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ASSESSMENT OF VEGETATION CANOPY USING GEO-SPATIAL TECHNIQUES OVER MINING AREAS OF PANDABESWAR IN BARDDHAMAN DISTRICT, WEST BENGAL, INDIA

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Abstract

Vegetation cover analysis was calculated and estimated with the use of Landsat imageries of the Pandabeswar mining area. At the present time, detection and determination of vegetation cover change is the major and the most widespread form of environmental problems in Pandabeswar block OC Coal mines region. Population pressure due to mining growth, deforestation and uncontrolled exploitations of the available natural resource for firewood, construction and other household usages often ultimately leads to severe degradation in the vegetation cover. Therefore, the goal of this paper is to monitor and assess the vegetation covering over the mining area using the remote sensing techniques. In this study an integrated Geo-spatial Information System (GIS) and digital Remote Sensing (RS) approach has been utilized to monitor and assess the vegetation canopy as of 2010. Landsat data of the study area were collected and analyzed using the digital image processing approach and verifications were carried out at the ground control points using GPS based technologies. In this study, different parameters i.e. NDVI, PVI, NDWI and SAVI are used for the overlay analysis in GIS Platform to generate the vegetation canopy over the mining area. The result of the study discourses that, vegetation cover is severely decreasing over time especially in and around the open cast coal mining effect.

Key Word: Vegetation, Mining, RS, GIS, NDVI, PVI, NDWI, SAVI.

Introduction

Vegetation is the important component of any ecosystem. Vegetation performs a very vital role in all aspects of environmental planning and control [1]. Presently, urbanization, mining and industrialization etc. are used to represent the trend of social and economic development of any area. Huge space is used for these activities leading to a decrease of forest areas and deforestation is common problem for all these regions. In forest areas, the forest density and greenness of the area are major issues for preserving the ecosystem, biodiversity etc. So vegetation management is the important part for greenery analysis [2]. The district of Barddhaman in West Bengal is one of the richest districts that abounds with large reserve of high grade coal and different mining companies operate here. Pandabeswar Block is one of them. This block of Sonpur-Bajari project is the largest open cast coal mining area within West Bengal. This block has a lot of open cast mines which lead to degradation of land (top cover) as well as vegetation in and around the area. Hence, monitoring the vegetation A vegetation index is a mathematical relationship used to estimate the likelihood of presence of vegetation using remotely sensed data over a particular area.

Study Area

The present study area of Pandabeswar is located in under Barddhaman district and it is situated between Damodar and Ajoy river. The location map is of the study area is shown in Figure 1. Covering the study boundary Latitude : 23° 38' 30'' to 23° 44' 30'' N, Longitude : 87° 10' 0'' to 87° 30' 45''E. Average temperature in hot season is 30°C while in the cold season as 20°C. The average rainfall is 150 millimeter.

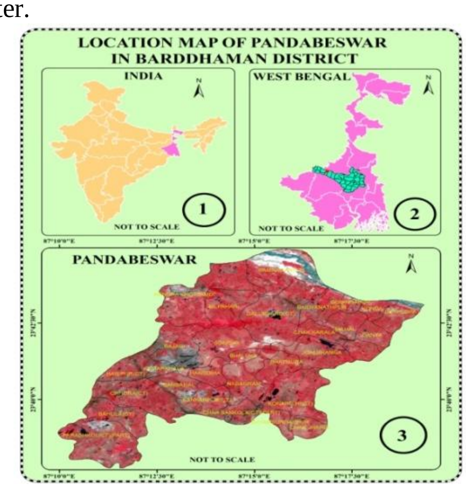

Figure 1. Location map of the study area.

In this study, we have used four indices namely, Normalize Difference Vegetation Index, Perpendicular Vegetation Index, Normalized Difference Water Index and Soil Adjusted Vegetation Index for generating the maps over the particular area of interest. Finally, the vegetation cover mapping in and around the mining area is also developed. The determination of the vegetation canopy forms the objective of the present study.

Data used

The main source of the data used for the vegetation mapping is satellite imagery (Table 1). The spatial resolution of Landsat 5 TM satellite imagery is 30 m and band6 (thermal band) is 120 m. The swath width covered by the image is 185 km. Using the proposed mathematical algorithms one these data different analyses have been performed. The path & row information of the satellite image is 139 and 44. This images are found to be cloud free and the image quality is observed to be excellent for the present analysis purpose.

Table 1. The data used for the present study

Sl. No.	Data use	Year	Source
1	Landsat 5TM	2010	USGS
2	Toposheet (73M/2,M/4)	1970	Survey of India
3	Google Earth Image	2010	Google Earth

Methodology

The proposed and adopted methodology for the present investigation is presented in figure 2. The Landsat TM data has been processed with the four different indices finding operations. These individual outputs were then overlayed for analyzing the vegetation density, after comparing with the present information obtained from the available Google map information and field observation.

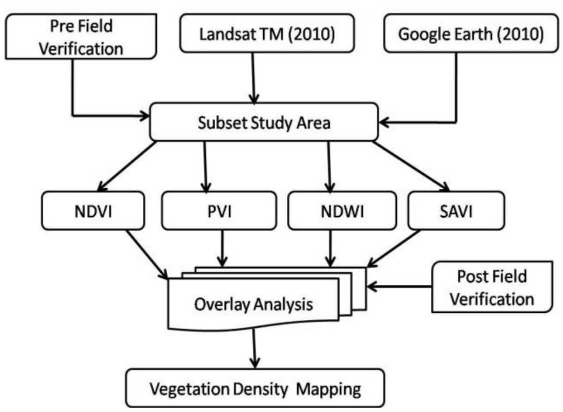

Figure 2. Flow chart adopted for the present study

Results and Discussion

Normalized Difference Vegetation Index (NDVI)

NDVI is a calculation, based on two spectral bands, of the photosynthetic output (amount of green stuff) in a pixel in a given satellite image. It measures, in essence, the amount of greenery / vegetation in the area. In this exercise, one uses the Multispecies ability to create new Channels' in an image to display the NDVI for an image. The NDVI calculations are mainly based on the concept that actively growing green vegetation strongly absorb radiations in the visible region of the spectrum while strongly reflecting radiation in the Near Infrared region.

NDVI are good indicators of photosynthetic activity on the vegetation surface. NDVI is the ratio of the differences in reflectivity's for the near-infrared band (b4) and the red band (b3) present in the area of interest in the satellite imagery, these are related using the equation is shown below:-

$$NDVI = \frac{(TMb4 - TMb3)}{(TMb4 + TMb3)} \quad ....(1)$$

The main observation is that NDVI relates positively to vegetation, i.e., healthy vegetation reflects very well in the near-infrared part of the electromagnetic spectrum.

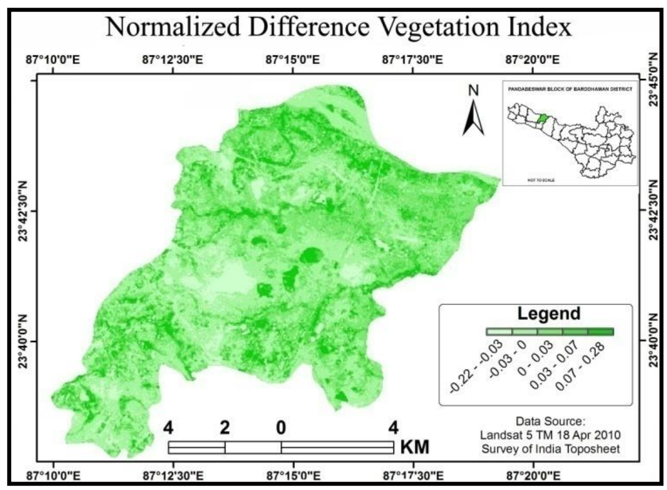

Figure 3. The generated NDVI map over the study area.

Figure 3 Shows NDVI density from Landsat image of the year of 2010 respectively.

Perpendicular Vegetation Index (PVI)

It is the distance based vegetation index designed to eliminate the effect of background soil wetness and only to detect the features of vegetation cover. It is actually a soil line related index. In this index the soil line approach is applied as a linear regression of NIR against red bands for pixel of bare soil. Richardson and Wiegand (1977) [3] used the perpendicular distance to the soil line as an indicator of plant development.

PVI equation is shown below:-

$$PVI = \sqrt{\left((\text{red\_soil} - \text{red\_veg})^2 + (\text{nir\_soil} - \text{nir\_veg})^2\right)}$$ ....(2)

where, red_veg = vegetation reflectance in the red band, nir_veg = vegetation reflectance in the near-infrared band, red_soil = soil reflectance in the red band, and nir_soil = soil reflectance in the near-infrared band.

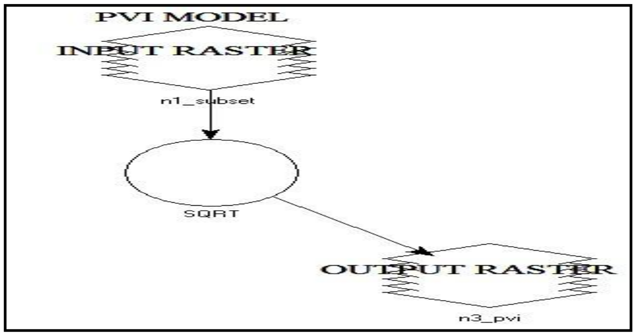

Figure 4. The used PVI model for the present investigation.

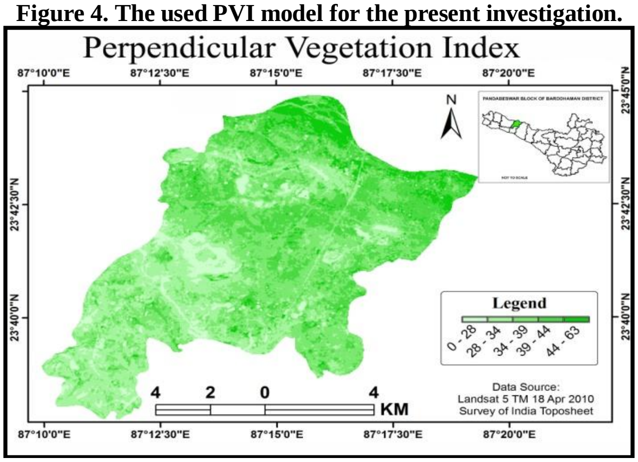

Figure 5. The generated PVI map over the study area.

In Figure 5 it may be seen that the PVI values range between 0 to 63. This whole range is classified into five classes as the presence of wet soil and low vegetation canopy to partial and full vegetation canopy cover.

Normalized Difference Water Index (NDWI)

The NDWI demarcates the open water features. Bo-Cai Gao (1996) proposed [5] this (NDWI) index. NDWI equation is shown below:-

$$NDWI = \frac{NIR(band\,4) - MidIR(band\,5)}{NIR(band\,4) + MidIR(band\,5)}$$ ....(3)

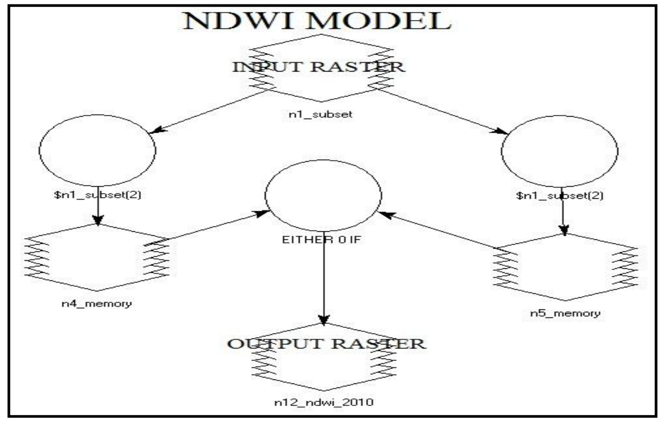

Figure 6. The used NDWI model in the present investigation.

This index maximizes the reflectance of water by using green portion of the wavelengths and minimizes low reflectance at the NIR range by water features while taking advantage of the high reflectance at NIR region by the vegetation and soil features in the area of interest of the imagery [14]. As a result, water features are enhanced leading to positive values, and the vegetation and soil portions are suppressed due to zero or negative values.

The extracted portions having water in these regions were consistently mixed up with the vegetation area noise because many vegetation area also have positive values in the NDWI derivative image. The signatures for the appearance of vegetation region in NIR band and Mid IR band shown in Figure 7 is analogous with those of water, i.e., both these wavelengths are reflected. Consequently, the computation of the NDWI also produces a positive value for vegetation area just as it was for watery portion.

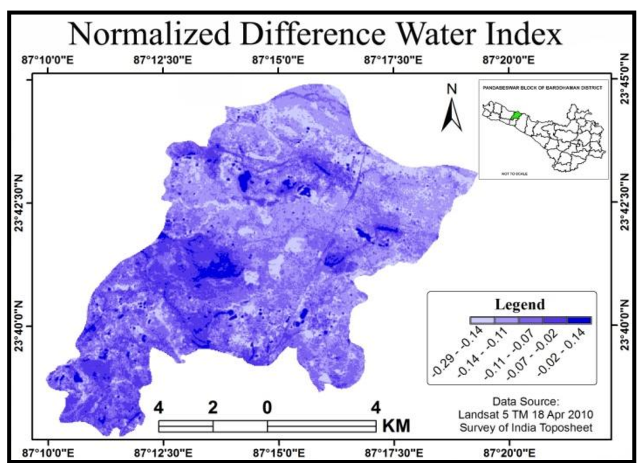

Figure 7. The generated NDWI map of the study area.

Soil Adjusted Vegetation Index (SAVI)

It is comparatively a newer method to present the minimized soil brightness influences from spectral vegetation indices involving red and NIR wavelengths. Graphically, the transformation involves a shifting of the origin of reflectance spectra plotted in NIR-red wavelength space to account for first-order soil-vegetation interactions and differential red and NIR flux extinction through vegetated canopies [4].

The SAVI is an index that attempts to "subtract" the effects of background soil from NDVI so that impacts of soil wetness are reduced in the index. SAVI equation is shown below:-

$$SAVI = \frac{(1+L)(P4-P3)}{(L+P4+P3)} \text{ ....(4)}$$

where; L is a constant for SAVI. If L is zero, SAVI becomes equal to NDVI. A value of 0.5 frequently appears in the literature for L. However, a value of 0.1 is used to better representation of the soils. The value for L can be derived from analysis of multiple images where vegetation does not change, but surface soil moisture does change.

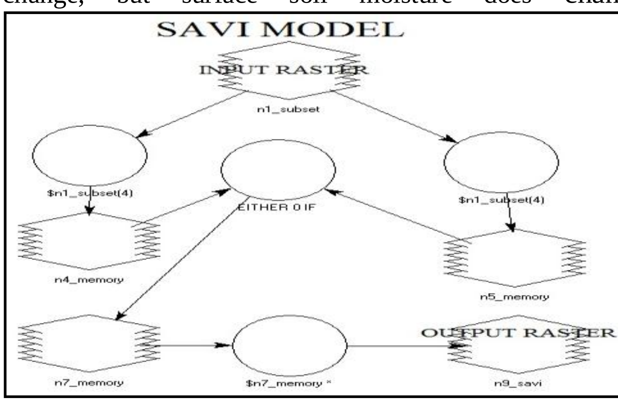

Figure 8. The used SAVI model in the present study.

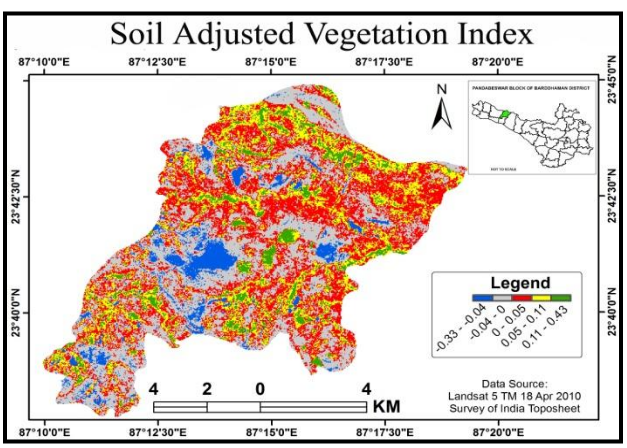

Figure 9 The generated SAVI map of the study area.

Vegetation Density

Vegetation density map is the map by which we find the vegetation density in mining area. In the Figure 10 for vegetation density map, five categories have been displayed. The north portion forms a part of the Ajoy River and here, in land under the rice cultivation, are found the usual marsh weeds of Ajoy river plain and many sedges. The mining area surrounded by the usual shrubberies of semi-spontaneous and sub-economic shrubs and small trees which often cover a considerable area. The more characteristic chrubby species are Glycosmis, Ployalthia suberosa, Clerodendron infortunatum, Solanum torvum. Other species of figs, notable the papal and banyan with the red cotton tree (Bombax malabaricum) mango and jiyal make up the arborescent part of these thickets in which Phanix dactylifera and Borassus flabelliffer are often present. Hedges and waste places are covered with climbing creepers and various milk weeds and also harbor quantities of Jatropha gossypifolia, Urena, Heliotropium, Sida andsimilar plants. Road-sides are often clothed with a sword of short grasses and open glades with tall coarse grasses.

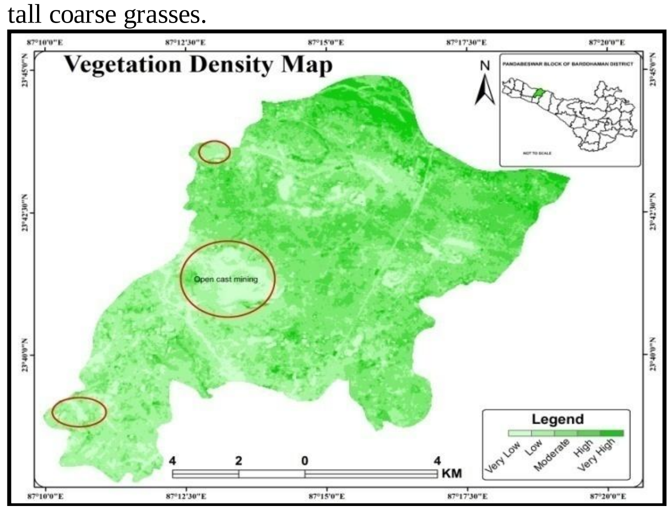

Figure 10 The vegetation density map obtained after overlay.

Figure 11 Some of the field photographs of study area.

Conclusion

The study is aimed at using the different vegetation indices for mapping (namely, NDVI, PVI, NDWI, SAVI) for 2010 using Landsat TM satellite data. It is possible to evaluate canopy density more accurately but it needs more parameters like DEM, slope, soil type and other values depending upon the environment of the study area. Vegetation indices have been calculated using the mathematical formulations show that the vegetation canopy gets influenced by the industrial operations like mining in the area. Forest cover also decreases due to the adverse effects associated with mining growth.

References

[1] Kokaly F. R., Despain G. D., Clark N. R., & Livo E. K. (2003). Mapping Vegetation in Yellowstone National Park Using Spectral feature analysis of AVIRIS data. Remote Sensing of Environment 84, 437-456. http://digitalcommons.unl.edu/usgsstaffpub/425

[2] Banerjee, K., Panda, S., Bandyopadhyay, J., Jain, K. M., (2014). Forest Canopy Density Mapping Using Advance Geospatial Technique. International journal of Innovative Science, Engineering & Technology, Vol. 1, Issue 7, September, 358-363.

[3] Richardson, A. J., and C. L. Wiegand, (1977) Distinguishing vegetation from soil background information: Photogrammetric Engineering and Remote Sensing, v. 43, 1541-1552.

[4] Huete, A. R. (1988). A Soil-Adjusted Vegetation Index (SAVI). REMOTE SENSING OF ENVIRONMENT , 25 (3), 295-309.

[5] Gao. Bo-Cai (1996). NDWI- A Normalized Difference Water Index for Remote Sensing of Vegetation Liquid Water from Space. Remote Sens. Environ. 58:257-266.

[6] Pramod Kumar G.R., A.M. Hemanjali, P. Ravikumar, R.K. Somashekar and B.C Nagaraja. (2013) "Assessment of forest encroachment at Belgaum district of Western Ghats of Karnataka using Remote Sensing and GIS". Journal of Environmental Biology, 35, 259-264.

[7] Pramod Kumar, G.R., Hemanjali, A.M., Ravikumar, P.,Somashekar, R.K., and. Nagaraja, B.C.Nagaraja. (2013). Assessing the historical forest Encroachment of Ko-dagu region of Western Ghats, South India using re-mote sensing and GIS. UMI-2013 NRSC/ISRO, (http://www.nrsc.gov.in/pdf/pram.pdf).

[8] Tucker C (1979) Red and photographic infrared linear combinations for monitoring vegetation. Remote Sens. Environ 8:127–150.

[9] Joshi, P. K., Roy, P. S., Singh, S., Agarwal, S., & Deepshikha Yadav. (2006). Vegetation cover mapping in India using multi-temporal IRS Wide Field Sensor (WiFS) data. Remote Sensing of Environment, 103, 190−202.

[10] Curran, P. J., & Franquin, P. (1980). Multispectral remote sensing of vegetation amount. Progress in Physics of Geography, 4, 315−341.

[11] Z. azizi, A. Najafi, H. Sohrabi (2008). Forest Canopy Density Estimating, Using Satellite Images. The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences. Vol. XXXVII. Part B8. Beijing, 1127-1130.

[12] Korhonen, L., Korhonen, K.T., Rautiainen, M. & Stenberg, P. (2006). Estimation of forest canopy cover: a comparison of field measurement techniques. Silva Fennica 40(4): 577–588.

[13] Bengal District Gazetteers hand book in burdwan - by J.C.K. PETERSON.

[14] Kamila. A., Pal. C. S. (2015). Urban Growth Monitoring and Analysis of Environmental Impacts on Bankura-I and II Block using Landsat Data. International Journal of Advanced Remote Sensing and GIS, Cloud Publication, Vol. 4, Issue 1: 965–975.

[15] Erener A. (2011) Remote sensing of vegetation health for reclaimed areas of Seyitomer open cast coal mine. International Journal of Coal Geology 86, 20–26.

[16] Md. Ejaz Alam, Javed Mallick, Atiqur Rahman, D. Dutta . (2013) Spatio-Temporal Assessment of vegetation covers in the upper catchment of kosi river basin using modis data. International Journal of Remote Sensing & Geoscience (IJRSG), Vol.2,Issue 6,November , 33–40.

[17] M. Shamshad Alam, Jamal A. Khan, Bharat J. Pathak, Sandeep Kumar (2014). Assessment of forest density using geospatial techniquesof a tropical protected area. International Journal of Scientific and Research Publications, Vol.4,Issue 3, March , 1–6.