Comparing the Effect of Deforestation Result by NDVI and SAVI

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Abstract- The surface reflectance indicated by vegetation obtained through remote sensing is distinct compared to other surface bodies over a given scene. Utilising this distinct capability allows the detection of presence of vegetation. Normalise Vegetation Index (NDVI) compares the total amount of visible red light absorbed with the amount of reflected near-infrared light by a surface. Soil Adjusted Vegetation Index (SAVI) is somewhat similar to NDVI but adjusted by a factor 'L' to correct for soil noise effects, which impact the results. Satellite imageries from Landsat data were used to determine the deforestation areas and the results was compared for ascertaining the discrepancies produced by the two methods. Spectral information contained in each of the bands defined by a band in an electromagnetic energy of interest was used for the energy level required in the combination. Forest changes shows effectively that there exist similarity in their patterns of change measured with both techniques but when the need to obtained actual areas of changes, one has to select the most appropriate technique. The result of the comparism of forested area by the two methods shows similar pattern and behaviour, the net vegetation difference ranges from +9.906% to +18.705%, forested area from +14.466% to 0.000% while open land, built –up and bare soil index cover shows decrease over the years ranging from -13.343% in 1990 to - 2.321% in 2013 respectively. However NDVI shows lower area covered by vegetation and forest compared to SAVI meaning that the total area affected by forest changes by the two methods is not in any way the same.

***Index Terms* -** Vegetation Index, Deforestation, NDVI and SAVI.

I. INTRODUCTION

Deforestation is the removal of trees to make room for something besides forest, it occurs when forested area is cut and cleared to make way for agriculture, grazing, bio-fuel, construction or manufacturing sites (Derouin, 2019). Deforestation can also be seen as the conversion of forest land in to farms, ranches, or urban use; describing as illegal way of cutting down of forest trees for human utilisation (Ever Green, 2020). Vasco *et al.,* (2018) explained deforestation in terms of clearing land for agriculture (small and large scale; food and cash crop production). Kanati and Alexander (2019) referred deforestation as the conversion of forested areas to non-forest land that is less bio-diverse ecosystems such as pasture, cropland, plantations, urban use, logged area or wetland without sufficient restoration.
Nigeria as a developing country has most of its population relying on wood for fuel wood as a major source of energy for cooking, industrial uses and other domestic use (Wada *et al.,* 2019). In the world, forest has covered more than 30% of the Earth's land surface, according World Wildlife Fund 2020. Wada et al., (2019) postulate that Nigeria is considered as one among highest in rate of deforestation in the world: from the data gathered, the country lost 55.7% of its primary forests over a period of five (5) years and the rate of forest change increased by 31.2% to 3.12% per annum (Wada *et al.,* 2019). These forested areas can provide food, medicine and fuel for more than a billion people (Derouin, 2019). A forest is a resource, and also large undeveloped land that can be transformed to various human purposes (Lorena *et al.,* 2015). Many areas that are not accessible in the past are now within reach due to roads, dams, rails constructed through the dense forests.

The environment and eco-system play a vital role to human lives. Changes in forest area through bush burning, bio-fuel and well as clearing thick forest in the name of agricultural land are major causes of deforestation (Lorena *et al.,* 2015). These affect biogeochemical circles changes on biodiversity, soil quality, runoff, erosion, sedimentation and climatic variation. The environmental changes lead to significant dynamics over time. Human forces affect forest cover, the pace and magnitude determines the rate at which the deforestation takes effect. Vasco *et al.,* (2018) said that the scale of environmental deforestation is dependent on both magnitude and timing in historical land use/cover not merely on snap shot of forest cover available that is directly observable today. The impacts shrub/scrub of deforestation on vegetation, grasslands, forests, and agriculture includes lower production in agricultural output, lower grazing land, increase desertification, erosion and reduction in water retainage by soil. Rothrock (2019) asserts that zero net deforestation on four big companies namely cattle, soy, palm oil and pulp and paper, in the supply chain are responsible for bulk of the world's deforestation. These will be affected by climate change, changes to human activities and the ecosystems (Rothrock, 2019). Projections of the changes in forest depend to some extent on rates of population and economic growth. Government policy can directly affect the rate of deforestation through measures that ensure sustainability of the forest itself. Wada *et al.*, (2019) said that the problem of Nigerian deforestation results from bush burning, irregular logging, and rapid urban development, use of bio-fuel as cooking fuel, soil erosion, agricultural activities and oil spillage. Kanati and Alexander (2019) said that forest depletion is among the major environmental problems that threaten and have severe consequences on our environments, by decreasing both floral and faunal species apart from giving more pressure to the forest dwellers that depend on them for survival in form of income and food supplement.

Thus, decisions can be made on the type of plant for farmers to affect response to changing growing conditions and/or for afforestation. However, household can be compelled to respond to policies of zoning or regulations (at national, state, county, or municipal levels) by elevating their houses to reduce the impacts associated with more increased in deforestation. Rothrock (2019); Juliano and Clarissa, (2019), said that resolution passed in response to evidence of risks associated to climate change and deforestation accounted for 20% of the global greenhouse emissions worldwide. Finer and Mamani (2019) analyzed deforestation data over Colombian Amazon to better understand its current trends, patterns and discovered a lost nearly 1.2 million acres (478,000 hectares) of forest between 2016 and 2018 of which 73% (860,000 acres) were primary forest. Vegetation cover is carbon reduction options in urban areas where high densities are found in tropical forests (Jayme *et al.,* 2019), with most of that carbon release by automobiles, household fuel, industrial output/waste, and etc found in not soil alone, but also in vegetation, landfills, buildings structures and etc. It absorbs the net sources of carbon from the atmosphere, and good source of oxygen to livestock. Muhammad (2019) asserts that a lot of efforts were made to secure mountain forest functions and to counteract the negative impact of declining forest often constrained by data uncertainty of factors contributing to deforestation. Brazilian Amazon (2019) reports that humans internationally set fires largely for agricultural purpose every year to prepare land for pasture and cropland, it consequently spread beyond their intended boundary and set forest fire causing damage to trees leading to deforestation.

The report on 'Targeting Zero Deforestation' also states that; some developing countries viewed that developed world, such as the United States of America, enjoyed cutting down their forests centuries ago and benefited economically from it, hence it seems hypocritical to deny other developing countries do the same, meaning the poor countries should not have to bear the cost of preservation when the rich countries created the problem. Globalization is another root cause of deforestation (Jayme *et al.,* 2019), despite that there are some instances in which the impacts of globalization have promoted localized forest recovery. Vasco *et al.,* (2018) in his identification and assessment of the condition of forests says; is not easy to uniquely define the agents of deforestation since different people have widely different views on what is contributing deforestation. Developing alternatives to deforestation by adopting sustainable farming practices can restore back the lost forest, through replanting trees in cleared areas or by simply allowing ecosystem regenerate forest over time (Lalisa *et al.,* 2019). Brazilian Amazon (2019) reports on deforestation highlighted some key solutions to sustainable forest management, these include;

i. Reverse the worldwide loss of forest cover through sustainable management, including protection, restoration, afforestation and reforestation efforts to prevent forest degradation, contributing to the global means in addressing climate change.

ii. Enhance forest-based economic, social and environmental benefits towards improving the livelihoods of forest-dependent societies.

iii. Increasing area of forests protection worldwide, sustainable management of forest and forest products.

iv. Mobilise new and additional resources from all sources for implementation of sustainable forest and straighten scientific, technical cooperation and partnerships.

v. Promote governance frameworks to implement sustainable forest management, including the United Nations forest instrument to enhance the contribution of forest development.

vi. Enhance cooperation, coordination on forest-related issues at all levels, within the United Nations system and across its member on forests, as well as across sectors stakeholders.

The major aim of forest restoration is to return it to its original state before it was cleared (Kemen *et al.,* 2019). This will quicken the ecosystem so that it can start to naturally repair itself afterwards, wildlife will return, water systems will re-establish, carbon will be restored as well as soil nutrients. Water content in the soil and atmospheric moisture can also improve the condition of living organism living within the forest zones (Doug *et al.,* 2014). Aforestation results in an improved environmental condition that supports conservation (Doug *et al.,* 2014). Appropriate and reliable monitoring frame work for deforestation through interpretation of satellite

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imagery provide a wide range of option in the identification of locations assessed to quantify the amount of area deforested (Lorena *et al.*, 2015), measured at the present time. The spectral reflectance behaviour across different bands measured by a given sensor of satellite imagery, to check the presence of vegetation over a given scene by combining two of such bands that enhances the contrast between the images, having high reflectance in vegetation and remaining aspects such as bare soil, manmade structures, can be helpful in analysing the forest of a given area.

NDVI basically, works by mathematical ratio of comparing the amount of absorbed visible red light and the reflected near-infrared light. The chlorophyll pigment in a plant absorbs most of the visible red light energy, while the cell structure of a plant reflects most of the near-infrared light for photosynthetic activity and is commonly associated with dense vegetation. This results in fewer reflectance observed in the red band and higher reflectance in the near-infrared band. The SAVI is similar to NDVI, it has additional soil adjustment factor 'L' in NDVI equation correcting for soil noise effects (soil color, soil moisture, soil variability across region, etc.), which affect the results. When a significant amount of the soil surface is exposed to remote sensing energy, the soil reflectance can influence the NDVI values in the imagery. The Light that was reflected from the soil has significant effect on NDVI values by changing the values. 'L' is a correction factor which ranges from '0' for very high vegetation indexed cover to '1' for very low vegetation index cover. A 0.5 value of 'L' is commonly used for intermediate vegetation cover, for 'L' value equal to zero, SAVI becomes the same equation as NDVI. For this research 'L' was set at 0.5 assumed on moderate forest ground.

II. STUDY AREA

Damaturu, the headquarters of Ngazaragamo emirate council is the state capital of Yobe State. It has a total area of 2,366 km² with a population of 88,014 at the 2006 census, connected to trunk A3 highway. It is located at an approximate geographical Coordinates: 11° 44′ 40″ N 11° 57′ 40″ E. The vegetation is predominantly of the Sudan savannah type, with scattered trees, it is a Sahel savannah zone consisting of sandy soils. There is little rainfall throughout year of about 649 mm on the average in a year. The average annual temperature is 25.2 °C and a time zone of WAT (UTC+1). Figure 1.1 shows the map of the study area.

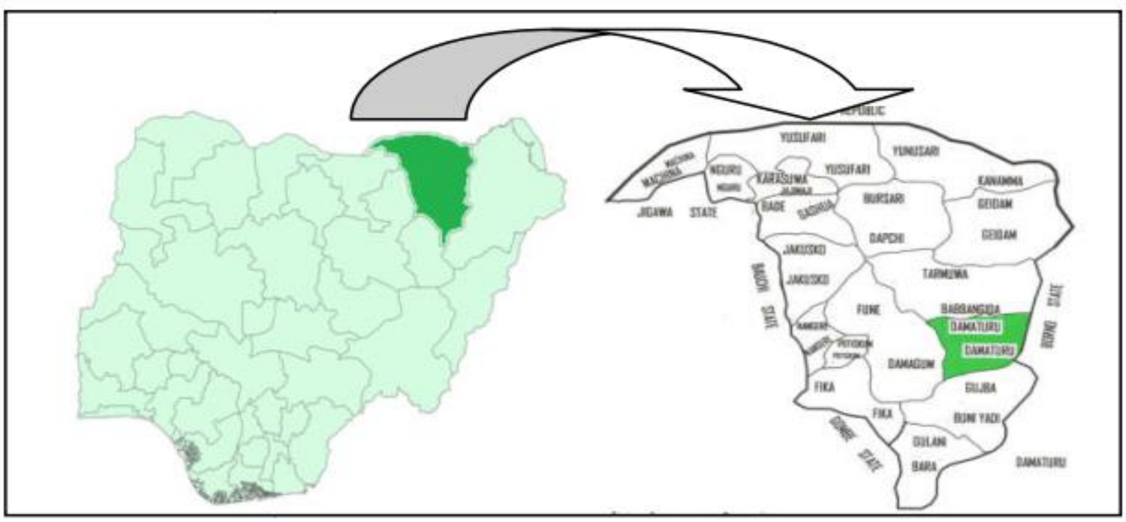


Figure 1.1 Map of Nigeria showing study area

III. METHODOLOGY

Satellite images were acquired covering the scene of the study area from United States Geological Survey Agency (USGS) from 1988-2018. The study area was extracted by the mask of the shape file from the administrative boundary of the local government. The extracted image of the study area were indexed into five classes through the use of normalise vegetation index (NDVI) and Soil Adjusted Vegetation Index (SAVI) to obtain the zones/areas vegetation and forest area. Wada *et al.*, (2019) adopted Normalize difference vegetation index (NDVI) to classify and produce maps for quantifying the vegetation changes. Results from NDVI calculation ranges from -1 to 1. Negative values indicate areas with water, marshy surfaces, manmade structures, rocks, clouds, snow; bare soil usually gives values that falls within 0.1- 0.2; while plants always have positive values ranging between 0.2 and 1. For healthy, dense vegetation canopy, the values are above 0.5, meanwhile sparse vegetation have its values ranging within 0.2 to 0.5. Generally, NDVI values between 0.2 and 0.4 are areas with sparse vegetation; 0.4 and 0.6 for moderate vegetation and anything above 0.6 indicates the highest possible density of green. The change in index result gave in-depth information on how these techniques vary. NDVI is given by the relationship:

$$\mathrm{NDVI} = \frac{\boldsymbol{NIR - RED}}{\boldsymbol{NIR + RED}}$$

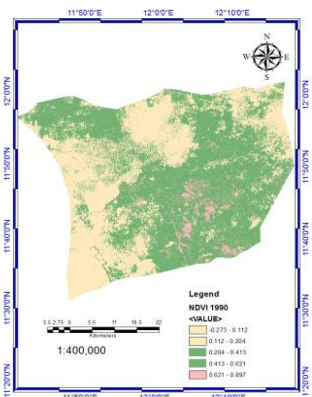
However, SAVI index aimed at minimizing the soil brightness and its influence was expressed in mathematical relationship given by:

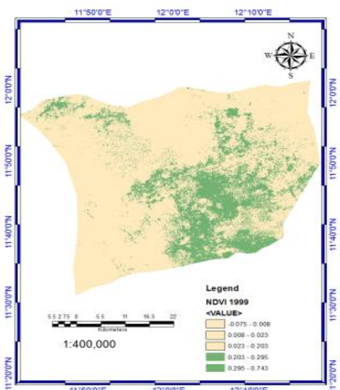
$$\mathrm{SAVI} = \frac{\boldsymbol{NIR - RED}}{\boldsymbol{NIR + RED + L}} * (1 + L)$$

Its values also range within -1 to 1 like NDVI, depending on the amount of green vegetation that is present in the area. The imagery used are that of 1990, 1999, and 2013, the level of forest change between the selected years in terms of reduction or increase in the index value was carried out and their significant changes where measured and analyzed.

IV. RESULTS and DISCUSSION

The result from NDVI map showing indices in the selected study years of 1990, 1999 and 2013 are given in the figure 1.2a to 1.2c respectively. The results indicate that there are differences in the forested land of the area across the years of the study considered. From the map, green colour area represents vegetation area; beige colour represents built-up, bare soil and open land while pink show the forested areas for the respective years. The second figure (Figure 1.2b) shows there was a great change in area covered by vegetation which occurred between 1988 and 1999 with significant changes also in the forested area. The forest area was very small compared to vegetation and open land, built-up and bare soil. In 1999 the forest area levelled pink has tremendous reduction in total area covered, this may be as a result in increase in the demand of fuel wood by the forest inhabitants as population increase compared to the previous years. And finally in figure 1.2c, the forested area was not even identified from the NDVI result implying deforestation has actually taken place.





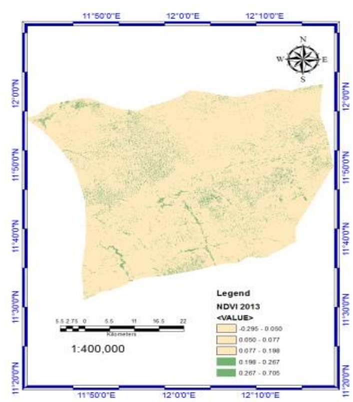


Figure 1.2a NDVI in 1990 Figure 1.2b NDVI in 1999; Figure 1.3c NDVI in 2013

So also the SAVI index maps were presented in figure 1.3a to 1.3c. They have similar pattern with the findings of result shown by the NDVI result above. A colour was varied in one variable to ensure contrast between the set of results, the index in the images with only change in colour cover was open land, built-up and bare soil, represented by Jade colour. The forest area was also very small compared to vegetation and open land, built-up and bare soil with reduction in total area covered, thus also showing deforestation has actually taken place.

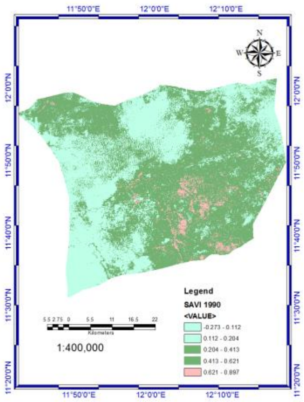


Figure 1.3a SAVI in 1990

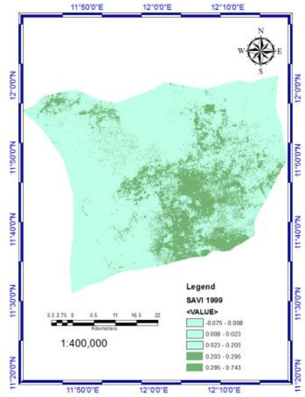


Figure 1.3b SAVI in 1999;

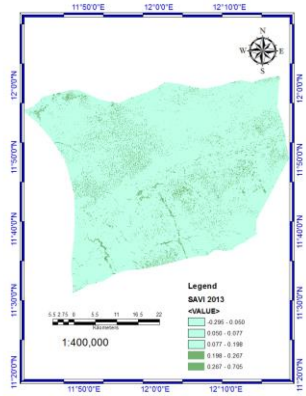


Figure 1.3c SAVI in 2013

Analysing the total area covered by vegetation, open land and forest for the study period. Table 1.1, shows the total area covered by each index for the NDVI map, forested land reduced from 98.176 km^2 to 0 km^2, Open Land, Built –up and Bare Soil increased from 887.213 km^2 to 2046.135 km^2 and vegetation reduced from 1380.189 km^2 to 319.443 km^2. It can be deduced that, there is a significant change in the index cover from 1990 to 2013. For percentage of area covered by NDVI, Table 1.2, the forest area decrease from 4.451 % in 1990 to 0.00 % in 2013, the vegetation cover also changes from 63.351% in 1990 to 13.503% in 2013, while the open land, built-up and bare soil increase from 32.499% in 1990 to 86.497% in 2013.

Table 1.1 Total area covered by each NDVI index

Cover Type	1990 (km^2)	1999 (km^2)	2013 (km^2)
Forested Land	98.l76	6.42	0
Open Land, Built –up and Bare Soil	887.213	1571.542	2046.135
Vegetation	1380.189	787.616	319.443
Total	2365.578	2365.578	2365.578

Table 1.2 Percentage of area covered by each NDVI index

Cover Type	1990 (%)	1999 (%)	2013 (%)
Forested Land	4.15	0.271	0
Open Land, Built –up and Bare Soil	32.499	66.433	86.497
Vegetation	63.351	33.295	13.503
Total	100	100	100

Table 1.3 shows the total area covered by each index for SAVI map, forested land reduced from 114.824 km^2 to 0 km^2, Open Land, Built –up and Bare Soil increased from 718.806 km^2 to 1998.634 km^2 and vegetation reduced from 1531.948 km^2 to 366.944 km^2. These indicate there is a change in the index cover from 1990 to 2013. Table 1.4 presents the percentage of area covered by each SAVI index, so also the pattern of change by exhibit same characteristics as former, from Table 1.4, the forested area decrease from 4.854% to 0.00% while vegetation change from 64.759% in 1990 to 15.512% in 2013.

Table 1.3 Total area covered by each SAVI index

Cover Type	1990 (km^2)	1999 (km^2)	2013 (km^2)
Forested Land	114.824	7.704	0
Open Land, Built –up and Bare Soil	718.806	1444.221	1998.634
Vegetation	1531.948	913.635	366.944
Total	2365.578	2365.56	2365.578

Table 1.4 Percentage of area covered by each SAVI index

Cover Type	1990 (%)	1999 (%)	2013 (%)
Forested Land	4.854	0.326	0
Open Land, Built –up and Bare Soil	30.387	61.052	84.488
Vegetation	64.759	38.622	15.512
Total	100	100	100

The result of the percentage in the differences in index covered by NDVI and SAVI were presented in Table 1.5 and 1.6. From Table 1.5 the results, SAVI shows an appreciable area than NDVI in only vegetation index and forested areas for all the study period in terms of the total area covered by the respective index giving positive difference. The total net area covered ranges from +1.284 km^2 to +151.759 km^2 for the study period. Negative difference was observed in the result of the index produced by Open Land, Built –up and Bare Soil ranging from -47.501 km^2 to -168.407 km^2. For the percentage results, SAVI shows an appreciable percentage than NDVI in vegetation index and forested areas for all the study period. So positive was observed. The index cover for open land, built-up and bare soil receive negative variations, this synonymous as inverse of proportionality curve. This is as a result of the value 'L' used in the formula for deducing the results. The net vegetation difference between two index maps varies from +9.906% to +18.705% and from +14.466% to 0.000% for forested area as produced by the two different methods. The index cover for Open Land, Built –up and Bare Soil shows decrease over the years and ranges from -13.343% in 1990 to -2.321% in 2013.

Table 1.5 Difference in cover area by NDVI and SAVI index

Cover Type	1990 (km^2)	1999 (km^2)	2013 (km^2)
Forested Land	16.611	1.284	0
Open Land, Built –up and Bare Soil	-168.407	-127.321	-47.501
Vegetation	151.759	126.019	47.501
Difference	0	0	0

Table 1.6 Difference in percentage of cover by NDVI and SAVI index

Cover Type	1990 (%)	1999 (%)	2013 (%)
Forested Land	14.466	16.667	0
Open Land, Built –up and Bare Soil	-13.343	-8.101	-2.321
Vegetation	9.906	13.793	18.705

V. CONCLUSION

From the results presented above, the comparism of results for forested area using NDVI and SAVI gave variation in total area attributed to the forest zones, despite showing similar pattern and behaviour, but the differences in the forested area becomes a problem. This implies that the total area affected by forest changes in NDVI and SAVI are not in any way the same. The study clearly shows that there was a decrease in the forested area over the study period and it might has been affected by cutting down of trees, bio fuel, agricultural land, built-up and etc. Population can also be major factor responsible for deforestation as increase in population can extend family demand on agricultural land or building site for households (Lorena *et al.*, 2015). Population is also a major factor responsible for deforestation as increase in population can extend family demand on agricultural land or building site for households. Measures on finding afforestation for a sustainable Environmental management should be made as government policy and implemented for forest restoration and guard against land degradation. Forest changes shows effectively that there exist a similarity in the pattern measured with both techniques, but when the need to obtained actual areas of changes, care must be taken to select the most appropriate one.

VI. RECOMMENDATIONS

In view of the result analyzed, the study recommends the use of higher resolution imagery in determination of similar variation pattern as it will enhances better index map. To recover lost forested areas, the following measures should be put in place:

(i) Good policy that will lead to avoidance of further deforestation.
(ii) Providing alternative energy source to bio-fuel consumption.
(iii) Replacement of felled trees with another to regenerate the lost species.
(iv) Improved agricultural practices.

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