ASSESSMENT OF VEGETATION HEALTH IN SAINT MARTINS ISLAND, BANGLADESH USING REMOTE SENSING & GIS

BISHAL ROY
Department of Geography and Environmental Science, Faculty of Life & Earth Sciences,
Begum Rokeya University, Rangpur-5400, Bangladesh
* pranto@brur.durmor07.com

ABSTRACT
Saint Martin's Island, Bangladesh has been one of the most popular tourist destinations in the country with rapid growth in this industry. It is also a very sensitive ecosystem that is being negatively affected by the increased number of human settlements on the island. This island is situated in one of the most cyclone-prone areas in this country. Increased consumption of resources along with consistent disasters has an impact on the health of vegetation on this island. This study assesses and visualizes the changes in vegetation health on this island from 2005 to 2019 spanning over 15 years using Remote Sensing (RS) and Geographic Information System (GIS). All of the data used in this study were collected from the United States Geological Survey's (USGS) Landsat-7 Enhanced Thematic Mapper Plus (ETM+). All the satellite raster images used were geometrically and radiometrically corrected. The gap or no data issue with Landsat-7 imagery was also corrected. The normalized difference vegetation index (NDVI) was then calculated for each of the years and the raster subtraction of 2005 from 2019 visualizes the differences. All these results are presented in classified categories. The results indicated that vegetation health has been changing over a large area during this period.

KEYWORDS: Remote Sensing, GIS, Saint Martin's Island, Vegetation Health, NDVI

INTRODUCTION
Saint Martin's Island is a small island in the southeastern part of Bangladesh. This island is the only coral reef island of Bangladesh and thus has a very unique and sensitive ecosystem. But this uniqueness has also caused a rapid expansion in its tourism industry. Thus, there has been a long term impact on the vegetation health on this island. NDVI is a normalized difference index that can be calculated using multispectral satellite images, specifically by red and near-infrared band. According to (Xue & Su, 2017), vegetation indices can be a simple but effective method for determining the vegetation of an area. Works from (Ozyavuz, Bilgili, & Salici, 2015) use the NDVI method for vegetation health detection with very high accuracy. (Olukayode, Blesing, Rotimi, & Oguntol, 2018) reaffirms that plant vigor and canopy cover calculated by NDVI is of high quality and usable in various applications.
Our study area is situated between 92°18' to 92°21'E and 20°34' to 20°39'N (Banglapedia) covering 36 square kilometers of area. The average this Island is 25.7 °C and annual precipitation is 4544 mm (Climate Data Organization). The average temperature is similar to the average of Bangladesh but the rainfall is almost double than the annual precipitation rate of Bangladesh which is 2666mm (The World Bank). Both of these parameters are suitable for the healthy growth of vegetation. This study aims to assess how much vegetation health has changed over this period using a scientific method such as NDVI calculated by multispectral satellite images.

DATA AND METHODS:
For calculating vegetation health on the island throughout 15 years, NDVI is the best method. As emphasized by various researchers, this is one of the most simple, efficient, and accurate method for this purpose. Proposed by (Rouse Jr, Haas, Schell, & Deerin, 1974), this formula can be expressed as the following,

$$\mathbf{NDVI} = \frac{(\mathbf{Near\ Infrared\ Band} - \mathbf{Red\ Band})}{(\mathbf{Near\ Infrared\ Band} + \mathbf{Red\ Band})}$$

$$\mathbf{NDVI\ Difference} = \mathbf{NDVI\ of\ 2019} - \mathbf{NDVI\ of\ 2005}$$

Our study timeframe was from 2005 to 2019 which required us to use USGS's Landsat-7 Enhanced Thematic Mapper Plus (ETM+) imagery. This study uses 2 bands from the multiband images captured by Landsat-7. The specifications are as follows.

Table 1: Spectral bands wavelengths and resolution

Band Name	Wavelength (µm)	Resolution (m)
Band3 - Red	0.63 – 0.69	30
Band4 - Near Infrared	0.77 – 0.90	30

To avoid variations in raw data due to climatic factors, we collected images from 03 December to 28 December in all four years and accepted cloud cover below 10%.
Flowchart of operation for this study is as follows.

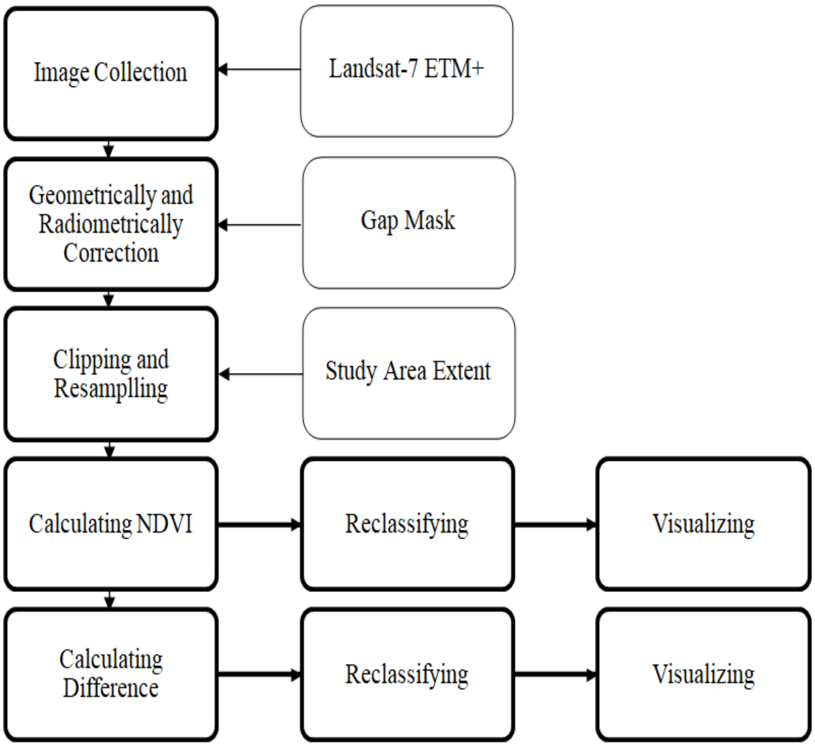

Figure 1: Flowchart of operation

The study area is very small in size, thus the images captured by Landsat-7 sensors are not of very high quality. For a better visibility, the images were resampled from 30m resolution to 1m resolution using cubic resampling method. The projection system used in this study is WGS 1984 UTM Zone 46N. NDVI values were calculated for better visualization of the data produced by NDVI analysis and as suggested by (Antognelli). The value ranges were classified based on the NDVI values of the study area rather than pre-defined ones as the higher value ranges were missing. The missing value from higher and lower end of the index indicates the lack of absolute presence or absence of vegetation range.

RESULTS AND DISCUSSIONS

Following the methodology, this study concluded with 5 raster images which indicate four points on time (2005, 2010, 2016, and 2019) and the total difference from 2005 to 2019. The resulting images are as follows.

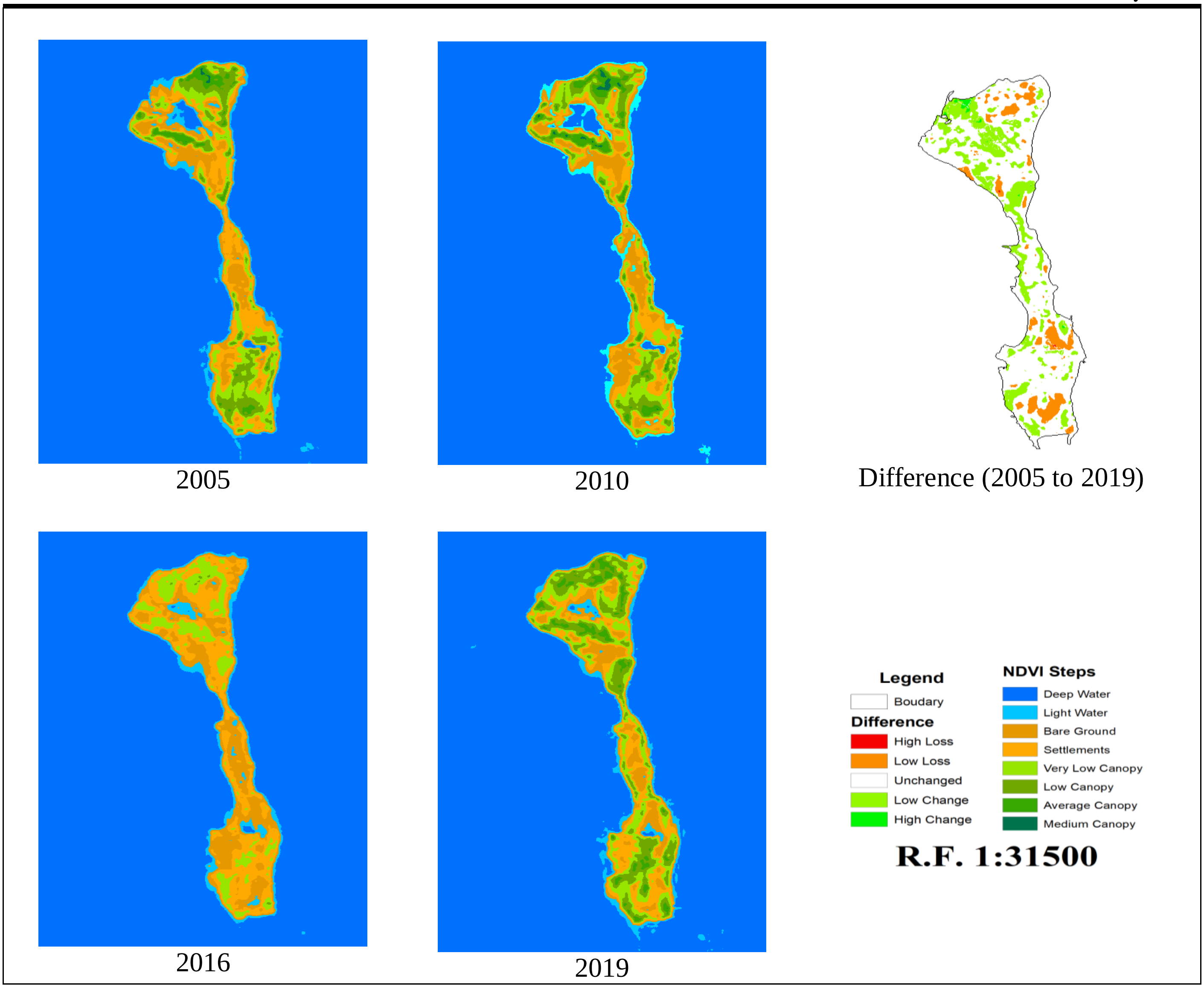

Figure 2: Maps showing NDVI in different years and their differences.

From Figure 2, the different stages of vegetation health along with water, bare land, and settlements are visualized. From an initial view, we can see that the vegetation health is changing over a large area during this period. These images show canopy cover as well as plant vigor (Antognelli). The most prominent changes occurred in 2016, where almost all vegetation health deteriorated to the low or very low canopy and plant vigor. But a good amount of canopy cover and vigor were restored in 2019. These values can be analyzed more thoroughly by calculating the area containing the different vegetation health categories.
The differences will be much more observable from the table that follows.

Table 2: Vegetation health status and corresponding land area (In Sq. Meters)

Values	Label	2005	2010	2016	2019
-1 to -0.1	Deep Water	69942784	69977448	69931386	69745186
-0.1 to 0	Light Water	483818	419541	462979	473034
0 to 0.1	Bare Ground	695776	756115	1033557	592005
0.1 to 0.2	Settlements	853291	758702	1228812	800413
0.2 to 0.3	Very Low Canopy	636859	639771	529153	764613
0.3 to 0.4	Low Canopy	443311	411626	5713	647109
0.4 to 0.5	Average Canopy	129803	205438	0	70
0.5 to 0.6	Medium Canopy	5958	22959	0	0
0.6 to 1	High Canopy	0	0	0	0

From the table of data, it is clear that the year of 2016 saw the most downfalls in terms of vegetation health. From 2005 to 2010 Average and Medium canopy cover and plant vigor were present about 22959 square kilometers. This health was completely lost and never recovered during this research. In the year of 2016, settlements and bare ground increased heavily, probably due to multiple cyclones from 2010 to 2016 which is a contributor to the lost vegetation health. To this day the island largely contains low and very low canopy cover and plant vigor.

Further, we assess the net changes during this time of 15 years. The following table is calculated by subtracting the 2005 NDVI raster data from 2020 NDVI raster data.

Table 3: NDVI changes over 15 years (2005 to 2019) (In Sq. Meters)

Values	Label	Count
-1 to -0.35	High Loss	1298
-0.35 to -0.1	Low Loss	346583
-0.1 to 0.1	Unchanged	2222058
0.1 to 0.35	Low Gain	844245
0.35 to 1	High Gain	20233

This table shows the net changes in vegetation health or other classes in the NDVI images. Almost one-third of the land area's cover was changed in these 15 years of time. The majority of the change is in the low gain category, which indicates that the change in value is very small. This is most likely to change low to very low class of canopy cover. A significant amount of area has also lost canopy cover, this area is most likely mid to average canopy cover which was lost after 2010.

This study, to an extent, supports the fact that the increased number of human involvement on this island has caused a decrease in the health of vegetation on this island. Though the results show a good percentage of canopy gain as well, these are in the lower classes of NDVI classes. Immediate actions should be taken to ensure vegetation growth on this island. This study is only based on the normalized difference vegetation index and this does not include other measures, such as soil adjusted vegetation index or normalized difference built-up index (NDBI). With all these accumulated data, it will be possible to determine the exact health status of vegetation on this island and also create a distinction between agricultural and forest plants as well.

CONCLUSION

Vegetation health is very important in terms of analyzing the state of ecosystem status and also the pollution level. When the vegetation health drops significantly, much like on the island, we should be concerned. Saint Martin's island has a very delicate and sensitive ecosystem unlike anywhere else in the country. Thus preserving this is of paramount importance. Human interactions on this island should be controlled and measures need to take to improve the vegetation cover and in a broader sense, improving the ecosystem.

REFERENCES

1) Works Cited Antognelli, S. (n.d.). NDVI and NDMI vegetation indices. Retrieved 7 13, 2020, from Agricolus: https://www.agricolus.com/en/indici-vegetazione-ndvi-ndmi-istruzioni-luso/
2) Banglapedia. (n.d.). St. Martin's Island. Retrieved 7 13, 2020, from Banglapedia: http://en.banglapedia.org/index.php?title=St_Martin%27s_Island
3) Climate Data Organization. (n.d.). Saint Martin Island's Climate. Retrieved 7 13, 2020, from Climate Data Organization: https://en.climate-data.org/asia/bangladesh/chittagong-division/st-martin-s-island-970192/
4) Olukayode, O. S., Blesing, L. O., Rotimi, A. D., & Oguntol, E. A. (2018). Assessment of plant health status using remote sensing and GIS techniques. Advances in Plants & Agriculture Research , 1-9.
5) Ozyavuz, M., Bilgili, B., & Salici, A. (2015). Determination of Vegetation Changes with NDVI Method. Journal of Environmental Protection and Ecology , 264-273.

6) Rouse Jr, J. W., Haas, R., Schell, J., & Deerin, D. (1974). Monitoring vegetation systems in the great plains with erts. NASA Special Publication , 309-351.
7) Satelite Imaging Corp. (n.d.). LANDSAT 7 ETM+ Satellite Sensor (15m). Retrieved 7 13, 2020, from Satelite Imaging Corp.: https://www.satimagingcorp.com/satellite-sensors/other-satellite-sensors/landsat/
8) The World Bank. (n.d.). Average precipitation in depth. Retrieved 7 13, 2020, from The World Bank: https://data.worldbank.org/indicator/AG.LND.PRCP.MM
9) Trading Economics. (n.d.). Temperature of Bangladesh. Retrieved 7 13, 2020, from Trading Economics: https://tradingeconomics.com/bangladesh/temperature
10) Xue, J., & Su, B. (2017). Significant Remote Sensing Vegetation Indices: A Review of Developments and Applications. Journal of Sensors , 1-17.

11) Satelite Imaging Corp. (n.d.). LANDSAT 7 ETM+ Satellite Sensor (15m). Retrieved 7 13, 2020, from Satelite Imaging Corp.: https://www.satimagingcorp.com/satellite-sensors/other-satellite-sensors/landsat/
12) Trading Economics. (n.d.). Temperature of Bangladesh. Retrieved 7 13, 2020, from Trading Economics: https://tradingeconomics.com/bangladesh/temperature