Turkish Online Journal of Qualitative Inquiry (TOJQI)
Volume 12, Issue 10, October 2021: 2464-2473

Vegetation Dynamics Assessment–A Case Study of Visakhapatnam Metro Region, India

Author[1] **Sridevi Talluri**, Research Scholar, Dept. of Geo-Engineering, Andhra University, India

Author[2] **S.Adi Seshu**, Professor, Department of Civil Engineering, Andhra University, India

Abstract

Changes in vegetation cover affects local climatic conditions and brings changes surface biomass.Vegetation change studies became significant indicators for global climate change, drought conditions and to study crop health. The normalized difference vegetation index (NDVI), which is anexcellent indicator for measuring vegetation health, stressed vegetation anddeforestation and droughtconditions. Time series of NDVI will give crop growth profiles .Satellite observations are used to produce global scale vegetation cover statistics.These NDVI based statistics bring comprehensive geographical and seasonal patternsof vegetation and surface energy balance. NDVI derived from remote-sensing data by measuring reflectance values in RED and Infrared regions,using Google Earth Engine. Sentinel-1(ESA) and Landsat8 data used to derive temporal variability of Normalized Difference Vegetation Index (NDVI). The study was carried out for a period of 2008, 2013 and 2019 in VMRDA region. Studybrings out vegetation statistics like vegetation cover changes, deforestation,and crop health in the study area. Thus,NDVI has a multidimensional indicator and has also been used for land cover classification, drought monitoring, vegetation health, crop stress, land degradation and forest carbon dynamics.

Keywords: NDVI, Greenness Index, temporal changes, Vegetation stress, drought, land degradation, LST, Google Earth Engine.

Study area description:

Visakhapatnam District is one of thefast growing districts of Andhra Pradesh and occupies an area of approximately 11,161 square kilometres and it lies between 17^{o}15'and 18^{o}-32' Northern latitude and 18^{o} 54' and 83^{o}-30' in Eastern longitude.As per 2021 master plan, theextent ofVisakhapatnam Metro Region was expanded to 7200 sq. km from its 1,721 sq. km area with atotal population (as per 2011 census) is 52,93,369 out of which, rural and urban population share is 54.3% and 45.6%.

The study area covers four districts. Srikakulam, (11 mandalas) Vizianagaram (16 mandals), Visakhapatnam (19 mandals) and East Godavari (4 mandals). Municipal corporations covered in Visakhapatnam Metro Region Development Authority (VMRDA) are GVMC,Vizianagaram Municipal Corporation, Srikakulam MunicipalCorporation, Municipalities covered area Amadalavalasa, Yelamanchili, and Tuni, Nagar panchayatsof Rajam and Nellimala. The current sanctioned Master Plan for VMR-2021 is due for revision. The revised masterplan will be prepared in accordance with the provision of Andhra Pradesh Metropolitan Region and Urban Development Authority (APMRUDA) Act 2016.

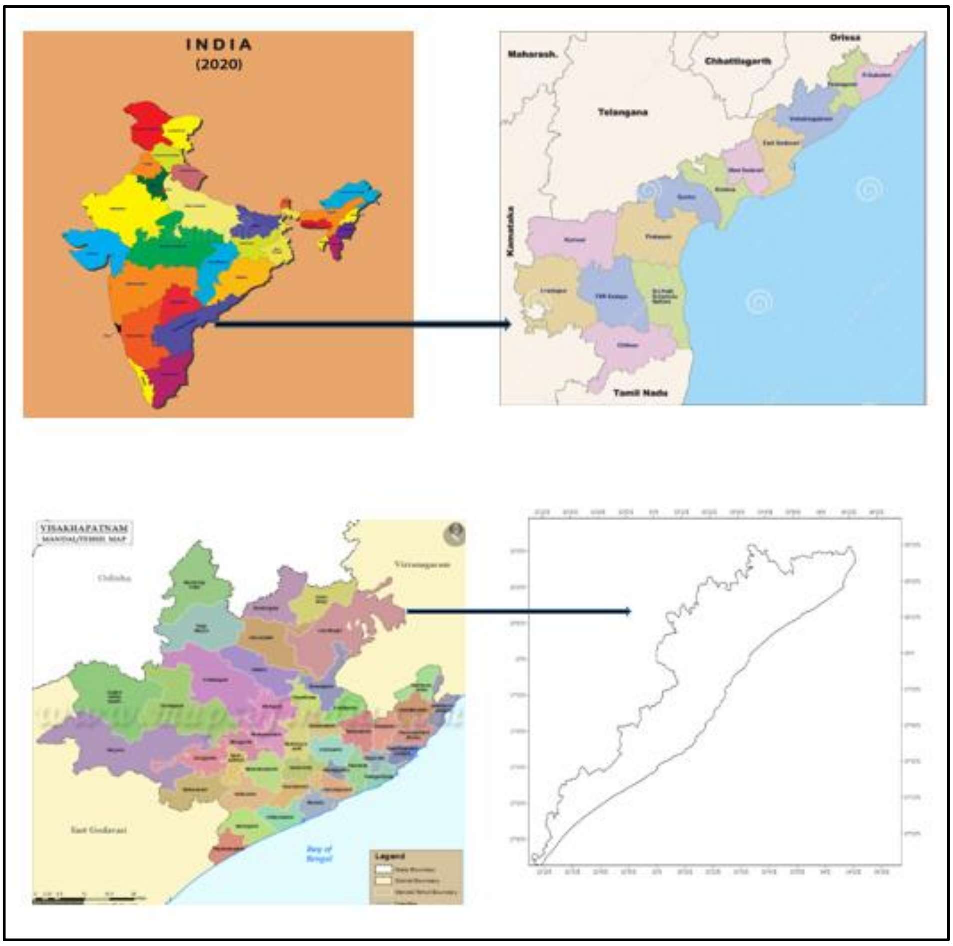

Fig.1: StudyArea Visakhapatnam Metro Region (proposed VMRDA Masterplan 2021)

Introduction

Vegetation is the index of biodiversity.Satellite based multi temporal products quantifies vegetation changes explicitly which enables to study geographical and seasonal patterns of potential changes of vegetation. Advanced remote sensing techniques and access to open data platforms has paved way for global monitoring of biodiversity and meteorologicalvariables with high resolution andaccuracy. This technology is used to find potential transitions of crop lands or grass lands and deforestation patterns.

Satellite derived vegetation statistics will provide crop conditions, local climate changes ontemporal and spatial scales.Vegetation is a major determinant in the environmental process. Vegetation indices act as sensitive indicators of anthropogenic influences and climate by modifying climate, energy balance, biological and hydrologic cycles.

The Normalized Difference Vegetation Index (NDVI) is one of the most important and commonly used satellite-based vegetation indexes to monitor vegetation changes and theirimpact on various climate variables on biosphere.It is associated with various vegetation parameters. NDVI data provide the resource management and global change communities with vegetation data for vegetation monitoring studies and historical trend analysis for land surfaces.

NDVI is an indicator that is calculated using the near-infrared and visible bands of the electromagnetic spectrum [2].NDVI will be used to assess green vegetation, crop yields, surface water, photosynthetic activity of the plant, amount of biomass and theleaf area index.Medium and high altitude rain forests have the highest NDVI values. Low level of greenness are indicated with the dips in the NDVI value.

Methodology

Solar radiation in the photo-synthetically active radiation (PAR) spectral region is absorbed by the live green plants which is used as a source of energy in the process of photosynthesis.

NDVI is a measure of plant health based on how plants reflect light at certain wavelengths. Chlorophyll which is a health indicator of plants, strongly absorbs visible light and the cellular structure of the leaves strongly reflects Near Infrared Light [2]. When the plant is affected with disease, or dehydrated,plant absorbs more infrared light. Comparing NIR with RED light provides an indication for presence of chlorophyll. Apart from plant health NDVI also helps to identify high crop productivity zones and low productivity zones which requires analysis [8].

The range of NDVI is always from -1 to +1.Water is indicated with a negative value. On the other hand, NDVI value close to +1 indicates a high possibility of dense green leaves. Furthermore, if the NDVI value is close to zero, it indicates the absence of green leaves. Moreover, it can even be an urban area.Healthy plants have a high NDVI value as they highly reflect infrared light and mildly reflect the red light.

In this paper, NDVI for VMR is calculated from 2008,2003 and 2019 data. The results indicate significant changes in green cover in the metro region. A loss of 14 % vegetation cover in the study area between 2008 and 2019 is observed.NDVI is calculated as a ratio between the RED (R) and near infrared (NIR) reflection values.Based on derived NDVI values vegetation transitions can be identified from forest to crop lands or pasture .Spatial patterns of deforestation can be derived from multi temporal NDVI raster datasets. Finally, NDVI can be correlated with aerial biomass, a strong indicator of forest health, through the validation of the method and can be usedto monitor deforestation.

Datasets

S.NO.	Dataset	Resolution	Bands	Period
1	Sentinel -1 ESA	10 meters (MS)	MSI covering 13 spectral bands (443–2190 nm)	2019
2	Landsat 7	30 m (ETM+)	8 spectral bands(445-900 nm band 1-4)	2008,2013

Table 1: Datasets used in the study

Google Earth Engine:

Google Earth Engine (GEE) is a cloud based remote sensing platform that performs raster and vector manipulations on large data sets. GEE is a powerful tool that provides access to a wide variety of imagery in one consolidated system. It can also perform spatial aggregations over global-scale data at a high computational rate.

The dataset used for NDVI study (2008-2013) is atmospherically corrected surface reflectance from the Landsat 7 ETM+ sensors. Landsat 7 hasone thermal infrared (TIR) band, two short-wave infrared (SWIR) bands and four visible and near-infrared (VNIR) bands along with one panchromatic band. The dataset used for NDVI study (2019) is from sentinel (ESA).Sentinel contains twelve spectral bands with seven visible bands, one NIR and three SWIR bands.

Calculation of vegetation Index:

To generate temporal variability of NDVI, the following formula was used.

$$NDVI = \frac{(NIR-RED)}{(NIR+RED)}$$

In Landsat 4-7, NDVI = (Band 4 – Band 3) / (Band 4 + Band 3).

Where NIR is the reflectance on the Near Infrared (4th) band, and RED is the red (3th) band of the Landsat 7 scene.

Where NIR is the reflectance on the Near Infrared (8th) band, and RED is the red (4th) band of the Sentinel scene.

NDVI metrics derived for three years 2008,2013 and 2019 and tabulated.

Change Detection Spatial and Temporal changes in Vegetation

NDVI trend analysis has been carried out using time series data of 2008 to 2019 using sentinel data.Time series changes of vegetation influence on agriculture, which is greatest source of income of our country, water resource and energy cycle. Analysis of vegetation coverage is important to understand the indicator of soil deterioration and desertification and urbanization behaviour and analysis helpful for future environment assessment and management support.

NDVI Range	No. of Pixels			Category
	2019	2013	2008	
<-0.3	498	246	77	Water or no vegetation
<0	1594866	111305	88522	Urbanized area
<0.3	43161947	933535	475958	Less vegetation
<0.6	29910934	6814680	6262980	Moderate vegetation
<0.9	994566	758180	1790409	Dense vegetation

Table 2: NDVI metrics of year 2019, 2013,and 2008

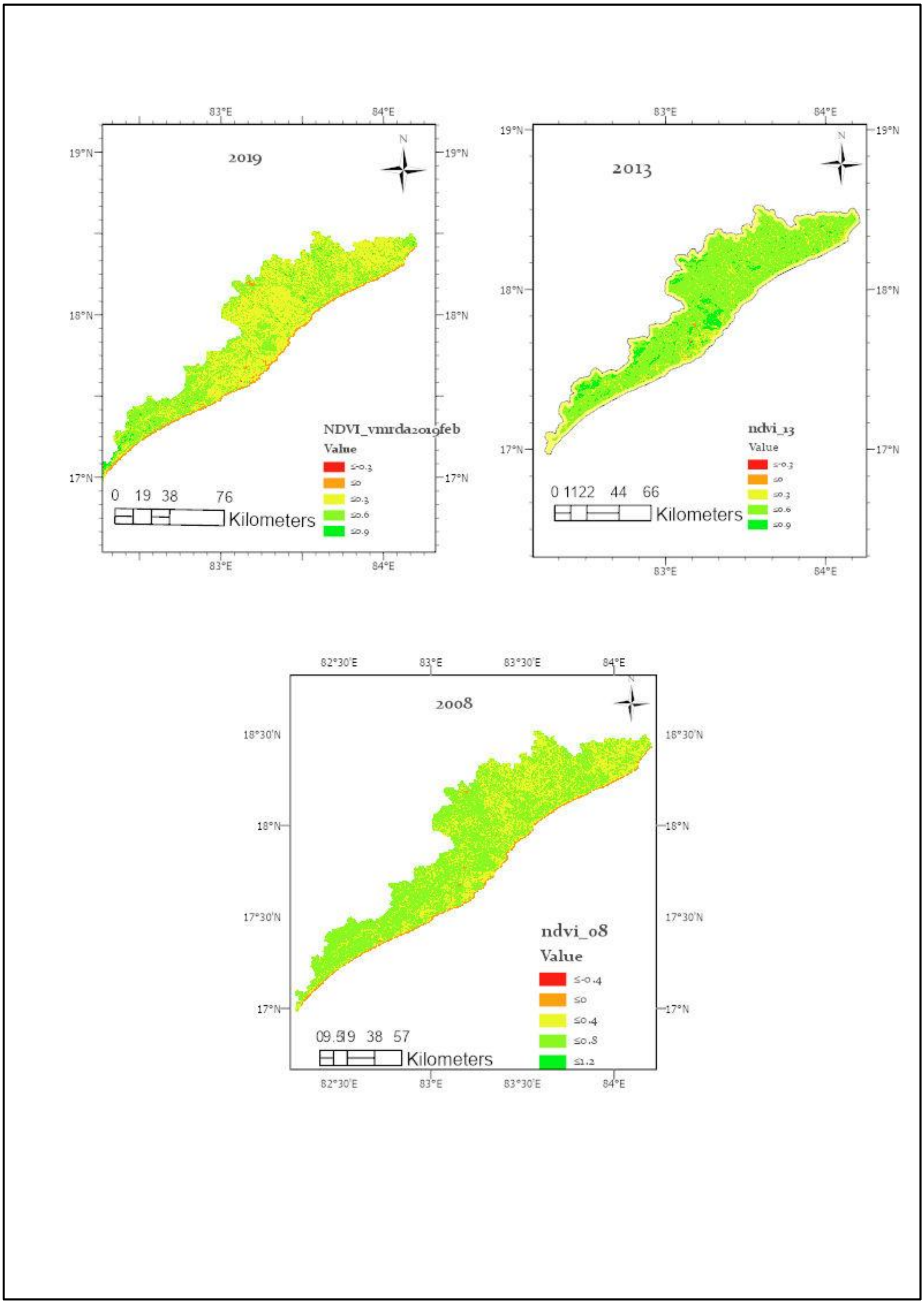

Fig 2: NDVI maps for the years 2008, 2013 and 2019

Methodology:

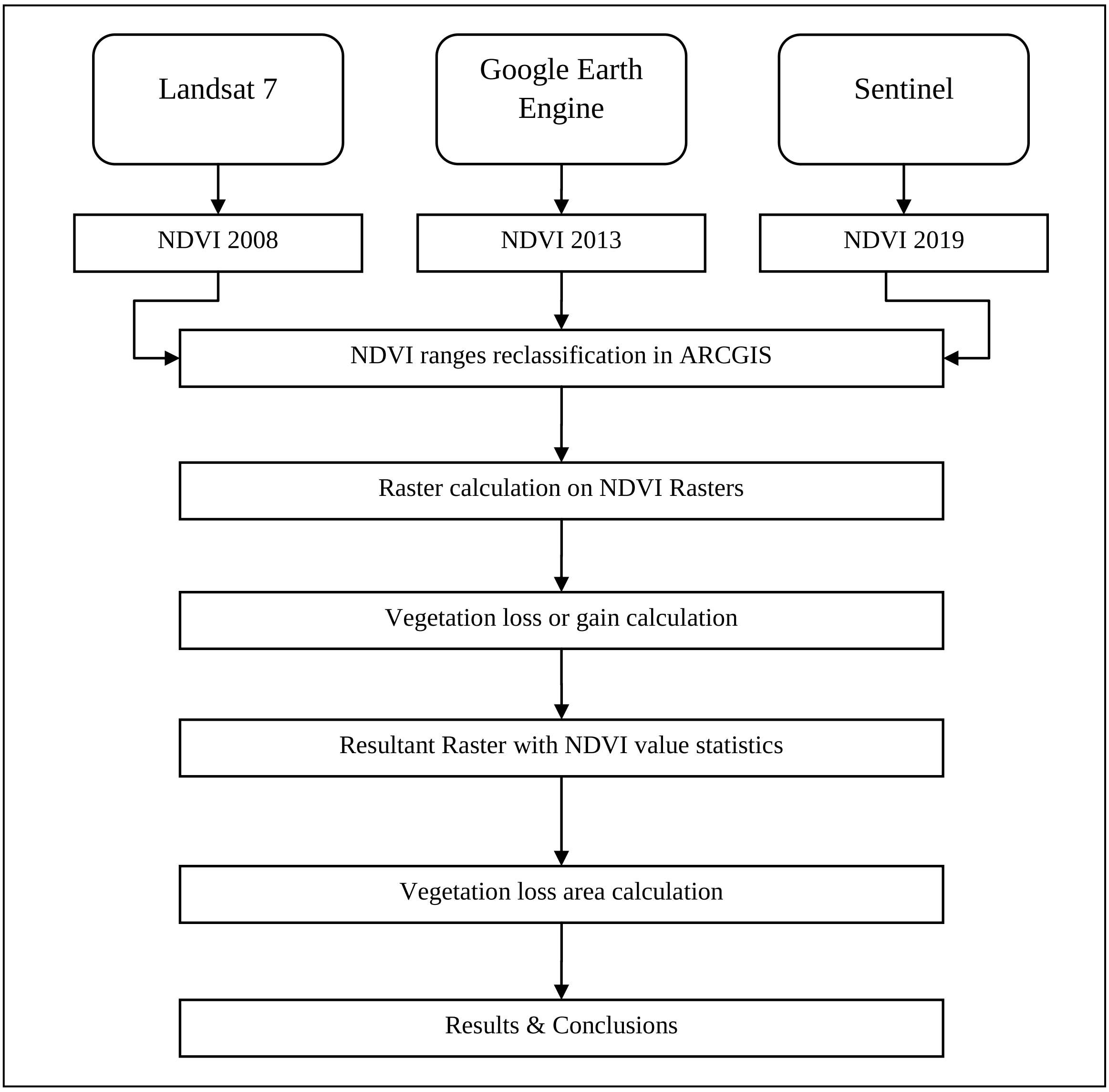

Fig 3:Flow Chart of the Methodology

Calculation of Vegetation loss or gain:

Using raster calculator ArcGIS tool, NDVI change detection is performed on both raster images of 2008 and 2019 to obtain vegetation loss or gain. Resultant raster reclassified into 6 classes. Wherein negative values indicate significant to minimum loss of vegetation and positive values indicates minimum to significant gain of vegetation.

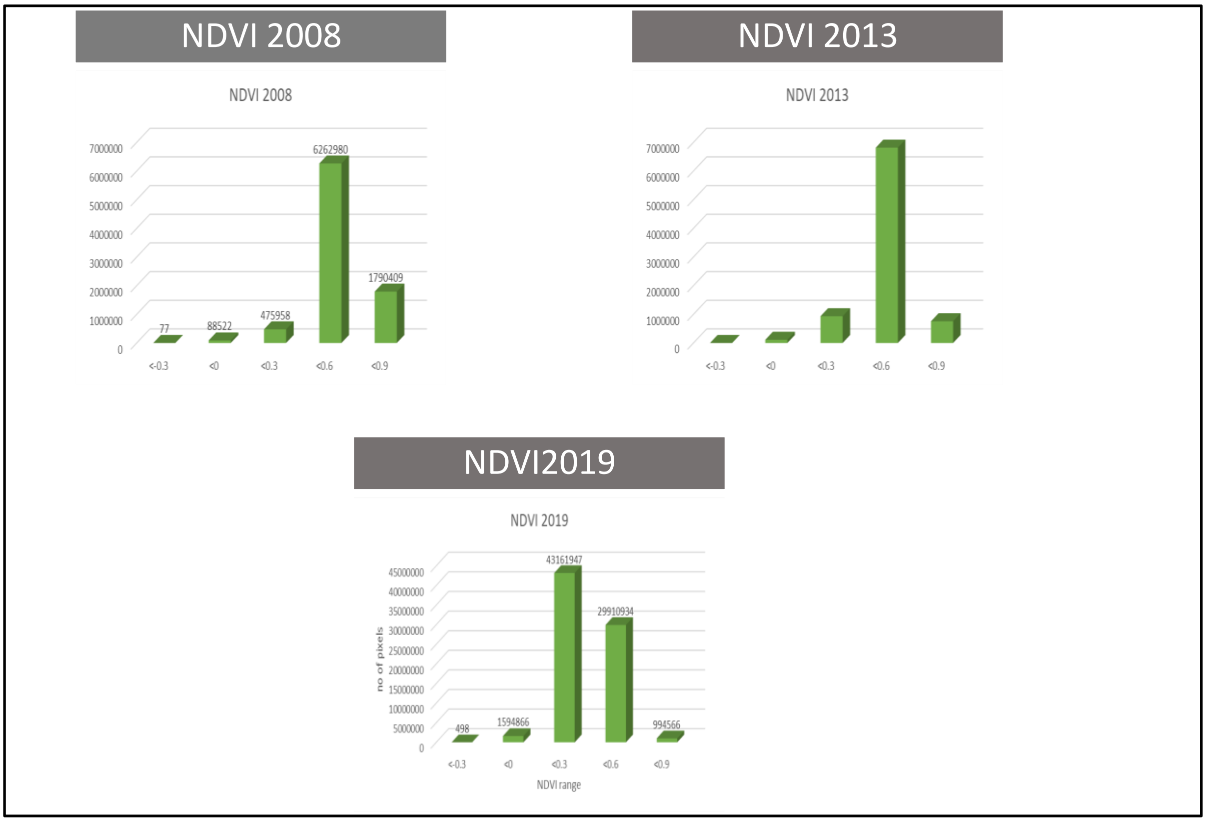

Fig 4: NDVI Values and Pixel Values in each range for the years 2008, 2013 and 2019

These observations can be applied for monitoring forest degradation and urban growth patterns.Fig.4 shows NDVI values and pixel values in each range for the years 2008,2013 and 2019. Table 3 shows NDVI ranges corresponding to the pixelcount. Vegetation loss is compared with yearly forest loss from Google Earth Engineglobal forest cover data Hansen Global Forest Change$V_{1.8}$Which is shown Fig.5.Results from time-series Landsat images gives global forest extent and change detection from 2000-2017 [8].

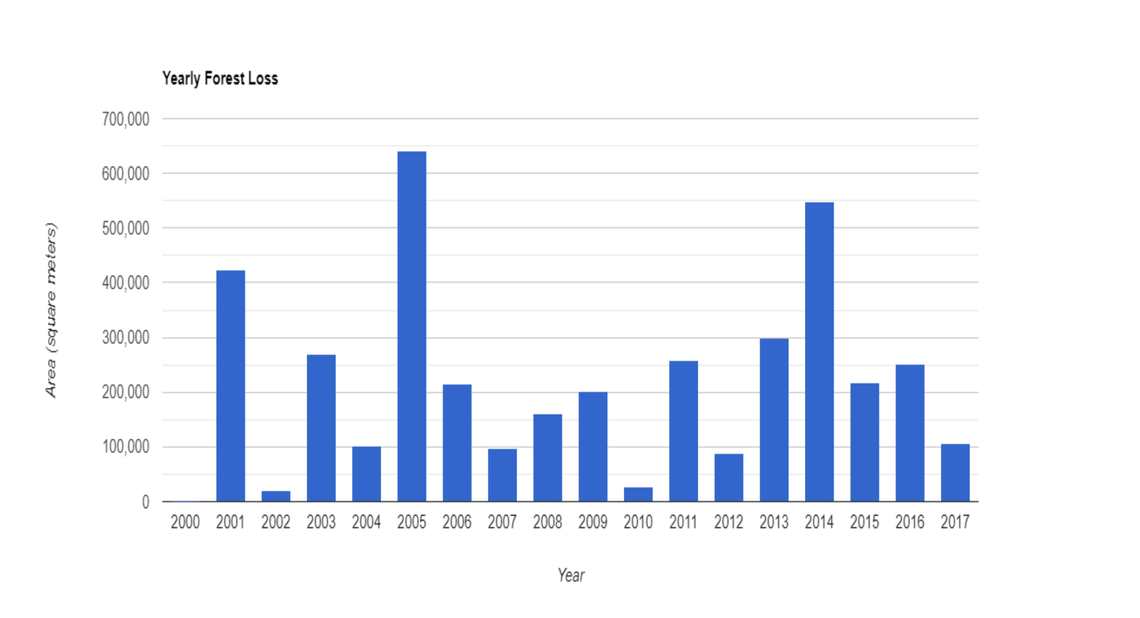

Fig. 5: Annual Forest Loss in Visakhapatnam from the year 2000 to 2017(GEE)

S NO	PIXEL COUNT	NDVI RANGE	CATEGORY
1	67	-0.89 to -0.58	Significant loss
2	15924	-0.58 to -0.26	Moderate loss
3	1261862	-0.26 to 0.04	Min loss
4	7000465	0.04 to 0.35	No change to min gain
5	338276	0.35 to0.67	Moderate gain
6	989	0.67 to 0.98	Significant gain

Table 3: NDVI ranges corresponding to the pixel count

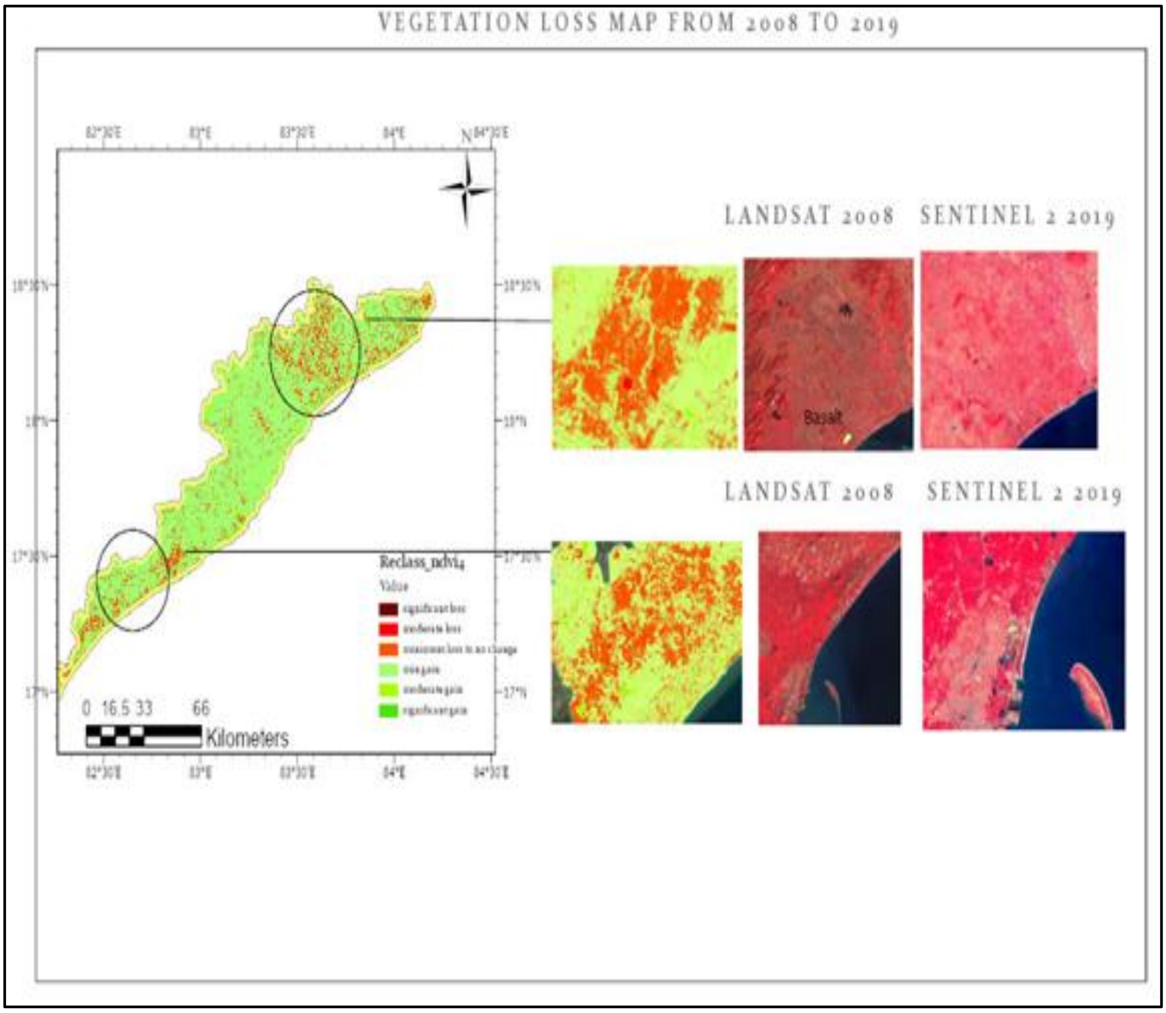

Fig.6: Vegetation loss in the study area from the year 2008 to 2019

S.No.	NDVI RANGE	AREA IN SQKM	CATEGORY
1	-0.89 to -0.58	0.06028	Significant loss
2	-0.58 to -0.26	13.64691	Moderate loss
3	-0.26 to 0.04	1074.758	Min loss
4	0.04 to 0.35	5963.456	No change to min gain
5	0.35 to0.67	288.2163	Moderate gain
6	0.67 to 0.98	0.848291	Significant gain

Table 4: Area of significant loss or gain of vegetation cover from 2008 to 2019 in the study area

Results and Conclusion:

The terrestrial deforestations, crop health and yield monitoring, potential transitions of forest to crop land or pasture can be better understood using NDVI multi-temporal statistics. In this aspect Vegetation indices(NDVI) calculated for multi years and multi seasons using Google Earth Engine. Ranges of NDVI changed significantly over the years, it was observed that vegetation cover significantly decreased by 14% over a period of ten years.

There is loss of vegetation area of 1088 sq.km. over a period of 10 years in the study area.According to the land use land cover statistics, forest cover in the study area occupies an area of 2300 sq.km. which is 28.2% of total geographical area of the study area.Forest cover here is dense tropical type, while the vegetation becomes sparse and shrub vegetation is more common.

The vegetation is largely broad-leaved deciduous type which occupies 13.8 %, evergreen forest covers 4.56% and shrubs and sparse vegetation covers 1.45% and 1.22% respectively. Normalized vegetation index (NDVI) calculated which is an indicator of loss or gain of vegetation, deforestation, and drought conditions. NDVI calculated for a period of 10 years (2008 to 2019). According to NDVI statistics. It was observed that vegetation cover significantly decreased by 14% over a period of ten years. There is loss of vegetation area of 1088 sq.km. over a period of 10 years and transition of forest cover to crop land occurred in the study area.

References[1]

[1] Hansen, *Hansen Global Forest Change v1.8 (2000-2020),* Hansen/UMD/Google/USGS/NASA, 2000.

[2] "NDVI," 11 September 2000. [Online]. Available: https://eos.com/make-an-analysis/ndvi/.

[3] N. Sidhu, E. Pebesma and G. Câmara, "Using Google Earth Engine to detect land cover change: Singapore as a use case," *European Journal of Remote Sensing,* vol. 51, no. 1, pp. 486-500, 2018.

[4] M. M. Islam and M. M. I. Mamun, "Variations of NDVI and Its Association with Rainfall and Evapotranspiration over Bangladesh," *Rajshahi University Journal of Science and Engineering,* vol. 43, pp. 21-28, 2015.

[5] Meneses-Tovar, C.L. , "NDVI as indicator of degradation," *Unasylva-238,* vol. 62, pp. 39-46, 2011.

[6] A. W. Salik and E. Karacabey, "Application of Landsat 8 Satellite Image – NDVI Time Series for Crop Phenology Mapping: Case Study Balkh and Jawzjan Regions of Afghanistan," *Çanakkale Onsekiz Mart Üniversitesi Fen Bilimleri Enstitüsü Dergisi,* vol. 5, no. 1, pp. 49-62, 2019.

[7] L. Singh and K. Y B, "Time series analysis of Land use and land cover and vegetation index change in Nagpur district using RS and GIS techniques," in *49th Annual Convention of IWWA on "Smart Water Management",* Nagpur, 2017.

[8] H. Yin, T. Udelhoven, R. Fensholt, D. Pflugmacher and P. Hostert, "How Normalized Difference Vegetation Index (NDVI) Trendsfrom Advanced Very High Resolution Radiometer (AVHRR) and Système Probatoire d'Observation de la Terre VEGETATION (SPOT VGT) Time Series Differ in Agricultural Areas: An Inner Mongolian Case Study," *Remote Sensing,* vol. 4, pp. 3364-3389, 2012.