Correlating Forest Cover Loss with Land Surface Temperatures of Nnamdi Azikiwe University, Awka using Remote Sensing Methods

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ABSTRACT

Human pressures, combined with changing hydrology and land resources, have a distinct effect on the carbon chain and ecosystem resilience. The increase in urban areas contributes significantly to the loss of vegetation cover (VC), which accelerates carbon emissions, increasing land surface temperature (LST) and global warming. This study used remote sensing and GIS techniques to estimate the Land Use/Land Cover (LU/LC) changes by focusing on VC loss and its impact on LST and carbon emissions in Nnamdi Azikiwe University during 2001-2021. The study's findings confirmed an reduction of VC of about -39% from 2001- 2011 with around 27.2% increase of vegetation cover loss, and corresponding LST rise from 22˚C to 35˚C. The trends were continuous, with a decrease in VC loss by -30% during 2011–2021, contributing 26˚C– 42˚C LST rise in the study area. Results indicate that the massive amount of carbon attracted the sun's rays due to the VC loss and raising the surface temperature by 20˚C since 2001, which directly contributing to global warming. Thus, to mitigate climate hazards, efforts to slow urbanization to reduce pollution gateways and increase carbon sinks through afforestation will significantly contribute to protecting humanity from global warming

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INTRODUCTION

Nowadays, global warming has become one of the most important environmental challenges facing humanity. Presently, many directions have been opened in the study of the relationship between forest resources and land surface temperature (LST).

Chen *et al*., (2022) expresses that rapid urbanization has led to the evolution of urban landscape patterns and processes that result to changes in the types of urban surface cover, and which in turn lead to further changes in the thermodynamic properties of urban surfaces that give rise to urban heat island (UHI) effect and other ecological consequences. In Nnamdi Azikiwe University (NAU), where urbanization is at its peak, NAU is facing rapid urbanization. The three decades' campus-level study by Ogbodo, *et al*., (2020) discovers that unplanned urban expansion contributes significantly to forest cover changes. NAU has witnessed remarkable expansion, growth and developmental activities such as building, road construction and many other anthropogenic activities since its inception in 1992, which has led to increased land consumption and a modification and alterations in the status of her land use over time. Unplanned transition of LULC classes could affect ecological sustainability and an increase of LST within the Awka campus of Nnamdi Azikiwe University.

Thus, the main task of this study was to assess the impact of urban heat island within the Awka campus of Nnamdi Azikiwe University by mapping the land surface temperature using multi-temporal satellite remote sensed images based on the various land cover types available within the University. Remote sensing approach has proven capability to modelling land surface temperatures (LST) from LULC within an ecological landscape (Hart and Sailor, 2009). Combining RS and GIS technology makes it easier to analyze, monitor, and simulate LULC and LST variations (Niyogi, 2019). Furthermore, due to the scientific progress of statistical algorithms, which are applied in remotely sensed data, spatiotemporal evaluation of LULC and LST dynamics have provided significant smart solutions of the temperature increasing problems due to haphazard land cover change (Celik,2019). Thermal remote sensing technology is to measure the urban heat island (UHI) which is considered as an effective approach to evaluate the inauspicious impacts of human activities on local climate over the last couple of decades (Naim and Kafy, 2021). In the light of the above, the goal of this study is to investigate a two-decade loss of forest cover and its impacts on LST (2001 to 2021) using Landsat satellite remote sensing approach in Nnamdi Azikiwe University Awka towards contributing to attaining sustainable university campus in line with the Paris Climate Agreement in Nigeria.

METHODOLOGY

i. Study Area: This study was conducted at Nnamdi Azikiwe University (NAU) in Awka, Anambra state. NAU is situated on the geographic coordinates of 6°14'38.4"N and 7°07'18.7"E. The temperature in Awka is generally 27–30oC between May and January but rises to 32–34°C between February and April, with the last few months of the dry season marked by intense heat (Ogbodo *et al*., 2020).

ii. Remote sensing data used in this study: Two multi-sensor Landsat imagery (i.e. Landsat 7 ETM and Landsat8 OLI) were downloaded from https://earthexplorer.usgs.gov and analyzed in this study. The above-mentioned data each has 30m spatial resolution. The Landsat satellite imageries were taken during the dry seasons of Years: 2001, 2011, and 2021.

iii. Ground-Truthing Data for Validation: To validate the classified maps, ground-truth (reference) data together with their Global Positioning System (GPS) coordinates were obtained from Google Earth in ascertaining how many ground truth pixels are correctly classified. Therefore, fifty (50) regions of interest (AOI) were purposefully sampled per land cover class in the study area (Lillesand *et al*., 2008).

iv. Estimation of Normalized Differential Vegetation Index (NDVI): For this study, NDVI values are grouped/ stratified into five classes using the raster calculator. The resolutions of the NDVI values were compared with standard NDVI values to determine the loss of VC over the study area for the years 2001, 2011 and 2021. The class of NDVI was estimated to identify the concentration of LST rise in different categories of VC classes. NDVI values were calculated using Equation 1:

$$NDVI = \frac{(NIR-R)}{(NIR+R)} \qquad (1)$$

v. Estimation of Land Surface Temperature (LST): Land Surface Temperature which measures the thermal radiance from the land surface where the incoming solar energy interacts with and heats the ground was estimated using Landsat thermal band images from 2001, 2011, and 2021 which are band 6 (2001 and 2011) and band 10 (2021). The LST for this study was calculated using the raster calculator in Arc GIS 10.3. Landsat sensors accumulate thermal data and Digital Numbers (DN and these DN were converted to LST with four steps process illustrated below (Kafy *et al*., 2021; Celik *et al*., 2019; Connors *et al*., 2013; Pal and Ziaul, 2017).

vi. Estimation of Land Cover

The satellite images were classified into five land cover classes, namely built-up area, forest, farm land, pave land and bare surfaces in the study area. The aforementioned land cover classes were made based on spectral characteristics of the at image analysis (Phiri and Morgenroth, 2017). Next, supervised classification was done by following three stages that included training data sets, classification and output. Training samples were taken for each land cover type that was identified on the supervised classification output. The classification was done by using maximum likelihood classifier (Shivakumar and Rajashekararadhya, (2018).

RESULTS

Land Cover Classification Analysis

In the supervised classification, false color composite of the image was created for the classification to be done, bands 7, 4, 2 for Landsat 7 images and 7, 5, 3 for Landsat 8 images. The data below in table 2 shows the percentages of change detected in 2001 over 2021, which are; built-up areas (67.39%), farm lands (62.77%) and reduction in forest (-55.50%), bare lands (-52.94%) as a result urbanization, agriculture, industrialization etc.

Analyzing the intensity of vegetation coverage from 2001 - 2021

The health status of Vegetation Cover in the study area for different time intervals is estimated using NDVI distribution analysis illustrated in figure 6 where the green areas indicates vegetation and the yellow and red areas indicates non- vegetation In the supervised classification, false color composite of the image was created for the classification to be done, bands 7, 4, 2 for Landsat 7 images and 7, 5, 3 for Landsat 8 images. The data below in table 2 shows the percentages of change detected in 2001 over 2021, which are; built-up areas (67.39%), farm lands (62.77%) and reduction in forest (-55.50%), bare lands (-52.94%) as a result urbanization, agriculture, industrialization etc. Figure 2 shows the land cover map for the period under investigation while figure 3 shows the graphical representation of the land covers distribution of the study years.

Table 4: NDVI values showing tree loss in the study period

Study year	2001	2011	2021
NDVI values	0.56	0.52	0.34

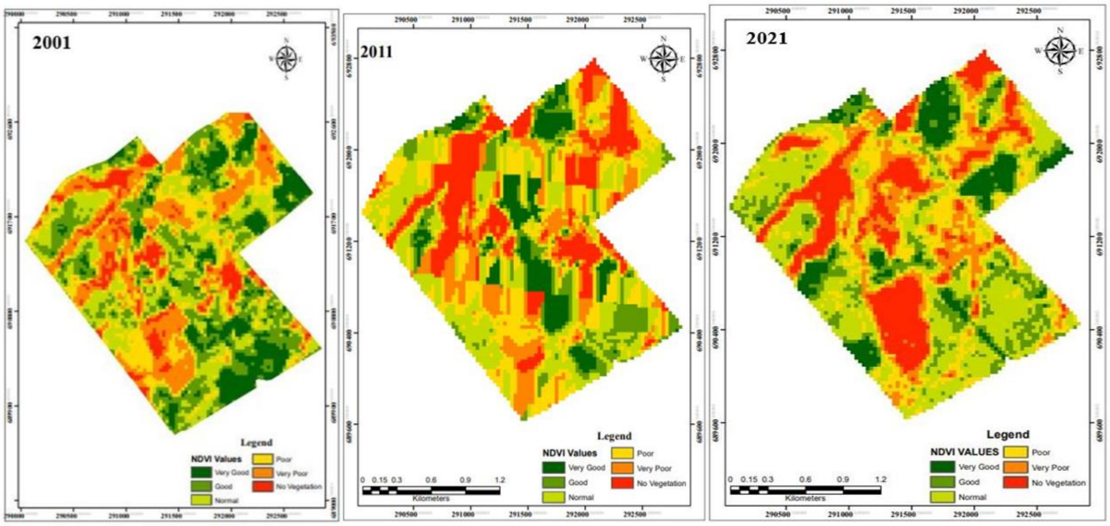

Figure 1: Map of the landcover types showing tree cover in green colour

Variations of LST – 2001, 2011 and 2021

Spatial distribution map in Figure 1 indicates the lowest and the highest LST values range that vary across the three selected periods which are; 22˚C - 33˚C for the year 2001, which increased to 26˚C to 35˚C in 2011 and further increased to 28˚C to 42˚C in the year 2021.

DISCUSSION

The Supervised classification scheme which was used and identified on the image is five land cover classes: Built-up Area, Bare Ground, Forest, Farmlands and Pave land. The Raster processing tools on ArcGIS were used for data processing and training samples from the different images were collected using image classification tools on ArcMap and the accuracy was evaluated. After the collection of training samples, the images are classified based on the algorithm specified.

Ogbodo *et al*. (2017) express that expansion of infrastructures is one of the factors that drive deforestation in public universities that are majorly situated within the natural forest part of Southern Nigeria. The results of this study is in agreement to Ogbodo *et al*. (2017) as forest land cover was the major land cover in 2001, but gradually reduced as a result of human induced factors, while built ups continued to increase and gradually became the major land cover in 2021 such as lecture theatres, administrative blocks, student hotels, without corresponding reforestation or afforestation. Furthermore, Igu *et al.,* (2021) expressed that, forest cover is reducing at astronomical scales as a result of a host of anthropogenic activities. Its greatest toll and impact are however seen in tropical landscapes where land use changes arising from agriculture and urbanization (built up areas) are growing in scale. Clearly, forest land cover suffers in the face of industrialization, urbanization, human population increase and infrastructural development; due to the fact that Governments and some individuals are more interested in the immediate economic growth, hence pay little attention to the environmental services that forest vegetation provide. Fiasal *et al.,* (2021), identified that deduction of healthy vegetation cover by impervious surfaces such as buildings and roads accelerates less sensible heat fluxes by replacing robust latent heat fluxes released by Vegetation Cover through evapotranspiration. Pettorelli, (2013) stated that, the health of a forest is mostly determined by how well its vegetation absorbs most of the visible light that hits it, while reflecting a large portion of the near – infrared light. Unhealthy or sparse vegetation reflects more visible light and less near – infrared light. This is line with this study.

While in 2021, it was observed that the forest cover reduced to 18.5%, likewise it's NDVI value to 0.34 and it's LST increased to 28◦C. This is an indication of a loss in the protective function of the forests in the study area, as more solar radiation directly hits the land surface. Such anomalies are expected and inevitable in an area with increasing population and attendant pressures such as the Niger Delta region and much of tropical landscapes (Igu, 2017). The declination of vegetation cover and the increase of non-vegetated areas have intensified this huge increase of LST. This period was characterized by intense deforestation and clearing of land for various developmental projects and agriculture which is made evident by the level of increase in observed bare land and built-up areas which are characterized by vegetal removal and the concomitant decrease in total vegetal cover. This rapid depletion of vegetation cover has a wide range of impacts such as in the reduction of the natural cooling effects of shading and evapotranspiration of plants and shrubs. However, rapid urbanization and reduction in Vegetation Cover are mainly responsible for temperature increase and Urban Heat Island effect.

CONCLUSION AND RECOMMENDATION

Due to urban growth of the university, there have been significant changes in the land cover of the study area such as decrease in the vegetated areas and increase in built up areas. The results of the NDVI values of the study area also showed that forest health declined through the years. A decline in forest health is an indication of forest degradation. The declining forest cover, as well as the NDVI values of the study area corresponded with increasing LST values through the study years. This is an indication of a loss in the protective function of the forests in the study area, as more solar radiation directly hits the land surface. Hence, the study findings confirm that Nnamdi Azikiwe University has been experiencing consistent Vegetation Cover loss since 2001.

In view of the observed trend in Land Cover change and the impact of Land Surface Temperature, the need for tree planting and increased awareness on the impacts of forest conversion/deforestation on our environment and general wellbeing should be emphasized.

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