "Awareness", which can be done through government policies and programmes, public enlightenment organs such as National Orientation Agency (NOA), Ministry of Information and Agricultural Extension Service responsible for information dissemination and mass media because without awareness campaigns, knowledge and ideas may hardly reach those who are in need of it (Arpn, 2013). Awareness helps to curtail the negative effects of harmful practices that endanger the eco-system, increase environmental hazards, and endanger man and means of livelihood (agricultural). It serves as an appetizer or a stimulant that arouses all stakeholders interested to seek more information on the idea in the subsequent stages of the adoption process (Aprn, 2013).
- There is the need to adapt small scale, low technology land management practices to prevent erosion and desertification through community based approaches and this can by analyzing the factors influencing these decisions through typologies.
- Remote sensing technology has been a tool, improved rapidly to develop key sectors including agriculture, thus it will continue to be an important factor in improving the present system of generating agricultural information.
- Protection of marginal lands, planting of indigenous tree and shrub species, sustainable agricultural practices and use of alternative energy source. Bush fallowing can no longer guarantee sustainable use of land and so it is recommended that a transformational approach is required in the rural development.
- In the area of rapid changes in the pattern of land use and urbanization, which leads to high consumption and utilization of resources. It has been observed that land use management in the urban region appears to be uncoordinated and ineffective and there is need for an integrated land use approach reflecting current global thinking and approach.

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