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ESTIMATING THE STATUS OF FOREST COVER IN ALMORA DISTRICT BY USING FOREST CANOPY DENSITY: A GEOGRAPHICAL STUDY

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Abstract

GIS and remote sensing play an important role in monitoring and management of forest resources on the earth's surface. Forest is highly essential to the existence of life on the earth's surface through the biosphere creation. Forest canopy density (FCD) is most of the one technique for the monitoring and management of forest resources with correlated GIS and remote sensing. The objective of the study was to estimate the status of forest coverin the Almora district by using forest canopy density (FCD). In this study, Four indexes that are known as Advanced Vegetation Index (AVI), Bare Soil Index (BSI), Shadow Index (SI), and Thermal Index (TI), has been used to calculate the forest canopy density which represents the status of forest cover in the study area. All these indexes were based on the Landsat 8 OLI satellite imagery.

As a result of this study, the total forest cover area of 1961.46 sq km was identified within the study area which represents 62.24% of the total area. In this study, forest cover area was classified into four classes such as Very Dense Forest, Moderately Dense Forest, Open Forest (OF), and Non-Forest Class. All classes were classified based onthe Forest Canopy Density Model (FCD). According to Forest classification, Moderately Dense Forest (MDF) and Open Forest (OF) classes were founded in a highly critical situation.

1. Introduction

On the earth's surface, vegetation cover is among the most crucial renewable resources for biosphere preservation. As a result of both natural and anthropocentric processes, the canopy density of shrubs and trees is gradually decreasing, posing a threat to the ecosystem. The projected annual net loss of forestry in the last 10 years has been about 5.2 million hectares(Sahana et al., 2015). The canopy density of a forest is the single most essential physiognomic feature(Loi et al., 2017). As a result, measuring forest density at diverse levels is important for the long-term management of natural resources. The Forest canopy density (FCD) model, which is based on the spectacular growth of forests, assists in the monitoring of changes in forest conditions over time(S., Himayah, Hartono, 2016). The Forest canopy density (FCD) as a planning tool makes it simpler to identify forest cover areas and provide forest disturbing regions(Gupta & Pandey, 2018). It can be notified as one of the most suitable techniques for the health of the forest(Sahana et al., 2015). Numerous studies have been conducted to evaluate the efficiency of the Vegetation Canopy Density model for measuring forest degradation using remote sensing data. (Rikimaru, 2002) was the first to use the Forest Canopy Density model when he used the Landsat TM data analysis instructions to identify and analyze Forest Canopy Density. After that, it was utilized almost everywhere in the world. Furthermore, the model is frequently used in tropical rainforests to evaluate and estimate forest canopy cover, afforestation, deforestation, forest health, and other variables.The aim of this study was to estimate the status of forest cover by using forest canopy density for understanding the different conditions of forest within Almora District.

2. Study Area

The district of Almora is in the Indian state of Uttarakhand. This district is bounded on the east by Tibet, on the west by Puri Garhwal, on the north by Chamoli andBagishwar, and on the south by Nainital. It has1861 meters elevation that notified above sea level on average. Almora district lies between latitudes of 20 degrees, eight minutes and 29 degrees, 8 minutes and longitudes of 71 degrees, 5 minutes and 81 degrees, 5 minutes east. According to the Office of the Service General of India, Almora District has 3139 square kilometers.

3. Datasets and Methodology

The Forest canopy density was estimated using Landsat OLI images from November 2016. The Forest Canopy Density component of the Forest Canopy Density technique is critical for evaluating forest situations.

Table1: Detail Information Landsat 8OLI Imagery

Satellite	Sensor	Spatial Resolution	Bands	Date
Landsat - 8	OLI	30 meters	1 to 11	22/11/2016

In this study, Advanced Vegetation Index (AVI), Bare Soil Index (BI), Shadow Index (SI), and Thermal Index (TI) were used. The vegetation Density was calculated through the Principal Component Analysis (PCA) with the help of the Advanced Vegetation Index (AVI) and Bare Soil Index (BSI). Scale Shadow Index was developed through the integration of Shadow Index and Thermal Index. The Forest Canopy Density (FCD) model was estimated by each pixel of satellite images that are formulated by integration of Vegetation Density and Scale Shadow Index. Plant size was one of the most important factors to consider when assessing forest density.

The condition of forest that can be known as forest classification within study area density was formulated by the Forest Canopy Density (FCD) that analyzed through the Very Dense Forest, Moderately Dense Forest (MDF), Open Forest (OF), and Non- Forest classes(Forest Survey of India, 2013). The optimal growth period for forest canopy is often November, and satellite images obtained during this period are considered the best for forest density. The whole strategy of evaluating forest cover and forest density has been explained in this article.

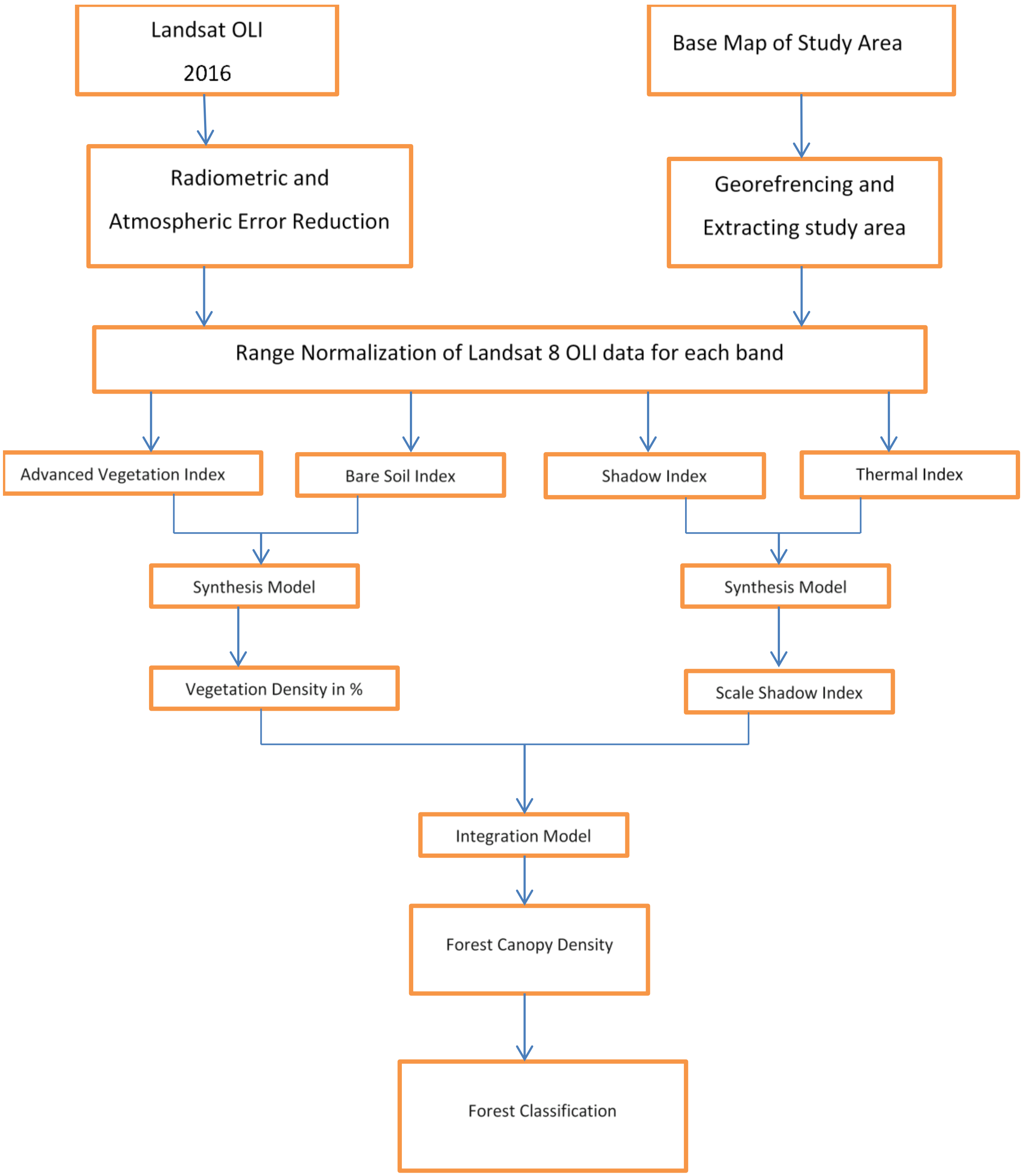

Figure1: Pathway of research methodology for this study

4. Result and Discussion

The Landsat OLI 30 m resolution raster image was used to estimate the Forest canopy density model (FCD). The sensitivity of the vegetation index was to all types of vegetation, including forest (Jiang et al., 2019; Li & Chen, 2014). These indices' values were computed for each pixel. When compared to NDVI, the advanced vegetation index (AVI) responds more strongly to the identification of the vegetation amount as well as forest density. It's important to note that when the advanced vegetation value rises, then the Shadow Index (SI) value was raised as well. To put it another way, where there is a lot of tree vegetation, there seems to be a lot of shade. Simultaneously, if there is a lesser bare soil Index (BSI), then Thermal Index (TI) value has been fallen as well. It's important to note that Vegetation is "saturated" before SI. It merely means that the highest possible values of vegetation index emerge earlier in the study (Sahana et al., 2015). This happens so because the vegetation index was collected from the overall biomass, regardless of tree or vegetation density. On the other hand, The SI values are mostly controlled by the quantity of tall vegetation that casts a considerable shadow, such as trees.

4.1 Advanced Vegetation Index(AVI)

The advanced vegetation index (AVI) was discovered to become more responsive to forest density and based on the morphological vegetation types than previously thought. This Eq. has been used to compute the advanced vegetation index (AVI).

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

$$\text{AVI} = 0 \quad \text{if B4} < \text{B3 after normalization.}$$

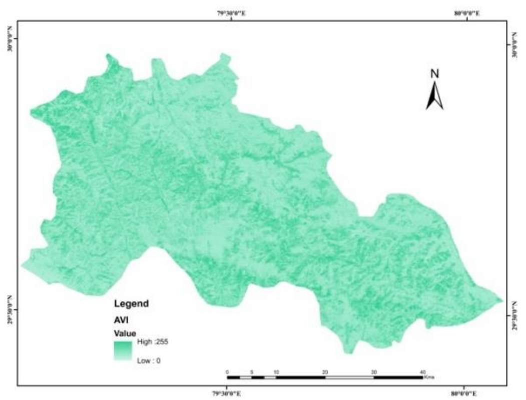

Figure 2: Advanced Vegetation Index Map

4.2 Bare Soil Index (BSI)

The difference between the sums of two reflective (NIR and Blue) and absorbing (SWIR 2and Red) bands is used to calculate the bare soil index (BI). This index supports the differentiation of vegetation with various backgrounds, such as fully barren, thin canopy, dense canopy, and so on. This Eq. has been used to calculate the index.

$$\text{BSI} = \frac{(\text{SWIR2}+\text{R})-(\text{NIR}+\text{B})}{(\text{SWIR2}+\text{R})+(\text{NIR}+\text{B})}$$

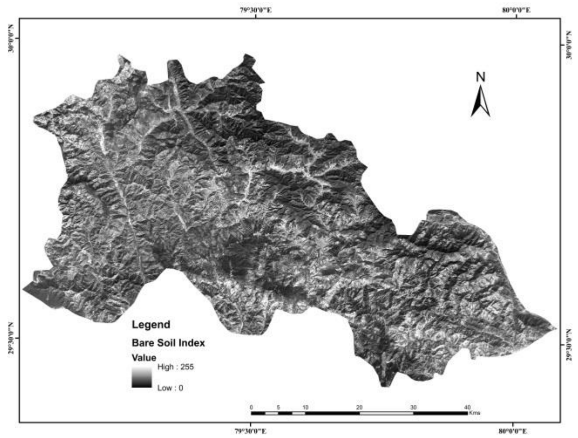

Figure 3: Bare Soil Index Map

4.3 Shadow Index (SI)

The type of crown organization in forest stands affects the spectral responses by creating shadow patterns. In comparison to open areas, mature forest stands have a relatively flat and low spectral axis. As a result, as relative to mature forest stands, immature forest stands have a lower canopy shadow index. This Eq.has been used to calculate the index:

$$SI = \{(256 - B1)(256 - B2)(256 - B3)\}^{1/3}$$

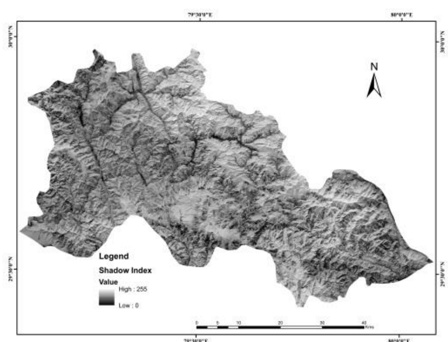

Figure4: Shadow Index Map

4.4 Thermal Index (TI)

The thermal index was produced from Landsat 8Oli images using the spectral radiance approach. A three-step procedure was used to calculate surface temperature, according to Lwin (2010). The following equation was used to determine spectral radiance:

$$L = LMIN + (LMAX - LMIN) * \frac{DN}{255} \quad (4)$$

where, L = spectral radiance, $LMIN = 1.238$, $LMAX = 15.600$, DN = digital number.

Spectral radiance (L) to temperature in Kelvin may be expressed as:

$$T_B = \frac{K_2}{ln\left(\frac{K_1}{L} + 1\right)}$$

where, K_1 = calibration constant 1 (607.76), K_2 = calibration constant 1 (1260.56), T_B = surface temperature.

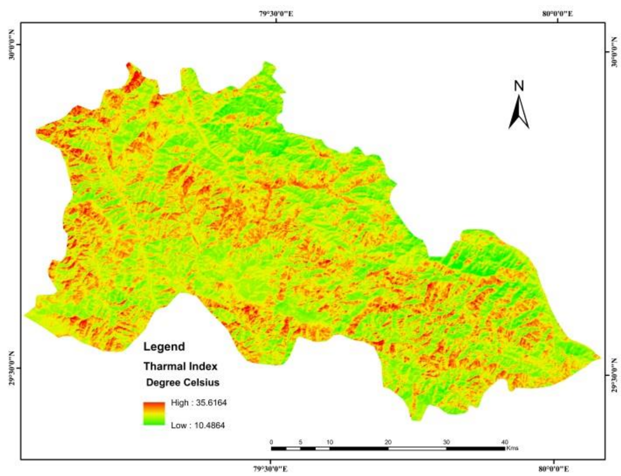

Figure 5: Thermal Index Map

4.5 Scale shadow index (SSI)

It's a metric for comparing the worth of one object to that of another. Its normalized value can be utilized in computations alongside other parameters. The SSI was established to integrate TI and SI values. Vegetation with the minimum shadow value (0 percent) has an SSI value of zero, while vegetation with the maximum shadow value (100%) has an SSI value of 100. SI is converted into SSI via a linear transformation. The SSI can discriminate between vegetation in the canopy and vegetation on the ground. It vastly improves the probability of delivering more trustworthy statistical results than previously achievable.

4.6 Vegetation density (VD)

The primary inputs for calculating vegetation density were the vegetation index and the bare soil index. Principle component analysis was used to combine these indices (PCA). The vegetation and bare soil have such a strong negative link, a scale of zero and one hundred percent is used.

4.7 Forest Canopy Density (FCD)

The averaged modification of the vegetative density (VD) and SSI parameters was used to calcul ate FCD in percentage scale units of density. By utilizing the following equation to determine Ve getation Canopy Density, it was essential to securely synthesize both of these indexes using the r elevant scales and dimensions of each. The FCD was calculated by the following formula:

$$FCD = (VD * SSI + 1)^{1/2} - 1$$

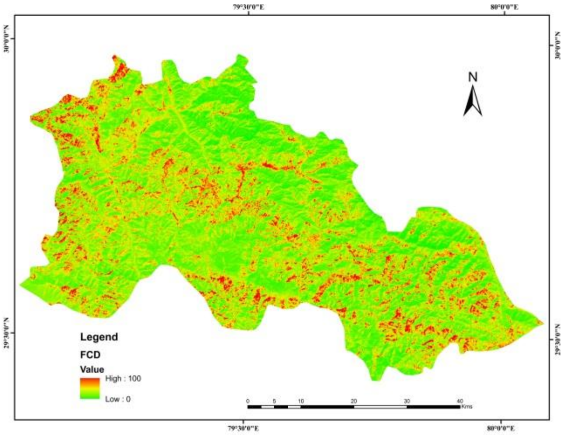

Figure 6: Forest Canopy Density Map

4.8 Forest Coverby FCD

The forest cover was calculated by the forest canopy density model that was categorized based onthe canopy density of the forest. The classes of forest cover were identified with the help of different colour schemes, which can be seen in four classes VDF, MDF, OP, and Non-Forest class. very dense forest (VDF) class was represented by the Dark Green, Moderately Dense Forest (MDF) class represented by the Light Green, Open Forest (OF) class represented by the Yellow colour, and Non-Forest Class represented by the Red colour.

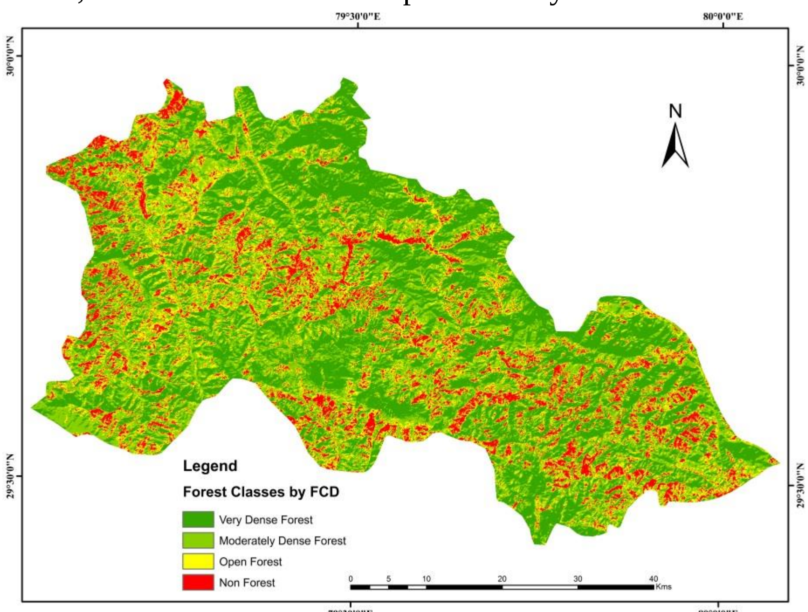

Figure 7: Forest Classes by FCD within Almora District.

Dark green was dominated the colour pattern of the forest classes, while redcolourwas covered the lowest portion of the Almora District map. It is possible to demonstrate this using a table.

Table 2: Detail information about forest cover in different classes in Almora District.

Classes	Pixels	Area(Sq km)	Percentage
VDF	1251162	1271.35	40.55
MDF	1072405	690.11	22.15
OF	621138	1053.53	33.42
Non Forest	340753	125.11	3.98
	3285458	3140.00	100.00

According to this table, the VDF class had the most pixels from the satellite image, which represented 1271.05 sq km inside the research region. In Almora District, the MDF Class was found at 690.11 square kilometers, the OF Class identified at 1053.53 square kilometers, and the Non-Forest Class was discovered at 125.11 square kilometers.

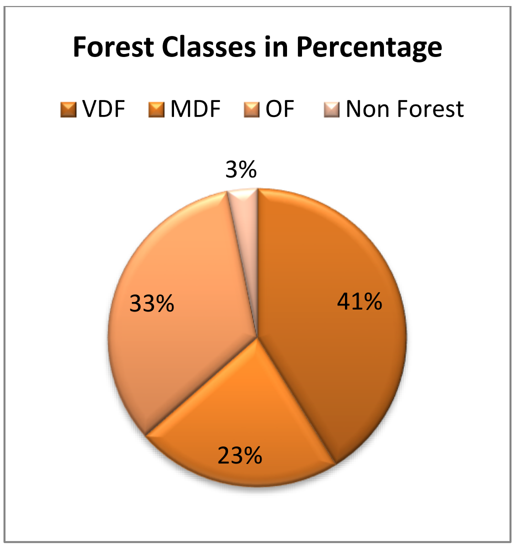

Figure 8: Pie diagram of classes of forest cover in percentage.
According to this Pie Chart, VDF class was notified by 41%, MDF was notified by 22.15%, OF was represented by 33% and Non-Forest class was identified by 3%.

5. Conclusion

The image of Landsat 8 Oli November 2016 was used to identify the status of vegetation cover in the study area. , the total forest cover area of 1961.46 sq km was identified which represents 62.24% of the total area within the study area.The identified forest cover status was obtained As per Vegetation canopy density. The Very Dense Forest (VDF), Moderately Dense Forest (MDF), Open Forest (OF), and Non-Forest (NF)classes were founded from the Forest Canopy Density Model. According to the forest classification Map, VDF class was dominated at all classes which represents a good condition of forest within the Almora District. Based on VDF class, the ecosystem is an excellent carbon sink, absorbing pollution from local fires, agriculture, and transport. It supports climate regulation, the earth's global carbon cycle, and the ecosystem of flora and fauna. Moderately Dense Forest (MDF) and Open Forest (OF) classes were founded in highly critical situations. Therefore, the Forest monitoring and management plan must be required within the study area. The open forest shows that now the forest was much more vulnerable to non-forest activities, such as grazing, logging, and other anthropogenic activity. Human stress on natural vegetation was founded a negative impact within the Almora District.

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