INNOVATIVE ENERGY TECHNOLOGY SYSTEMS AND ENVIRONMENTAL CONCERNS: A SUSTAINABLE APPROACH
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The Influence of Land Surface Temperature on Vegetation Condition: A Case Study of Raichur District, Karnataka, India

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Abstract

The objective of this study is to assess the influence of temperature on Vegetation Condition of Raichur district, Karnataka, India. The Raichur district covers an area of 8433 km2 in which agriculture covers 6874 km2 (81.51%). The climate of the district is characterized by dryness for the major part of the year and a very hot summer. To understand the relationship between temperature and vegetation, we derived two indices namely VCI (Vegetation Condition Index) and TCI (Temperature Condition Index). VCI changes from 0 to 100, corresponding to the changes in vegetation conditions from extremely bad to optimal. TCI also varies from 0 to 100, corresponding to changes in vegetation condition from unfavorable to favorable. 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 VCI. 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 derive TCI. There is loss of data between June to October because of rainfall. The result describes that the temperature has strong influence on the condition of vegetation. The value of VCI has high negative correlation with LST (-0.633) and the value of TCI has a moderate positive correlation with NDVI (0.565).

1. Introduction

Remote sensing is one of the important concepts to monitor the growth of plants. Generally NDVI is used to study the amount of chlorophyll content in the vegetation and it is one of the first remote sensed indices successfully used for monitoring vegetation condition and drought at regional scale [6]. The concept of NDVI has two main problems for monitoring vegetation condition. First is the missing of data during rainfall and second is the influence of precipitation on vegetation phenology.

To overcome these problems, the concept of LST in vegetation condition approach started. The surface temperature is a good indicator of energy partitioning at the surface [6]. The common problem in both NDVI and LST is time lag between rainfall.

Normalized difference vegetation index (NDVI) has been widely used for qualitative and quantitative estimation of vegetation cover and growth activity [7]. Vegetation Condition Index (VCI) and Temperature Condition Index (TCI) are one and the same which mainly used

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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.

Some of the researchers gave their contribution to this concept. One approach, used by Nemani et al. (1993), made use of the fact that the NDVI is an indicator of green vegetation cover within the pixels, and therefore the slope of LST vs. NDVI plot gives a measure of stomata conductance and evapotranspiration [5]. Goetz (1997) reported that there is a negative correlation between the LST and the NDVI and indicted that surface temperature can rise rapidly with water stress [3]. Gillies and Carlson (1995) developed the concept of the LST vs. NDVI relationship and described the triangular shape of the data falling between the LST and the NDVI axes [2].

2. Materials and methodology

2.1 Site description

Raichur district lies between 15° 09’ and 16° 34’ N latitude and 75° 46’ and 77° 35’ E longitude and in between two major rivers, namely, the Krishna and the Tungabhadra. Agriculture is the major source for living, The district covers an area of 8433 km2 in which agriculture covers 6874 km2 (81.51%). The climate of the district is characterized by dryness for the major part of the year and a very hot summer.

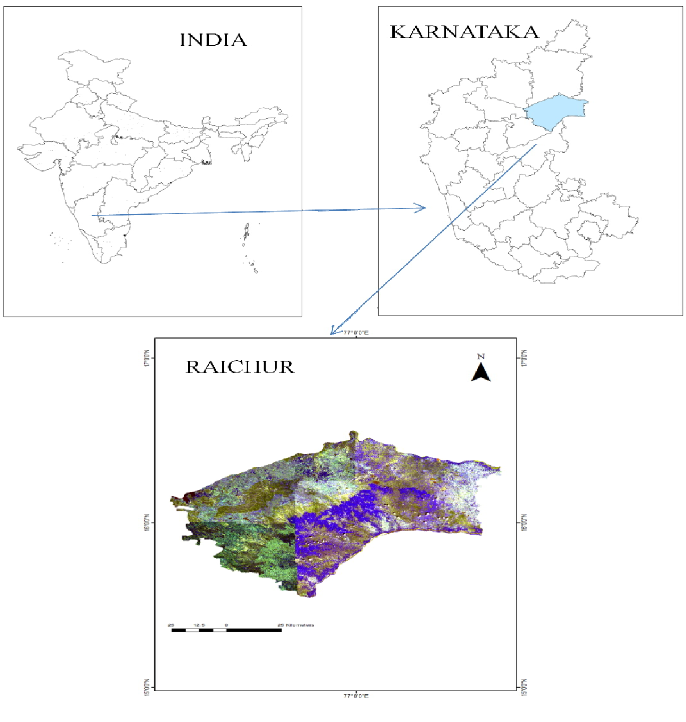

Fig. 1: Study area.

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

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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)

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

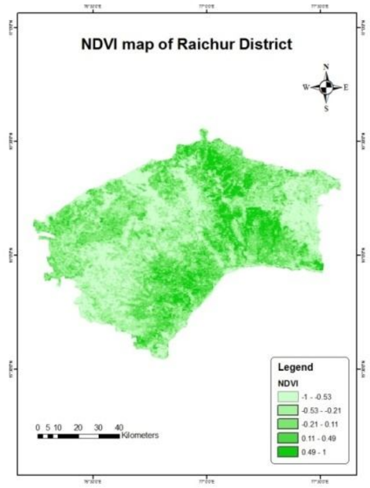

Fig. 2: NDVI of Raichur District.

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,

Temperature=(DN * 0.02)-273.15 ºc

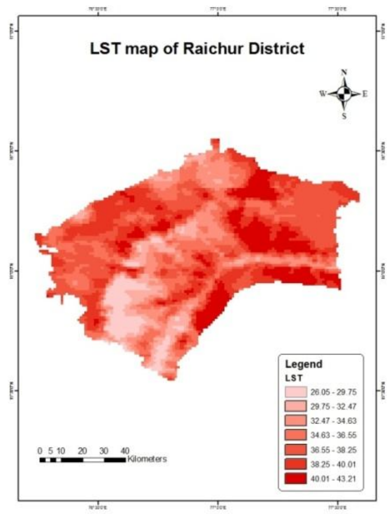

Fig. 3: LST of Raichur District.

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2.3 Methodology

A simple correlation method is used in this study. The entire assessment is based on statistics of vegetation and land surface temperature. 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.

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.

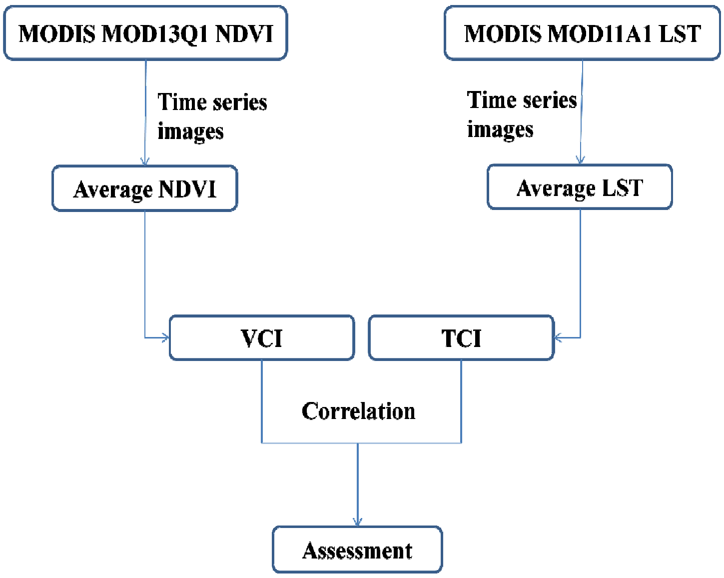

Fig. 4: Flowchart showing methodology.

2. Results and Discussion

By statistics we can notice that, the temperature has a strong influence on vegetation condition. Both VCI and TCI are used to study the vegetation condition. The NDVI usually shows the best result but in this study the temperature also shows the good result for vegetation condition studies.

By considering the average 16 days NDVI and temperature, it gives that the correlation between NDVI and LST is high negative correlation (-0.68), the correlation between TCI and VCI is high positive correlation (0.56). These results describes the LST can use as one of the vegetation condition indicator.

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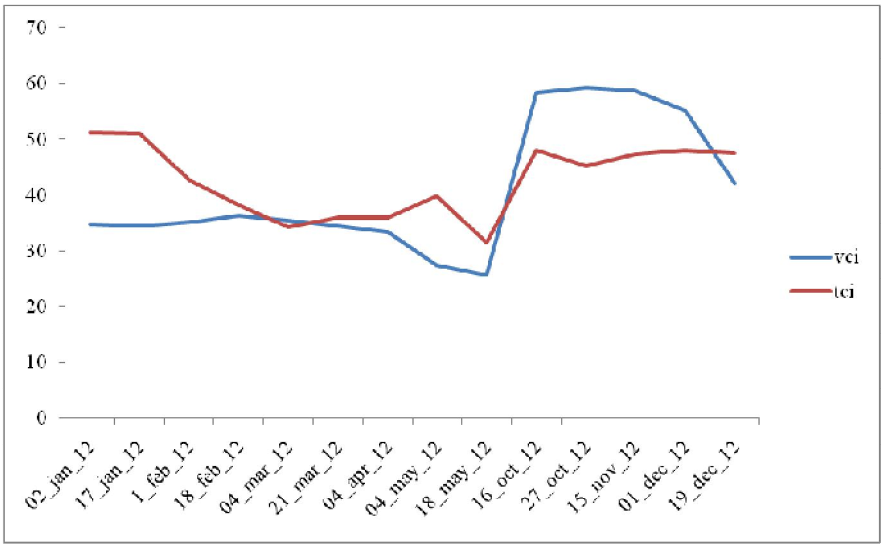

Fig. 5: Line chart showing relationship between VCI and TCI.

Table 1: Correlation coefficients.

Factors	NDVI	Temperature	VCI	TCI
NDVI	1			
Temperature	-0.68	1		
VCI	0.98	-0.63	1	
TCI	0.56	-0.85	0.56	1

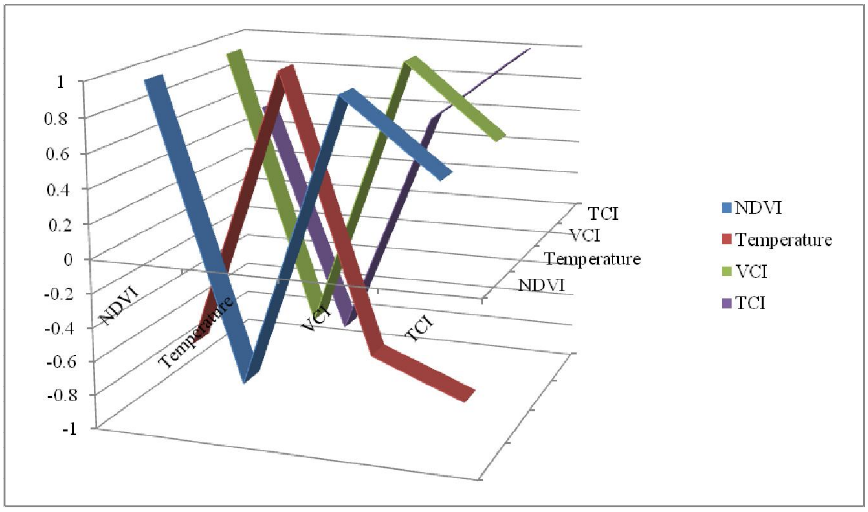

Fig. 6: Line chart showing correlation coefficients between NDVI, Temperature, VCI and TCI.

3. Conclusion

Remote sensing plays a major role in understanding the phenology of plants. This paper analyzed the relationship between NDVI and LST by deriving VCI and TCI. The results describes that temperature has strong influence on vegetation condition and it is inversely

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proportional. Due to loss of data during rainfall, the conditions of vegetation not studied completely throughout the season. The use of precipitation data may helps to overcome this problem.

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