

Monitoring of Forest Cover Dynamics by Geospatial Technique — A Study in Nayagram Block of West Medinipur District, West Bengal, India

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Abstract: With the increasing human activity and over exploitation, the forest cover scenario is changing very rapidly in India. Particularly different forests of high population density areas like West Bengal, second most densely populated state having 1028 population per Km² are facing this problem most severely. A study was conducted to monitor the changing forest cover scenario in Nayagram block which is located in the south western part of West Medinipur district, West Bengal. Selected site carries its historic entity by the name Jangal Mahal covering 28.48% of area with semi deciduous forest with dominated sal (Shorea robusta) species. Monitoring of forest cover dynamics gets a new dimension after the advent of remote sensing (RS) and geographical information system (GIS) techniques. Multispectral indices based forest monitoring system could only help to separately enhance the vegetation internal characteristics like health, height, vigor, etc. but fails to represent forest cover as a single feature. Present study develops forest cover using multi criteria decision making (MCDM) based weighted overlay analysis of three distinct vegetation indices, i.e., modified atmospheric and soil adjusted vegetation Index (MASAVI), bare surface index (BSI) and scaled shadow index (SSI). To reveal the actual situation in terms of forest cover dynamics, LANDSAT imagery of the year 2001 and 2010 respectively have been processed. Attempts are made to geospatially monitor the dynamics of forest cover in the study area at temporal scale.

Key words: forest cover, RS and GIS technique, vegetation index, factor

1. Introduction

Conventionally exploration of available forest resource has been successfully done by the processing of digital imagery [1-4]. The method roughly include two broad groups, namely sample training area based qualitative image analysis and algebraic operation based object oriented spectral band combination [5, 6]. In training area based vegetation cover analysis either low contrast of image due to atmospheric and environmental condition or limited spectral discrimination power of human eye, sometime both the cause influence the accuracy of the obtained result. Whereas using of spectral band combination not only helps in the enhancement of targeted vegetation spectral from the associated feature but also provides ample scope to remove the atmospheric noise as well as surface influxes. Application of such operation to digital image improves the visual appearances for better interpretability and subsequent digital analysis [7].

It seems that vegetation cover enhancement algorithms are indeed very much fruitful in defining vegetation class from different aspects. More than 40 types of vegetation indices have currently been defined, e.g., normalized differential vegetation index (NDVI), perpendicular vegetation index (PVI), soil-adjusted vegetation index (SAVI), all were widely used in areas like environment, ecology and agriculture [8]. Estimation of forest cover in terms of analyzing single

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or multiple indexes separately can only explore the single feature of vegetative pixel at a time, like growth, height, density, shadow etc. A new methodology, multi criteria decision making (MCDM) based forest cover mapping on the basis of three new parameters, i.e., modified atmospheric and soil adjusted vegetation index (MASAVI), bare surface index (BSI) and scaled shadow index (SSI) has been developed to purposefully cluster the spectral information conveyed by selected parameters.

Forests account for 75% of the gross primary productivity of the earth's biosphere and contain 80% of the earth's plant biomass [9]. It also plays an important role in energy exchange, recycling carbon dioxide, purify water and managing natural hazards. Much of our increasing concern semi deciduous forests of West Bengal are declining at an alarming rate which pose a serious threat of being thoroughly degraded in near future. According to Wastelands Atlas of India 2011 (State Forest Report, West Bengal, 2011) out of total degraded forest in the state 91.01% was of semi deciduous type. In order to monitor the forest cover dynamics of such forests, a forest inventory geospatial model has been developed using MCDM based forest cover maps for the year 2001 and 2010.

2. Study Area

Nayagram, a community development block is bounded by 22°44' N to 22°74' N latitude and 88°08' E to 88°13' E longitude covering an area of about 501.44 Km². Elevation of the area varies between a maximum of 110 m. in central north to a minimum of 10 m. in south east (from MSL). The Study area possesses an undulating topography having a gentle to moderate slope from north west to south east direction. As the place lying in the eastern fringe of Chotanagpur plateau, abundance of primary and secondary laterite profiles is very common. The drainage of the area is controlled by Subarnarekha river which flows along the north eastern boundary of the block. Prevalent climate of the area is



Fig. 1 Location of the selected area.

tropical monsoon type with an annual rainfall around 1615 mm.

3. Materials and Methods

In this present study Landsat ETM and TM digital data (P/R–139/45) of 27th January 2001 and 13th February 2010 having resolution 30 m has been used and processed in TNT Mips Pro and ARC GIS software package.

In an image, pixel having chlorophyll influence will reflect greater in Near infra-red (NIR) band than Red band. Using this properties a generic normalized differentiate vegetation index (NDVI) has been developed to assesses the vegetation cover [10]. Although NDVI is very useful in estimating vegetation properties many external and internal influences restricts it global utility [11]. Drawbacks like atmospheric aerosol scattering and soil background factors has been dealt in this study to form a new vegetation index, i.e., modified atmospheric and soil adjusted vegetation index (MASAVI) [12]. In it blue band have been used in correction of atmospheric aerosol scattering reduction in red band [13]. The soil background factor has been adjusted by using the soil line concept which is a linear correlation of NIR band against red band. On the basis of this consideration MASAVI can be calculated as:

 $MASAVI = [(pNIR - pRED) / \{pNIR + (pRED - pBLUE) + L\}] (1)$

where, pRED, pNIR, pBLUE = Reflectance value of Red, Near-infrared and Blue bands respectively of TM5 Sensor, L = Coefficient, varies with the trend line value of NIR and Red band correlation)

Vegetation index are not so reliable in situations where the vegetation cover exist in less than half of the area [14]. The value of vegetation index does not always extract the actual vegetation status correctly. For more reliable estimation, the information of Middle infra-red (MIR) band and Green bands can be included to form a bare surface index (BSI) [12]. The underlying logic of this approach is based on the high reciprocity between bare surface and vegetation. It is a normalized differenced index of the sum of two separate band clusters having the most contrastive value in terms of bareness and vegetation. Correlation value of MIR and NIR band have been used as an adjustment factor for soil background correction. BSI can be calculated as:

BSI=[{(pMIR+pRED)-(pNIR+pGREEN)}/[{(pMIR+ pRED) + (pNIR+pGREEN)}* 1/L (2)

where, pRED, pGREEN, pNIR, pMIR = Reflectance value of Red, Green, Near-infrared and Middle infra-red bands respectively of TM5 Sensor, L = Coefficient, varies with the correlation of MIR and NIR band.

The arrangement of forest canopy develops marked variations in shadow pattern. By utilizing the spectral information of the forest shadow and the thermal information on the forest influenced by shadow, a scaled shadow Index (SSI) has been formulated [12]. The index used the spectral value of three visible bands, Blue, Green and Red respectively. SSI has been calculated as:

$$SSI = \left\lceil 3\sqrt{\left\{256 - \left(\left(pBLUE + pGREEN + pRED\right)/3\right)\right\}}/10\right\rceil(3)$$

where, pBLUE, pGREEN, pRED = Reflectance value of Blue, Green and Near-infrared bands respectively of TM5 Sensor.

In the present study three parameters, MASAVI, BSI and SSI were used as multi-parametric dataset in order to delineate forest cover map of the area. For the qualitative evaluation of the input dataset they were classified into five distinct categories on the basis of quantile method. A pairwise comparison matrix under multi-criteria decision making approach has been constructed for determine the individual weight of parameters [15] as per Table 1. Subweights of the individual parameter class have been set between values — 3 to 6 by giving maximum weightage to vegetative class. Finally a weighted linear combination (WLC) was performed to generate overall attribute as:

$$S = Wi * Xi$$
 (4)

where, Wi = weight assign to each parameter and Xi = sub weight of each parameter.

The methods of forest cover mapping have been applied both for the images of year 2001 and 2010. The first two class of both forest cover map were identified as forest class and the rest classes were merged to represent non forest class. A combination function has been used between the forest cover raster of the respective years to get the changing status of different forest classes, i.e., deforested, no change and afforested area from the year 2001 to 2010. In order to generalize the obtained raster deforested, no change and afforested area were merged for monitoring the forest cover dynamics.

4. Result and Discussion

In order to delineate multi criteria based forest cover mapping, it was very essential to accurately estimate the different parameters along with their individual classes. From the MASAVI, BSI AND SSI outputs (Figs. 2-4) derived by using equations (1), (2) and (3) for the year 2001 and 2010 have shown the changing dynamics of forest cover. Broadly deterioration status was observed in very high and high vegetative class while up gradation experienced in moderate to low vegetative class.

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	MASAVI	BSI	SSI
MASAVI	1	5	3
BSI	1/5	1	1/2
SSI	1/3	2	1

Table 1Pair-wise comparison matrix.



Fig. 2 MASAVI of the area.



Fig. 3 BSI of the area.



Fig. 4 SSI of the area.

From the pair wise comparison matrix individual weight of parameters was constructed. By following Satty's Analytical hierarchical process (AHP) process normalized weight for MASAVI, BSI and SSI have been generated as 62.5%, 23.8% and 13.7% respectively. Finally a consistency ratio has been calculated for the judgment with an acceptable result of 0.019.

From the forest cover map (Fig. 5) of 2001 and 2010, it is found that dense forest class has been deteriorated by 19.521% of its previous area. Although interestingly open to dense forest class have been upgraded by 58.313% of its earlier dimension. This fact suggests that overall forest area have increased significantly due to afforestation but the permanent loss of dense forest area is a matter of serious concern.

The class wise forest change map (Fig. 6) shows high deforestation and low afforestation, i.e., 9.43% and 5.56% respectively of total study area in dense forest class and the reverse trend is found in dense to open forest class. As per category wise forest cover dynamics map, out of total forest area 31% forest area were found deforested in nature and 27% were afforested or newly developed. This result indicates that afforestation has been taken place at a large scale in the area yet during the study span but it failed to make up the loss due to deforestation.

In consultation with the local people it was identified that under development, inaccessibility, illegal forest



Fig. 5 MCA based forest cover map.

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Fig. 6 Forest dynamics of the area.

cutting and awareness were root cause behind the degradation of forest cover in the area. All these causes are much active in the recent past. Planning must be implemented for eradication of this root cause in order to save the forest.

5. Conclusion

From the above study it can be concluded that integrated geospatial approach of forest cover monitoring provides a new dimension for planning of management policy. Although government initiative for management of forest resource in the study area is found quite satisfactory yet most of the efforts are found in contrastive with ecological need. People awareness is also a matter of great concern in this regard. Nevertheless the study will surely help in the formation of forest resource management by which future flow of such valuable resource smoothens.

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