Analysis of Vegetation Health of the Sundarbans Region - Using Remote Sensing and GIS Techniques

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Abstract

Nowadays the satellite images emerge as the major instrument for land use and land cover mapping in developing countries. For better management of natural resources like Forest, cultivable land and to find out new mining areas satellite images processing is gaining popularity among the researchers. Forest resources have a pivotal role in economic growth, better forest management is needed in every country. To monitor the vegetation growth different forest health measurement indexes have been introduced viz. NDVI, GARI, FCD, and many more. NDVI is an age-old indicator that determines the density of green on a tract of land. In this article our keen interest in assessing the vegetation health of the Sundarban region under India, applying different vegetation indexes viz. NDVI on USA satellite Landsat8 images from 2014 to 2020 and determine the depletion of vegetative health over those years. A great effort has been put forward to assess to indicate the regions where afforestation measurement should be taken at the earliest to check the further deterioration of deltic greeneries on the Indian side.

Keywords: GIS, Sundarban, NDVI, Landsat-8, Remote sensing, Land coverage, wetland

1. Introduction

A part of the Sundarban region, situated at the south of West Bengal state in India has been chosen for our current research work. It spans across the borders of two neighbouring countries India and Bangladesh and serves as a shield for the coastal regions against the repeated hit of super cyclones formed each year in the Bay of Bengal. To protect its rich bio-diversity UNESCO declared four protected regions as World Heritage sites. Despite the utmost strive of the central and the state Government to preserve its ecological balance, Sundarban's vegetation health is facing a great threat from urbanization, poaching, and sea-level transgression due to global warming.

Vegetation cover is of utmost need along the river banks and in the inland areas to protect the soil cover from the natural calamities viz. hurricanes, cyclones, and tsunamis[1]. It plays a substantial role to sustain an ecological balance, boosting up the biodiversity, and diminishing the adverse effect on the regional climate. The Sundarban region has a great ecological effect on the coastal region of both countries viz. India and Bangladesh. Its western boundary has been demarcated by Hooghly river, and Ichamati, Kalindi, Raimangal, the famous distributaries mark its eastern boundary. On the north its area is terminated by the Dampier Hodge line and the Bay of Bengal bathes its foot at the south. Numerous distributaries of Ganga, Brahmaputra, and Meghna along with the main rivers contribute to the origin of the Sundarban region in an intertidal zone, encompassing nearly 10,000 km^2 [2]. It's 60% of area falls under Bangladesh whereas India claims only 40% of its area. The United Nations Educational and Scientific Co-operation (UNESCO) declared it as a biosphere reserve in the year of 1989 and spurred the activity to preserve its biodiversity and to foil the illegal human activity for deforestation.

A sharp decline of the mangrove forest areas had been registered throughout the world. Though a slight increase of forest area was recorded in 1970 to 1990. In later decades it faced depletion of forest area nearly 2.5% during 1990 to 2000 [3]. Nearly 0.42% area had been permanently deforested from 1975 to 2006 due to an increase of human habitation and uncontrolled felling down of trees to suffice human needs[4].

Under these grave circumstances, remote sensing and GIS clubbed with image processing techniques, emerges as a convenient tool to assess the overall scenario of the vegetation cover of any forested region of the world. Repetitive satellite images are capable of gathering information about forested regions, changes of vegetation type over the time and pattern of land use of a region. To assess the health of the specified forest region NDVI [5] is the most useful index available. Forested area reflects more in the near-infrared (NIR) band, but it absorbs more in the red band. So the conjunction of these two bands mirrors the fact about the vegetation density of a forested region.

2. Study Area

Our study area comprises the southern portion of the district of South 24 Parganas of West Bengal state which is shown in Fig 1.It belongs to the Sundarbans Reserved Forest. It contains diverse mangrove species, which only could be found in this forest [6]. The mangrove forest occupies 69% of the area and the remaining area gets submerged with saline water of the sea and the wide estuaries of numerous crisscrossed distributaries of river Hooghly. The forest is a natural resort of overwhelming 528 species of plants. Out of them, 24 species are true mangrove, other 70 species closely related to the mangrove species[7]. This wild habitat is blessed with enriched animal diversity with a staggering total of 1135 species which includes a large group of endangered species viz. the Royal Bengal Tiger, river dolphins, and Ghorials[8]. The study area embraces a good many deltaic islands viz. Bhangaduni, Baghmara, Mayadwip, Gana bordered by mangrove forests. The coordinates of our study area are given below in Table I.

TABLE I: Coordinates of The Study Area

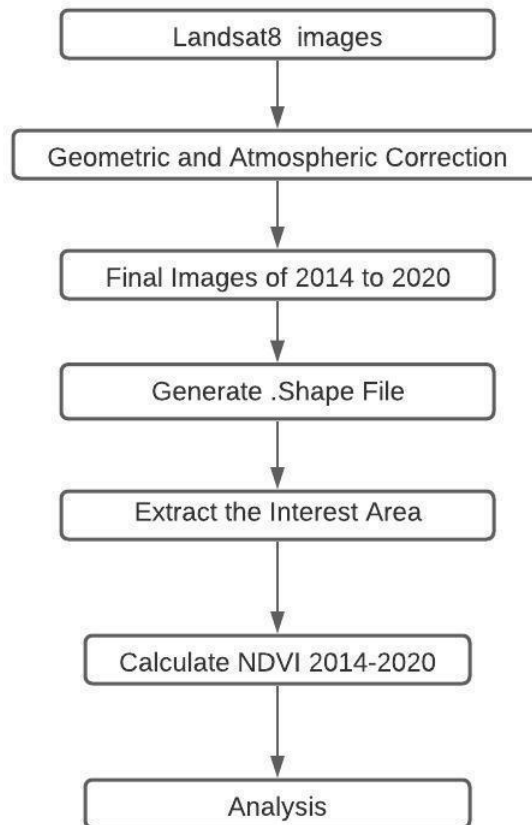| Area	Latitude	Longitude
Upper Left	22°24'44.64"N	88°25'28.20"E
Lower Left	21°32' 6.18" N	88°24'56.79"E
Upper Right	22°23'50.00"N	89°38'0.01"E
Lower Right	21°31'13.89"N	89°37'2.00"E
Center	21°58' 2.70" N	89°1'21.93" E

Fig. 1: Location of Study Area

3. Data

This research had used Landsat 8 imagery obtained from Jan 2014 to Jan 2020 from USGS Earth Explorer Site. All the images were acquired in the December - January session to incorporate a cloud free scene over an interval of 12 months. A pixel embraces a 900 sq mt area of the ground. The Scenes are associated with Path 138, Row 45 of Landsat8. It orbits the Earth from north to south at a height of 705 km from the ground, inclined at 98.2 degrees. It finishes a single orbit around the Earth in every 99 minutes. According to WRS2 (worldwide reference system 2), we took the images from path 138 row 45 and clipped out the reference area.

3.A. Landsat8 band description

Two types of sensors are incorporated in Landsat 8 satellite, one is the Operational Land Imager (OLI), and the other one is the Thermal Infrared Sensor (TIRS). Landsat 8 captures data in different ranges of frequencies along the electromagnetic spectrum. It gathers data in 11 bands from two separate sensors, and incorporates two separate thermal bands VIZ. Band 10 and 11. As per our requirement, we have used 5 bands (B2 to B6).

4. Methodology

Fig 2: Research Methodology

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┌─────────────────────────────────────┐
│          Landsat8  images            │
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                  │
                  ▼
┌─────────────────────────────────────┐
│  Geometric and Atmospheric Correction │
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│       Final Images of 2014 to 2020   │
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┌─────────────────────────────────────┐
│         Generate .Shape File         │
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│        Extract the Interest Area     │
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│        Calculate NDVI 2014-2020      │
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│              Analysis                │
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4.A Image Processing

Seven Landsat 8 images were pre-processed using QGIS software to make it ready for analysing. The pre-processed images enable us to assess the important features from remotely sensed data from 2014 to 2020. Image pre-processing has been performed using QGIS 3.16 software. Landsat 8 multispectral sensors can capture eleven bands including red, NIR, green, SWIR, Thermal bands 10, and 11. Band information are used to bring forth the various features. The NIR band is very much sensitive to green vegetations. Other image pre-processing works like geometrical and atmospheric corrections are done by QGIS software.

4.B Calculation of NDVI

Depending upon the composition, every material on the earth has its unique reflectance signature along the electromagnetic spectrum. Freshwater reflects high frequency blue light whereas turbid water is visible as brownish due to high sediment suspensions. Bare land reflects light depending on its constituent materials.

NDVI is mostly used in finding out the density of the green coverage on an area of land. During photosynthesis, the chlorophyll present in the plant's leaf highly absorbs visible light, whereas it

strongly reflects the NIR frequencies from 700 nm to 1100 nm. Taking these properties into account, NDVI [9] assesses the rate of reflection for NIR and red frequencies of an area. It converts it into an image that denotes the health of green vegetation. The following equation gives the value of NDVI for each pixel of a ground area using two bands.

$$NDVI = (NIR-RED)/(NIR+RED)$$

The NDVI values stretch from -1 to +1 per pixel. A highly negative value indicates the presence of water bodies whereas +0.5 and onward it signifies a presence of healthy vegetation cover. +1 NDVI values signify a densely forested area.

5. Result Analysis

NDVI has been calculated for 2014 and 2020 for the interested region and the regions are divided into four categories. NDVI values less than zero are considered to be water. The shallow region is mainly a muddy beach area along the rivers and their estuaries. The vegetation regions are categorized in three different regions Viz. Low vegetation, Medium vegetation, and Dense vegetation.

Table 2: Normalized Difference Vegetation Index

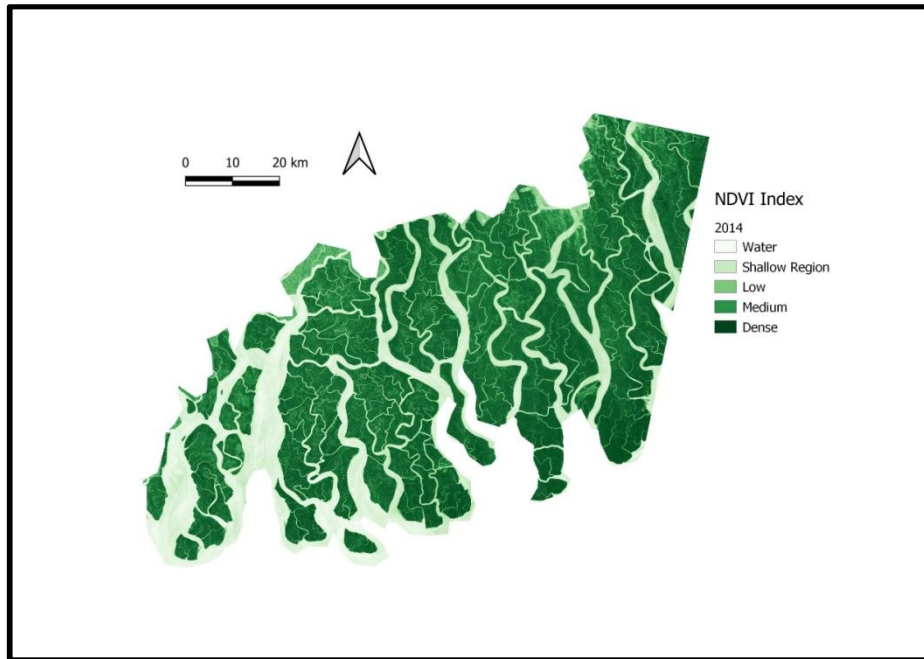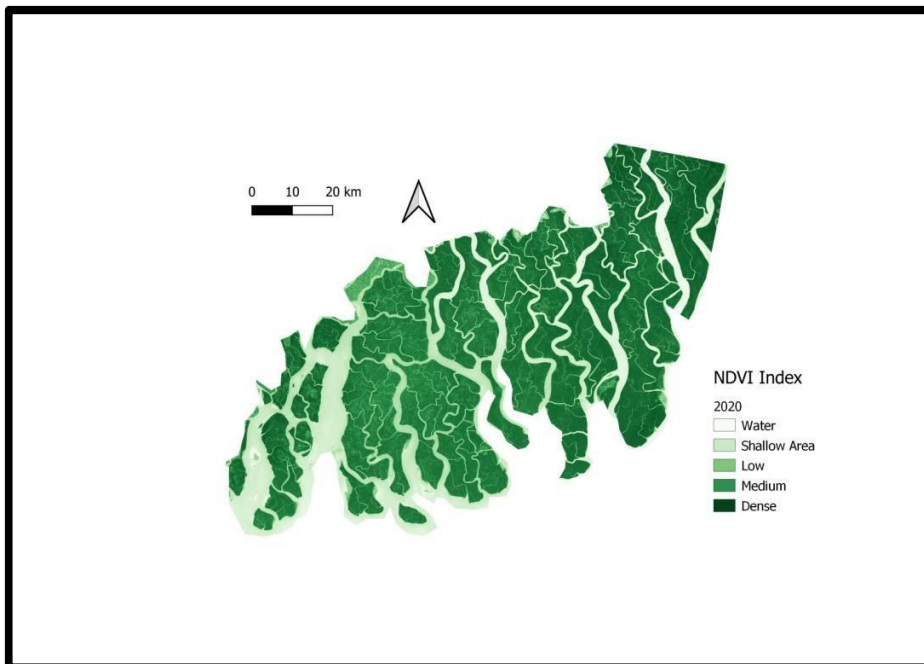| NDVI Value	Category
<=0	Water
<=0.1	Shallow Region
<=0.3	Low Vegetation
<=0.5	Medium Vegetation
>0.5 to 1.0	Dense Vegetation

Fig 3: NDVI of 2014


Fig 4: NDVI of 2020

Comparing the above-mentioned images subtle changes are evident in the southwest region of the point of interest area. Vegetation depletion takes place around the coastal region and solitary islands. NDVI difference technique has been employed to deduce the vegetation loss and gain areas. In the NDVI difference technique, the difference of the NDVI is taken into account pixel by pixel. The loss of vegetation is slightly greater than the vegetation gain.

Table 4: NDVI Difference

NDVI Difference	Meaning
0	No Change
<0	Vegetation Loss
>0	Vegetation Gain

Fig 5: NDVI Difference
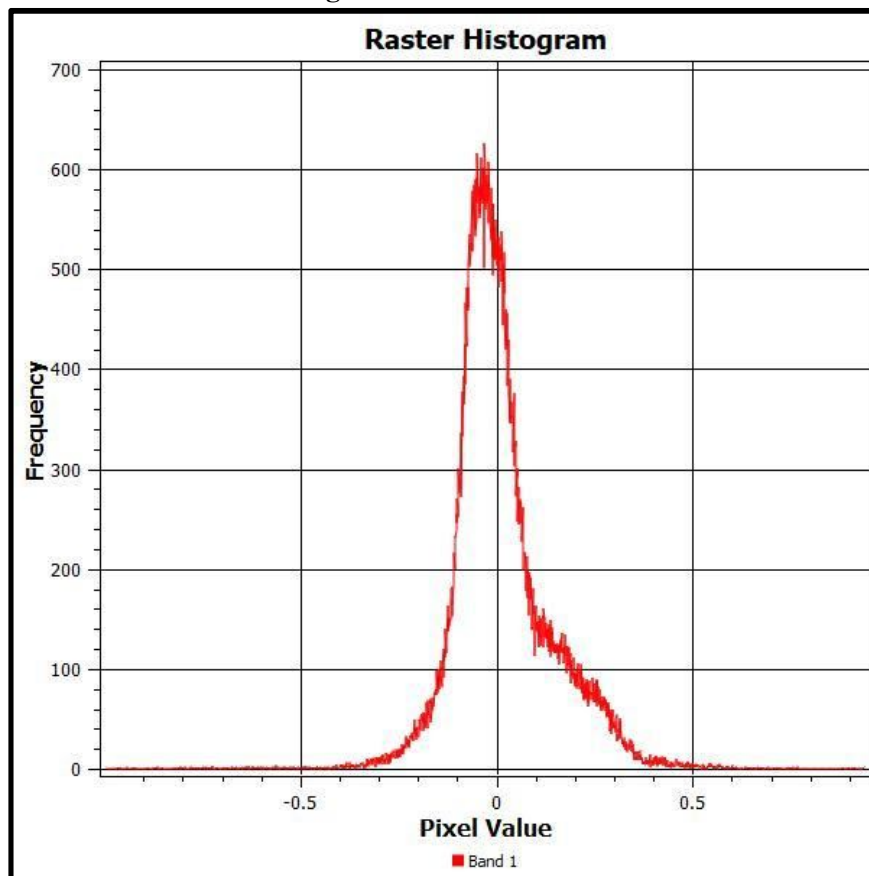
In Fig 5 the histogram is showing the pixel frequency in above mentioned three categories in Table 4. The entire histogram is left aligned and pixel frequencies are greater in the negative zone than the zero or the positive zone. In the course of seven years 2014 to 2020, it seems that the region has a downward tendency of losing its vegetation cover.

According to Fig 6 Sharp depletion of NDVI is noticed along the coastal region of solitary islands of southernmost areas of Sundarban. Along the coastal region of the Gosaba River, isolated islands like Bhangaduni and Dalhousie islands are subjected to severe deforestation. The North-Western region of the point of the interest area experiences a gain of vegetation cover. But the Sajnekhali wildlife

sanctuary [Fig 7] tends to lose its vegetative cover. In the last decade, despite the effective measures to protect this region and to preserve this area as a wild habitat for the Royal Bengal Tigers, it experiences a negative change in vegetative cover. Other areas nearly remain unaffected. The northeastern region of the POI experiences a positive change in vegetative cover.

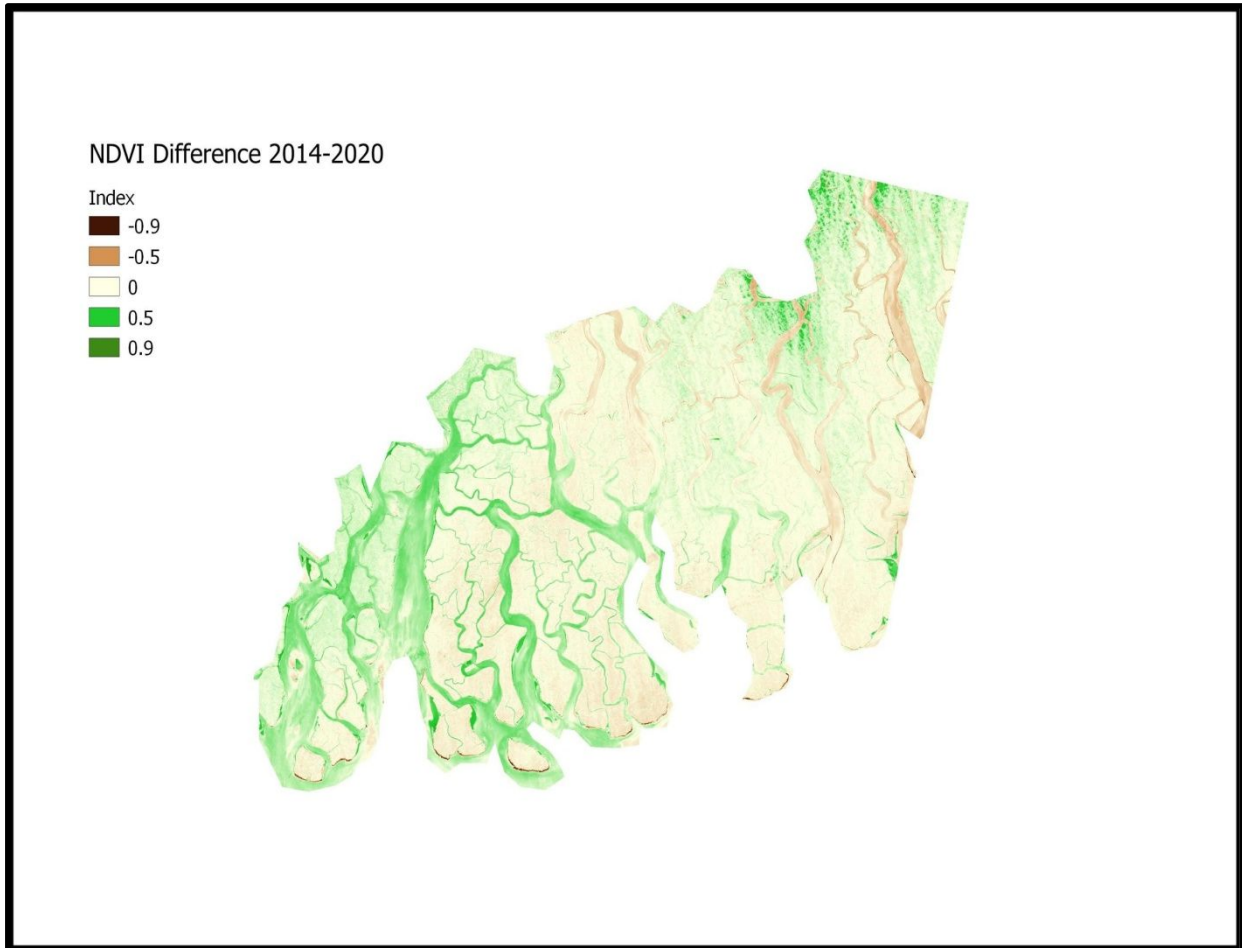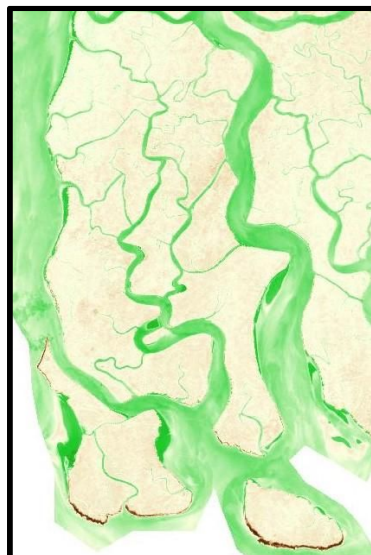**Fig 6: Changes of Vegetation cover during 2014-2020**

Fig 7: Map of Bhangaduni island(southwest) Dalhousie island(southeast) and Sajnekhali wildlife sanctuary (Upper Part)

6. Conclusion

The mangrove region of the Sundarban region is under threat due to tidal wave erosion, repeatedly hit by super cyclones. There is a gradual change of climate due to the gradual increase of salinity in the estuary, which affects the species distribution in the different parts of Sundarban mangroves. Advance action should be taken to prevent new human settlement and deforestation due to human activity in the affected regions**.**

7. References

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