Spatio-Temporal variation of vegetation in Godavari Eastern delta

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Abstract:

Spatial variability in land use changes creates a need for a wide range of applications, including landslide, erosion, land planning, global warming etc. This study presents the analysis of satellite image based on Normalized Difference Vegetation Index (NDVI) in Godavari eastern delta. Four spectral indices were investigated in this study. These indices were NIR (red and near infrared) based NDVI, green and NIR based GVI(Green Vegetation Index), red and NIR based soil adjusted vegetation index (SAVI), and red and NIR based perpendicular vegetation index (PVI). These four indices were investigated for 2011-12 kharif, rabi and 2016-17 kharif, rabi of Godavari eastern delta. Different threshold values of NDVI are used for generating the false colour composite of the classified objects. For this purpose, supervised classification is applied to Landsat images acquired in 2011-12 and 2016-17. Image classification of six reflective bands of two Landsat images is carried out by using maximum likelihood method with the aid of ground truth data obtained from satellite images of 2011-12 and 2016-17. There was 11% and 30% increase in vegetation during kharif and rabi seasons from 2011-12 to 2016-17. The vegetation analysis can be used to provide humanitarian aid, damage assessment in case of unfortunate natural disasters and furthermore to device new protection strategies.

Keywords: Land use/ Land cover, Geographical Information System, Toposheet

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Introduction:

Vegetation Indices are a mathematical combination of various bands. Normalized Difference Vegetation Index (NDVI) is a standardized vegetation index and mostly used vegetation index. Chlorophyll absorption in Red band and high reflectance of vegetation in Near Infrared band (NIR) are using for calculating NDVI. Remote sensing imaging is considered one of the main sources of information about the earth's cover. These are used in detecting and monitoring vegetation changes at various scales. The use of satellite-based remote sensing data as a cost effective technique has been widely applied to develop land coverages over large geographic regions. Vegetation cover is an important part of land cover. Change detection has become an outspread application of remotely sensed data because of repetitive wide coverage, short revisit intervals and good image quality. Change detection is the process of identifying differences in the state of phenomenon or an object by observing it at different times. The main precondition in using remote sensing data for vegetation change detection is that changes in land cover values and changes in radiance are large with respect to radiance change caused by others factors such as differences in atmospheric conditions, differences in soil moisture and differences in sun angles (Badamasi *et al.*, 2010). Water has NDVI esteem under 0, exposed soils somewhere around 0 and 0.1, and vegetation more than 0.1 (*Mushtaq Ahmad Ganie et al., 2016*).

Study area:

The Godavari Eastern Delta consists of part of Godavari delta, is situated in East Godavari district of Andhra Pradesh in East coast of India. The study area covers about 1138 km^2 located in the southern part of Godavari delta and is bounded by Bay of Bengal in the Eastern side (Fig. 1). The average annual rainfall in the study area is about 1,157 mm and distributed unevenly over 54 rainy days. About 70 % rainfall occurs during the southwest monsoon season (June–September). During the northeast monsoon (October–December), the rainfall varies from 225 to 450 mm. July is the wettest month contributing to about 26 % of the annual rainfall and nearly 56 % of the SW monsoon rainfall.

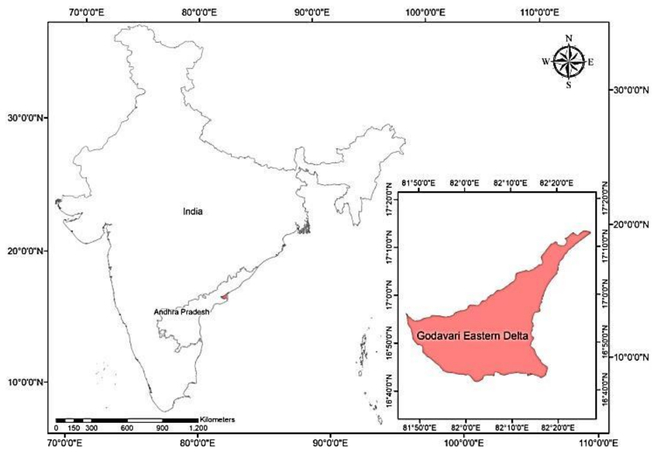

Figure 1: Location map of Study area

Materials and methods:

NDVI

The density of green on a patch of land can be determined by observing the distinct colors (wavelengths) of visible and near-infrared sunlight reflected by the plants (Earth observatory, 2000). As can be seen through a prism, many different wavelengths make up the spectrum of sunlight. When sunlight strikes objects, certain wavelengths of this spectrum are absorbed and other wavelengths are reflected (Earth observatory, 2000). The pigment in plant leaves, chlorophyll, strongly absorbs visible light (from 0.4 to 0.7 µm) for use in photosynthesis. The cell structure of the leaves, on the other hand, strongly reflects near-infrared light (from 0.7 to 1.1 µm). The more leaves a plant has, the more these wavelengths of light are affected, respectively.

By taking the ratio of red and near infrared bands from a remotely-sensed image, an index of vegetation “greenness” can be defined. The Normalized Difference Vegetation Index (NDVI) is probably the most common of these ratio indices for vegetation (Fintan Corrigan, 2019). NDVI is calculated on a per-pixel basis as the normalized difference between the red and near infrared bands (Hien Phu La *et al.*, 2013).

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

where NIR is the near infrared band value for a cell and RED is the red band value for the cell. NDVI can be calculated for any image that has a red and a near infrared band. The biophysical interpretation of NDVI is the fraction of absorbed photosynthetically active radiation (StackPointers, 2018).

DATA:

Landsat satellites have been collecting images of the earth's surface. The large archive of Landsat data has become the main data source for monitoring the earth's surface change. The image of study area has been acquired during the month of October with minimum cloud cover. The details of satellites and their spatial and spectral resolution are given in Table 1,2,3,4.

Table 1: Details of the images used in the study

Image	Path/Row	Acquisition Date	Spatial Resolution
Landsat 8	141/48	25.10.2016	30M
Landsat 8	142/48	16.10.2016	30M
Landsat 8	142/48	20.01.2017	30M
Landsat 8	141/48	14.02.2017	30M
Landsat 5	142/48	19.10.2011	30M
Landsat 5	141/48	26.09.2011	30M
LISS III	103/61	28.02.2012	23M

Table2: **Spatial and Spectral resolution of Landsat 5 satellite**

	Band No.	Band Name	Wave length	Resolution
Landsat 5 (TM)	1	Visible blue	0.45-0.52	30M
	2	Visible Green	0.52-0.60	30M
	3	Visible Red	0.63-0.69	30M
	4	NIR	0.76-0.90	30M
	5	SWIR-1	1.55-1.75	30M
	6	Thermal	10.40-12.550	120M
	7	SWIR-2	2.08-2.35	30M

Table3: Spatial and Spectral resolution of Landsat 8 satellite

	Band No.	Band Name	Wave length	Resolution
Landsat 8 **Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS)**	1	Coastal aerosol	0.435-0.451	30M
	2	Blue	0.452-0.512	30M
	3	Green	0.533-0.590	30M
	4	Red	0.636-0.673	30M
	5	NIR	0.851-0.879	30M
	6	SWIR 1	1.566-1.651	30M
	7	SWIR-2	2.107-2.294	30M
	8	Pan	0.503-0.676	15M
	9	Cirrus	1.363-1.384	30M
	10	TIR 1	10.60-11.19	100M
	11	TIR 2	11.50-12.51	100M

Table4: **Spatial and Spectral resolution of LISS III**

	Band No.	Band	Spectral resolution (µm)	Spatial resolution(m+)
LISS III	1	Green	0.52-0.59	23.5
	2	Red	0.62-0.68	
	3	Near Infra-Red	0.77-0.86	
	4	Shortwave Infra-Red	1.55-1.70	70

Generation of NDVI is done by using ERDAS 14 software (Fig. 2). The layer stacking of bands was performed. The layer stacked image tiles were mosaicked and then clipped with study area shapefile. Image rectification was done to correct distortions resulting from the image acquisition process. Image classification for both years (2011-12 & 2016-17) was performed through supervised classification using maximum likelihood classifier. The results of both the years were also compared, which show significant changes in land use/land cover

over a period of time in the study area. The overall methodology is briefly presented in a flow chart (Fig. 3.)

(NDVI) = (NIR−RED) / (NIR+RED)

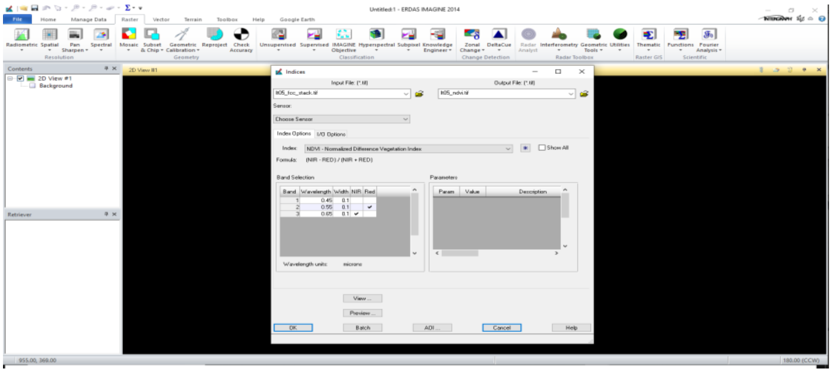

Figure 2 . Generation of NDVI using ERDAS IMAGINE 14

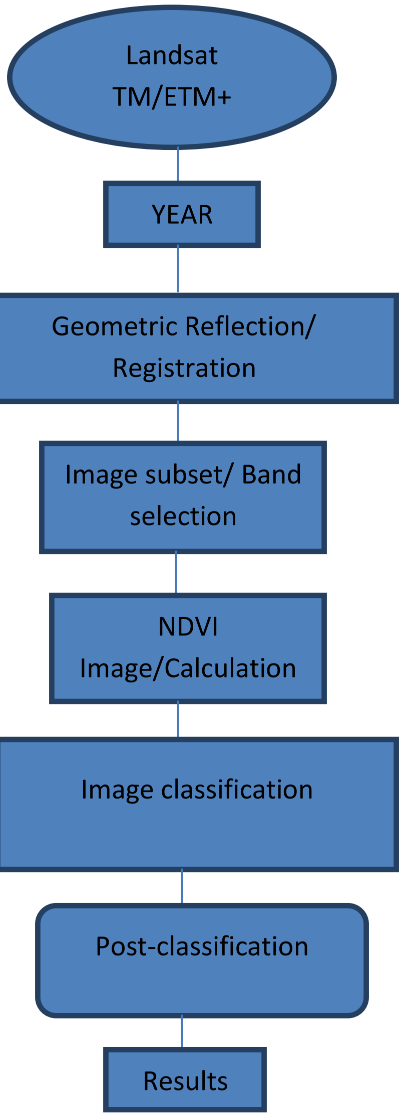

Figure 3: Flow Diagram of development of NDVI

NDVI process needs to separate each and every band for the detection of the vegetation index from a Multi Spectral Remote Sensing image which is present in the Satellite image. After different bands are separated, NDVI method is applied according to its characteristics like vegetation at different NDVI threshold values such as 0.1, 0.15, 0.2, 0.25, 0.3, 0.35, 0.4 and 0.5. Knowledge-based thresholds can be applied to the composite images to classify them into crop and non-crop once the NDVI composites for Kharif and Rabi seasons for the crop years 2011-12 and 2016-17 are generated. Theoretically, NDVI values range from -1 to 1, but the actual values of NDVI are seldom higher than 0.8 or lower than -0.5. An NDVI value between 0.3 and 0.8 indicates moderate to dense vegetation. The characteristic NDVI values for agricultural crops range between 0.3 and 0.6, while dense forests have NDVI value greater than 0.6. Water has an NDVI value close to zero; it can be a very low positive or a very low negative value. For bare soil, NDVI value is less than 0.3, but greater than 0.1. Shrubs and grasslands have NDVI values between 0.2 and 0.3.

Results:

The results represent the various features, which have been extracted from the satellite images of Godavari Eastern Delta.The results compared with the Google earth image, that shows the development considerably.The study of satellite images of the study area represent subsequently Red band, NIR band, Green band. For the detection of the vegetation index from a multispectral remote sensing image, each and every band was separated which is present in the satellite image in NDVI process. Various NDVI threshold valuesare used to extract best result from satellite images. Based on the above knowledge, and after investigating the NDVI composite images, the areas with NDVI>0.35 were classified as crop and the remaining areas as non-crop. In the non-crop area, pixels with NDVI < 0.1 were separated as water bodies. These thresholds remained almost constant for the four seasons, namely, Kharif 2011-12, Rabi 2011-12, Kharif 2016-17, and Rabi 2016-17 considered in this study. Area under this study covered is 147015.96ha. The generated NDVI images are shown in Fig. 4. Kharif vegetation is 113954ha and 93489.7ha for rabi during 2011-12, followed by 126231ha for kharif and 121540ha for rabi during 2016-17.

Discussion:

There is a lot of change in vegetation during kharif and rabi, because the main growing season is kharif. The vegetation change from 2011 to 2017 has been presented in Table 5.

Table 5: Change in vegetation from 2011-12 to 2016-17

Vegetation Change from 2011-12 to 2016-17			
	Area (Hectares)		
	2011-12	**2016-17**	**% Change**
Kharif	113954	126231	10.77
Rabi	93489	121540	30.00

The above table shows the changes in vegetation from 2011-12 to 2016-17. There was nearly 11 percent of change in *Kharif*season whereas it was 30 percent in *Rabi* season. The increase in vegetation may be due to rainfall, irrigation, converting fallow lands to croplandsand social forestry through land development activities. When soil water availability decreases, due to any environmental reason (stress by water deficit); the green vegetation tends to disappear and the values of NDVI may decreases.

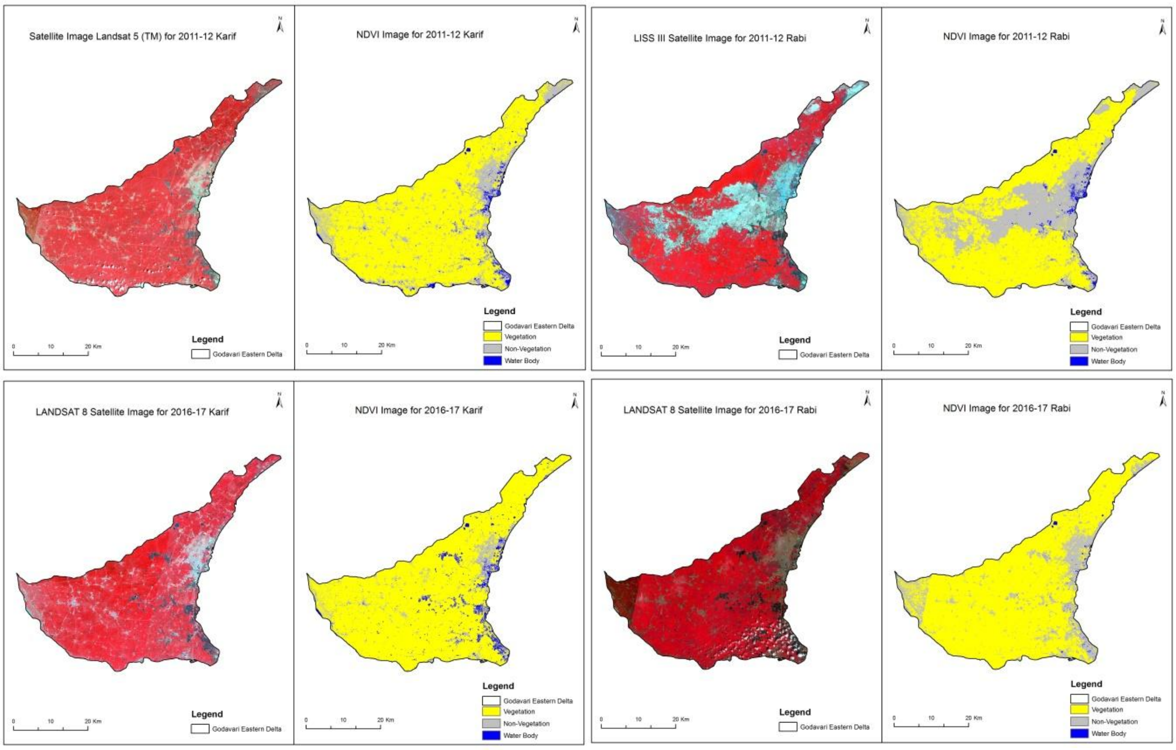

Figure 4: NDVI images for kharif and rabi during 2011-12 and 2016-17

Conclusions:

The normalized difference vegetation index technique with different threshold values has beenemployed for features extraction of Godavari Eastern Delta (India).An increase in vegetation was observed from 2011-12 to 2016-17. This study was performed mainly to monitor the vegetation changes between years. Rainfall plays a vital role in vegetation. Thus, monsoon rains have lot of impact in this area.The NDVI have been used widely to examine the relation between spectral variability and the vegetation vigour or growth rate. The developed NDVI of the study area provides knowledge on spatial variability of vegetation which can be effectively used in land use planning.

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