

Monitoring the Proportion of Degraded Land over the Total Land Area of Gombe State, Nigeria

Ishiyaku Abdulkadir, J. Satish Kumar

Abstract: Land Degradation is a complex field of study because it's characterized by participation of climatic, ecological, geographical, and social fields of study. It pointed at long-term decline of natural productivity of land from the processes of climatic variations and unsustainable man-environment relationship. It's therefore vital to monitor this phenomenon to inform decision making in providing mitigation measures to ensure sustainable land use. It's in that regard, that this paper aim to assess the implementation of SDG target 15.3, to determine the extent of degraded area in Gombe State for the period of 2001-2015. The research was conducted in Trends.Earth tool where ESA-CCI land cover, AVHRR/MODIS, and soil grid datasets were used for separate change detection analysis of land cover, land productivity and soil organic carbon Stock respectively. The information from the three sub-indicators were combined and derived the degraded land area. The result appears that the extent of degraded land occupied 12,248.8 sq.km traced to about 68.3% of the state land area. Areas with stable condition account for 4,180.4 sq.km equivalent to 23.3% of the state area. The extent of land areas with improved conditions covered 780.9 sq.km represent 4.4% of the state land area and water body covered 718.7 sq.km with 4%. The paper recommend nature-based solutions to reverse and restore part of the degraded land for better ecosystem services.

Keywords: Sustainable Development Goals, Land degradation, Land cover, Land Productivity, Carbon Stock, Trends. Earth

I. INTRODUCTION

In January 2016, 17 sustainable development goals, 169 targets and 232 indicators entered into force toward a sustainable future for all. The SDGs address number of topics, attributed to economic development, social perspective and sustainable environment to ensure success by 2030 [1]. SDG Target 15.3 aim to attain a land degradation neutral world. However SDG indicator 15.3.1 (aim to determine the proportion of land that is degraded over the total area) was adopted as part of the instruments to measure the achievements of target 15.3 [2].

Land Degradation comprise of different interconnected field of study integrating: climatic, ecological, geographical, and social views [3]. There are number of definitions of land degradation by scholars like [4, 5]. In this paper, it is define as long-term decline of land primary productivity from a process or combined processes of climatic variations and unsustainable man-environment relationship in a way the land cannot recover unaided. There are argument concerning the drivers of this phenomenon [6, 7, 8, 9] attributed the phenomenon to inappropriate land use patterns.

Revised Manuscript Received on March 15, 2020.

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[10, 11] pointed that human activities have greater significance in its expansion, on the other hand its reverse is significantly by climate change [11]. It is also organized universally that away from climate change, human induced factors are the major driving forces in the mishandling of the environment through deforestation, excessive grazing, constant and consistent farming [12, 13, 14, 15, 16, 17].

Deforestation is one of the global environmental problems resulting from unsustainable man-environment relationships for the purpose of urbanization, agriculture, mining, logging, road and dam construction etc. This phenomenon is responsible for other environmental problems (flooding, irregular heat balance, disturbed water budget and weather cycles etc.) because ecosystem balance is being abused at various scale

The 30 set-aside forested areas in the Gombe state are largely depleted by various land use exposing the soil to an accelerated erosion, the forest reserves exist only on the map, instead they are depleted overtime for other functions [18], the proportion of forested land area in the state between 1990 and 1996 stood at 15%, 11% in 2001 and 9% for 2004 and 2006 [19], 9.1% in 2016 [20]. This percentage is quite low and below the recommended 25% of international standard [21], because of exploitation for the purpose of cultivation, search of fuel wood, urbanization, intense grazing, and bush burning either for farm clearing or hunting [22]. There is widespread dependence on fuel wood for cooking and financial gains from the business in the state. It was reported that about 35-40 loaded pick-up of fuel wood are being conveyed to the urban Gombe daily, as source of energy for domestic use [22].

Intensive farming activities affect physical and chemical content of soil in a way that farmlands that undergo continuous farming activities without proper managements experience a decline in the soil fertility because of over utilization [23], even in the areas with abundant rainfall [24]. The carbon stocks in the natural forest range between 7906-9510 gCm⁻² while the soil that undergo excessive farming had about 1978-2822 gCm⁻², this can be traced to about 70% lower when compared to that of the natural forest [25], the environment responds to these changing conditions from human manipulations [26], by making a condition that adapt the continuous processes in space and time. It's in this context, that this research aimed to determine the proportion of degraded land over the total land area of Gombe State.

II. MATERIALS AND METHOD

A. Study Area

Gombe State, is referred to as "Jewel in the savannah", was created on 1st October 1996, from the former Bauchi State.



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The state is found in the northern Nigeria. Gombe State is bounded by Yobe state to the north, to the south by Adamawa and Taraba states, Bauchi state to the west and to east by Borno state. It has eleven local government areas with the state capital in Gombe. The climate of the state is under the influence of two air masses: (1) Westerlies air masses are wet and humid and brings wet season during April and October, with an average rainfall of 850mm. (2) Easterlies air masses blow across Sahara desert, its dry and introduce harmattan and dry season between November and March, with annual temperature of about 32°C. The alternation of these seasons is triggered by seasonal shift of inter-tropical discontinuity zone (ITD) between the two air masses. The soil of the state consists of sandstones, clay and silt, and vegetation that is characterized as savanna woodland with unevenly distributed shrubs and trees. However, the vegetation is being modified by various human activities, including, bush burning, excessive cultivation, overgrazing and urbanization. The state has population of 2,365,040 people [27].

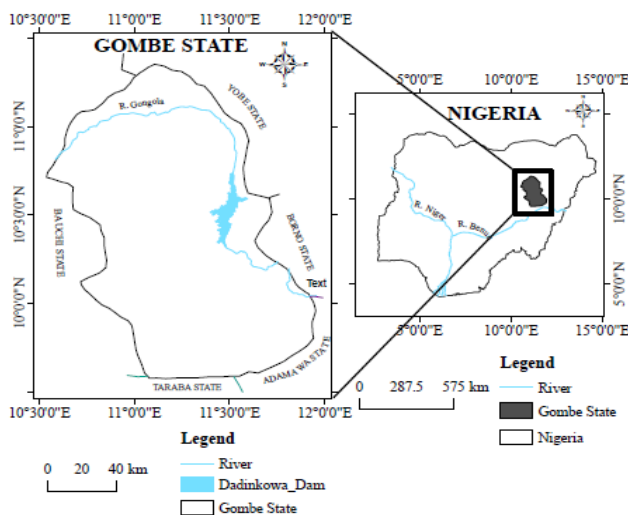


Fig. 1: Study area Gombe state

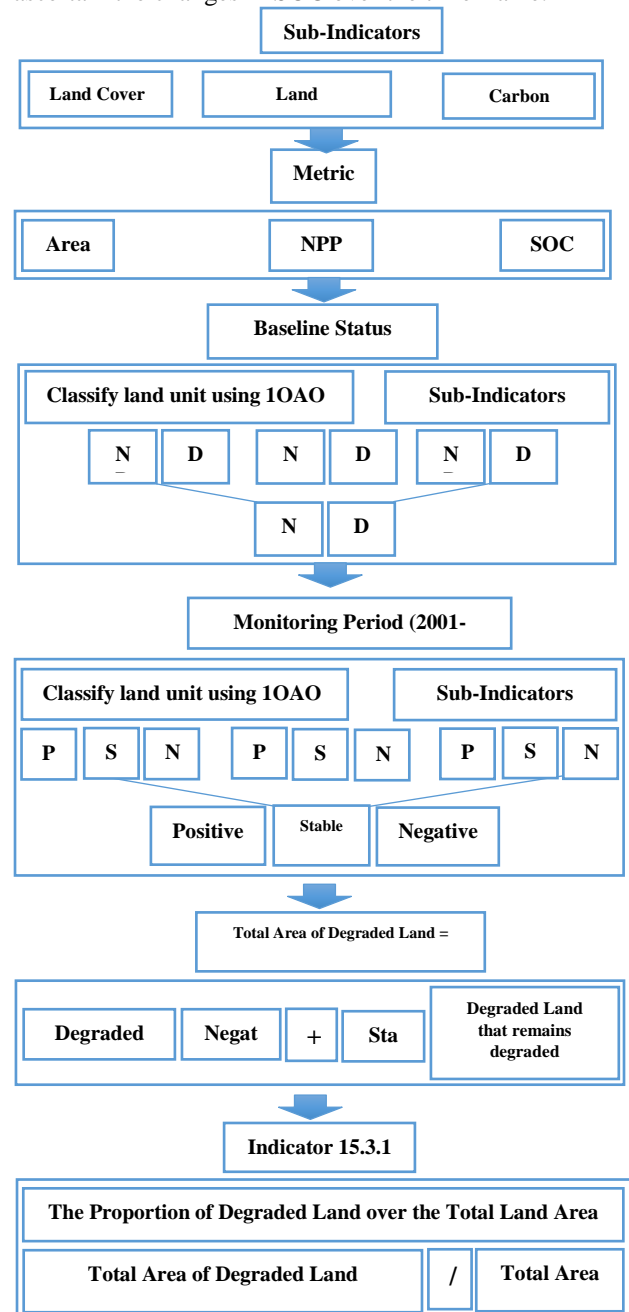
B. Methodology

The whole research work was conducted in Trends.Earth tool, an extension of QGIS Software for the monitoring land trends using earth observations in a cloud based system. Assessing the key Land conditions involves evaluation of three sub-indicators separately which would later be combine together to determine the degraded area. Baseline of 2001-2015 was used to analyze the initial status of the sub-indicators and identify areas degraded or not degraded conditions.

- **Land productivity** focus on the differences in the wellbeing and gainful potential of the vegetation and speaks the net impacts on plant and biomass generation from changes in ecosystem. Land productivity is computed using Earth observation datasets (AVHRR/MODIS) for net primary productivity to determine areas with declining greenness as an early sign of degradation. NDVI is the surrogate of NPP which applied red and near infrared portion of the electromagnetic spectrum to identify changes in the wellbeing and gainful potential of plant.
- **Land cover** stand the sum of the external and physical features which forms the cover of Earth's surface. This best account for natural and cultural features. This speaks

about man-environment relationships as either positive or negative. Land cover is computed using European Space Agency's Climate Change Initiative Land Cover (ESA-CCI-LC) dataset at 300m resolution, classes with different schema are aligned with one another with the aid of Land Cover Meta Language (LCML).

- **Soil Organic Carbon** is vital in plant growth, ensuring soil fertility, filter and store clean water. Changes in this sub-indicator speaks about the soil conditions as integral part of a functioning ecosystem. Soil Grids datasets covering a depth in upper layer of soil profile of about 30 cm and at 250m resolution was used in the computation to ascertain the changes in SOC over the time frame.



Source: Good practical Guidance
Where ND is not degraded, D is degraded

Fig 2: workflow for assessing the extent of degraded land.

Change Detection was conducted in each of the sub-indicators to quantify the level of changes over the time the frame, and to identify areas with improved or positive, stable, negative or declined status especially areas where these changes overlap spatially in two or three of the sub-indicators. One out all out statistical method was used to compute the sub-indicators for estimating the extent of degraded land area.

III. RESULT AND DISCUSSION

The figures obtained from this analysis (Table 1) reveals that degraded land area occupied 12,248.8 sq.km and traced to about 68.3% of the state’s land area. The result in (Fig. 3) further reveals the magnitude of Land degradation spatially, (Fig. 4) also indicating that it’s getting higher and at alarming rate.

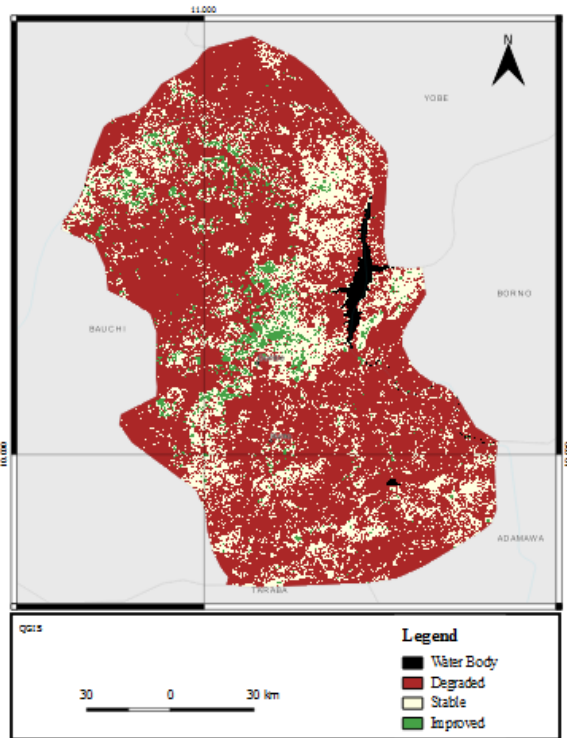


Fig.3 Extent of Land Degradation in Gombe State

Table 1: Classes of Land Area

Land areas	Area (sq.km)	%
Improved	780.9	4.4
Stable	4,180.4	23.3
Degraded	12,248.8	68.3
Water Body	718.7	4.0

The sign of this phenomena has taken greater percentage of the state’s land area because of the conversion of forested areas into grasses or patches of grasses that end up in desert-like sand with irregular heat balance, disturbed water budget, depleted soil nutrient, soil erosion etc. This phenomenon is a product of inter-related factors that arise as a result of climatic variations and anthropogenic factors. Anthropogenic factors in particular are the major drivers of this phenomenon in the state, ranging from various improper land use that occur for years and continue to put more pressure on the available resources by the growing number of human population in order to meet up with day to day

requirements without allowing enough time and space for regeneration of anew lost resources. Therefore indiscriminate cutting down of trees for the purpose agricultural activities, urbanization, and search of fuel wood, overgrazing, bush burning in the name of farm clearing or hunting and drought are counted as direct causes of land degradation in State, exposing the soil from anchorage provided by vegetation and make it prone to erosion and with low infiltration ratio that increases run-off through gullies.

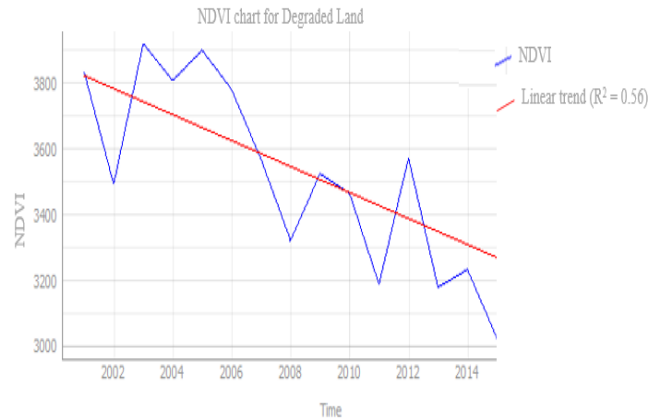


Fig. 4: NDVI chart of the degraded land area

The proportion of forested areas in the state was earlier reported declining from 15% in 1996 to 9% in 2006 due to the pressure of exploitation. Occasional trees are being deforested to reopen farmlands while others are being expanded almost every year to increase productions but rather graduated into consistent and continuous farming that the landscape suffers environmental problems.

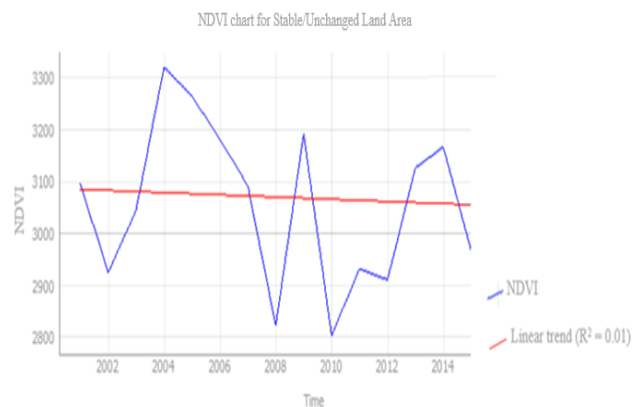


Fig. 5: NDVI chart of the stable land area

Fuel wood provides about 90% energy for domestic and bake purposes in the state. The ever increase demand of this product has caused the destruction of greater percentage of the forested areas in the State to fulfil the food needs and for the financial gain from the business for those involve in the collection and supply. One of the previous research reported that Gombe metropolis alone is being supplied with about 30-40 pick-up of fuel wood on daily basis and stressed that hundreds of tree species are facing extinction annually.

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However eleven Northern Nigerian States (Gombe State included) are said to have high carrying capacity that continue to deteriorate the land conditions. These states homed about 38% of Nigeria's population at the same time support over 90% of the country's cattle population, about two-thirds of the goats and nearly all the camels, horses and donkeys. It's in that context another previous research reported that these states are being affected by desertification ranging between 50% and 75% of their respected land areas.

The result also shows that stable land area covered 4,180.4 sq.km representing 23.3% of the total land area. Improve land area account 780.9 sq.km account to 4.4% of the state's land area. Water body covered 718.7 sq.km traced to 4% of the state's land area.

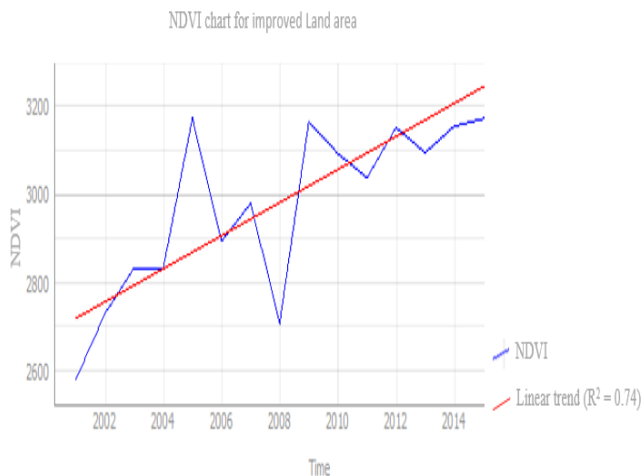


Fig. 6: NDVI chart of the improve land area

IV. CONCLUSION

It has been observed that economic conditions and the increase demand for food, feed, fuel etc. to sustain the ever growing number of human population have influence resource users to overlook the expense of land degradation on the ecosystem services. This has force the environment to respond in some ways like: biodiversity decline, nutrient depletion, low yield in farm produce, soil erosion, flooding, and desert encroachment among others. In essence this phenomenon jeopardize the ecosystem resiliency in the performance and supply of environmental services. The result obtained in this research reveals that degraded land area account for about 68.3% of the state's land area, pointed that the proportion of degrade land in the state is getting high and posing a threat on food security and other related economic activities.

V. RECOMMENDATIONS

- Nature-Based Solutions should be employed for better soil performance, soil nutrient, maintain and restore biodiversity, protect ground water and sustainable food production and make less severe condition in flood.
- Environmentally-friendly land use should be used and subsequent land use should be below the carrying capacity of the land and that enough time and space should be provided to regenerate afresh condition.
- Private efforts are needed to reverse and restore the affect areas because part of this phenomenon takes place in private own properties.

- Raise awareness on the effect of inaction and the importance of action across the chain of resource users.
- Awareness on other source of energy towards a sustainable future.
- Overcome communication gap within the chain of instruments of decision making.

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