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Analysis of vegetation index of Cross River National Park, Nigeria between 2000 and 2020

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Abstract

The study analysed the vegetation quality index of Cross River National Park, Nigeria between year 2000 and 2020. The Cross River National Park has two sections which are the Oban and the Okwango sections. The near real time data of MODIS Terra and Aqua Normalized Difference Vegetation Index (NDVI) of 16 Day global resolution was employed for vegetation index data acquisitions for the study. The NDVI imageries between 2000 and 2020 were considered for the two sections (Oban and Okwango) for the study. Descriptive statistics in form of Tables, mean, standard deviation and maps aided the study in data presentation and interpretation of results. Findings revealed that vegetation health recorded mean values of 0.5678 in year 2000; 0.5603 in year 2014; and 0.4703 in year 2020. Thus, the vegetation health/quality of the Cross River National park had reduced between year 2000 and year 2020. This implies that there is reduction in the size of thick forest vegetation in the Cross River National park which has affected the vegetation quality overtime. The study suggested that control measures to safeguard the national park from further degradation should be initiated in order to protect and conserve the park in the face of expanding human activities.

Keywords: Vegetation index, Vegetation health/quality, Deforestation, MODIS, NDVI, ArcGIS 10.5, Cross River National Park

Introduction

National Parks are so important because they are forested areas carved out for the purpose of preserving, enhancing, protecting and managing vegetation and wild animals in their natural environment. National parks are large areas of public land set aside for native plants, animals and the places in which they live. National parks protect places of natural beauty. National park is home to many endemic species (National Parks of Turkey, 2014). They also protect places important to Aboriginal people, and places that show how people lived in the past. National parks are actually protected areas. International Union for Conservation of Nature (IUCN) (2013) definition of a protected area: "a clearly defined geographical space, recognized, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values". Conservation of biodiversity (the variety of our native species and the ecosystems they form) is the central purpose of protected areas (National Parks). High levels of biodiversity keep ecosystems healthy and resilient, which means that they continue providing vital ecosystem services such as nutrient cycling, climate regulation, air and water purification and pollination (IPCC, 2013). Protecting biodiversity is vital to safeguard our economy; our cultural, spiritual and aesthetic values; and the intrinsic value of species and ecosystems. National parks provide a safe home for native plants and animals and also help keep the air clean.

National parks and reserves have increased in Nigeria but only 3.6% of Nigeria is protected under IUCN categories I-V (Nigeria Forest Information and Data (NFID), 2018). Consequently without any conservation efforts or education, the Nigerian society is not aware of how to properly treat finite natural resources. Thus, very few steps have been made to try to lower the deforestation rates and to stop illegal logging (NFID, 2018). Deforestation all over the globe is threatening the sustainability of the environment but has had especially detrimental effects in Nigeria due to their high rates. Deforestation puts at risk all aspects of the environment, the economy and of the citizens of the country (Akinbami, 2003; Odjugo, 2010; FAO, 2018). Nigeria is home to 1417 known species of fauna and at least 4715 species of vascular plants according to figures from the World Conservation Monitoring Centre.

Consequently, much of the allowance for deforestation in Nigeria comes from their demand for fuel wood (Odjugo, 2010; FAO, 2018). For instance, 90% of the Nigerian population stated that they relied on kerosene as the main energy source for cooking but because it is expensive and often unavailable, 60% said they used fuel wood instead. The usage of fuel wood for cooking is higher in rural areas of the country where more of the population is concentrated (Akinbami, 2003). There are also incentives to people living in rural areas surrounding the process of deforestation because it is a source of income to many of them. They extremely high levels of poverty in the country are very much connected to the issue of deforestation (Akinbami, 2003; FAO, 2018). For sustainable forest management, it is therefore important to assess the vegetation quality of the conserved areas in Nigeria as findings can aid in putting forward effective control measures and management procedures.

Conversely, geospatial techniques are useful tools in vegetation assessment and analysis overtime (United States Geologic Survey (USGS), 2018). Presently ecological informatics provides an important support for development of modern ecology, and it serves for ecosystem management directly (Yu et al., 2003). Regional vegetation coverage is an important integral part of spatial database of terrestrial eco-information. It plays an important role in modeling ecosystem change and conservation. Natural vegetation coverage can been surveyed by using satellite remote sensing technology, which have become an important mean of obtaining eco-information on regional or global scale (Liu et al., 2006). Contrasted with NOAA/AVHRR, the terra-MODIS is a kind of new-style and important satellite remote sensor, and has higher spatial and spectral resolutions

MODIS-derived Normalized Difference Vegetation Index (NDVI) and Enhanced Vegetation Index (EVI) are the most widely used Vegetation indices in satellite monitoring of vegetation information (Huete et al., 2002; Wang et al., 2006; Peckham et al., 2008; Mildrexler et al., 2009). Research has shown that when developed a linear relationship with photosynthetically active radiation, leaf area index and biomass of vegetation, EVI or NDVI can be utilized (Wim et al., 2012). Furthermore, methods and data for assessment and validation of natural vegetation coverage obtained from remote sensing is a critical issue. Over the last two decades, remotely sensed data has offered a means of measuring vegetation properties at regional to global scales (Lu et al., 2013). MODIS-NDVI and EVI are closely tied to vegetation coverage, therefore NDVI and EVI will change closely natural vegetation coverage. Previous studies have used NDVI and EVI in semiarid climates (Laneve and Gastronuovo, 2015; Kawamura et al., 2015). This paper therefore carries out vegetation index (health/quality) analysis of National park for years 2000, 2014 and 2020.

Materials and Methods

i. Description of the Study Area

The study area is Cross River in the south-south region of Nigeria. The Cross River National Park is located in Cross River State, Nigeria. It is located geographically within 5^0 0' 00'' N and 7^0 10' 00'' N and longitude 8^0 0' 00'' E and 9^0 35' 00'' E (Figure 1). There are two separate sections, Okwangwo and Oban (Nigerian National Park Service (NNPS), 2010). The park has a total area of about 4,000 km^2, most of which consists of primary moist tropical rainforests in the North and Central parts, with mangrove swamps on the coastal zones (NNPS, 2010a). The study area features a tropical climate with a l ong wet season that stretches from March/April to October with an average temperature of around 26^0C as part of the Niger Delta region (Adejuwon, 2012; Elenwo and Ochege, 2018).The annual temperature range is small as low as 3^0C. Mean monthly temperature is 26-28^0C (Adejuwon, 2012). Rainfall is between 1800mm and 3000mm per year (Emaziye, Okoh and Ike, 2012); and it is heaviest in July. The geology of the river basin in Cross River includes the Pre-Cambrian Oban Massif, Cretaceous sediments of the Calabar flank and the recent Niger Delta sedimentary basin (Eze and Effiong, 2010). The drainage of the study area is comprised of River Niger that drains the southern parts of the country and releases into the ocean through its few distributaries (Aweto, 2001). The vegetation varies from the mangrove swamp along the coast to the rainforest in the middle and the savanna in the north (Adejuwon, 2012; Aphunu and Nwabeze, 2012). The Okwangwo Division in Cross River national park has richly diverse flora, with about 1,545 species representing 98 plant families recorded. Some of these species are endemic to the area. Others were unknown until recently (NNPS, 2010). The types of occupation of the people of Cross River include farming, fishing and industrial jobs.

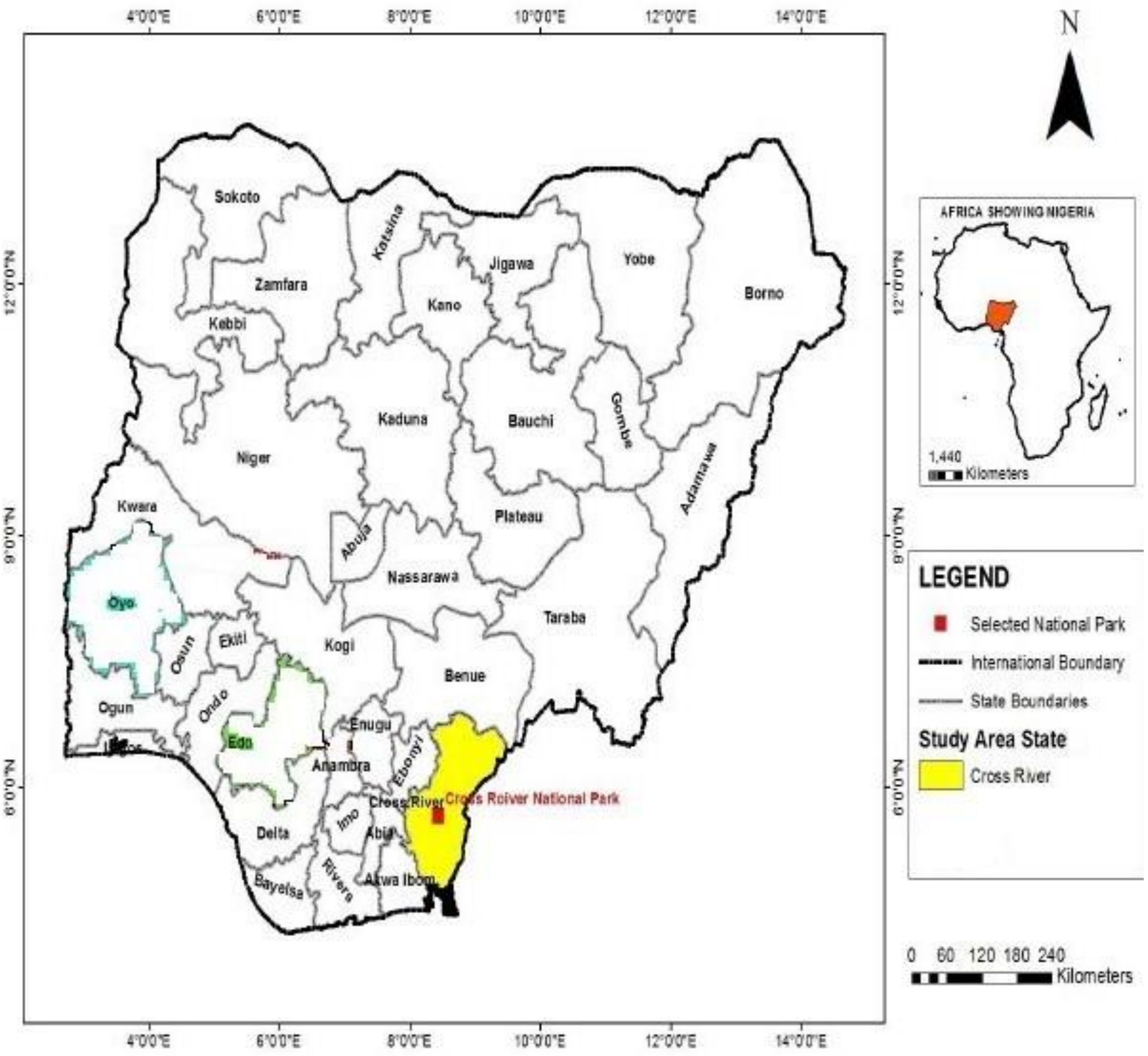

Figure 1. Nigeria locating Cross River National Park

ii. Data Acquisition and Analytical Procedure

The primary data sources were employed for this study. The primary data sources included near real time data of Landsat Enhanced Vegetation Index (EVI) and Moderate Resolution Imaging Spectroradiometer (MODIS) Terra and Aqua Normalized Difference Vegetation Index (NDVI) of 16 Day L3 Global 250m resolution from https://earthexplorer.usgs.gov were employed to determine the vegetation health (greenness) of the Cross River National Park between year 2000 and 2020. One of the most used and implemented indices calculated from multispectral information as normalized ratio between the red and near infrared bands is the NDVI (Karnieli et al., 2010). A direct use of NDVI is to characterize canopy growth or vigor (c). NDVI is the most commonly used vegetation index because it has been shown to be related to vegetation vigor, percentage green cover, and biomass (Xue and Su, 2017). It is a non-linear function that varies between -1 and +1 and is undefined when both Pred and Pnir are zero (Wenlong, 2009; Xue and Su, 2017). Pred and Pnir are reflectance in red and near infrared bands of the satellite imageries respectively. The values greater than 0.5 indicate dense vegetation whereas values lower than 0.1 indicate near zero vegetation such as barren area, rock, sand, water, snow, and built up areas (Xue and Su, 2017). Only active vegetation has a positive NDVI being typically between about 0.1 and 0.6 values at the higher end of the range indicating increased photosynthetic activity and a greater density of the canopy (Tarpley et al., 1984). The analyses were carried out in ArcGIS 10.5. The boundary shapefile of the study area were used to clip the NDVI images of different years and zonal statistics shall be used to extract data from the images both as tables and graduated maps. The zonal statistics show the minimum, maximum, mean and standard deviation. The mean values of NDVI were used for further analysis. The original mean NDVI values were multiplied by 0.0001 as a multiplication factor to scale the original NDVI value to range from 0 to 1 (Daucsavage and Bennett, 2014).

Results of the Analysis

Vegetation index (health/quality) analysis for Cross River National park (2000-2020)

The analysis of vegetation health (NDVI) of Cross River national park in year 2000, 2014 and 2020 is revealed on Table 1, Figure 2, Figure 3, Figure 4 and Figure 5. It is shown that the vegetation health (NDVI) in year 2000 ranged between -0.0511 and 0.9962 with mean value of 0.5678. In year 2014, the vegetation health ranged between -0.069 and 0.997 with mean of 0.5603; while in year 2020, the vegetation health ranged between -0.0846 and 0.9258 with a mean value of 0.4703. This analysis showed that vegetation health in the Cross River national park had reduced over time between year 2000 and year 2020. Deforestation is one of the major contributors to vegetation loss thereby affecting vegetation quality overtime.

Table 1: Vegetation Index (NDVI) for Cross River National Park between year 2000 & 2020

Parameter	Year	Minimum	Maximum	Mean	SD
NDVI	2000	-0.0511	0.9962	0.5678	1184.9
	2014	-0.069	0.997	0.5603	1613.9
	2020	-0.0846	0.9258	0.4703	843.6

*SD – Standard Deviation

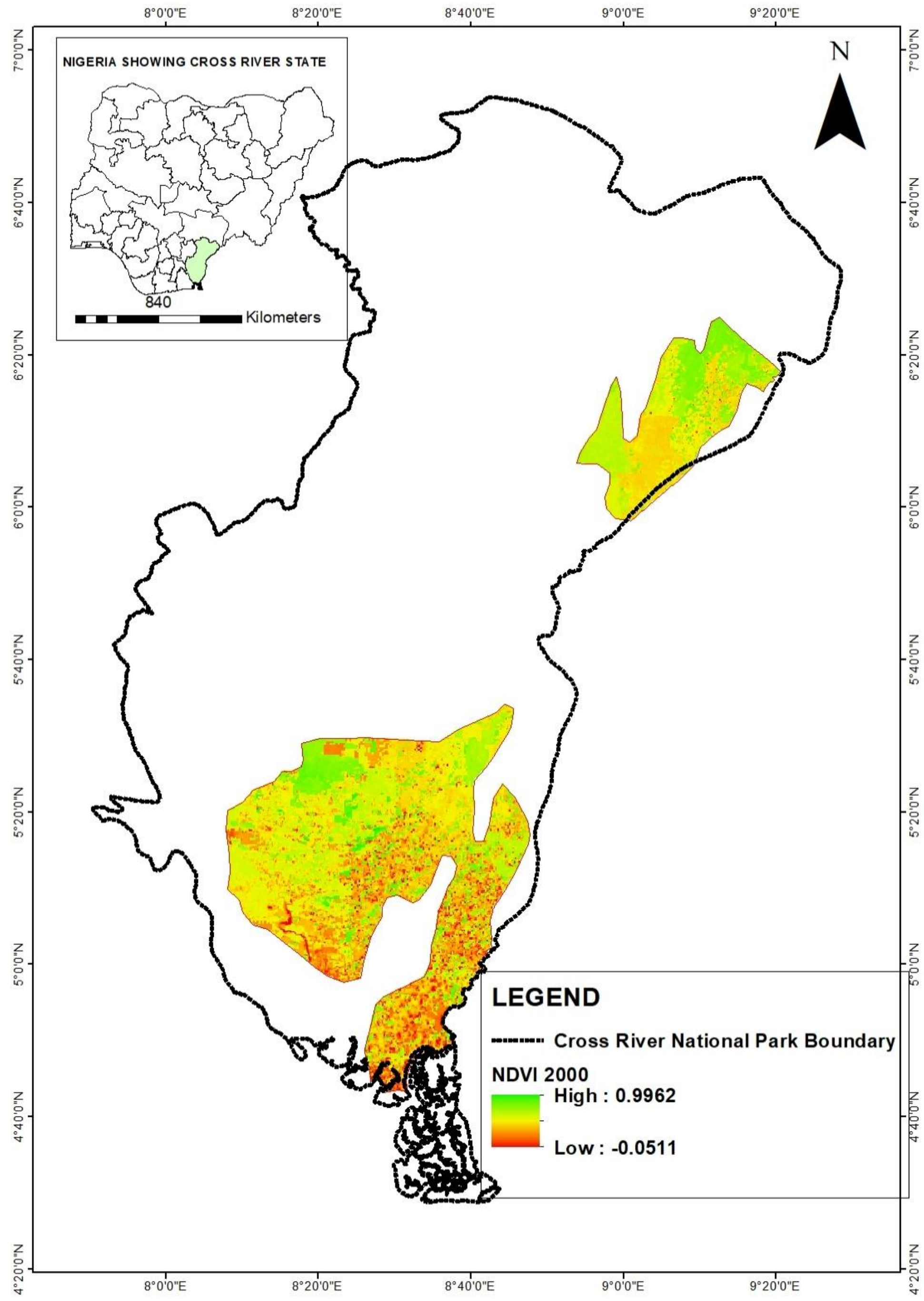

Figure 2: Vegetation index/health for Cross River National Park (2000)

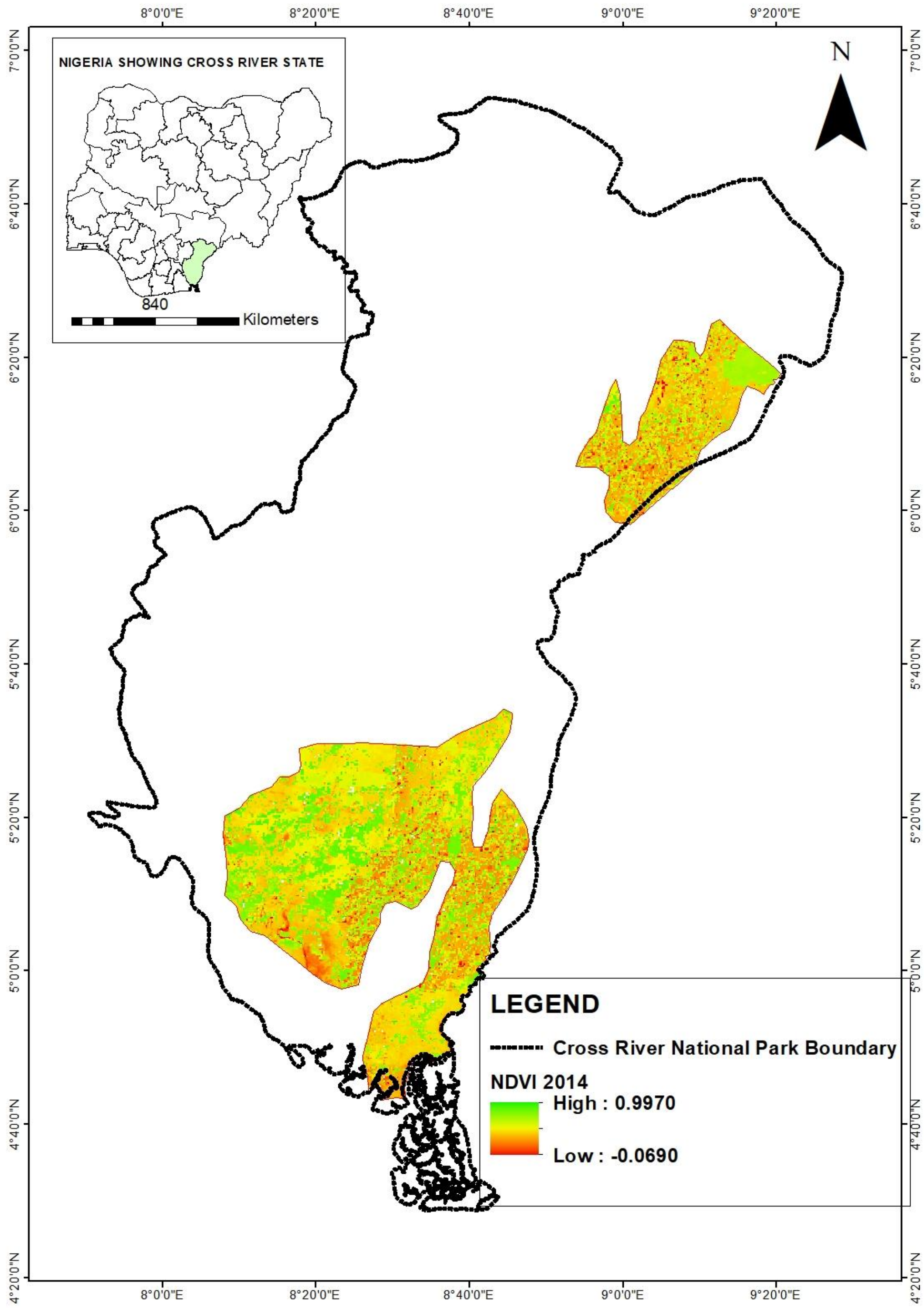

Figure 3: Vegetation index/health for Cross River National Park (2014)

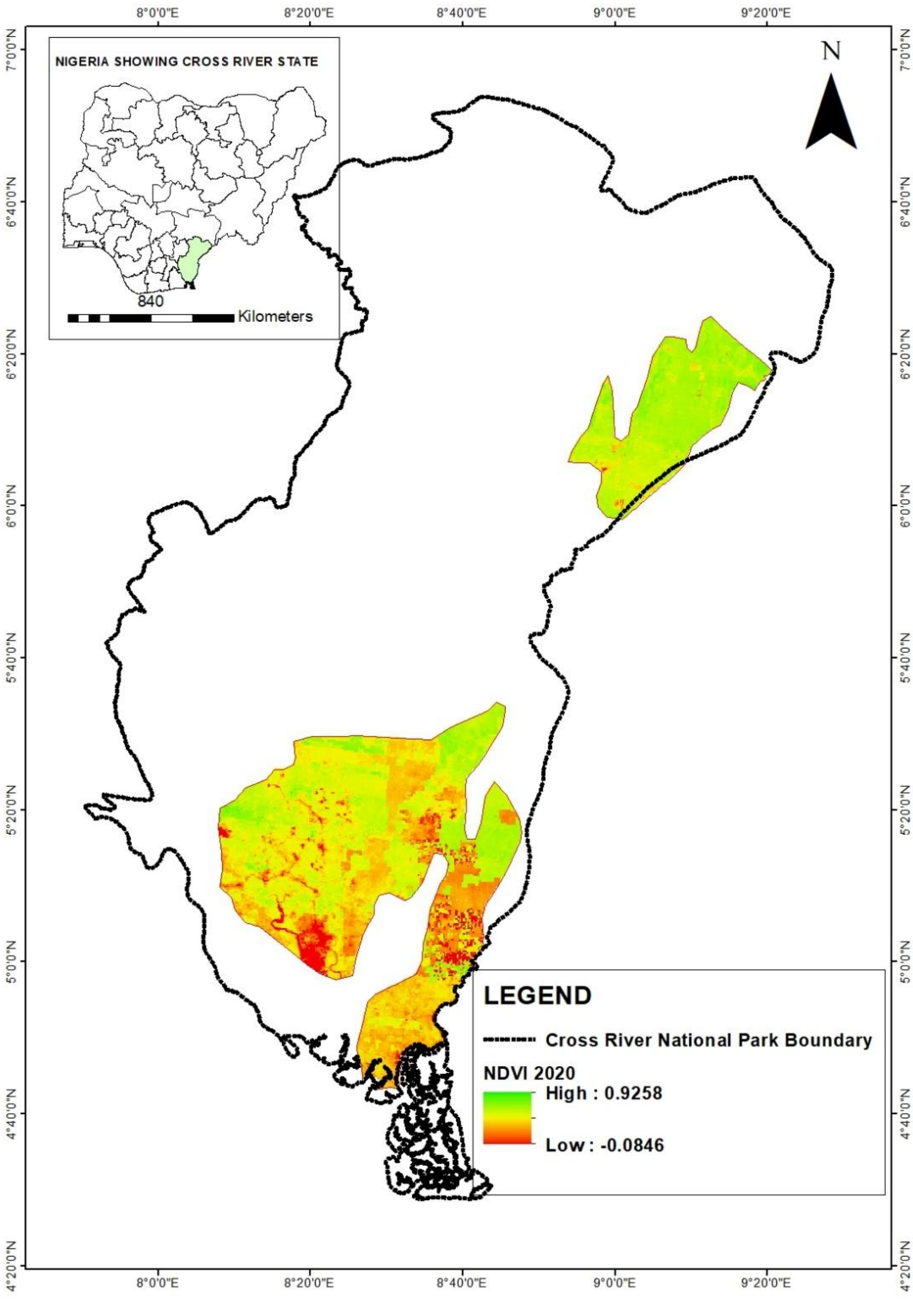

Figure 4: Vegetation index/health for Cross River National Park (2020)

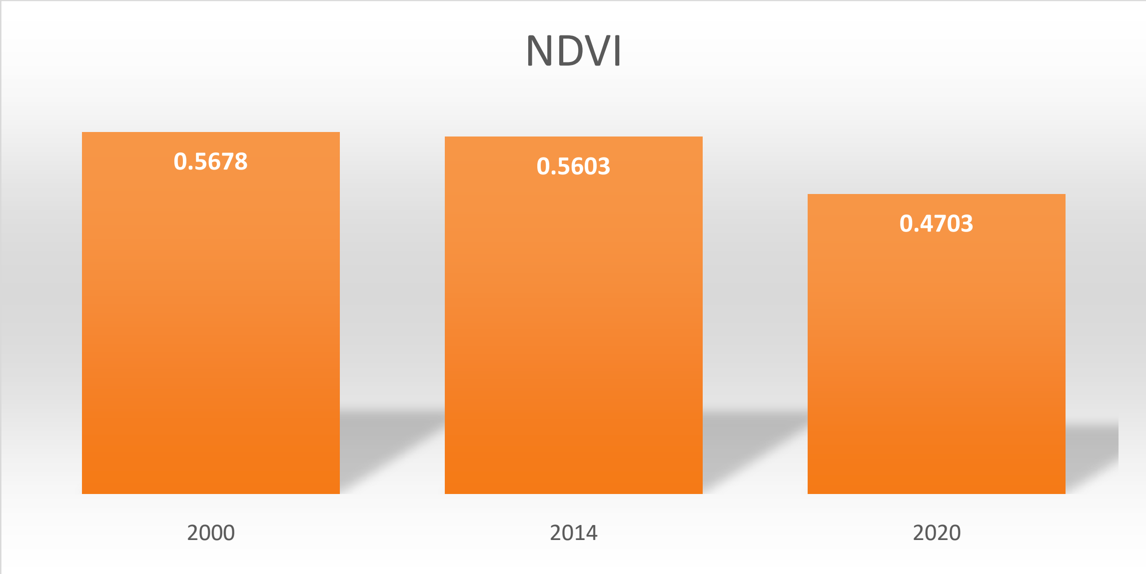

Figure 5: Trend of Vegetation quality (NDVI) of Cross River National Park (2000-2020)

Discussion

Descriptive statistics in the of form minimum value, maximum value, mean value, standard deviations in Tables 1 was used to explain the results of the vegetation health of Cross River National Park. Findings of the study discovered that the vegetation health (NDVI) analysis of the national park declined considerably between year 2000 and year 2020 indicating loss in forests cover which directly means loss in biodiversity overtime. More significantly, the loss vegetation quality of the mangrove forests poses several implications on flooding in the Cross River national park due to high loss in forest cover of the mangrove forests in the national park. This finding agrees with Numbere (2019) who discovered that mangrove forests in the Niger Delta are gradually losing its spatial coverage due to uncontrolled anthropogenic activities. The study further agrees with the findings of Omokhua and Asimiea (2015) on the fact that increasing human activities and encroachments leading to deforestation are affecting biodiversity in sacred forests in Emohua LGA of Rivers state. In addition, the study attributed the rate of increase in deforestation in recent times as factors causing reduction in vegetation index in the Cross River National Park because of human activities. Thus, the study also agrees with the views of Ndoho *et al.*, (2009) who earlier reported that the sizable area of Stubbs Creek forest reserve in Akwa Ibom state has been degraded because of the anthropogenic activities.

Conclusion and Recommendation

The study revealed the usefulness of NDVI in the assessment and analysis of vegetation health in the Cross River National Park. The vegetation quality of the Cross River National Park had reduced overtime due to several forms of disturbances and encroachments causing deforestation. Thus, based on these findings the study recommended that: control measures to safeguard the national park from further degradation should be initiated in order to protect and conserve the park in the face of expanding human activities; human activities (both individuals and government) currently diminishing thick forests size should be discouraged at all cost; uncoordinated deforestation practices should be stopped while increased efforts should be directed on those activities that encourage forest conservation at all times; focus should be shifted from the immediate benefits derived from conversion of forested areas to agricultural or other developmental projects to sustainable future benefits for proper forest management practices in the national parks; lastly, adequate awareness should be created among community residents within the national park on the importance of forests ecosystems like the national park and the need to conserve it at all times.

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