FOREST TREE ANALYSIS AT GUNUNG BASOR RESERVE FOREST BASED ON SPOT IMAGES

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ABSTRACT: Forests are the most important ecosystems and carbon pool, imparting with ecological offering and show a significant function in economic advantages. However, in present years, with the economic development and fast populace increase, global forests are going through a sequence of threats, which is sharp declined in forest range, biodiversity damage and degradation in environmental and biological system. Forest resource analysis and monitoring are drastically essential to explore and prevent climate change, ecological degradation and environmental loss. Forest canopy cover is relatively critical parameter that being evaluated in forest analysis and forest inventory. This study is to evolve a systematic framework for Forest Canopy Density (FCD) in tropical rainforests that gives significant in forest regulatory, microclimate changing and soil conditions. FCD model components are based on few of indexes, which are advanced vegetation, bare soil and canopy shadow. The final results of Forest Canopy Density (FCD) for each classes which consist of 30% very dense, 37.3% moderately dense, 18.2% low forest, 8.2% shrub and 6.3% non-forest. The highest value of r^2 is 0.94 which was between FCD and AVI. This research study propose novel method to use high-resolution satellite images. Remote sensing has been plausible to be able to assess the forest structure and large area biomass in a way that is more accurate at relatively low cost. SPOT images provide better outcomes when categorizing variables of forest standoff and forest cover, as they have greater spatial resolution. Hence, SPOT-7 making it ideal for applications for forest analysis.

1. INTRODUCTION

Tropical rainforest is a hot, wet biome discovered near Earth's equator. The tropical rainforest is the complex terrestrial ecosystem with its incridble appearance of vegetation that have massive tree crown and holds a vital reservoirs for earth's biodiversity (Sodhi, 2008). In Malaysia, forest resources monitoring has been growing towards larger region, short duration and massive scale. Forest resources monitoring traditional method are usually primarily based on time-utilizing and difficult site measurements, which are not favourable to scale data acquisition or huge location, and cannot link to ecological construction and forestry manufacturing require of the time. With the benefits of data can be amassed shorter over large topographic areas at incredibly lower expenses, structural parameters and extraction of forest composition are widely use remote sensing technology. It is presenting a strong practical support for forest resources monitoring.

Recently, estimation of tree height, biomass, stand volume, basal area and also other forest stand parameters are mainly focusing on using remote sensing image. Additionally, estimating the canopy cover of a tropical rainforest also has been part of the inventory agenda. Size of the tree crown will decide, among others, carbon absorption, shade, tree growth and filtering the air particulates. Forest canopy density model (FCD) also as a developing tool that assists in identifying canopy cover and priorities for reforestation and afforestation (Biradar *et. al*, 2005). However, the canopy density of forest cover is continue to decline and affecting the ecological status due to natural as well as anthropogenic activities.

After decades, there have been tremendous advances made in demonstrating the potential and the limitations of remote sensing applications in forestry. Remote sensing detects, identifies, classifies, assesses and also measures the various characteristics of forests by two ways. First, the qualitative way, remote sensing can classify the types of forest cover. Forest Canopy Density is utilized as a significant variable for the forest status attributes. FCD depends on the development segment and it can represent the level of degradation (Rikimaru, 1999). Not only that, quantitative analysis can also measure or estimate forest parameters such as diameter at breast height (Dbh), altitude, basal area, tree number of each unified area, timber volume and wood biomass.

Remote sensing has been plausible to be able to assess the forest cover, forest structure and large area biomass in a way that is more accurate at relatively low cost. The information about the forest is regularly obtained based on remote sensing images using classification algorithms (Md Rodi *et. al*, 2018). SPOT optics gives more details to estimate basalt forest area, volume and average height compared to an active sensor, which is the radar (Hyyppa *et. al*, 2000). SPOT images deliver better outcomes as they have greater spatial resolution especially when categorizing variables of forest standoff and forest cover (Salajanu & Olson, 2001).

2. STUDY AREA

The study area is located in Gunung Basor Reserve Forest in Jeli, Kelantan as in Figure 1. The Gunung Basor Forest Reserve is a reserve forest, which still retains most of its desert crusts and ecosystems. Gunung Basor has an altitude of 1840 meters (6,038 feet). According to the Kelantan Forestry Department, Gunung Basor was placed mostly in the late 1970s to 1980s by selected management systems. Gunung Basor is gazetted as a permanent forest reserve. Another area of 5,850 hectares of Gunung Basor was targeted as production forest (Kelantan Forestry Department, 2003). The average minimum and maximum temperatures of Gunung Basor are 32 °C and 25 °C with average annual rainfall of 2750-3000 mm.

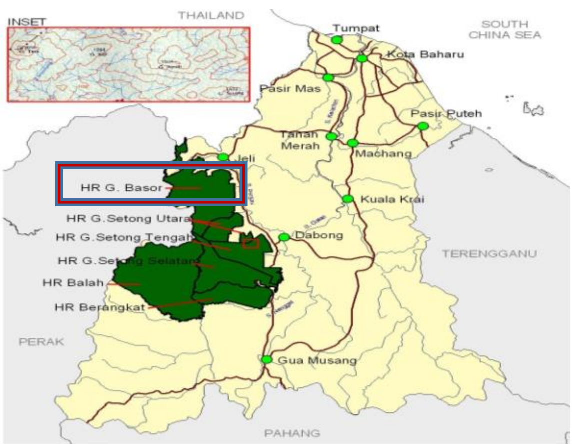

Figure 1 Map of Gunung Basor Reserved Forest

3. METHODOLOGY

3.1 Image Acquisition And Pre-Processing

In this study, satellite imagery data will be used. Satellite image data was performed on November 7, 2018. Pre-processing is carried out to provide images for further procedures. Digital number (DN) is converted to radiance and reflectance using radiometric correction. The raw DN in SPOT-7 images can be converted into top-of-atmosphere (TOA) radiance or reflectance. The calculation for radiance value of SPOT-7 is in Equation (1).

$$\text{Radiance} = \frac{\text{DN - OFFSET}}{\text{GAIN}} \quad (1)$$

Where Radiance is spectral radiance at the sensor's aperture, DN refers to digital number for channel, OFFSET = sensor offset for channel and GAIN = sensor gain for channel. Conversion of radiance into top-of-atmosphere (TOA) reflectance as in Equation (2).

$$\rho_{SAT} = \frac{\pi \times L_{SAT}}{E_o \times \cos\theta_z} \quad (2)$$

Where ρ_{SAT} is the planetary of the TOA reflectance, L_{SAT} = spectral radiance (W/(m2 sr µm)), E_o = spectral irradiance of mean solar (W/(m^2 µm)) and $\cos\theta_z$ = solar zenith (degree). Forest Canopy Density model components are based on few of indexes, which are the procedure is illustrated in flowchart in the Figure 2.

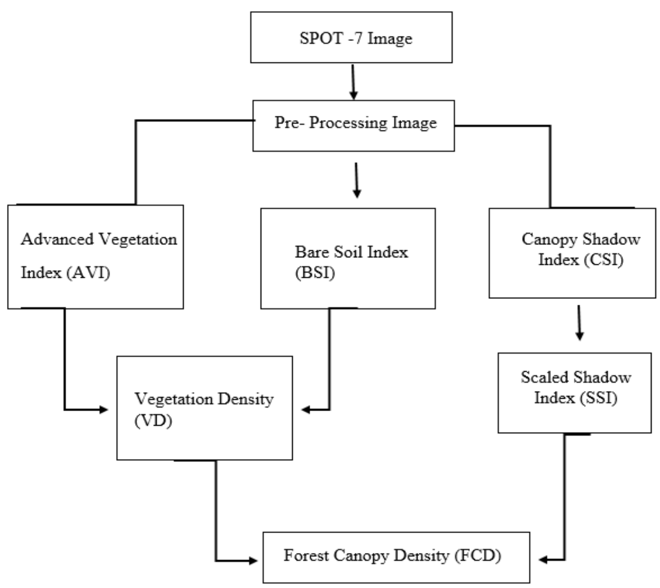

Figure 2 Flowchart of Research Methods

3.2 Components of Forest Canopy Density Models

Advanced Vegetation Index (AVI) is more sensitive to quantitative analysis of vegetation (Azizi *et. al*, 2008). In estimating canopy density, AVI is considered more useful when contrasted with Normalized Difference Vegetation Index (NDVI) as it was not able features the small changes in canopy density. Increments in AVI as the vegetation cover increase which is calculated by Rikimaru (1999) using Equation (3).

$$AVI = [(B3 + 1)*(874 - B2)*(B3 - B2)]^{\frac{1}{2}} \tag{3}$$

Where, B2 is red and B3 is near infrared are the bands of SPOT-7 satellite image data. Bare Soil Index (BSI) is the index set to analyze soils that separates barren and bare land from vegetation so that it is possible to distinguish bare vegetation that have gaps from dense vegetation areas. It increases as the level of exposure bare soil of ground to sunlight increases (Azizi *et. al*, 2008). Therefore, BSI has been determined using Equation (4).

$$BSI = \frac{(B3+B1) - B2}{(B3+B1+B2)} \tag{4}$$

Where B2 is red, B3 is near infrared and B1 is green are the bands of SPOT-7 satellite image data.

Canopy Shadow Index (SI) characterizing different forest shadow based on the structure, age and distribution of the species. Young forest plants have lower value of canopy shadow index compared to the mature forest plants. Calculation for SI is in Equation (5).

$$SI = (874 - B1)*(874 - B2)^\wedge(1/2) \tag{5}$$

Where B2 is red and B1 is green are the bands of SPOT-7 satellite image data.

3.3 Forest Canopy Density Models

Forest Canopy Density (FCD) is accomplished in percentage by integrating Vegetation Density (VD) and Scaled Shadow Index (SSI). VD and SSI integration means conversion for forest canopy density values. VD is obtained by synthesis of AVI and BI utilizing Principal Component Analysis (PCA). Because of AVI and BI have high correlation of negative values, PCA measures the value range from zero percent to one hundred percent. The values are then calibrated to determine the VD. SSI is calculated by calibrating Canopy Shadow Index (SI) values. Calculation of the FCD model through the formulas specified in Equation (6).

$$FCD = (VD * SSI + 1)^{\frac{1}{2}} - 1 \tag{6}$$

4. RESULT AND DISCUSSION

In this study, Forest Canopy Density (FCD) was estimated through satellite imageries SPOT-7 using few of indices in ArcGIS and ENVI Software. The FCD model comprises bio-physical phenomenon modelling and analyse the utilizing of the data that obtained from these indexes which are Advanced

Vegetation Index (AVI), Bare Soil Index (BI) and Canopy Shadow Index or Scaled Shadow Index (SI, SSI). The formula of these indexes was derived in Envi Software using Band Math tool.

AVI and BSI are used in Principal Component Analysis (PCA) to carry out Vegetation Density (VD). PCA can identify duplicate data over several channels, decrease the redundancy and processing time more efficient. However, clouds have higher irradiance values than soil data. In addition, the amount of irradiance can be differs depending on whether the clouds are gray, white, black, or a combination of different colors. These factors influence the statistics and analysis of imagery data. These problems can be reduced using a histogram based on data derived from SPOT-7 bands by creating a cloud shadow mask. Same goes to water bodies. Water bodies should also be masked since water absorbs near infrared. This is done through similar transformation masked of the cloud area. Therefore, this process had been done before synthesis AVI and BSI to integrate VD using PCA.

The Scaled Shadow Index (SSI) is derived by Canopy Shadow Index (SI) direct transformation. It is now possible to distinguish between vegetation on the ground and vegetation in the canopy with the development of the SSI. The vegetation density (VD) and SSI parameters have been integrated to estimate FCD in percentage scale density unit. Map of Forest Canopy Density (FCD) was sliced into five density classes in Figure 7.

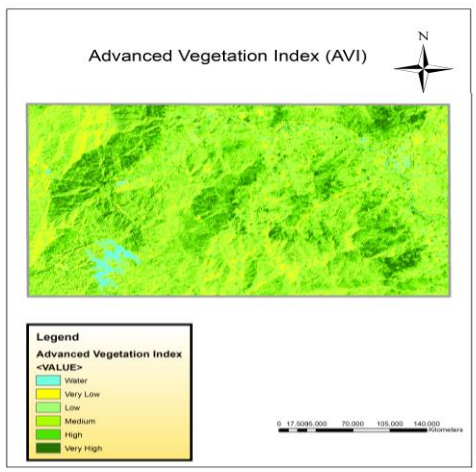

Figure 3 Advanced Vegetation Index (AVI)

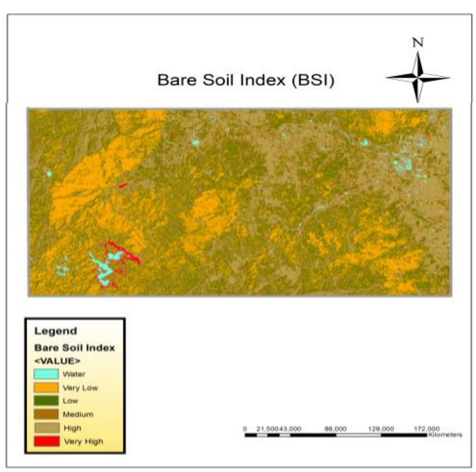

Figure 4 Bare Soil Index (BSI)

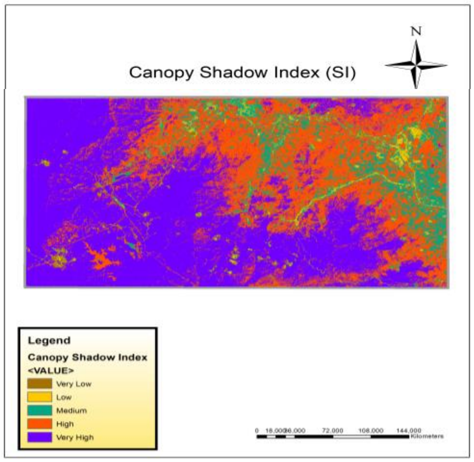

Figure 5 Canopy Shadow Index (SI)

Table 1 The area category of FCD

No	Class of FCD	Description	Area (%)
1	Very Dense	Forest canopy density of land 70% - above	30
2	Moderately Dense	Forest canopy density of land 40% - 70%	37.3
3	Low Forest	Forest canopy density of land 10% - 40%	18.2
4	Shrub	Forest canopy density of degraded forests lands < 10%	7.6
5	Non-Forest	Except any of above classes	6.9

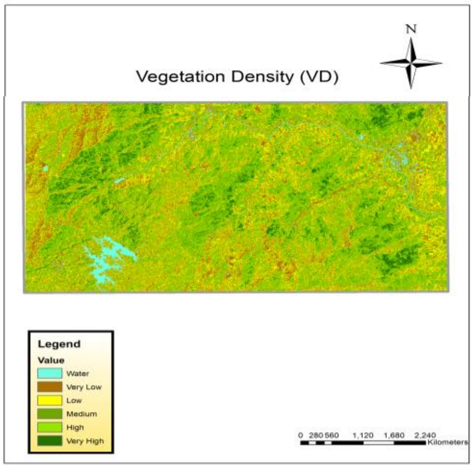

Figure 6 Vegetation Density (VD)

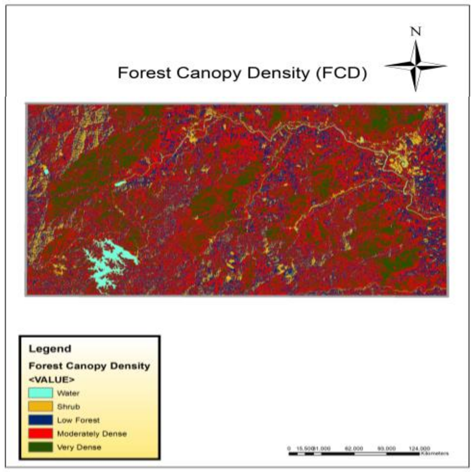

Figure 7 Forest Canopy Density (FCD)

The area categories of each density classes are shown in the Table 1. By percentage, each cell was classified into five classes of forest canopy density: very dense forest density, moderately dense forest density, low forest density, shrub and non-forest. The overall analysis of forest canopy density showed that most of the forest in the study area had canopy density of 40% to 70% which is moderately dense. The high forest density class covers approximately 30% of total area while the low forest density constitutes about 18.2% of total area. Shrub density covers around 7.6% where other or non-forest covers about 6.9% of total area. Small pond or lake has been seen in the study area. Therefore, it can be concluded that the water sources are available in the study area and so that it contributes to the growth of the vegetation.

5. CONCLUSION

Forest Canopy Density (FCD) was achieved using SPOT-7 satellite image. In this study, SPOT-7 satellite data was used to estimate large-scale forest variability. Due to its higher spatial resolution, SPOT imagery can capture complex details of lower classes FCD. Forest canopy density map shows how the state of Gunung Basor Reserve Forest area through the level of canopy density. However, this study can also continue develop by using many satellite images over different periods of time. This will help to evaluate changes in forest canopy density over time and space. This is one of the vital criteria to forest management for assessing forest quality and contributing information.

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