INNOVATIVE ENERGY TECHNOLOGY SYSTEMS AND ENVIRONMENTAL CONCERNS: A SUSTAINABLE APPROACH
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The Influence of Terrain Factors on VCI and TCI of Jogimatti Forest, Chitradurga District, Karnataka, India

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Abstract

The objective of this study is to assess the influence of terrain factors on Vegetation Condition Index (VCI) and Temperature Condition Index (TCI) of Jogimatti forest, Chitradurga district, Karnataka, India. Jogimatti forest is a dry deciduous to scrub with undulating chain of hills that covers an area of 90.78km^2. Understanding the relationship between VCI, TCI and terrain factors is very important to protect environmental and natural resources. The MODIS MOD13Q1 NDVI (Normalized Differential Vegetation Index) Images of the year 2012 with a spatial resolution of 250m and temporal resolution of 16days are used to investigate the relationship between VCI and topography. MODIS MOD11A1 LST (Land Surface Temperature) Images of the year 2012 with a spatial resolution of 1km and temporal resolution of 16days are used to investigate the relationship between TCI and topography. There is loss of data between June to October because of rainfall. Three terrain attributes, namely, elevation, slope and aspect are derived from Cartosat-1 digital elevation model (DEM) of 30m spatial resolution. The result describes that the topography has strong influence on the condition of vegetation but not on temperature condition. The value of VCI has High positive correlation with elevation (0.78), low positive correlation with slope (0.39) and no correlation with terrain aspect (-0.13). The TCI has no significant relationship with elevation (-0.04), slope (-0.06) and aspect (-0.03).

1. Introduction

Forest and biodiversity plays a major role in all life forms. Vegetation is one of the important components of terrestrial biodiversity, it is also a major resource for socio-economic activities. The vegetation is strongly influenced by three major components, which is climate, human activities and topography. Foresters and researchers are in general conservative, in the beginning they were reserved in applying aerial photography and nowadays other remote sensing techniques are not embraced whole-heartily [5].

Normalized difference vegetation index (NDVI) has been widely used for qualitative and quantitative estimation of vegetation cover and growth activity [6]. Vegetation Condition Index (VCI) and Temperature Condition Index (TCI) are one and the same which mainly used to detect drought conditions. The VCI is estimated relative to maximum/minimum NDVI values and the TCI is estimated relative to maximum/minimum temperature envelope. Both these parameters help to study the condition and distribution of vegetation in the forest or agricultural lands.

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Additionally, several studies reported that terrain factors including elevation, aspect and slope have effects on the distribution and growth of vegetation (Zhan *et al* 2011). Walsh *et al* [3] studied multi-scale statistical correlation analysis on terrain attribute and NDVI, which showed that the correlation of slope and elevation etc terrain attribute and NDVI is different in various scales. Chen *et al* [1] extracted statistics of terrain using GIS technique and analyzed the relationship of vegetation distribution and terrain factors in northwestern of Sichuan Longmen Mountain.

2. Materials and Methodology

2.1 Site description

The study area Jogimatti forest lies between 14° 03’ and 14° 12’ N latitude and 76° 21’ and 76° 27’ E longitude with an elevation of 1029 m above mean sea level. The terrain is not uniform throughout the district and it is characterized by vast stretches of undulating plains, it is a dry deciduous to scrub with undulating chain of hills [4], which covers an area of 90.78km^2.

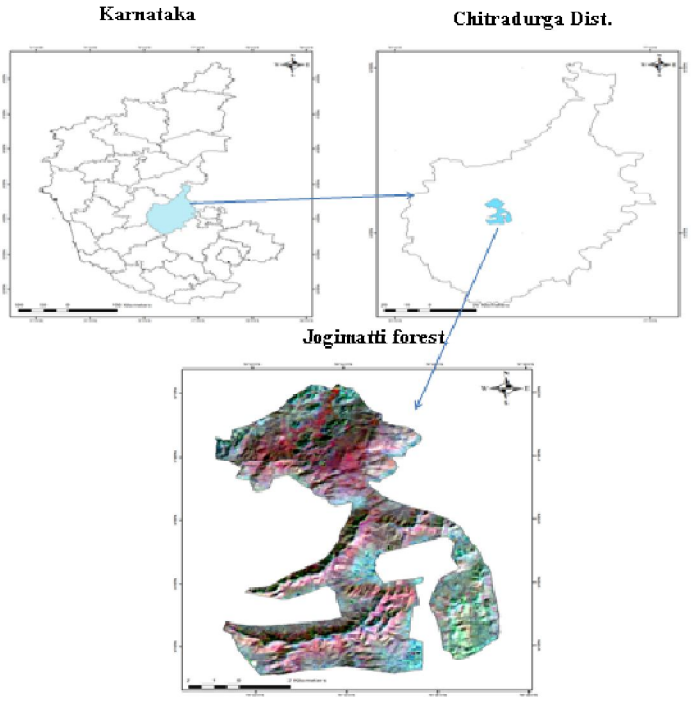

Fig. 1: Study area.

2.2 Data used

2.2.1 MODIS MOD13Q1 NDVI

Global MOD13Q1 provides NDVI data for every 16 days at 250 meter spatial resolution as a gridded level-3 product in the sinusoidal projection. Vegetation indices are used for monitoring condition of vegetation and land use land cover change detection. These data may also used to study surface biophysical properties, including net primary production and gross primary production.

The formula of NDVI is as follows,

NDVI=(NIR-VIS) / (NIR+VIS)

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Where, VIS and NIR stands for visible red and near-infrared regions, respectively. The value of NDVI ranges between -1 to +1.

2.2.2 MODIS MOD11A1 LST

Global MOD11A1 provides daily LST at 1km spatial resolution in sinusoidal projection. These data mainly used to global temperature mapping in which land, soil and canopy temperature are main components, which helps to study the rate of growth of vegetation. Some highly sensitive components like evapotranspiration, snow and ice melt can be discriminate using these data. The digital numbers (DN) of LST data is converted to degree Celsius by using following formula,

$$\text{Temperature}=(DN * 0.02)-273.15\ ^{o}c$$

2.2.3 Cartosat-1 digital elevation model (DEM)

The Indian Space Research Organization (ISRO) launched Cartosat-1 satellite in May 2005. It carries two cameras which acquire stereoscopic images in the visible region of electromagnetic spectrum and it is used to produce DEM. DEM is a key component for many analysis such as runoff analysis, feature extraction, conservation plan for natural resources, delineation of terrain parameters such as slope, drainage network, aspect, watershed boundaries etc.

2.3 Methodology

The method used in this study is quite a simple and good, the entire assessment is based on statistics of vegetation, temperature and terrain factors. The NDVI of study area, before and after rainfall extracted from the MODIS MOD13Q1 NDVI image. These time series NDVI images are added to single image and the average NDVI at particular pixel is extracted and then the VCI is calculated using the formula,

$$VCI=100 * (NDVI-NDVI_{min}) / (NDVI_{max}-NDVI_{min})$$

Where NDVI, $NDVI_{max}$ and $NDVI_{max}$ are average NDVI of particular pixel, maximum NDVI and minimum NDVI respectively. The VCI varies from 0 to 100.

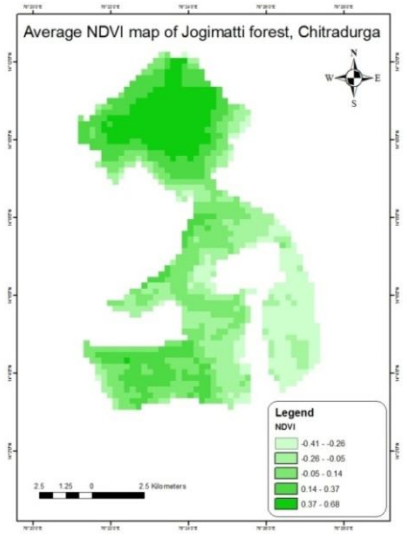

Fig. 2: NDVI of Jogimatti forest.

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Similarly, the LST of study area before and after rainfall extracted from the MODIS MOD11A1 LST image. These time series LST images are added to single image and the average temperature at particular pixel is extracted and then the TCI is calculated using the formula,

$$TCI=100 * (T_{max}-T) / (T_{max}-T_{min})$$

Where T, T_{max} and T_{min} are average temperature of particular pixel, maximum temperature and minimum temperature respectively. The TCI also varies from 0 to 100.

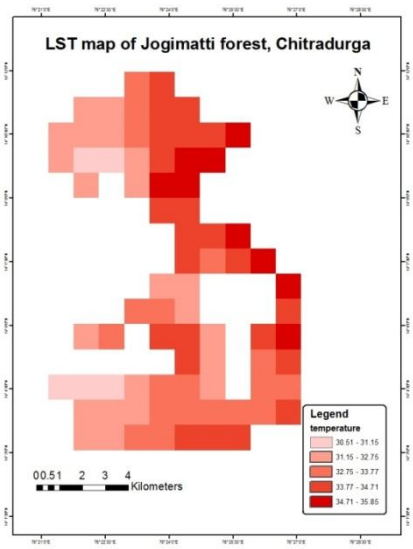

Fig. 3: LST of Jogimatti forest.

The elevation derived directly from the DEM and to extract slope and aspect we used surface analysis of Cartosat-1 digital elevation model. The complete statistics of terrain factors is correlated with TCI and VCI for the assessment.

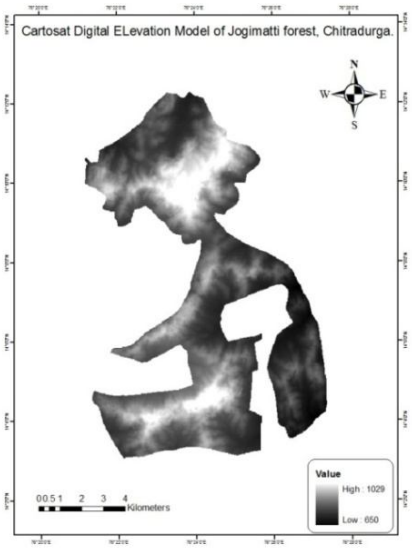

Fig. 4: DEM of Jogimatti forest.

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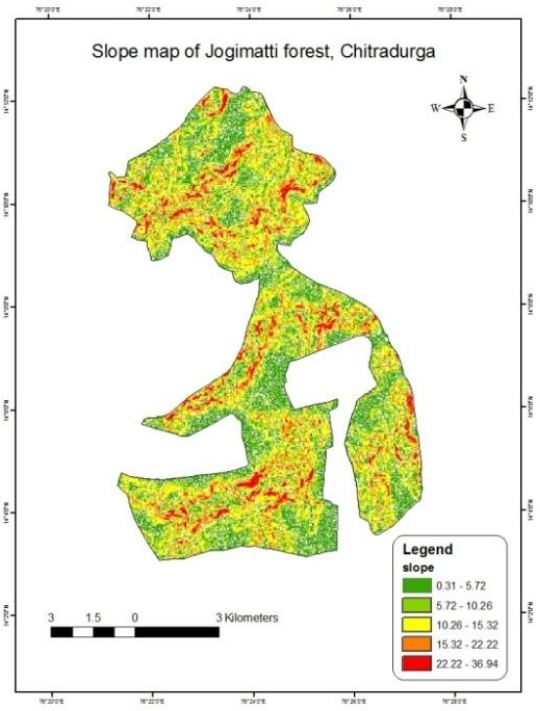

Fig. 5: Slope of Jogimatti forest

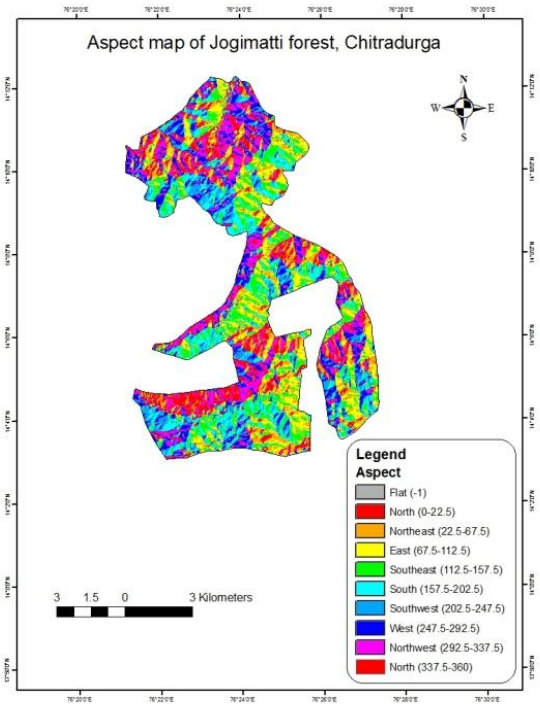

Fig. 6: Aspect of Jogimatti forest.

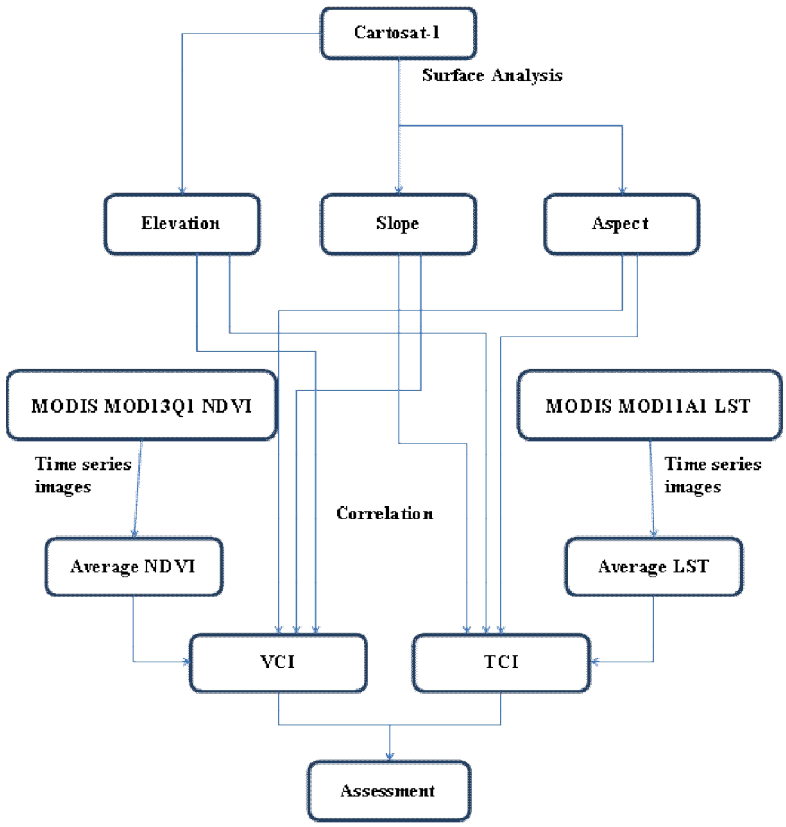

Fig. 7: Flowchart showing methodology.

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3. Results and Discussion

By statistics we can notice that, the elevation has a strong influence on vegetation condition. Both VCI and TCI are used to study the vegetation condition but TCI is not much correlated with it in this scenario. The VCI has a high positive correlation with elevation (0.78). The correlation between VCI and slope is low positive (0.39), in general the relationship between vegetation condition and slope is negative relationship but the study area is a bunch of undulating chain of hills, which influence the relationship between VCI and slope to low positive. There is no correlation between VCI and aspect (-0.12) which shows that, the distribution of vegetation is not influenced by the direction of slope.

Table 1: Correlation coefficient between VCI and terrain factors.

Factors	VCI	Elevation	Slope	Aspect
VCI	1			
Elevation	0.78	1		
Slope	0.39	0.19	1	
Aspect	-0.12	0.09	-0.19	1

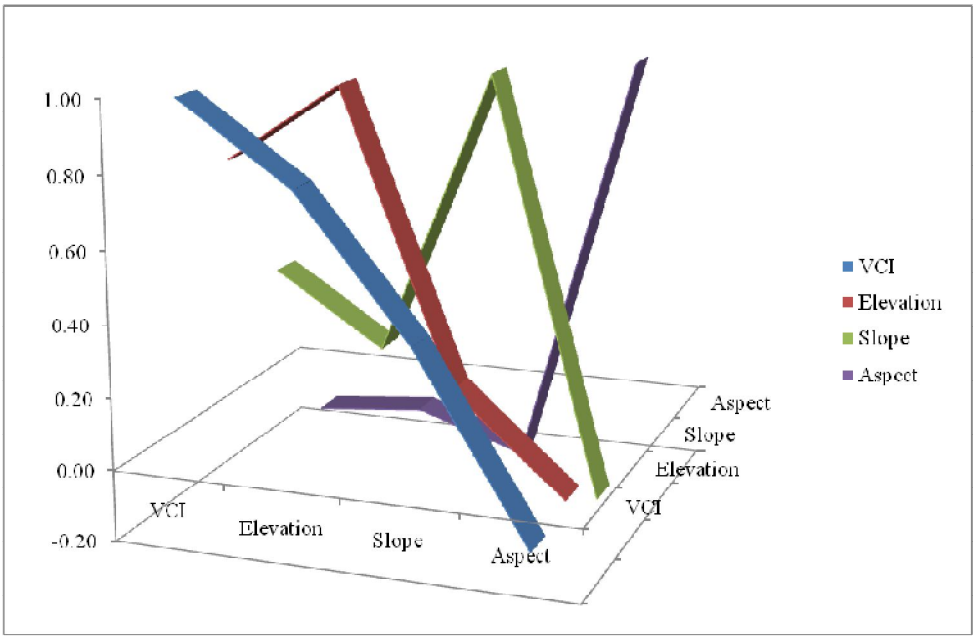

Fig. 8: Line chart showing correlation coefficient between VCI and terrain factors.

The temperature is another key parameter to study the vegetation condition, the image used in this study is of spatial resolution 1km, and according to study area this spatial resolution may not be the best to study TCI. The parameters elevation (-0.041), slope (-0.061) and aspect (-0.035) has no correlation with TCI.

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Table 2: Correlation coefficient between TCI and terrain factors.

Factors	TCI	Elevation	Slope	Aspect
TCI	1			
Elevation	-0.04	1		
Slope	-0.06	0.19	1	
Aspect	-0.03	-0.09	-0.19	1

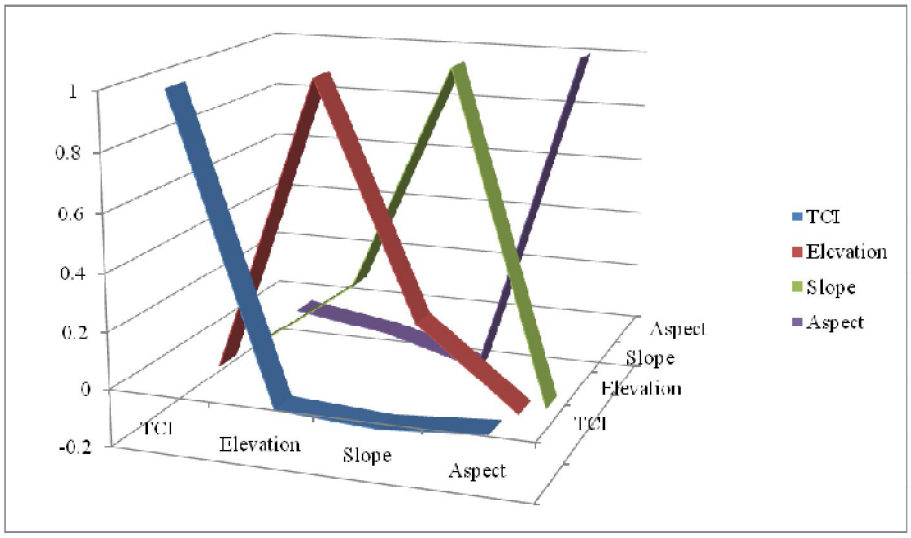

Fig. 9: Line chart showing correlation coefficient between TCI and terrain factors

4. Conclusion

Remote sensing plays a major role in understanding the biodiversity distribution. Understanding the relationship between VCI, TCI and terrain factors is very important for protecting environmental and natural resources, this paper analyzed the relationship between VCI and TCI with elevation, slope and aspect. The results shows that topography has strong influence on vegetation condition and its growth hence it's proved by VCI but there is no significant relationship found between topography and TCI.

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