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Research Article

Impact of Changes in Land use and land cover on Agricultural Productivity in Northern Nigeria

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Abstract
The challenges posed by changes in land use and land cover are greatly affecting agricultural productivity in the semi-arid region of Nigeria. Land use and land cover change affects ecosystem functions and services, which leads to land degradation and in turn reduces agricultural productivity. The research studies the impact of the changes land use and land cover have on agricultural productivity and the factors inducing the changes. To accomplish this research, remotely sensed information were collected and processed for the year 1990 (The Landsat Image), 2005 and 2021 (Landsat Enhanced Image). The result of the classification shows 6 classes of land use and cover were obtained. The research results indicates a reduction in the landmass covered by scrub, marshland (wetland) and water body, whereas areas covered by cultivated land, settlement, and bare surface/dunes increased, from the year 1990 to 2020. Increasing lands occupied by cultivated land, dunes and settlement were predominantly as a result of changes in climate resulting from a movement of dunes from the Sahara desert southward, overgrazing, and over cultivation. Consequently, over cultivation and overgrazing exacerbate land degradation, which impact negatively on agricultural productivity. Based on the research findings, appropriate measures should be employed to incorporate climate smart agricultural practices for environmental sustainability.

Keywords: *Climate change, Climate smart agriculture, Land use & cover change, environmental sustainability*

Introduction

Modification of natural environment into the built milieu such as settlements and the management of semi-natural environment including managed woods, arable fields, and pastures is known as land use. (Lucas et al. 2019). Also, Garba and Brewer, (2013) describes land cover as the physical environment on the earth surface, such as bare ground, grasses, water, trees, etc. Modifications in land use and land cover are very important driver of environmental change (Lambin et al, 2001; Lambin et al, 2006). Alterations in the arrangement and organization of land use and land cover affect flora and fauna, climate, biogeochemical cycles, human livelihood, and agricultural productivity (Vitousek et al., 1997). In addition, the modifications in land use and land cover, negatively impacts on the environments and agricultural production at local, regional and global scales (Kasperson et al., 1995). Scientific studies have revealed that few landscapes on the earth surface are currently in their natural state, as a result of human activities such as farming activities and climate change (Cordonnier et al, 2017). Therefore, the unsustainable land use has a deep effect on the natural environment and agricultural productivity (Wijitkosum, 2016). The rate of increase in the pollutions, soil degradation and desertification are the result of land use and land cover changes. Biodiversity is high on the land that is quite untouched, and low on land that is intensively used including, deforested land, farmland, urban centre, etc. (Ellis, 2011). Deforestation is the major contributing factor to

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land use change in the tropics resulting to high carbon dioxide emissions and low crop yield in the tropics in since 1990s. The amount of carbon emission ranges between 0.6 and 2.8 Giga tone of carbon (Gtc) per year (UNFCCC, 2019). Thus, changes in land use/land cover determine the susceptibility of farmers and their farmlands to socio-economic perturbations (Lambin and Geist, 2016). Moreover, the alterations on the land use/cover result in land degradation, which alters the environment services and disturb the ability of biotic systems to support human needs (Lambin and Geist, 2016). Therefore, the predominant environmental problem in the Sahel region of Nigeria is land degradation resulting to reduction in agricultural productivity (Eze, 2018).

Studies have shown that land use and land cover change, land degradation and climate change remain inseparably connected through feedbacks between land degradation agricultural production and precipitation (Eze et al. 2020; IPCC, 2019; Odjugo, 2015). Increase in occurrence and severity of climate change tends to escalate land degradation and reduction in agricultural productivity (IPCC, 2014). Eze et al (2022) argues that through the modification of weather and climatic element resulting to climate change may worsen the agricultural productivity and land use and land cover change. On the other hand, carbon dioxide induced climate change through the release of carbon dioxide from bare and dead vegetation and reduction of the carbon sequestration potential of bare land, aggravates low agricultural productivity (Eze et al 2022). The consequence is predominantly poor agricultural productivity, increased greenhouse emission into the atmosphere, and continuation of a cycle involving climate change (IPCC, 2019).

In the semi-arid region of Nigeria, the demand for the limited cropping and grazing land and its resources by the rural farmers, compounded by incidences of droughts, desertification and the influx of migrants, particularly, herdsmen which have resulted in continuous low agricultural productivity and over-exploitation of ecological resources (Eze, 2018). The over-exploitation of the surroundings has degenerated into land degradation and food insecurity (Yusuf, 2014). Consequently, land degradation has, in turn, worsened the problem of desertification. The pressure of continuous cropping and migrating herdsmen and their populated livestock have led to exhaustive use of the delicate dry land environment resulting in further degradation, poor agricultural productivity and food insecurity even through time of regular precipitation (Olagunju, 2015). Thus, there is a need to adopt climate smart practices for managing renewable resources in the dry land environment and minimize reduction of non-renewable resources, to achieve food security and ecological sustainability. Environmental sustainability is described as the ability to sustain the rates of the return of renewable resources, waste creation, and reduction of a non-renewable resource without going beyond the rate of reinforcement, and adaptation capacity of the surroundings.

Scholars have carried out researches on land use and land cover at local, and regional level in different parts of the world. The research studies are predominantly on the impacts of land use and land cover change on soil erosion (Wu &Tiessen, 2002; Lambin et al, 2001), soil degradation (Lambin et al, 2006; Vera et al 2007), soil quality (García-Ruiz, 2010; Liu et al 2010), biodiversity (Wang et al, 2012 Wijitkosum, 2012;). Little or no work has been done on the Impact of Land use and land cover change on Agricultural Productivity in the semi-arid region of Nigeria. Food and Agricultural Organization (FAO) indicates that it is important to understand the link between land degradation, agricultural productivity and land use and land cover change. The research outcome will guide the lawmakers in making rules that will improve sustainable forms of land use (FAO, 2022). Moreover, the understanding the main drivers of land use and land cover change is crucial for land use planning (Kleemann et al 2017). Against this background, this research assesses the Impact of Land use and land cover change on Agricultural Productivity, to come up with the strategies to conserve land resources in the semi-arid region of Nigeria.

Materials and Methods

Yobe State as a case study, is one of the States in the north-eastern Nigeria It is found on latitudes 10°30'N to 13°25'N and longitudes 9°35'E and 12°30'E. The area of study is semi-arid, characterized by dry and wet seasons. The duration

of dry season starts in November and end in June (8 months) while rainy season starts from July and ends in October (4 months). The rainfall amount in the study area per annum is less than 600mm, while the mean annual temperature is about 28^{o}C (Eze, 2018). Evapotranspiration in the study area constantly exceeds the rainfall amount. The area of study is in Sahel savannah vegetation, with the southern part under Sudan savanna. Agriculture is the major activities of the inhabitants in the area. However, area is susceptible to land degradation. Therefore, the dwellers and their source of revenue are susceptible to land degradation (Eze et al, 2022).

Data collected were for the year 1990 (The Landsat Image), 2005 and 2021 (Landsat Enhanced Image), Image processing was carried out to derive classes of land use and land cover using software on Earth Resource Development Assessment System (ERDAS). A geometric correction was performed to reduce the distortions required for image matching in the case of the multi-date images used. False-colour composites of all the satellite images collected were created and imported from ERDAS format into an Integrated Land and Water Information System (ILWIS) format for classification. Supervised image classification was carried out to produce the six distinct land use and land cover classes using the Maximum Likelihood method. The classes are settlement, bare/dunes, cultivation, marshland (wetland), water-body and scrub land.

Results and Discussion

Table 1 shows the statistics of the 6 classes of land use and land cover occupied in kilometre squares and in percentages. In 1990, scrub land occupied 20537.5km^2 (45.14 %), cultivated land 9736.4km^2 (21.40%), bare/dune 7060.6km^2 (15.52%), marshland (wetland) 5362.6km^2 (11.78 %,), water-body 1609.9km^2 (3.54%) and settlement 1194.3km^2 (2.62%). In 2005, scrub land occupied 17305.2km^2 (38.1%), cultivated land 12654.6km^2 (27.8%), bare/dunes 8417.5km^2 (18.5%), marshland/wetland 4055.4km^2 (8.9%), water-body 1336.4km^2 (2.9%), and settlement 1733.2km^2 (3.8%). In 2021, scrub land occupied 10471.6km^2 (23.01%), cultivated land 17108.1km^2 (37.6%), bare/dune 10861.9km^2 (23.92%), marshland (wetland) 3153.5km^2 (6.94%), water bodies 1113.5km^2 (2.41%) and settlement/ residential houses 2792.7km^2 (6.1%)

Figure 5 is the Synopsis of variations that happened on land use/land cover within the study area. The degree of increase/reduction from 1990 to 2005 in scrub land was -7.10%, cultivated land was 6.40%, bare/dune was 3.00%, marshland (wetland) was -2.90%, water-body was -0.60% and settlement was 1.2%. The rate of increase/decrease between 2005 and 2021 were -15% in scrub land, 9.90% in cultivated land, 5.30% in bare/dune, -2.0% in marshland (wetland), -0.50% in water-body and 2.30% in settlement. Also the rate of expansion/reduction between the year1990 and 2021 were -22.2% (scrub land), 16.4% (cultivation), 8.6% (bare/dune), -5.1% marshland (wetland), -1.3% (water-body) and 3.7% (settlement) (Figure 5). Thus, the peak of expansion happened on cultivated land while the maximum reduction occurred on scrub land in 1990/2005, 2005/2021 and 1990/2021. On the other hand, the smallest expansion happened on settlement and the smallest reduction occurred on water-body in 1990/2005, 2005/2021 and 1990/2021 (Figure 5).

The research results have shown that there have been important changes in the land-use and land cover in the study area. The changes particularly between the year 1990 and 2021, in bare/dunes, show that the rate of increase is very high. bare/dunes covered 15.54% of the total land area in 1990. Also, bare/dunes have increased from 15.54 to 18.5% in 2005 and then, increased to 23.9% which has covered about one-third of the total landmass in 2021. Therefore, indicating a high rate of land degradation particularly desertification in the study area. Additionally, scrub land which covered the largest part of the total land area in 1990 has reduced considerably to become the 3rd largest after cultivated land and bare surfaces in 2021. The area occupied by built-ups/settlement in 1990 was more than doubled in 2021. The areas covered by farmland and bare surfaces nearly increased twice from 1990 to 2021. Also, the areas covered by marshland (wetland) and water-body from 1990 to 2021 indicate a slow and continuous decrease. These changes that have happened between 1990 and 2021 could be credited to different factors such as overgrazing, climate

change, increase in farming activities, increasing deforestation, increasing demand for shelter, increasing use of marshland (wetland) and a southward movement of dunes. IPCC, (2014) states that, as severe weather events rise in occurrence and harshness due to climate change, land degradation tends to increase. Also, Eze et al, (2022) argues that climate change might worsen land degradation through changes in spatial and temporal pattern in rainfall, temperature, solar insolation, and winds. On the other hand, land use & cover change exacerbate carbon dioxide induced climate change through the release of carbon dioxide from unoccupied/dead vegetation and reduction of the carbon sequestration potential of degraded land (FAO, 2017). Moreover, more than 654 million people in African continent are predominantly farmers and mostly depend on rain-fed agriculture (Eze et al, 2022). Water scarcity and land degradation is already affecting the Africa continent, which will be further exacerbated by overgrazing, deforestation, over-cultivation etc (FAO, 2017). Thus, socio-economic and cultural forces such as high population growth, overgrazing, migration, poverty, deforestation, and weak tenure system result to changes in the natural milieu (Agyemang, 2012). Moreover, increasing agricultural activities, climate variability and bush fires contribute to land use & cover changes (Eze et al, 2020). Also, Lambin et al (2021) argue that enhancing household financial opportunities also facilitate land use & cover changes. The land use & cover changes are indication of increasing human pressure on dry land resources, unsustainable agricultural practices and the effect of physical factors on the environment, resulting from climate change, increasing dunes, increasing droughts occurrences, increasing farming activities, overgrazing, over-cultivation and deforestation (Eze, 2018). Consequently, the increase in bare/dune, cultivated land, and decrease in scrub lands, water-body, and marshland (wetland) has exacerbated environmental unsustainability, leading to desertification in Northern Nigeria.

Conclusion

Land use and cover have shown substantial changes between 1990 and 2021 on settlement, cultivated land, scrub land, water-body, marshland (wetland), and bare/dunes. On the other hand, settlement, bare/dune and cultivated land, showed an increase in the landmass between 1990 and 2021. Therefore, cultivated land recorded the highest increase in terms of land mass, while scrub land recorded the highest reduction in land mass. Thus, factors that result to land use and cover includes increasing human pressure on the land resources, and physical factors such as increasing droughts, dunes, farming activities, overgrazing, over-cultivation etc. Consequently, these changes have exacerbated land degradation, resulting to poor agricultural productivity and food insecurity in Northern Nigeria. Based on the research findings, appropriate measures should be employed to incorporate climate smart agricultural practices for environmental sustainability.

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Table 1: Land use and Land cover Statistics (sq.km) from 1990 to 2021

Rank	LULC CLASS	1990	2005	2021	% change 1990/2005	% change 2005/2021	% Change 1990/2021
1	SCRUB LAND	20538.5 (45.14%)	17305.2 (38.1%)	10471.6 (23.01%)	-7.1%	-15%	-22.1%
2	CULTIVATION	9736.4 (21.40%)	12654.6 (27.8%)	17108.1 (37.6%)	6.4%	9.9%	16.2%
3	BARE LAND / SAND DUNE	7060.6 (15.52%)	8417.5 (18.5%)	10861.9 (23.9%)	3.0%	5.3%	8.4%
4	MARSHLAND (WETLAND)	5362.6 (11.78%)	4055.4 (8.9%)	3153.5 (6.9%)	-2.9%	-2.0%	-4.9%
5	WATER-BODY	1609.9 (3.54%)	1336.4 (2.9%)	1114.5 (2.4%)	-0.6%	-0.5%	-1.1%
6	SETTLEMENT	1194.3 (2.62%)	1733.2 (3.8%)	2792.7 (6.1%)	1.2%	2.3%	3.5%
	TOTAL	45502.2 (100%)	45502.2 (100%)	45502.2 (100%)			

Source: Source: Fieldwork 2023 (Computed by the author)

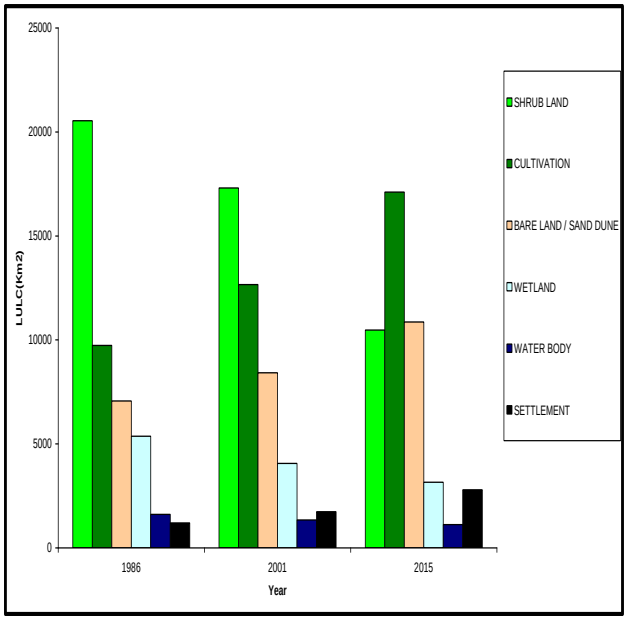

Fig 5: Synopsis of Land Use and Land Cover Change (sq.km) from 1990 to 2021 (*Source: Fieldwork 2023)*