ASSESSMENT OF GREEN COVER IN FARIDABAD DISTRICT (INDIA): A GEOSPATIAL APPROACH

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ABSTRACT: The inventory of tree resources is accountable to hold documented vegetation cover, which is of utmost importance in framing development plans, effective land use management and to monitor ecological balance / imbalances. The present study aimed at assessing the current status of vegetation cover, with the help of geospatial technology, utilizing World View II, and fused product of Resourcesat 2 LISS-IV and Cartosat data. A series of vegetation categories (forest cover and trees outside forests) were identified and classified in the study area of Faridabad district (Haryana) located at 28°23'1" and 28°22'39" north latitudes and 77°20'44" and 77°32'36" east longitudes covering an area of 741 sq. km. The notified forest area (Aravali plantations, Reserved forests (RF), Protected forests (PF) and Section 4 & 5) were found extending to an area of 9237.5 hectares observed prior to digitization on World View II imagery. The corresponding Forest Canopy Density (FCD) was generated using Integration Model which utilizes Advanced Vegetation Index (AVI), Bare Soil Index (BSI), and Shadow Index (SI) indicating 1438.07 ha area of forests as degraded with the canopy density falling in the range of 0 - 25%. The trees outside forests were sub-classified in point, linear and block formations with an area of 4885.4 hectares found roofed by linear and block formations and the individual trees (small, large and cluster) forming a number of 30946. The results indicated the green cover to be 19.27 % of total geographical area of the district. It is evident that the resulting maps will provide timely, detailed and precise data applicable to update from time to time. The study also finds its utility for biogeochemical models where the type and extent of cover is the major input to monitor and sustain the ecological balance.

1. INTRODUCTION

Nature has been bountiful to us providing the substance which has been the basis of all our material and cultural progress. The importance of forests and forest resources in the economy of the state/country is really very important as they perform productive, protective and aesthetic functions and confer other advantages to the community. The forests conserve and enrich soil, helping in maintaining geographical, geological and climatic conditions. Forest resources both major and minor cater to the multiple and basic needs of the community and contribute more to the ecological stability. Forest and forest resources have a profound influence on the socio-economic conditions of people and the economy of the state by their impact on rain, water, heat, cold, moisture, vegetation, industry, income, employment etc. Apart from the forest trees are also found outside the forest serving the same purpose. The study deals with mapping and assessing the tree resources present in forest and outside forest forming total green cover of the study area.

The introduction of newer technologies for managing tree resources are gaining attention over a period of time since they provide reliable and flexible information which can be easily retrieved and updated over time. The use of remote sensing and GIS technologies have gained importance as they provide synoptic view to a location and accurate information could be extracted from the derived datasets. The decision making process derives a meaningful output to strategize and manage our tree resources. The occurrence of trees outside forests is generally focused on their location in either agricultural fields or urban areas forming the urban green cover. The studies on assessing TOF utilize datasets with low resolution (Perry et al. 2009, Zomer et al. 2014), medium resolution (Kumar et al. 2008, Lee and Lathrop 2005, Levin et al. 2009, Myeong et al. 2006, Small and Lu 2006, Thornton et al. 2006) and high resolution (Boggs 2010; Fehrmann et al. 2014; Herold et al. 2003; Ouma and Tateishi 2008; Tansey et al. 2009; Walker and Briggs 2007; Walton 2008).

The use of high resolution data has overcome the problem of pixel mixing (Herold et al. 2003) and a clear distinction among objects was observed. The sampling locations derived during manual interpretation are helpful in either complete mapping or deriving information again by interpreting in the grid locations (Fensham and Fairfax 2002; Hansen 1985; Holmgren et al. 1994; Walton et al. 2008).

The current study is carried out with a focus to assess the available green cover of a district and document it for any update in forthcoming years. The health of notified forest areas has also been generated in the form of Forest Canopy Density to intensify the status of forest cover.

2. STUDY AREA

The Faridabad district located in southern part of Haryana state lies between 28°23’1” and 28°22’39” north latitudes and 77°20’44” and 77°32’36” east longitudes (Fig.1). The Total geographical area of the district is about 741 sq. km (www.esaharyana.gov.in). The climate condition of the district slightly differs from other southern districts of Haryana state. The climate characteristics of the district are dry air, except during monsoon, hot summer and cold winters. The normal annual rainfall is 521.1 mm. It increases towards east. About 77 percent of annual rainfall in the district is received during the monsoon months i.e. July to September. The western part the district is the extension of Rajasthan desert. The natural vegetation of the district is dominated by Kikar (Acacia).

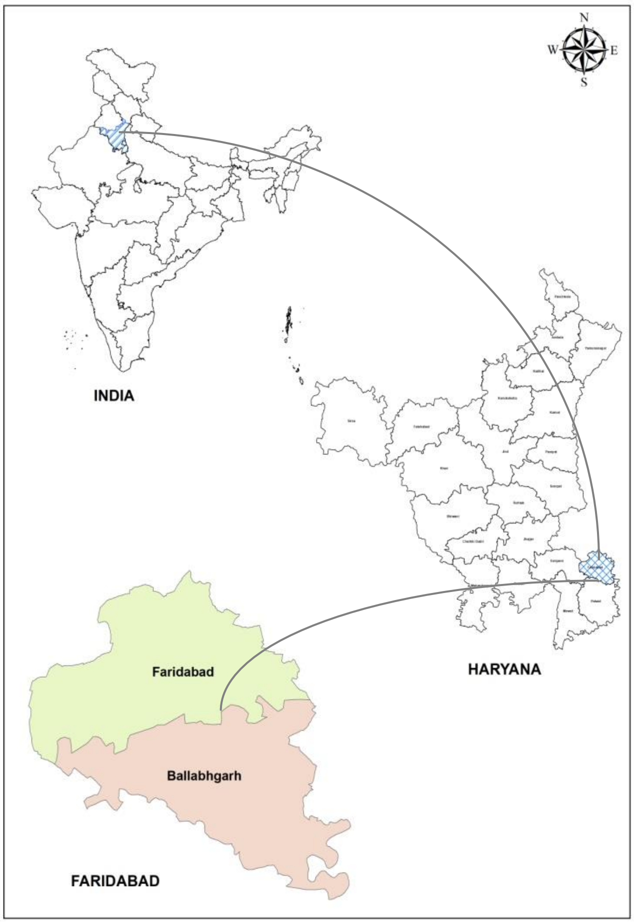

Fig.1. Study Area Map

3. DEMARCATION OF BLOCK FORESTS AT CADASTRAL LEVEL

The mussavies of the study areas were collected from District Revenue Office and used to generate cadastral planimetric vector data. These maps were georeferenced and overlaid on the ortho-rectified satellite imagery for further analyses. Mussavi refers to 16 murabba as mapping sheet. Each murabba had 25 killa (5x5) of each. Killa is the smallest land parcel in mussavi with ownership represented by the positive integer of 1 to 25. Murabba grids (200 karam x 180 karam) and khasra grids (40 karam x 36 karam) were generated. The murbba grid was generated utilizing same origin as that of killa grid in *Arc GIS* software. The line feature forming murabba grid was transformed to polygon feature and the label of each murabba placed at its centroid. 16 murabbas comprices to each musavi. Village tri-junctions, bi-junctions etc. features were digitized as point features. As dimension specified on the map digitization of the features was done. The partioned / beta parcels were produced by dividing the killa line boundary as per the distance / dimension mentioned in the map.

By integrating RoR data, Spatial data base was geo-linked and transformed into *.shp/*gdb file formats by compiling quality assurance with the positional accuracy, attribute accuracy, logical consistency, completeness and exact mosaic fit of the data. Entire area of the village is compiled by aggregating the parcels with the area obtainable with the Land Records in the RoRs. A separate layer of grid vector from cadastral map was formed for notified forest land and Killa / murabba grid number were identified for the same. The scanning and geo-referencing process was undergone for forest boundary maps of Faridabad district using ortho-rectified World View II data and digitization of forest boundary was carried out. The digitized boundary was used as reference to partition killa grids by overlaying Forest land grid vector layer. An integrated approach to acquire forests boundaries by incorporating high resolution satellite imagery, GPS survey and cadastral data was introduced by the study. Finally, the updated cadastral forest maps were prepared on a scale of 1:2,000 (Fig.2).

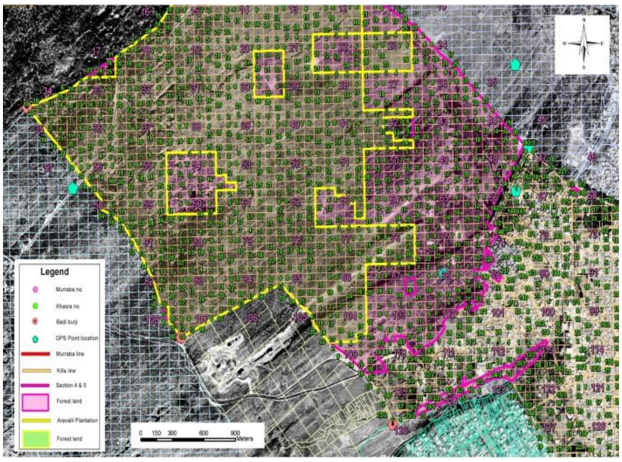

Fig.2. Illustration of Badkhal Forest Area, Faridabad

These Forest maps represent forest area as per notification overlaid over ortho - rectified World View satellite data and is validated in GIS environment. The demarked categories of forests in the district were Aravali Plantation, Section 4 & 5, Reserved Forests and Protected Forests and have been summed up for their estimated area of extent in Table 1. The prepared maps were further verified on the ground and were authenticated by the respective Foresters, Range Officers and finally by the Divisional Conservator of Forests. The GPS observation points were used as a comparison with randomly selected automated GCPs for assessing their accuracy. A similar comparison was made between randomly selected parcels for tie line (length) and area measurements of computer generated format with that of actual field measurement. The variations obtained are recorded in Table 1.

Table 1. Area statistics of identified forest categories

S. No.	Forest Category	Area (acre)	
		GIS layer	**HFD Notification**
1.	Aravali Plantation	9486.58	9017.30
2.	Section 4 & 5	13357.49	10448.38
3.	Reserved Forest	393.12	393
4.	Protected Forest	4.25	3.24
	Total	**23241.44**	**19861.92**

4. ESTIMATION OF FOREST CANOPY DENSITY

The Integration Model was used to generate Forest Canopy Density (FCD) utilizing Advanced Vegetation Index (AVI), Bare Soil Index (BSI), and Shadow Index (SI). The model serves best in time saving and cost effective manner. The satellite images were subjected to radiometric correction before generation of indices to correct the reflectance received from the surface. The reflectance of earth's surface is influenced by various atmospheric factors, variations caused by sun's azimuth and response generated by sensors. The reduction of radiance over bright pixels and increase at dark pixels causative of adjacency effect (Sharma *et al.*, 2008) and removal of any distortion also need to be resolved by radiometric corrections. The path radiance and noise was removed from all the acquired sub-scenes of area of interest. The conversion of DN to radiance (Eq. 1) and radiance to reflectance (Eq. 2) was followed.

$$L\lambda = \frac{SR_k \times DN}{DN_{max}} \qquad (1)$$

Where, SR_k=Saturation radiance of k^{th} band; DN_{max}= Maximum possible value of pixel.

$$R_{sensor} = \frac{L\lambda \times \pi \times \mathrm{d}^2}{E_{Sun} \times \cos\theta_z} \qquad (2)$$

Where, π =3.14159; R_{sensor} = reflectance at the sensor; $\mathbf{L}_\lambda$= spectral radiance at the sensor's aperture; E_{sun}= mean solar exo-atmospheric irradiance; θ_z = solar zenith angle; d = earth-sun distance.

The three indices namely, AVI (Rikimaru, 1999), BSI and CSI (Azizia et al. 2008) were used in integration to calculate canopy density of each visualized and classified pixel (Eq. 3, 4 and 5 respectively) based on the Bands characteristics of LISS IV (B2: 0.52 to 0.59 microns; B3: 0.62 to 0.68 microns; B4: 0.76 to 0.86 microns).

$$AVI = \sqrt[3]{B4 \times (DN_{max} - B3) \times (B4 - B3) + 1)} \qquad (3)$$

$$BSI = \frac{((B4 + B2) - B3)}{((B4 + B2) + B3)} \qquad (4)$$

$$CSI = \sqrt{((DN_{max} - B2) \times (DN_{max} - B3))} \qquad (5)$$

Table 2. Area statistics of classified FCD classes

FCD (%)	**> 85**	**70-85**	**55-70**	**40-55**	**25-40**	**10-25**	**<10**
AREA (ha)	3269.59	1657.37	1374.78	970.5	682.28	473.94	964.13

The forest plantations were then classified based on their canopy coverage. Table 2 indicates the area of forest falling under different canopy density. The canopy density falling below 25% indicates degradation in the forest land. The area of 1438.07 (sum of FCD class lying between 10-25% and <10%) is found to be degraded in respect to its canopy density and require tremendous efforts in regenerating and redeveloping the crown cover. The highest area of 3269.59 is occupied by the canopy density class of >85% which is an indicative of hale, hearty and vigorous growth of trees in forest area.

5. MAPPING TREES OUTSIDE FORESTS

The methodology essentially is based on on-screen digitization of various features using standard image interpretation keys like tone, texture, size, pattern, association, etc. In on-screen visual interpretation the imagery is displayed on the computer screen (normally as FCC) and intended classes are delineated based on keys of image interpretation elements, ancillary and legacy data. Ground truth/ field verification, an important component in mapping and its validation exercise was carried out to note the field details and necessary corrections were incorporated.

Two approaches; classification and identification were followed to identify, classify and map the ToF categories. The resultant output from this was derived in the form of vector format, which supports the complex GIS analysis and has smaller file size. Illustrations depicting the image elements harnessed for delineating ToF have been provided herewith in Table 3 and Fig.3 for the state of Haryana, for clarity on context.

Fig.3. Illustration of TOF features

Each of the theme interpreted shows distinct image elements in terms of density of the crowns and their alignment with the feature considered.

Table 3. Identification criterion for selected ToF Categories.

S. No.	Attribute	Description
1.	Individual/ Point ToF	Large crowns and small crowns were independently interpreted and pooled for statistics generation. Cluster of trees are assumed to contain at least three trees presently for calculation of population (post inventory average for cluster

		would strengthen the estimate).
2.	Linear ToF	Linear Formations of trees along Road, Canal, Rail, River and Farm bunds were interpreted. Stocking level of crowns (packed densely due to good crown formations and stocking) were considered for generation of spatial information.
3.	Patch / Block ToF	Areas showing up tree clad in a densely packed manner, generally in a matrix (background) of cultivated / fallow with indicative roughness (rugosity) of crown. Stocking level was also considered for interpretation.

The area distribution of various ToF classes is shown in the Fig.4 In Faridabad district, the Miscellaneous Plantations (US) category is found to be 2780.76 ha which is followed by Scrub Open having an area of 1254.65 ha while the category of Railway (US) is found to be least (1.05 ha).

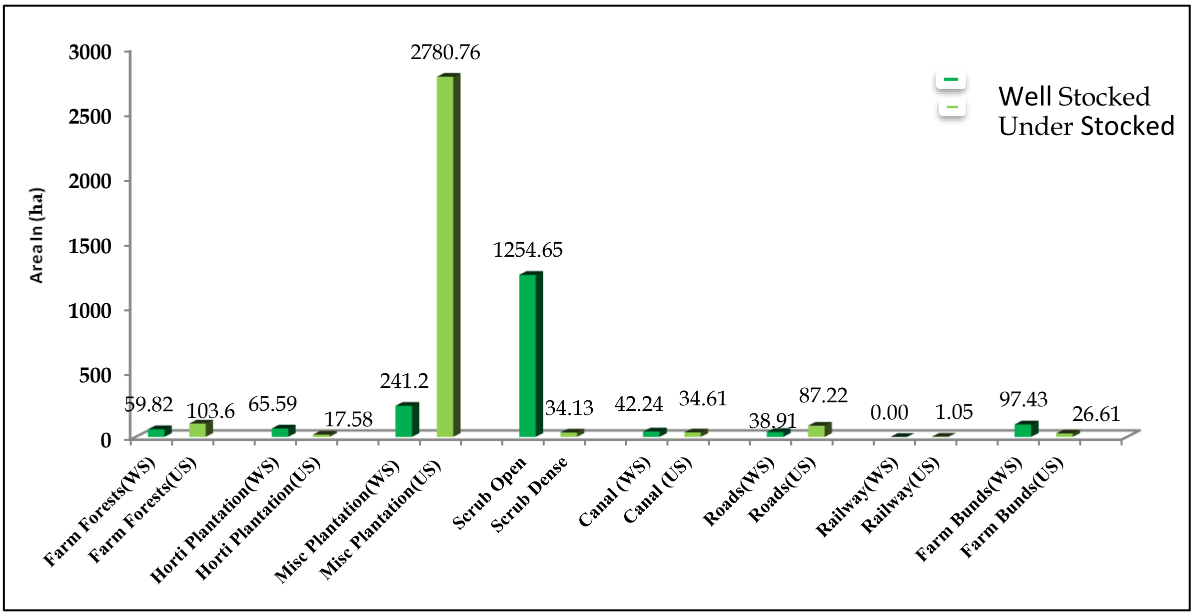

Fig.4. Area coverage of various ToF classes in Faridabad District

The maximum number of trees found in the district is large trees which have a developed crown. The point ToF present in the district is represented in Fig.5. The maximum number of trees found in the district is large trees which have a developed crown.

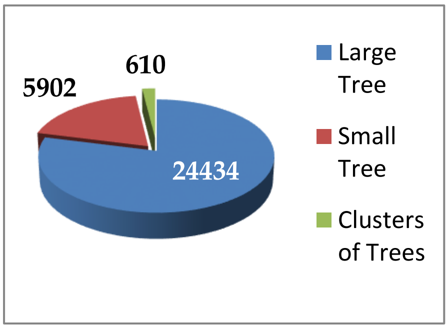

Fig.5. Status of Individual ToF

6. CONCLUSION

The study culminates to map total green cover of Faridabad district which include Forest areas and Trees outside Forests. Based on the cadastral mapping approach a total of 23241.44 acres block forests were identified and mapped on the satellite imagery and their status was evaluated by adoption of discussed methodology to determine Forest canopy density (FCD) owing to its usefulness in managing and protection of forests. The indices adopted in the study for model development provide for a better and significant method to access canopy densities of forest resources. The effectiveness of model is proved by reliability and time saving approach. It was evident from the study that 1438.07 ha of forest area are found to be degraded based on their canopy density and requires utmost care for proliferation.

The trees outside forests (ToF) classified as point, linear and polygon based on their occurrence indicated Miscellaneous Plantations as the category with highest occupied area with 2780.76 ha. followed by the category of Scrub Open having an area of 1254.65 ha while the category of Railway (US) is found to be least (1.05 ha). The study opens the future scope to monitor green cover of the district on timely basis and also enhances the applicability of remote sensing and GIS to explore new areas suitable for plantation aiding to increment green area.

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