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Ndvi: Vegetation change detection using remote sensing and gis – A case study of Vellore District

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Abstract

This article presents an enhanced Change Detection method for the analysis of Satellite image based on Normalized Difference Vegetation Index (NDVI). NDVI employs the Multi-Spectral Remote Sensing data technique to find Vegetation Index, land cover classification, vegetation, water bodies, open area, scrub area, hilly areas, agricultural area, thick forest, thin forest with few band combinations of the remote sensed data. Land Resources are easily interpreted by computing their Normalized Difference Vegetation Index for Land Cover classification. Remote Sensing data from Landsat TM image along with NDVI and DEM data layers have been used to perform multi-source classification. The Change Detection method used was NDVI differencing. NDVI method is applied according to its characteristic 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. The Simulation results show that the NDVI is highly useful in detecting the surface features of the visible area which are extremely beneficial for policy makers in decision making. The Vegetation analysis can be helpful in predicting the unfortunate natural disasters to provide humanitarian aid, damage assessment and furthermore to device new protection strategies. From the empirical study, the forest or shrub land and Barren land cover types have decreased by about 6% and 23% from 2001 to 2006 respectively, while agricultural land, built-up and water areas have increased by about 19%, 4 % and 7% respectively. Curvature, Plan curvature, Profile curvature and Wetness Index areas are also estimated.

1. Introduction

The Multi Spectral Remote Sensing images are very efficient for obtaining a better understanding of the earth environment [1]. It is the Science and Art of acquiring information and extracting the features in form of Spectral,

Spatial and Temporal about some objects, area or phenomenon, such as vegetation, land cover classification, urban area, agriculture land and water resources without coming into physical contact of these objects [2].

The Remote Sensing data has many application areas including: land cover classification, soil moisture measurement, forest type classification, measurement of liquid water content of vegetation, snow mapping, sea ice type classification, oceanography [2]. The multispectral remote sensing images carry essential integrating spectral and spatial features of the objects [3]. In this article, the multispectral image of Vellore district is used to calculate the percentage of versatile features such as vegetation, hilly areas, water bodies, open area, scrub area, agricultural area, thick forest, thin forest are presented in this image, and to subsequently make these extracted features available to the public for further analysis in order to avoid any sort of natural disasters like flood.
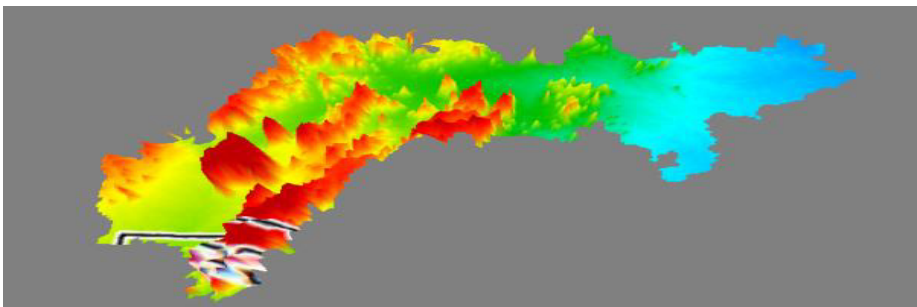
The National Aeronautics and Space Administration of USA (NASA) uses 7-band data for feature extraction, and it is called as LANDSAT image [5].The multispectral remote sensing data image of Vellore district is received from the National Remote Sensing Agency and it is called INSAT image. It consist 3-band data and the information is accomplished by the help of these 3 bands named near infrared band, red band and green band. Each band contains some specific information and with the help of these three bands, the features can be extracted. On the basis of wavelength, remote sensing is classified into three types as: visible and reflective infrared remote sensing, thermal infrared remote sensing, and microwave remote sensing [6].

Digital image processing of satellite data provides tools for analyzing the image through different algorithms and mathematical indices. Features are based on reflectance characteristics, and indices have been devised to highlight the features of interest on the image [7]. There are several indices for highlighting vegetation-bearing areas on a remote sensing scene. NDVI is a common and widely used index [8]. It is an important vegetation index, widely applied in research on global environmental and climatic change [8]. NDVI is calculated as a ratio difference between measured canopy reflectance in the red and near infrared bands respectively [9]. This article shows how the differences between the visible red and near-infrared (NIR) bands of an INSAT image can be used to identify areas containing significant vegetation and other different features.

Many researchers have reported the use of NDVI for vegetation monitoring [10, 11] assessing the crop cover [12], drought monitoring [13, 14] and agricultural drought assessment at national [15, 16] and global level [17] Vegetation index (VI) is a simple and effective measurement parameter, which is used to indicate the earth surface vegetation covers and crops growth status in remote sensing field [17].

2. Study area and data collection

The investigations were performed as a Case study on Vellore district (6077 sq. km.) of Tamil Nadu. It lies between the north latitudes 12° 55' N and east longitudes of 79° 11' E which is shown in Fig. 1.
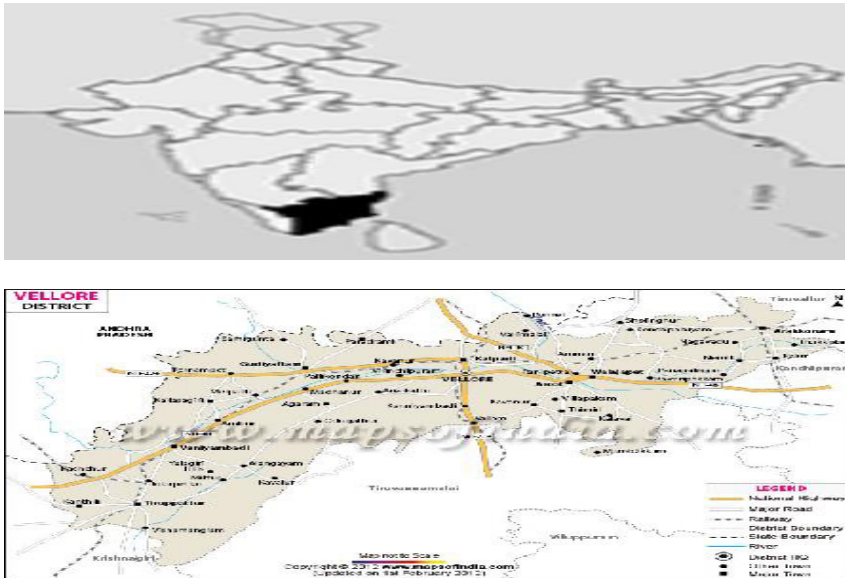
Fig 1. Base Satellite map of Study Area

The forests are combined with areas of grass and mountain Vegetation. Landsat data and Shuttle Radar Topography Mission (SRTM) has been downloaded from http://glcf.umd.edu/ for 2001 and 2006. 3D data. Landsat TM / ETM images were rectified and projected to Universal Transverse Mercator (UTM). Interpretations of land use / land cover were done with image contrast technique using ERDAS IMAGINE software. Information about land use/ land cover classes and associated information was collected and the feature class such as forest classes and wetland / dry land cover were recognized for the year 2001 and 2006.

2.1 Methodology

In this Section, the NDVI technique is used for extracting the various features presented in the 3-band Satellite image of VELLORE district. Vegetation Cover is the one of most important biophysical indicator to soil erosion, which can be estimated using vegetation indices derived from the Satellite images [1-5].

Vegetation indices allow us to delineate the distribution of vegetation and soil based on the characteristic reflectance patterns of green vegetation. The NDVI is a simple numerical indicator that can be used to analyze the remote sensing measurements, from a remote platform and assess whether the target or object being observed contains live green vegetation or not. From the equation (1) and equation (2), NDVI is calculated as

$$RNDVI = \frac{NIR - RED}{NIR + RED} \qquad \text{where } (0 < NDVI > 1) \tag{1}$$

$$GNDVI = \frac{NIR - GREEN}{NIR + GREEN} \qquad \text{where } (0 < NDVI > 1) \tag{2}$$

where RED is visible red reflectance, and NIR is near infrared reflectance. The wavelength range of NIR band is (750-1300 nm), Red band is (600-700 nm), and Green band is (550 nm). The NDVI is motivated by the observation

vegetation, which is the difference between the NIR and red band; it should be larger for greater chlorophyll density. It takes the (NIR - red) difference and normalizes it to balance out the effects of uneven illumination such as shadows of clouds or hills.

Table.1. describes the wavelength range and the characteristics for different features. In other words, on a pixel by pixel basis subtracts the value of red band from the value of NIR band and divides by their sum. Very low value of NDVI (0.1 and below) correspond to barren areas of rock, sand, or snow. Moderate values represent shrub and grassland (0.2 to 0.3), while high value indicates temperate and tropical rainforests (0.6 to 0.8). Bare soil is represented with NDVI values, which are closest to 0 and water bodies are represented with negative NDVI values [4-7].
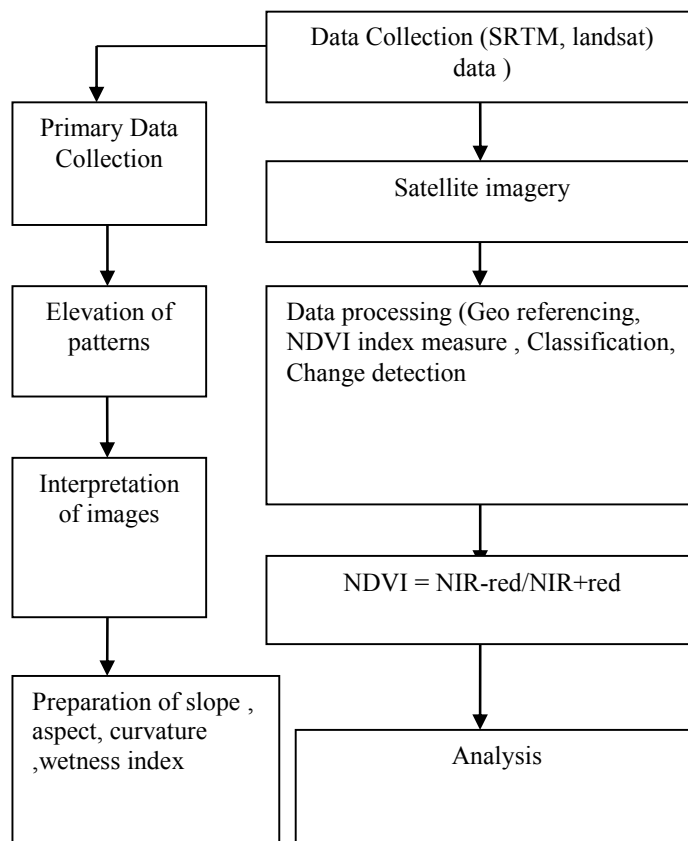

Fig.2. Flowchart of Methodology

In other words, the degree of greenness is equal to the chlorophyll concentration. NDVI values vary with the absorption of red light by plant chlorophyll and the reflection of infrared radiation by water-filled leaf cells. All visible ranges are captured by the Satellite camera in form of bands through which features can be extracted after applying the NDVI method for different characteristics. A complete flowchart routine of the proposed methodology is illustrated in Fig.2. The bands are expressed in terms of wavelengths, in the order of 1 μm. Although, the other features can be extracted with the help of these four visible ranges (visible blue, middle infrared, thermal infrared and middle infrared), only three visible bands are used (near infrared, visible red and visible green) in this work for the feature extraction.

2.2 To find vegetation in a multi spectral Satellite image

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 the different band are separated, NDVI method is applied according to its characteristic 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. Various NDVI threshold values are used to extract best result from Satellite image of Vellore district.

3. Results and Discussion

The NDVI have been used widely to examine the relation between Spectral variability and the changes in vegetation growth rate. It is also useful to determine the production of green vegetation as well as detect vegetation changes. The results, included in Table 2, represent the various features, which have been extracted from the satellite image of Vellore The result is compared with the Google earth image, which shows the improvement significantly.

After the analysis of first image [Fig.3], it has been found that the multispectral images are giving best result for all the features at NDVI value of 0.3, whereas second image [Fig. 4], giving good result for all the features at NDVI value of 0.2 with changes of year 2001. In this work, the NDVI value is varied from (0.1 to 0.5) so that best features can be extracted from Vellore district and the classes discrimination are depicted in Fig 5. NDVI 2006 variations are presented in Fig.6. The lowest values are found on the less vegetated soils and presumably because reflection from the soil is high, and produce low values in NIR band and high values in red band; hence the NDVI values are low.

Table 1. Thematic bands of NASA are as LANDSAT Satellite

Band	Name of the band	Wavelength (μm)	Characteristics and usage
1	Visible blue	0.45 - 0.52	Maximum Water Penetration
2	Visible Green	0.52 - 0.60	Good for measuring plant vigor
3	Visible Red	0.63 - 0.69	Vegetation Discrimination
4.	Near InfraRed	0.76 - 0.90	Biomass and shoreline mapping
5.	Middle InfraRed	1.55 - 1.756	Moisture Content of Soil
6.	Thermal Infrared	10.4 – 12.5	Soil moisture and Thermal Mapping
7.	Middle InfraRed	2.08-2.35	Mineral mapping

Fig.7 depicts the Surface morphology, where slope, aspect, normal to slope, plan curvature, profile curvature, wetness index are shown. The histogram classification is shown in Fig. 8. The Normalized Difference Vegetation Index technique with different threshold values and the histogram variations are employed for features extraction as shown in for the year 2006 are shown in Fig. 9 and Fig. 10.
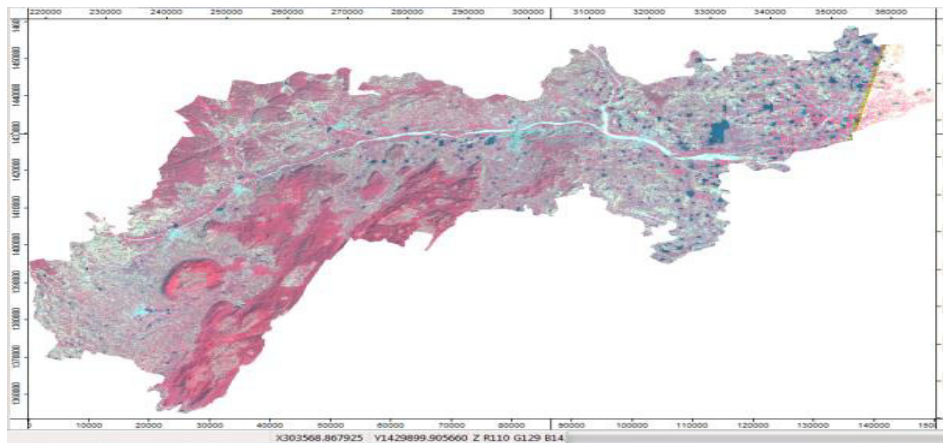
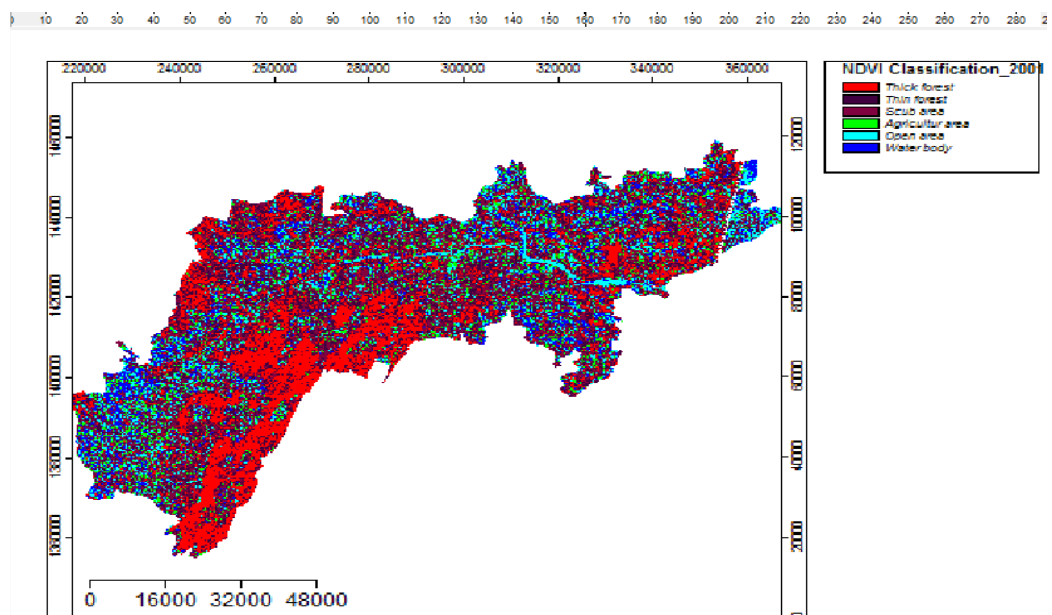Fig.3. Satellite image of Vellore dist

Fig. 4. NDVI classification 2001

When soil water availability decreases, due to any environmental reason (stress by water deficit); the green vegetation tends to disappear, then the values of NDVI decreases. From Fig.13, it is known that Change Detection analysis of Vegetation remains green (high NDVI values) due to availability of water in the soil. It clearly shows that the percentage of vegetation is almost same for different threshold value. Empirical study implies the percentage of vegetation is found to be 32.1304% at NDVI threshold of 0.3, water bodies & river are found to be 6.5771%, agricultural area is found to be 23.4949% and remaining area is found to be 37.7976%. In the year 2006, the percentage of vegetation in the given study area is found to be 46.4376% at NDVI threshold of 0.2, water bodies & river are found to be 8.6978%, agricultural area found to be 30.8418% and the remaining area is found to be 14.0227%. The NDVI method gives superior results for vegetation varying in densities and also for scattered vegetation from a multispectral remote sensing image). Fig. 11 shows the changes shown in histogram. Fig.12

presents changes between 2001 and 2006. Fig.13 shows Curvature, Plan curvature, Profile curvature and Wetness Index.
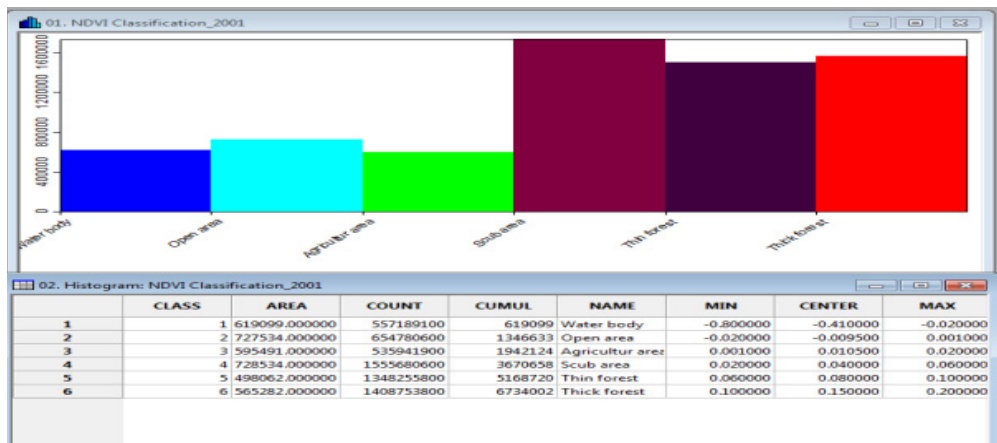

	CLASS	AREA	COUNT	CUMUL	NAME	MIN	CENTER	MAX
1	1	619099.000000	557189100	619099	Water body	-0.800000	-0.410000	-0.020000
2	2	727534.000000	654780600	1346633	Open area	-0.020000	-0.009500	0.001000
3	3	595491.000000	535941900	1942124	Agricultur area	0.001000	0.010500	0.020000
4	4	728534.000000	1555680600	3670658	Scub area	0.020000	0.040000	0.060000
5	5	498062.000000	1348255800	5168720	Thin forest	0.060000	0.080000	0.100000
6	6	565282.000000	1408753800	6734002	Thick forest	0.100000	0.150000	0.200000

Fig.5.Classes discrimination

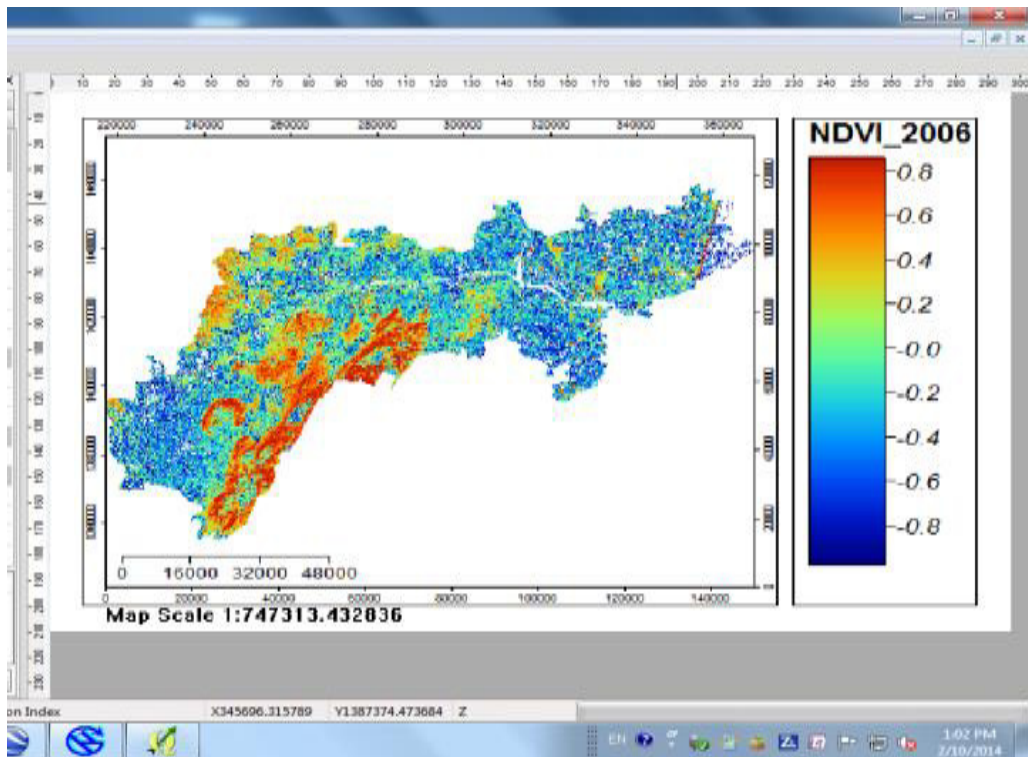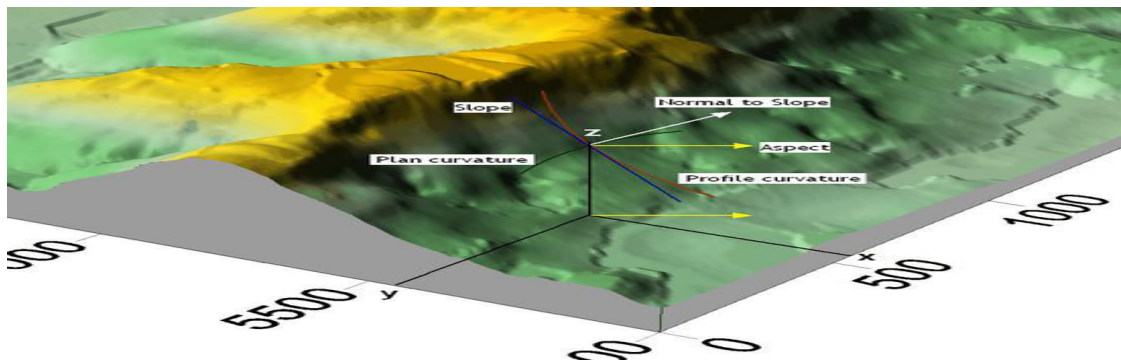Fig.6. NDVI 2006

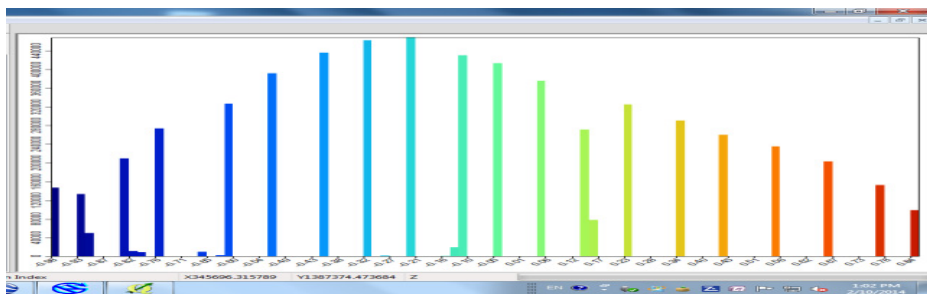Fig. 7. Surface Morphology(adopted [18]

Fig. 8. Histogram classification 2001
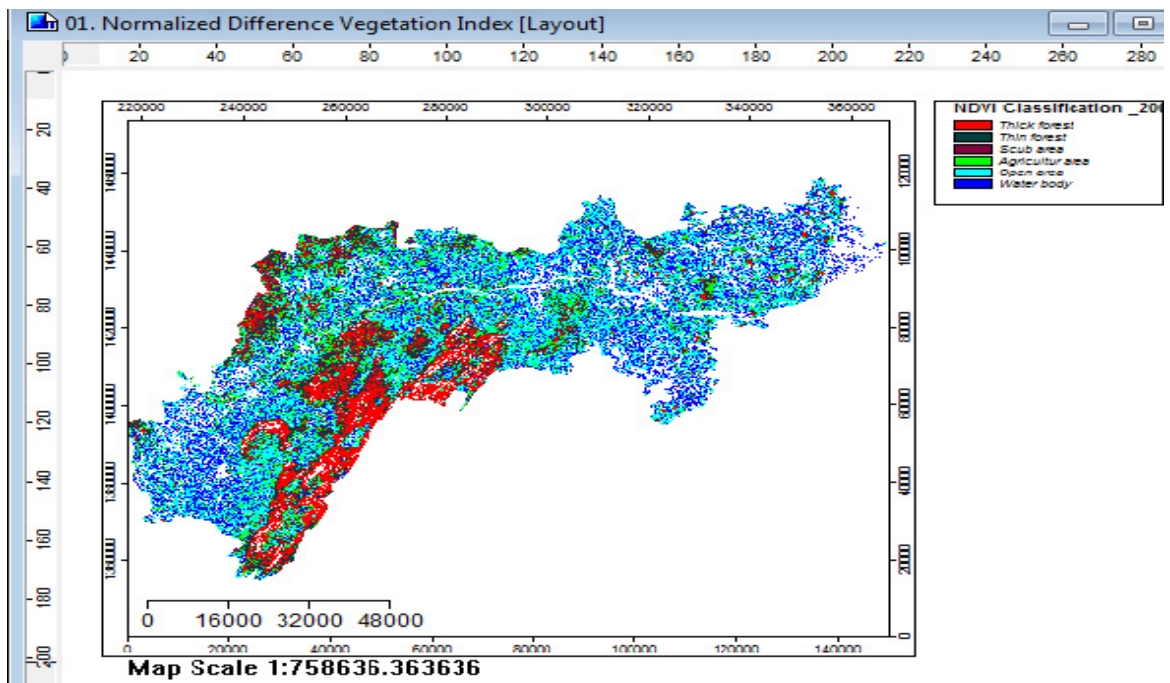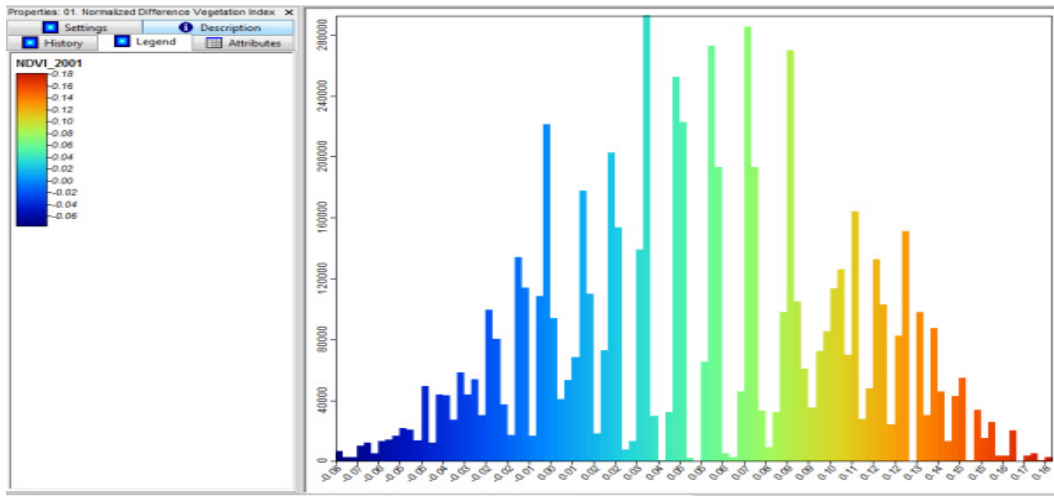

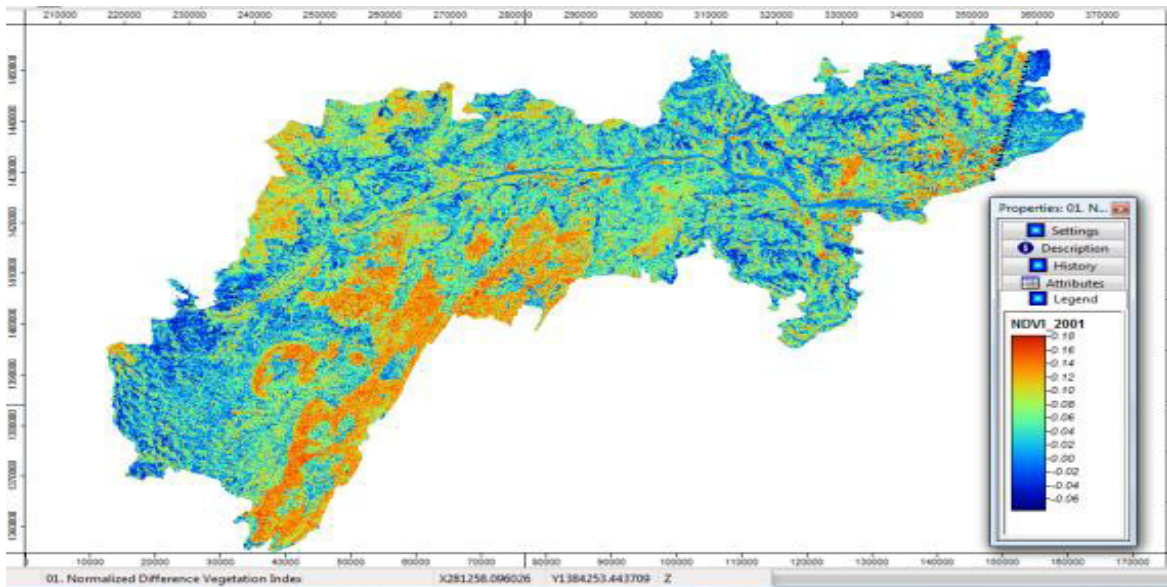
Fig. 9. NDVI classification 2006

Fig.10. Histogram 2006

Fig.11. Changes shown in histogram

Wetness index [18]: this index contains spatial distribution of soil moisture in landscape length unit that was computed in equation (3) by the following formula

$$w = \ln(\frac{As}{\tan\beta}) \ - $$
(3)

Where As is given area of watershed (m2) and β is slope in degree (More et al., 1991

Profile Curvature [18]: It defines the shape of the surface in the immediate neighbourhood of the sample point contained within the vertical plane. As shown in equation (4), it represents the rate of change of the slope at that point in the vertical plane, and is negative if the shape is concave, positive if the shape is convex and zero if there is

no slope. Profile curvature is defined as:

$$k_{pr} = \frac{\dfrac{\partial^2 z}{\partial x^2}\left[\dfrac{\partial z}{\partial x}\right]^2 + 2\dfrac{\partial^2 z}{\partial x \partial y}\dfrac{\partial z}{\partial x}\dfrac{\partial z}{\partial y} + \dfrac{\partial^2 z}{\partial y^2}\left[\dfrac{\partial z}{\partial y}\right]^2}{pq^{3/2}} \tag{4}$$
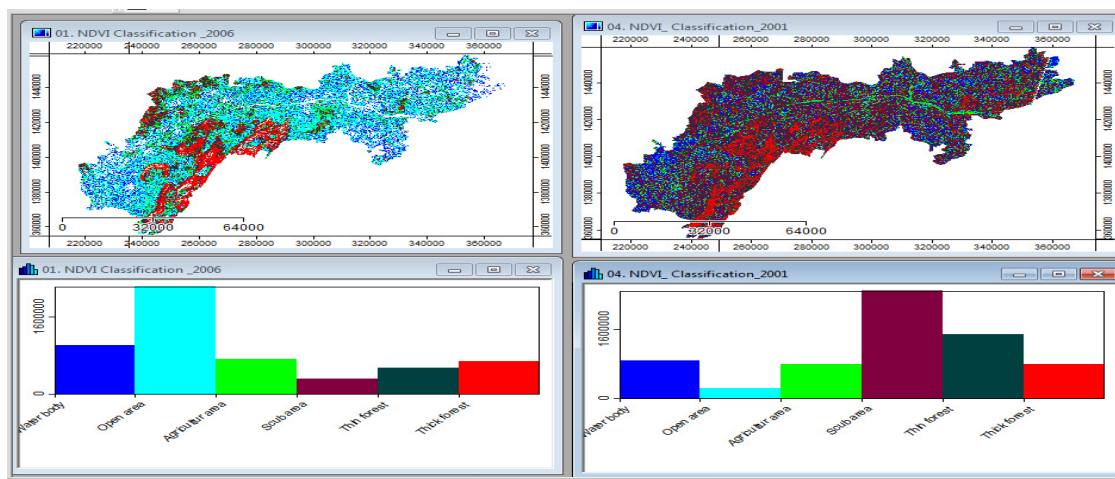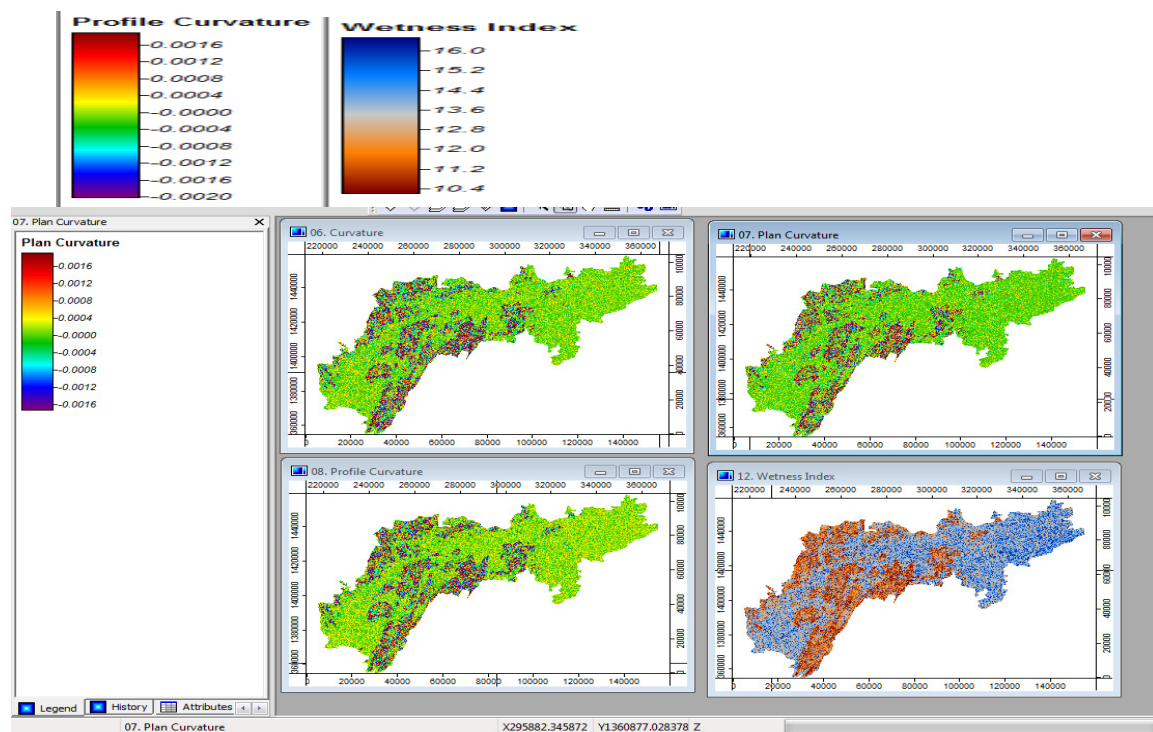

Fig. 12. Changes between 2001 and 2006

Fig. 13. Curvature, Plan curvature, Profile curvature and Wetness Index

The **Plan Curvature [18]** is the shape of the surface viewed as if a horizontal plane has sliced through the surface at the target point (the labelled green line in Fig.13. It is essentially the curvature of a contour line at height z and location (x,y). The differential expression for plan curvature is similar to that for profile curvature which is shown in equation (5):

$$k_{pr} = \frac{\frac{\partial^2 z}{\partial x^2}\left[\frac{\partial z}{\partial x}\right]^2 - 2\frac{\partial^2 z}{\partial x \partial y}\frac{\partial z}{\partial x}\frac{\partial z}{\partial y} + \frac{\partial^2 z}{\partial y^2}\left[\frac{\partial z}{\partial y}\right]^2}{pq^{3/2}} \tag{5}$$
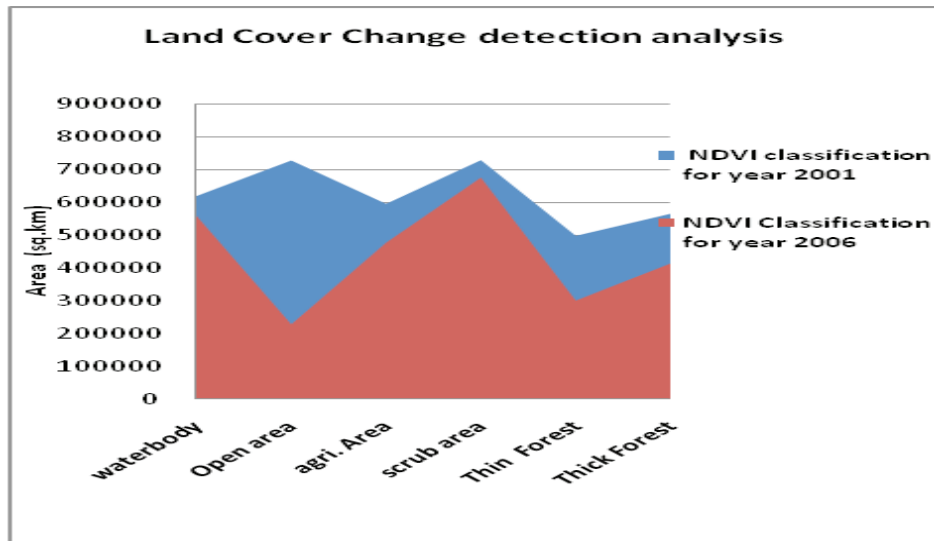

Fig 14. Land Cover Change detection

From the empirical study, the forest or shrub land and open area cover types have decreased by about 6% and 23% from 2001 to 2006 respectively, while agricultural land, built-up and water areas have increased by about 19%, 4 % and 7% respectively. Fig.14 presents the Land Cover Change detection analysis.

3. Conclusion

The Change Detection analysis is an efficient way of describing the changes observed in each land use category. Over a decade there were considerable variations in agricultural land, hilly area with vegetation and in dry farming. Supervised classification of Landsat images and cross verification by ground truth traverse has results an overall accuracy of the image interpretation classes. A high resolution satellite data would suitably improve the land use classification.The normalized difference vegetation index technique with different threshold values has been employed for features extraction.

It clearly shows that the percentage of vegetation is almost same for different threshold value. Empirical study implies the percentage of vegetation is found to be 32.1304% at NDVI threshold of 0.3, water bodies & river are found to be 6.5771%, agricultural area is found to be 23.4949% and remaining area is found to be 37.7976%. In the year 2006, the percentage of vegetation in the given study area is found to be 46.4376% at NDVI threshold of 0.2, water bodies & river are found to be 8.6978%, agricultural area found to be 30.8418% and the remaining area is found to be 14.0227%. The NDVI method gives superior results for vegetation varying in densities and also for scattered vegetation from a multispectral remote sensing image.

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References

1. Ahmadi H, Nusrath A, "Vegetation change Detection of Neka river in Iran by using remote   sensing and GIS", Journal of geography and Geology, 2 (1)., pp. 58-67., 2012.
2. Karaburun A. A. K. Bhandari, "Estimation of   C factor for soil erosion modelling using NDVI in Buyukcekmece watershed", Ozean Journal of applied sciences 3, 77-85., 2010.
3. Chouhan R, Rao N," Vegetation detection in   Multi spectral remote sensing images: protective   Role-analysis of coastal vegetation in 2004   Indian Ocean Tsunami. Geo-Information for Disaster Management ", Procedia Technology   6, pp., 612 – 621., 2012.
4. Xie Y, Zhao X, Li L, Wang H," Calculating NDVI for landsat7-etm data after atmospheric   Correction using 6s model: a case study in Zhangye City, China, In proceeding IEEE Geo Informatics 18th international conference, pp. 1-4., 2010.
5. Hu Y, Ban Y, Zhang X, Liu J, Zhuang. D,"Spatial- temporal pattern of GIMMS NDVI   and its dynamics in Mongolian Plateau", In IEEE Proceeding on earth observation and remote sensing applications, pp.1-6., 2008.
6. Merwan Achibeta, Stefan Balevb, Antoine Dutotb, Damien Olivierb," A Model of Road Network and Buildings Extension Co-Evolution Agent-based Modeling and Simulation of Cities   Procedia Computer Science", 32, pp. 828 – 833. 2014.
7. Shikhar Deep , Akansha Saklani, " Urban Sprawl modeling using cellular automata" , The Egyptian Journal of Remote Sensing and Space Sciences, 17, pp. 179–18., 2014.
8. A.K. Bhandari, A. Kumar, "Feature Extraction using Normalized Difference Vegetation Index (NDVI): A Case Study of Jabalpur City", Proceedings of Communication, Computing & Security. Procedia Technology Volume 6, pp. 612– 621, 2012.
9. Nageswara PPR, Shobha SV, Ramesh, KS, Somashekhar RK," Satellite -based assessment of Agricultural drought in Karnataka State, Journal of the Indian society of remote sensing ", 33 (3), pp. 429-434., 2005
10. Yang Y, Zhu J, Zhao C, Liu S, Tong, The spatial continuity study of NDVI based on Kriging and BPNN algorithm" , Journal of Mathematical and computer modelling., pp. 77 - 85, 2010.
11. Lan Y, Zhang H, Lacey R, Hoffmann WC, Wu W," Development of an integrated sensor and instrumentation system for measuring crop conditions", Agricultural engineering journal ,   11, pp.11-15., 2009.[12] Bechtel A, Puttmann W, Carlson TN, Ripley DA," On the relation between NDVI fractional vegetation cover, and leaf area index. Remote Sensing environment, 62 (3), pp. 241 - 252. 1997.
12. El-Shikha DM, Waller P, Hunsaker D, Clarke T, Barnes E," Ground-based Remote Sensing for assessing water and nitrogen status of broccoli , Agriculture water management, 92, pp. 183-193., 2007.
13. Kim H, Kwak HS, Yoo JS," Improved clustering algorithm for change detection in remote sensing International journal of digital content technology and its appications, 2008; 2 (2), 55-59.
14. Yamaguchi T, Kishida K, Nunohiro .E, Park JG, Mackin KJ, Matsushita kHK, Harada I., "Artificial neural network paddy-field classifier using Spatiotemporal remote sensing   data", Artificial life and robotics 2010; 15 (2), pp. 221-224.
15. Demirel H, Ozcinar C, Anbarjafari G., " Satellite image contrast enhancement Using discrete wavelet transform and singular value Decomposition. IEEE Geosciences and remote sensing letters", 7 (2), pp. 333-337, 2010.
16. Zhang X, Hu Y, Zhuang D, Oi Y, Ma,"NDVI spatial pattern and its differentiation on the Mongolian plateau", Journal of geographical Sciences, 19, pp., 403- 415, 2009
17. GeoSpatial Analysis 5th Edition, 2015 Smith, Goodchild, Longley. http://www.spatialanalysisonline.com/HTML/?profiles_and_curvature.htm