# FOREST CANOPY DENSITY ESTIMATING, USING SATELLITE IMAGES

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**ABSTRACT:**

Forest Canopy density is a major factor in evaluation of forest status and is an important indicator of possible management interventions. Forest canopy cover, also known as canopy coverage or crown cover, is defined as the proportion of the forest floor covered by the vertical projection of the tree crowns. Estimation of forest canopy cover has recently become an important part of forest inventories. Using satellite imagery to estimate crown coverage has a long history.Conventional remote sensing methods assess the forest status based on qualitative data analysis derived from "training areas". This has certain disadvantages in terms of time and cost requirements for training area establishment. Forest Canopy Density Model is one of the useful methods to detect and estimate the canopy density over large area in a time and cost effective manner. This model is based on four indices i.e. soil, shadow, thermal and vegetation. This model requires very less ground truths, just for accuracy check.In present work, we have tested the FCD model by using IRS image in an old growth forest of north forest division of Iran. The overall accuracy for IRS image was 84.4% and Kappa Coefficient was 78.3%.

## 1. INTRODUCTION

The increasing use of satellite Remote Sensing for civilian use has proved to be the most cost effective means of mapping and monitoring environmental changes in terms of vegetation, especially in developing countries.

Perhaps the broadest use of remote sensing has been to identify and to map vegetation types (Tucker et al, 1984). Forest canopy cover, also known as canopy coverage or crown cover, is defined as the proportion of the forest floor covered by the vertical projection of the tree crowns (Jennings et al, 1999). Estimation of forest canopy cover has recently become an important part of forest inventories.

The anthropogenic intervention in the natural forest reduces the number of trees per unit area and canopy closure. Satellite remote sensing has played a pivotal role in generating information about forest cover, vegetation type and landuse changes (Saei jamalabad, Abkar, 2000).

For better management of forest, changes of density should be considered. Forest canopy density is one of the most useful parameters to consider in the planning and implementation of rehabilitation program. It is possible that there isn't any change in the area of forest during the time but the density of forest canopy is changed.

Satellite based methods are conventional remote sensing method and biophysical response modeling. Different conventional remote sensing method such as slicing, image arithmetic, segmentation and multispectral image classification are prepared by different authors.

One of the most complete of these methods is classification. Classification is based on qualitative analysis of information derived from "training areas" (i.e ground truthing or verification). However, this has certain disadvantages in terms of time and cost requirements for training area establishment.
Forest land cover information is often derived from remotely sensed images using classification algorithms (e.g. Franklin et al, 1986; Mickelson et al, 1998), many of which require a substantial amount of reference data (Townshend, 1992, Hall et al, 1995). Reliable reference data is also required for assessing classification results.

Approaches to map forest canopy density, produced categorical maps with two (Boyd et al., 2002) or more classes (Rikimaru, 1996; Rikimaru et al., 2002) rather than a continuous variable. Joshi et al. (2005a) argued that canopy density should be treated as a continuous rather than discrete variable.

The aim of this study is to examine ability of IRS imagery for estimating forest canopy cover.

## 2. STUDY AREA

In this research, the method of Forest Canopy Density (FCD) that has been developed by other researcher is tested in an area, which is located in the north of Iran. The study site is covered by old growth forest plantation of north forest division of Iran. This area is between latitude 36º 37' to 37º 39' N and longitude of 50º 55' to 50º 59' E. The climate is wet and it is characterized by high rainfall, high relative humidity and equable temperature.

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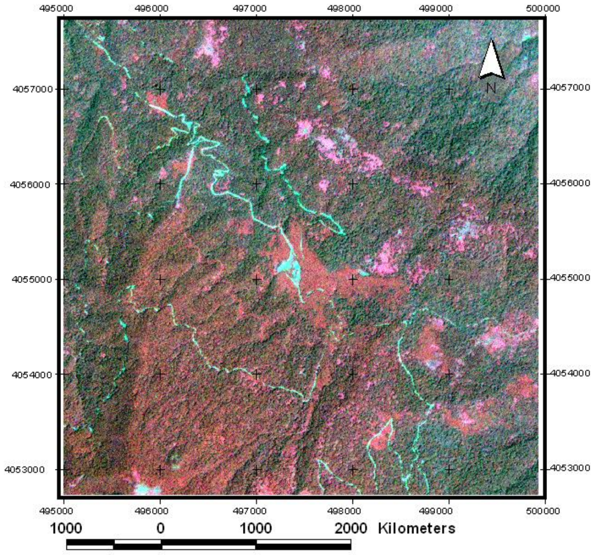


Figure.1. IRS LISS III image of study area.

## 3. DATA

IRS Imagery 2007 was used in this study. The images were geometrically corrected. The control points were selected from common points recognizable on the topographic map. The IRS image were corrected by 30 points using $2^{nd}$ degree polynomials (RMSE=0.5 pixel).The pixels were resampled by the nearest neighbor method to maintain their original data.

## 4. METHODOLOGY

In this investigation forest canopy density modeling has been prepared. The Forest Canopy Density model utilizes forest canopy density as an essential parameter for characterization of forest conditions. This model involves bio-spectral phenomenon modeling and analysis utilizing data derived from tree indices.
- Advance Vegetation Index (AVI).
- Bare Soil Index (BI).
- Shadow Index or Scaled Shadow Index (SI, SSI).

Using these tree indices the canopy density was calculated in percentage for each pixel.

### 4.1 Characteristics of Forest Indices

The indices have some characteristics as below. The Forest Canopy Density Model combines data from the tree (3) indices. Fig. 1 illustrates the relationship between forest conditions and the tree indices (VI, BI and SI). Vegetation index responses to all of vegetation items such as the forest and the grassland. Advanced vegetation index AVI reacts sensitively for the vegetation quantity compared with NDVI. Shadow index increases as the forest density increases. Thermal index increases as the vegetation quantity increases. Black colored soil area shows a high temperature. Bare soil index increases as the bare soil exposure degrees of ground increase. These index values are calculated for every pixel. Table.1 shows combination characteristics between tree indices.

| | Hi-FCD | Mid-FCD | Low-FCD | Grass-Land | Bare-Land |
|---|---|---|---|---|---|
| AVI | Hi | Hi | Mid | Hi | Low |
| BI | Low | Low | Low | Mid | Hi |
| SI | Hi | Hi | Mid | Low | Low |

Table 1. Combination Characteristics between tree Indices

**4.1.1. Advanced vegetation index:** NDVI is unable to highlight subtle differences in canopy density. It has been found to improve by using power degree of the infrared response. The calculated index has been termed as advanced vegetation index (AVI). It has been more sensitive to forest density and physiognomic vegetation classes. AVI has been calculated using equation 1.

$$AVI = \{(B4+1)(256-B3)(B4-B3)]^{1/3} \quad (1)$$

**4.1.2. Bar Soil Index:** The bare soil areas, fallow lands, vegetation with marked background response are enhanced using this index. Similar to the concept of AVI, the bare soil index (BI) is a normalized index of the difference sums of two separating the vegetation with different background viz. completely bare, sparse canopy and dense canopy etc. BI has been calculated using equation 2.

$$BI \quad \frac{(B4+B2)-B3}{(B4+B2)+B3} \quad (2)$$

**4.1.3. Canopy shadow Index:** The crown arrangement in the forest stand leads to shadow pattern affecting the spectral responses. The young even aged stands have low canopy shadow index (SI) compared to the mature natural forest stands. The later forest stands show flat and low spectral axis in comparison with open area. SI has been calculated using equation 3.

$$SI = \sqrt{(256-B2)(256-B3)} \quad (3)$$

### 4.2 The Procedure of FCD Model

The flowchart of the procedure for FCD mapping model are illustrated in Fig.2. Image processed result corresponding to the flowchart shows in fig.2.

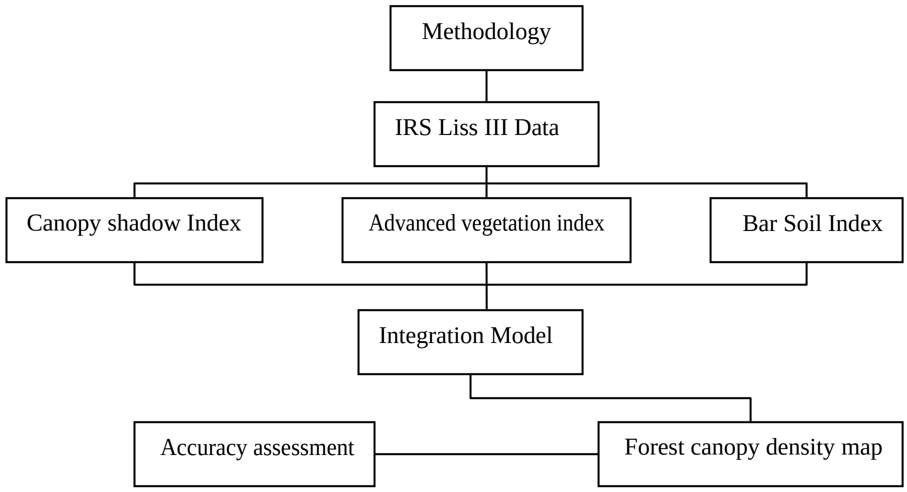


Figure 2. Flow chart of forest cover mapping density using remote sensing

## 5. FOREST CANOPY DENSITY MAP

The degree of forest density is expressed in percentages:

- High Forest Canopy Density
- Middle Forest Canopy Density
- Low Forest Canopy Density

For accuracy assessment and collected ground truth, the distance between classes were changes to the form below:
Class1) High Forest =HF (71-100%density)
Class2) Middle Forest =MF (41-70%density)
Class3) Low Forest = LF (5-40%density)
Class4) Grass Land =GL
Class5) Bare soil =Bs

Figure 3 indicates this map with these classes.

The Fig.3 indicates forest canopy density map of the study area for IRS Liss III image.

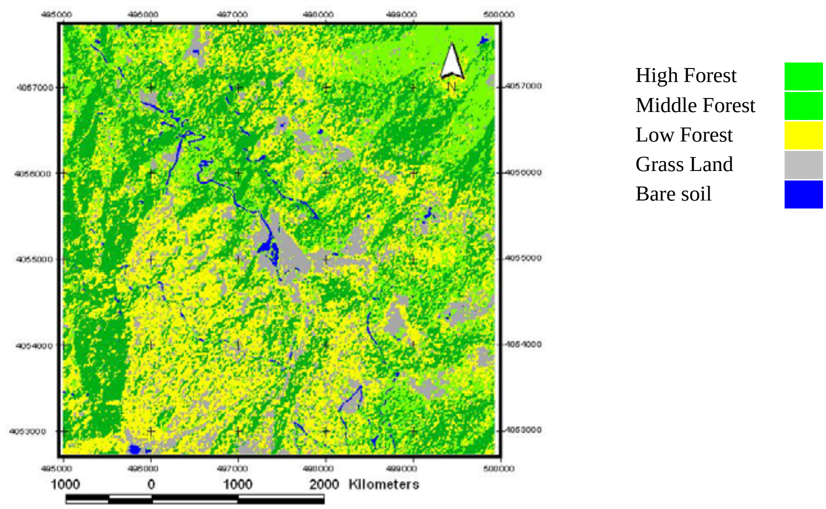


Figure 3. classes density map

| | HF | MF | LF | GL | Bs | Total | UA% |
|---|---|---|---|---|---|---|---|
| **Class1** | 17638 | 2084 | 1237 | 134 | 18 | 21111 | 83/5 |
| **Class2** | 1845 | 9261 | 780 | 87 | 8 | 11981 | 77/3 |
| **Class3** | 1386 | 1429 | 19034 | 453 | 10 | 22312 | 85/3 |
| **Class4** | 22 | 34 | 393 | 5874 | 31 | 6354 | 92/4 |
| **Class5** | 1 | 8 | 16 | 27 | 690 | 742 | 93/0 |
| **Total** | 20892 | 12816 | 21460 | 6575 | 757 | 62500 | |
| **PA%** | 84/4 | 72/3 | 88/7 | 89/3 | 91/1 | | |

Table 2. Classification accuracy statistics showing overall accuracy (OA), producer's accuracy (PA) and user's accuracy (UA).
**Overall Accuracy:** 84.4% **Kappa Coefficient:** 78.3%

## 6. CONCLUSIONS

Conventional RS methodology, as generally applied in forestry is based on qualitative analysis of information derived from "training areas" (i.e. ground-truth). This has certain disadvantages in terms of the time and cost required for training area establishment, as well as to ensure a high accuracy. Unlike the conventional qualitative method, the FCD model indicates the growth phenomena of forests by means of qualitative analysis. The accuracy of methodology is checked in field test. The case of Iran, the correlation coefficient value between FCD model and field check shows 0.84. It indicates higher correlation and accuracy compared to conventional remote sensing method. FCD model is very useful for monitoring and management with less ground truth survey.

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