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Research Article

Land Degradation and Its Occurrence in Nigeria: Drivers and Mitigation

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***Abstract*—** Land or soil degradation can be influenced by land use and land cover (LULC) changes brought on by both human and natural influences. One of the biggest environmental issues endangering the world's ecosystem is land degradation, which is more prevalent in developing nations. This review focuses on land degradation in Nigeria. Specifically, it provides evidence of land degradation in Nigeria, the sources and effects of land degradation in Nigeria, and potential solutions to land degradation in Nigeria. Process of land degradation mapping and assessment was discussed. It was demonstrated in this study that the application of remote sensing in monitoring land degradation is of high benefit, which is in its ability to offer cost-effective, timely, accurate, and dependable information on degraded lands. Although there is much literature on land degradation, technological advancements point to the necessity for a review that will capture the most recent advanced methodology used in identifying causes and assessing soil degradation. As a result, this review's importance cannot be overstated.

Keywords—Biophysical, deforestation, desertification, LULC, monitoring, satellite data

1. Introduction

Land is a non-renewable resource that provides space and the necessary materials for the growth of people and societies. Land is important in meeting all of humanity's basic needs, including food, housing, water, and oxygen [1]. It is also necessary for soil nutrient cycling, carbon sequestration, hydrological regime control, biodiversity preservation, and more. However, a significant portion of the planet's land—roughly 75% has undergone detrimental transformation or degradation due to persistent anthropological influences and natural causes [2]. Land degradation (LD) is the loss of biomass or decrease in land throughput over a long period caused by on-going spatiotemporal interactions between social and natural processes [3-5]. It affects humans and ecosystems differently [6].

Because land degradation modifies the earth's hydrological and biogeochemical cycles, it has emerged as a severe environmental issue threatening the planet today. Of course, the world population is growing, the environment is changing, and there are conflicting claims to land. Therefore, to support the global response to land degradation, it is necessary to encourage sustainable land-based initiatives [7]. Numerous international initiatives have been launched in this regard such as the United Nations Convention to Combat Desertification (UNCCD) [8]. Also, the Great Green Wall Initiative (GGWI) was established to restore one hundred million hectares of land across the Sahel by 2030. A similar effort is the African Forest Landscape Restoration Initiative [AFR100] [9]. Yet, continuous decline in the biological efficiency, environmental reliability, or anthropological worth of land remains a multifaceted issue [6,10].

Agriculture and natural resources provide the primary source of income for many rural residents in Sub-Saharan Africa; consequently, LD exacerbates their vulnerability to these sources of income [11]. According to Le et al. [4], 28 percent of Africans live on degraded land. Generally speaking, LD in the SSA is characterized by the gradual degradation of vegetation, the conversion of vegetated areas into barren or desert-like landscapes, and the disappearance of water bodies like Lake Chad. Correspondingly, there is high level of LD in with significant losses of agricultural productivity and a decline in biomass every year. This is primarily because cropland is more in demand [12], which causes land degradation [6].

Many scholars have conducted research on land degradation in Nigeria. However, a review that will capture the most recent state-of-the-art methodology for land degradation research is of great necessity. Thus, this study is of great significance. It is arranged in four sections with section 2 containing research method, Section 3 covers the results and discussion while Section 4 presents the conclusion of the research work.

2. Methodology

This paper presents a review, where different articles on land degradation were collated, analysed, and evaluated. First, a literature search was conducted through reliable electronic databases using explicit search terms to spot pertinent articles. The search term used include 'Land degradation' AND 'Land degradation mitigation' AND 'Land degradation in Nigeria'. Pertinent papers were cautiously chosen with consideration to ordered topics and the criteria for inclusion/exclusion of papers were formulated. Also, research materials that are not relevant to the subject matter were eliminated while others that are related to the topic were included with regards to their significance, reliability, and influence. Furthermore, the included papers were read exhaustively, reviewed in full detail, and examined. Subsequently, the significant information was summarized with respect to the search terms used in collecting the papers.

3. Results and Discussion

3.1 Drivers of Land Degradation in Nigeria

The entire ecosystem (e.g., soils, water, forests, croplands, and biodiversity) is impacted by land degradation. The factors that drive land degradation in Nigeria come in different degrees including low, moderate, and high (see Table 1). Furthermore, drivers of soil degradation comes under proximate and underlying factors [13] as presented in the ensuing subsections.

Table 1: The main factors of land degradation in Nigeria

Driver	Low	Mod.	High
Overgrazing			X
Land pollution			X
Increasing population			X
Urbanization			X
Mining			X
Unsustainable water usage		X	
Poverty			X
Rainfall pattern		X	
Subsistence farming			X
Commercial farming		X	
Expanding industrial areas	X		
Land tenure system		X	
Climate change			X
Limited financial resources			X
Poor financial management			X
Weak policy implementation			X
Poor cross-sectorial collaboration		X	
Lack of adoption of technologies			X
Political interference in land management			X

Source: Nigeria finishing report of the LDN objective setting plan, 2018

3.1.1 Proximate causes of land degradation

If certain factors have direct effects on land, they are referred to as proximate factors. Some of them are as follows:

i. Climate change

Climate change is a significant ecological problem our day [14]. It is evident and may continue to occur [15,16] due to both natural and man-made factors [17] in the form of excess emissions of atmospheric greenhouse gases (GHGs), such as carbon dioxide. Altering the spatiotemporal pattern of the climate parameters is one apparent way that climate change can influence the rate of land degradation. For example, El Niño events have caused droughts in the past [18]. This is because precipitation spells typically get drier during the El Niño phase [19]. The evidence of climate change occurrence in Nigeria is indicated in many studies (e.g., Abdussalam [20]; Abdulkadir, [21]; Ikpe, Sawa, and Ejeh [22]). Undoubtedly, the severity of drought in Nigeria is increasing due to climate change, particularly in the northern area. Furthermore, forecasts for the future show that droughts will become more commonplace as hydrological cycle is anticipated to change due to global warming (see Vicente-Serrano et al. [23]; Gonçalves et al. [24]). Nigerian droughts have several detrimental effects, such as decreased water availability and quality, crop failure and food scarcity, land degradation and desertification, etc.

ii. Land use and land cover

Land use refers to practical application of land by humans. On the other hand, many studies have shown that land cover means actual physical covering of the earth's surface (e.g., Homer et al. [25]; Chen, Sun, and Saeed [26]). LULC is the major cause of environmental alteration in Nigeria are. Some obvious examples include the transformation of forest to other usages, such as industrial use [27], mining, agricultural expansion, urbanization, and others [28]. Usually, this change influences Land degradation. In summary, human activities have consistently impacted LULC.

iii. Deforestation and forest degradation

Forests are very important as their vegetation significantly aid in sustaining the nutrient cycle and energy flow [29]. They also maintain soil and climate stability, control water flow, and promote sustainable agriculture. Unfortunately, both natural and man-made factors have a considerable impact on the structure and function of the forests [30,31]. Deforestation and forest degradation are among the biggest ecological issues in modern era [32,33]. A variety of activities like farming and industrialization are the main causes of it [34]. Another cause of deforestation is excessive wood extraction [35] for various uses.

The public's incomplete understanding of the effects of deforestation aggravates persistent deforestation in Nigeria [36]. Also, Nigeria has a very high rate of deforestation due to developmental projects; and the activities of the poor people living on the margins whose survival depends on the forests. This usually results to soil degradation in Nigeria because without protective vegetative cover, soil erosion becomes extremely likely to occur on lands or in soil.

iv. Overgrazing

When a piece of land's probable carrying capacity (PCC) is exceeded, it is said to be overgrazed. It is common in places where animal husbandry (see Figure 1) is carried out. This is prevalent in the northern Nigeria, which provides a large portion of the nation's livestock. Of course, the northern Nigeria houses the highest percentage of the cattle, goats and sheep, donkeys, camels, and horses in the country [37].

Figure 1: Cattle grazing in a field outside Kaduna, northwest Nigeria.

Overgrazing destroys natural vegetation causing desertification [38]. This occurs because the vegetation cover that shields the soil are usually removed in the process. Agriculture machinery and grazing animals can influence the soil structural deformation. Naturally, this effect can both increase the soil bulk density and decrease the soil porosity. In turn, soil compaction lowers the infiltration capacity and increases surface runoff [39]. Likewise, the combination of compacted soil and the reduction in vegetation brought on by overgrazing typically speeds up soil erosion. In conclusion, the amount of soil loss as a result of surface-water erosion can regulated by vegetation cover [40].

v. Mining

During mining, a sizable amount of Earth's materials are extracted [41]. Important minerals are typically removed during this process, and waste is disposed of on the job site [42]. This has caused disastrous effects on Nigeria ecosystems that are sensitive such as the forest, water, and soil. Similarly, degraded land produced by open-pit mining frequently cannot support biomass [43]. This is prevalent at various solid mineral mines in the North central region of Nigeria. Also, mine wastes can have a variety of negative effects [44] including loss of biodiversity, toxicity, air and water pollution, soil erosion, altered soil composition, and changed landscape beauty.

vi. Practicing unsustainable agriculture

Land degradation is influenced by agricultural practices [45] such as overstocking herds [46], extracting wood and charcoal [47], cultivating on steep slopes, contaminating water and land supplies, clearing land, and burning bush. Furthermore, burning bush is a common practice in Nigeria. This usually start uncontrollable fires, and areas that are prone to wildfires can experience significant soil erosion.

3.1.2 Underlying causes of land degradation

In general, the term "underlying causes" describes the intricate relationships between basic political, economic, social, cultural, and technical courses that frequently exist far from the areas in which they have an impact. Some of the major underlying sources of LD in Nigeria are poverty, population growth, and urbanization.

i. Poverty

The connection concerning poverty and LD appears to be understudied, especially in Africa where the topic is hotly contested [48]. This relationship is an extremely intricate phenomenon. The reason for this is that poverty both causes and is influenced by land degradation. This is especially true for the rural population. This most impoverished segment of our society lives, for the most part, on degraded land. Due to the traditional nature of farming systems and an over-reliance on favourable weather conditions, many farmers in Nigeria typically produce low amounts of crops. To supplement their output and incomes, most of them thus turn to felling trees and other vegetation for fuel wood. By and large, there is evidence in the literature to support the likelihood of links between poverty and land degradation. However, no strong quantitative research on the prevalence and degree of poverty has been conducted in that regard [49].

ii. Population

The capability of the land to offer the ecosystem services will undoubtedly be diminished by an expanding population if appropriate land management is not implemented. There is no doubt that the spread of agriculture to sensitive areas, and the reduction of fallow periods of cultivated plots in Nigeria can be influenced by population pressure [50]. The loss of biodiversity is influenced by the unprecedented urban encroachment into natural biomes and agricultural areas [52,52]. However, research has shown that population pressure promotes agricultural growth, land productivity, as well as institutional and technological innovation, all of which slow the natural resources depletion.

iii. Urbanization

Urban areas usually offer jobs' prospects and means of livelihood that are different from agriculture but require the conversion of land for housing [53]. The pressure on land for competing uses, such as housing and infrastructure development has increased due to rapid urbanization [54] Land degradation usually results from the excessive strain on land use from urban sprawl [55] and industrialization.

3.2 Effects of Land Degradation

In Nigeria, LD is a serious problem that affects many areas and has numerous related effects. It is causing widespread soil erosion, a loss of biomass, land pollution [56], and others. Selected effects of land degradation are discussed as follows:

i. Soil erosion

Soil erosion is a main ecological issue that confronts almost everywhere in Nigeria. The major types are those by water [57], wind [58], and harvest erosion. Soil erosion primarily results from deforestation [59], overgrazing [60], and mining. When forest vegetation is cleared, the soil is exposed to high rainfall, which results in sheet erosion. Also, when vegetation in the northern region of Nigeria is cleared; soil particles is lifted and carried away by the wind, causing wind erosion.

Gully erosion is the most damaging kind of soil erosion [61] in Nigeria (see Figure 2). It result to damage of agricultural lands, homes, highways, pipelines, and roadways [62].

Figure 2: gully site in Auchi, Edo State. Source: Airenakho [63]

In the highly populated sections of the country, excessive agriculture and grazing have exposed and depleted the soil, which results to severe incidences of gully erosion. Generally, the soil erosion decreases soil structure and fertility.

ii. Loss of arable land

In the course of construction, the soil is often degraded through the loss, mixing, and compaction of the topsoil and subsoil [64]. Creating trenches and hollows throughout the excavation process to get building materials makes the land unusable for cultivation. The area is unsuitable for any productive use, including farming or raising cattle, because of the changes in the terrain brought about by building activity. It has been shown that as a result of the loss of arable land, fewer farms are producing enough food to sustain everyone (see Oluwatosin et al. [65]).

iii. Low agricultural production

Low crop yields are the result of improper agricultural practices [66]. Since agricultural productivity slowly declines with intense cultivation, this has an impact on the farmlands' production as well. When soil salinity rises and land degradation occurs, crop yields also decrease [67]. Neglecting the soil results in low soil fertility and, consequently, low agricultural output since the soil is not safeguarded.

iv. Poor land quality

Large swaths of land in metropolitan centres are overpopulated [68], which has resulted in low land quality. Lands covered with waste materials, metal scrap, plastics, packaging debris, and building debris are not fit for the optimal use [69] that such property should have. Due to the occupation and damage caused by land pollution, the quality of such lands is low.

v. Desertification

The term desertification defines land degradation caused by various activities in arid, semi-arid and sub-humid regions [70]. Nigeria is currently suffering rapid desertification with substantial effects on the northerner region [37]. Various estimates on the extent of desertification in Nigeria are in the literature. For instance, the global desertification map show that almost 15 percent of Nigeria's land is prone to desertification [71]. Furthermore, Olagunju [37] show 15 desertification frontline states in Nigeria accounting for almost 63.83% of the country. Similarly, Bashiru [72] showed 11 desertification frontline states in Nigeria (see Figure 2).

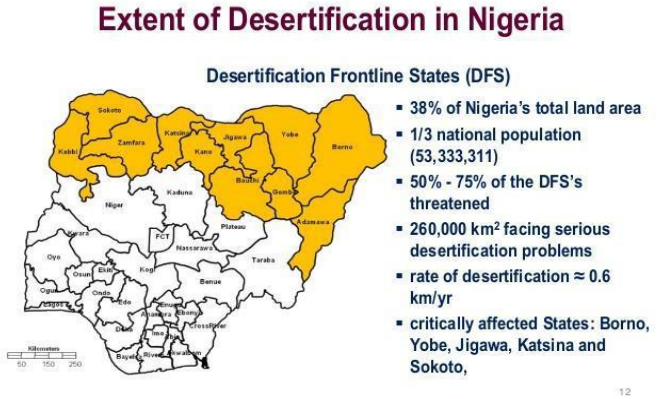

Figure 2: Desertification map of Nigeria. Source: Dogara Bashiru [72].

Information in various reports indicate the rate at which desertification in northern Nigeria progresses is about 0.6 km annually. Of course, approximately 350,000 ha of land are being lost to desert encroachment every year [73]. This desert encroachment is moving aggressively southwards. Desertification is increasing in Nigeria and has become a threat to the nation's economy [74]. Among other negative effects, it reduces biological variety, increases the burden of illness, modifies the geochemical makeup of the soil, depletes water supplies, lowers agricultural production, increases food insecurity, and slows down economic progress.

3.3 Mapping and Monitoring Land Degradation in Nigeria

The conventional methods for assessing land degradation rely on extensive fieldwork, feature estimate, supplementary data processing and eye observation, which make it difficult since it requires a lot of work, time, and money. The Revised Universal Soil Loss Equation (RUSLE) and other empirical models are used to estimate land degradation in this instance. For example, Borrelli et al. [58] mapped the potential rates of

soil erosion worldwide at 250m spatial resolution using the RUSLE empirical model. RUSLE has some intrinsic drawbacks, including being localized, time-consuming, and laborious, despite its high accuracy. Nonetheless, it is now simpler to do evaluate LD at various scales with high levels of accuracy using satellite remote sensing. In other words, mapping and monitoring LD currently relies on remote sensing applications (see Dubovyk [75]; Reddy et al. [76]; Ahmad and Pandey [77]). Remote sensing is used to gather data about an object, region, or phenomenon by observing how electromagnetic (EM) radiation interacts with the object, region, or phenomenon. The remote sensing system has a many spectral, spatial, and temporal characteristics. As a result, Earth may be observed in real-time as well as in the past and present. While in-situ research necessitates the use of

more resources and is frequently conducted at the field level, remote sensing provides an affordable evaluation over wide areas. Remotely sensed imaging is a great tool for collecting numerous images of the earth's features at intervals that are likely to correlate to changes in land use or the environment since it is widely available and has reasonably high spatial and spectral resolutions. Because of its extensive image collection, which extends back to 1972, remote sensing has thus emerged as the primary instrument for visualizing events and their extent as well as for aiding in the analysis of historical trends.

The majority of biophysical indicators of land degradation are related to soil qualities [78], such as fertility, productivity, compaction, and soil loss; erosion, such as sand shifting over fertile soils, river turbidity and sedimentation, soil loss, and incidence of gullying; land cover, such as LULC alterations; and landform, such as elevation. The spectral characteristics of the target features determine how these indicators are mapped using remote sensing. For example, spectral reflectance values and soil erosion are closely associated [79], making it possible to map and identify the features and severity of soil erosion. Of course, the soil variables such as mineral composition, soil texture, soil moisture, and organic matter content can significantly impacts the spectral fingerprints of bare land that characterize soil erosion and its intensity. Furthermore, the spectral curves of sandy and clay soils differ [80], indicating a clear correlation between soil texture and the observed discrepancies. When compared to clay, sandy soils exhibit a significant reflectance in the visible and near-infrared regions of the EM spectrum due to their bigger particles and often drier nature. Conversely, clay is smooth and fine and absorbs the majority of light that enters it. Additionally, a higher degree of soil organic matter results in a darker appearance, which lowers spectral reflectance. Conversely, lower degree of soil organic matter causes a higher spectrum reflectance since it increases soil albedo. Organic matter is therefore a reliable marker of soil deterioration.

It is possible to track plant dynamics and their spatiotemporal variability using a variety of satellite imageries (see Xu et al. [81]) due to vegetation spectral features. For detection and mapping, vegetative spectral indices take advantage of the correlation between the spectral reflectance values and the land cover characteristics [82]. Thus, vegetation indicators can show whether or not there is biomass in the vegetation. The presumption of bareness or a lack of vegetation denotes soil erosion. More people use NDVI (Normalized Difference Vegetation Index) than any other vegetation index. Its value is a number between -1 and +1, where places with light vegetation have a lower value and areas with dense vegetation have higher values. Using the NDVI, the degree of land degradation have been determined as demonstrated by many studies. For example, Le, Nkonya, and Mirzabaev [4] computed the global NDVI from 1982–2006 and utilized the information to predict the loss in biomass production. They made use of information from AVHRR-derived Global Inventory Modeling and Mapping Studies (GIMMS). The preference for the dataset stems from its ability to account for the impacts of atmosphere and rainfall.

4. Conclusions

This review sheds light on the cause for and effects of land degradation in Nigeria. Generally, it would be feasible to identify regions with degraded land for focused mitigation efforts that require urgent policy attention at various geographical scales if spatially explicit information on degraded land and the causes of land degradation are made available.

This work has demonstrated that trends seen from remote sensing studies can show land deterioration in Nigeria. With remote sensing imageries, one can identify areas where vegetation have reduced or disappeared due to the reduction in soil moisture content brought on by a protracted drought. Satellite data is more important for mapping, evaluating, and monitoring land deterioration at various geographical and temporal dimensions. Naturally, remotely sensed data offer cost-effective, precise, and fast information about degraded areas at certain intervals.

Data Availability
No applicable.

Conflict of Interest
None.

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Authors' Contributions
T.U.O. carried out the studies.

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