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REMOTE SENSING BASED GREENNESS MODELING OF DIFFERENT CROPS IN LALGUDI BLOCK USING LANDSAT 8 IMAGE

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ABSTRACT

The objective of this paper is to estimate three vegetation indexes concerning with different crops grown in Lalgudi block of Trichy District, Tamil Nadu. The indexes estimated were Normalized Difference Vegetation Index (NDVI), Soil Adjusted Vegetation Index (SAVI) and Leaf Area Index (LAI). Landsat 8 satellite images with Operation Land Imager (OLI) sensor and Thermal Infrared sensor (TIRS) were used in this study. Two pairs of images were acquired (December 2014 and January 2015 and December 2017 and January 2018) to maintain homogeneity in dataset and the indices were estimated. Apart from spatial estimation of vegetation indexes, the point values of vegetation indexes of different crops were extracted from spatial vegetation index map for different time period. The results revealed that NDVI for different crops varied between 0.3 to 0.5. The LAI of paddy was 3.77 m^2 m^{-2} during active tillering stage, 4.75 m^2 m^{-2} during panicle initiation stage and 4.41 m^2 m^{-2} during the dough stage. The LAI value for banana and sugarcane during the second regrowth was 1.4 m^2 m^{-2}. A linear relationship was found between SAVI and LAI. The settlements, waterbodies and sand bed exhibited relatively lesser or negative values for vegetation indexes. This kind of spatial estimation of vegetation indexes helps in further study of crop behavior, crop monitoring and planning.

(Key words: Greenness, Normalized Difference Vegetation Index, Soil Adjusted Vegetation Index, Leaf Area Index)

INTRODUCTION

Greenness of the leaves is better illustrated by near infrared band (Lillesand *et al.,* 2008). Various mathematical combinations of near infrared band and other spectral bandproved to be sensitive indicators of the presence and condition of green vegetation. These mathematical quantities are referred to as vegetation indices.

Routinely calculated simple vegetation index is normalized difference vegetation index (NDVI). The highest NDVI value is assumed to represent the maximum vegetation "greenness". Numerous investigators related the NDVI to several vegetation phenomena like vegetation seasonal dynamics at global and continental scales to forest clearance (Silveira *et al.,* 2008), leaf area index measurement (Carlson and Ripley, 1997), biomass estimation (Gonzalez-Alonso *et al.,* 2006), percentage ground cover determination (Waylen *et al.,* 2014) and photo synthetically active radiation estimation (Hatfield and Prueger, 2010).

Empirically derived NDVI products was found to be unstable, varying with soil colour, soil moisture, and saturation effects from high density vegetation. An attempt was made to improve NDVI, Huete (1988) developed a vegetation index that accounted for the differential red and near-infrared extinction through the vegetation canopy. This index called as Soil Adjusted Vegetation Index (SAVI) is a transformation technique that minimizes soil brightness influences from spectral vegetation indices involving red and near-infrared (NIR) wavelengths.

The Leaf Area Index (LAI) is the ratio of the total area of all leaves on a plant to the ground area represented by the plant. It is an indicator of biomass and canopy resistance. Direct or semi-direct methods involves measurement of leaf area, using either a leaf area meter or a specific relationship of dimension to area via a shape coefficient.Indirect methods infer leaf area index from measurements of the transmission of radiation through the canopy, making use of the radiative transfer theory. From

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the satellite images, the LAI is calculated as a function of SAVI.

These vegetation attributes were used in various models to study surface albedo (Salifu and Agyare, 2012), photosynthesis, carbon budgets (Pandapotan *et al.,* 2016), water balance and related processes. So far studies related to comparison of vegetation indexes for different crops at different stages is fewer. Therefore, this study attempts to estimate the spatial variation of vegetation indexes and provide reliable values of NDVI, SAVI and LAI for different crops.

MATERIALS AND METHODS

Description of Study Area

The study was conducted in Lalgudi block, which is located at Tiruchirapalli District, Tamil Nadu, India (Fig. 1). The northern part of Lalgudi block has dense vegetation and barren lands. The southern part is bounded by River Coleroon. The Lalgudi Town is located at the central part of the block. Most of the inner part of the Lalgudi has cultivated areas (80%) where paddy, sugarcane, banana and other vegetables are grown.

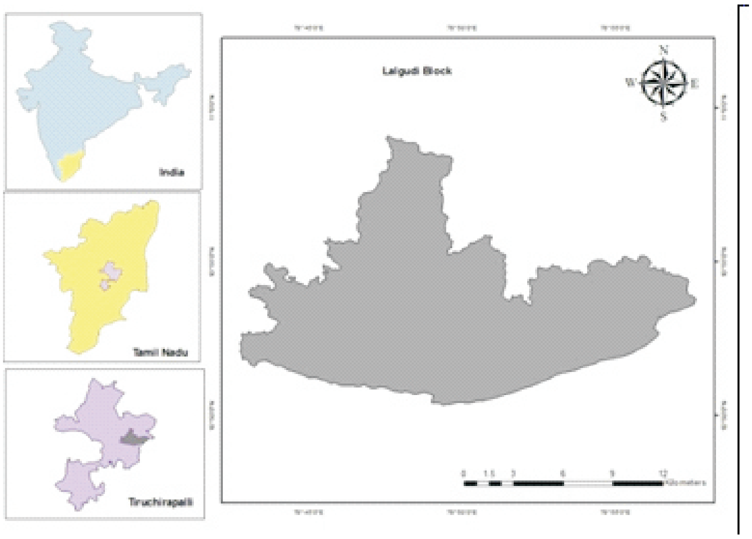


Fig. 1. Geographical Location of study area – Lalgudi Block

Image Selection

Landsat 8 is the most recently launched satellite of Landsat series. The Landsat 8 satellite images were downloaded from the USGS Earth Explorer website. Landsat 8 satellite images have two different sets of images that are from Operation Land Imager (OLI) sensor with nine bands (band 1 to 9) and Thermal Infrared sensor (TIRS) with two bands (band 10 and 11) (Roy *et al.,* 2014). To maintain the homogeneity in dataset, two pairs of images were acquired (December 2014 and January 2015 and December 2017 and January 2018). Table 1 summarizes the image acquisition date, solar elevation angle and zenith angle for the Landsat 8 data products used in this study. The images were selected such that there is no or minimum cloud cover (Table 1) in order to avoid errors in classification.

Table 1. Particulars of Landsat 8 image used in this study

S. No.	Acquisition Date (yyyy $mm^{-1}dd^{-1}$)	Solar Elevation Angle(degrees)	Solar Azimuth Angle (degrees)	Cloud Cover in image (%)	Cloud Cover in study area (%)
1	2014-12-05	49.38	146.60	2.46	0.77
2	2015-01-22	48.22	138.31	0.01	0.00
3	2017-12-29	47.08	144.18	23.15	0.40
4	2018-01-30	49.39	135.62	0.17	0.00

Computation of Vegetation Index

(a) Normalized Difference Vegetation Index (NDVI)

NDVI is the ratio of difference in reflectivity of near-infrared (NIR) band and red band to their sum. The expression for estimation of NDVI is as follow:

$$NDVI = \frac{\rho_5 - \rho_4}{\rho_5 + \rho_4} \qquad (1)$$

In Landsat 8 image, the near infrared is band 5 (ρ_5) and the red is band 4 (ρ_4). Using Raster Calculator tool in ArcGIS, NDVI raster is obtained.

(b) Soil Adjusted Vegetation Index (SAVI)

The SAVI is an index that attempts to "subtract" the effects of background soil fromNDVI so that impact of soil wetness is reduced in the index. It is given by:

$$SAVI = (1+L)\frac{(\rho_5 - \rho_4)}{(L + \rho_5 + \rho_4)} \qquad (2)$$

where L is a canopy background adjustment factor. The value of canopy background adjustment factor was taken as 0.5 in reflectance space because it minimized the soil brightness variations and eliminated the need for additional calibration for different soils. This transformation was found to nearly eliminate soil-induced variations in vegetation indices.

(c) Leaf Area Index (LAI)

The LAI is the ratio of the total area of all leaves on a plant to the ground area represented by the plant. It is an indicator of biomass and canopy resistance. LAI was computed by the following empirical equation:

$$LAI = -\frac{\ln\left(\frac{0.84 - SAVI}{0.65}\right)}{0.91} \qquad (3)$$

where; SAVI is calculated from Equation (2) using avalue of 0.5 for L. The maximum value for LAI is 6.0, which corresponds to a maximum SAVI of 0.687.

RESULTS AND DISCUSSION

The spatial and temporal variation of NDVI, SAVI and LAI are presented in figure 2a – 2l. The southern part of the study area is bounded by River Coleroon and hence negative values of NDVI, SAVI and LAI was observed. Some paddy fields (planted late) with standing water in puddled conditions also exhibited negative values for all vegetation indexes.

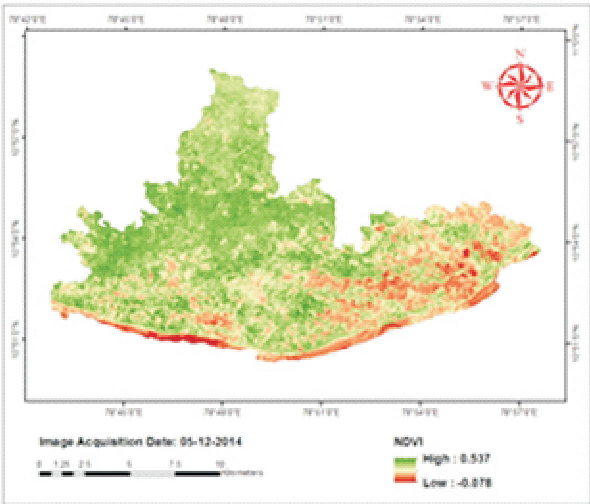
The estimated NDVI for waterbodies ranges from -0.07 to -0.09 (Figure 2a – 2d). Similarly settlements and sandbed in the River Colleroon also exhibited negative or comparatively lower values of all vegetation indexes.

During the year 2014, the Samba season paddy was planted in the last week of September. The scenes used in this study falls in panicle initiation stage and dough stage of paddy respectively. The estimated NDVI values for paddy in 05-12-2014 and 22-01-2015 scenes exhibited an overall decreasing trend because of phenological changes in paddy. Subsequently, the maximum LAI values observed was 4.75 m^2 m^{-2} during the panicle initiation stage and reduced to 4.41 m^2 m^{-2}during the dough stage. Similarly Din *et al.* (2017) also reported maximum LAI values estimated with hyper spectral images, ranging between 3.04 and 5.85 for different levels of nitrogen application. A decrease in LAI values from booting stage to heading stage was also reported by Din *et al.* (2017).

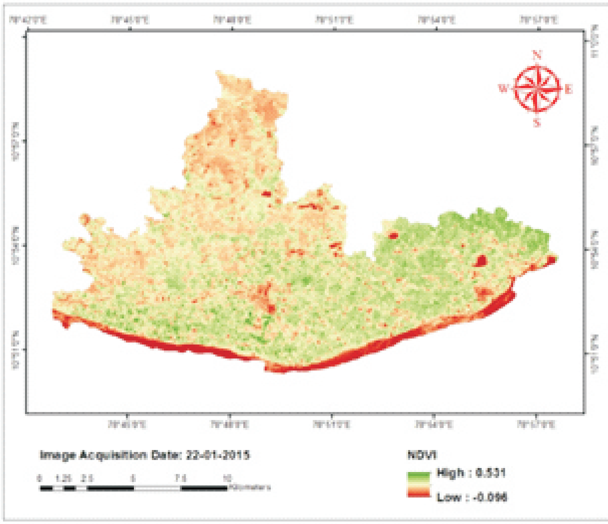
Subsequently in the year 2017, the Samba season paddy was planted in the mid of November. Thereby the scenes used falls in active tillering and panicle initiation stage. The spatially estimated NDVI values for paddy in 29-12-2017 and 30-01-2018 exhibited an increasing trend as the greenness increased from tillering stage to panicle initiation stage. The LAI values also increased from tillering stage to panicle initiation stage. Regardless of planting dates, the relationship between SAVI and LAI was approximately linear. Likewise Mokhtari *et al.* (2018) also reported a linear relation between SAVI and LAI for winter wheat crop in Abjek country.

These vegetation indices estimated at the early stage of crop growth, was highly accurate and decreased in the late growth stages, especially after heading stage. The problem arose from the fact that canopy reflectance strongly depend on both structural and biochemical properties of the canopy. In the late period of crop growth, panicles changed the canopy structure of crops and affected the crop canopy spectral reflectance.

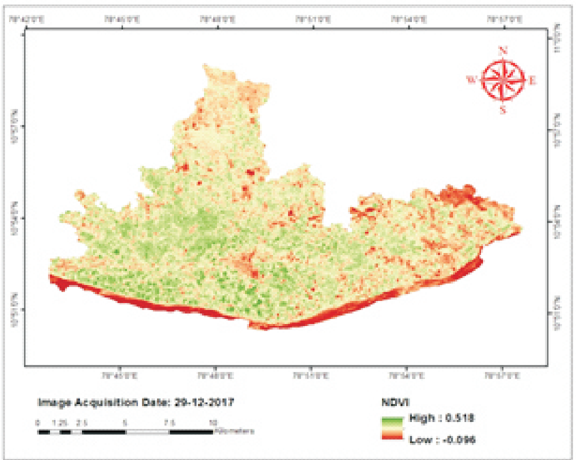
The northern part of Lalgudi block has sparsely dense, dry vegetation like cactus and prosopis which exhibited relatively lesser values of NDVI when compared to paddy. Similar trends were observed in case of SAVI and LAI.



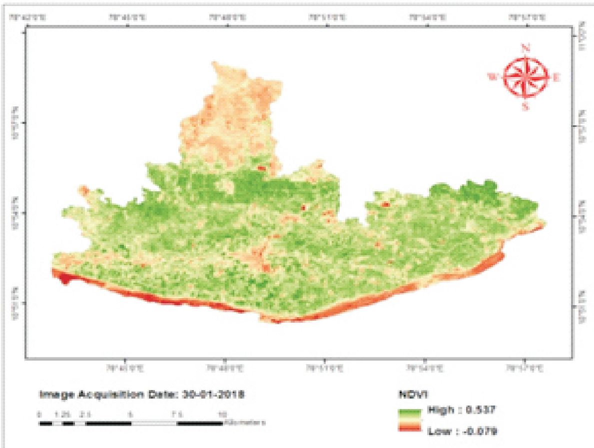
a) NDVI-Dec 2014



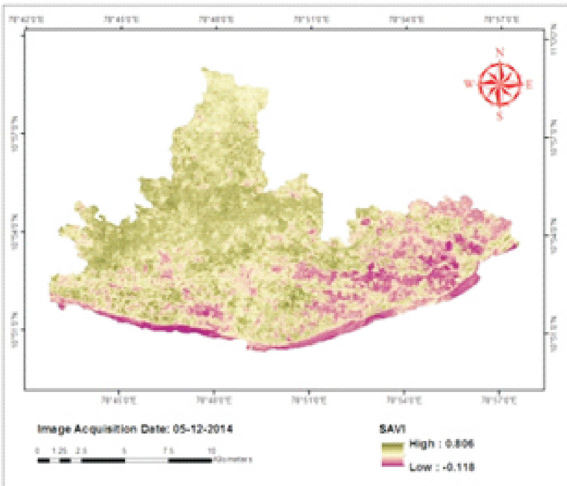
b) NDVI - Jan 2015



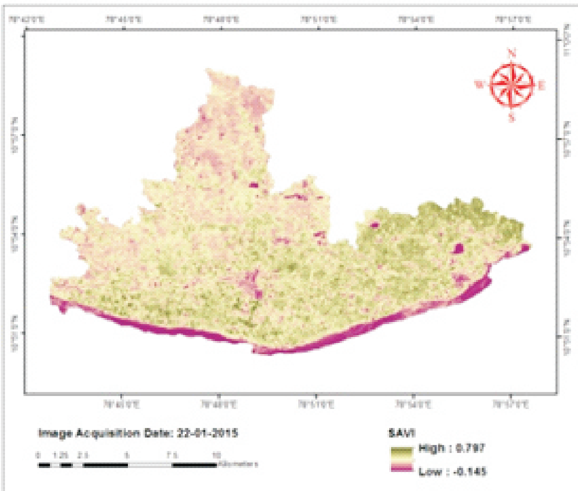
c) NDVI - Dec 2017



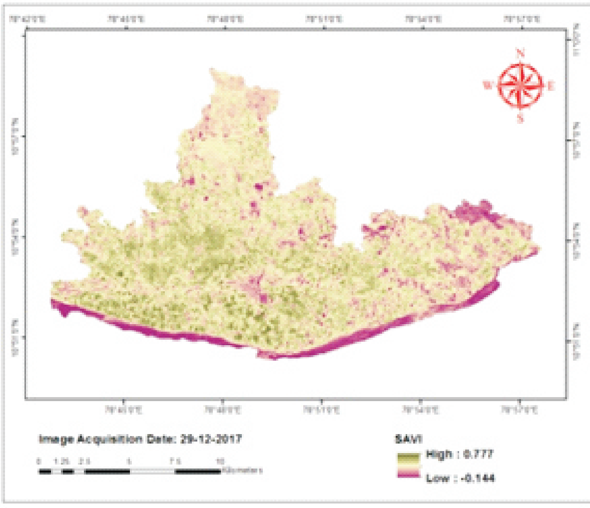
d) NDVI - Jan 2018



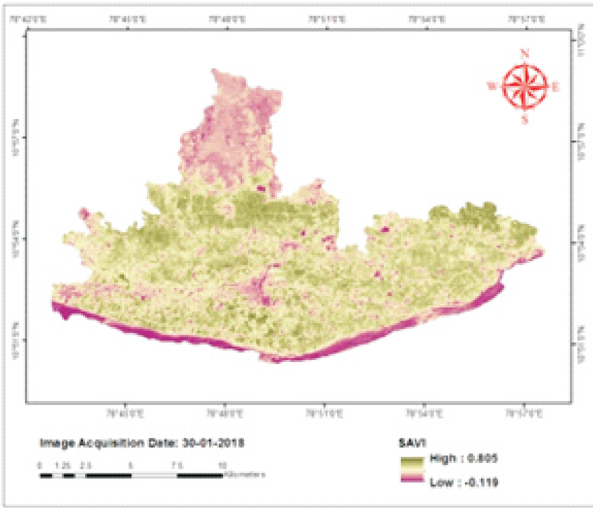
e) SAVI - Dec 2014



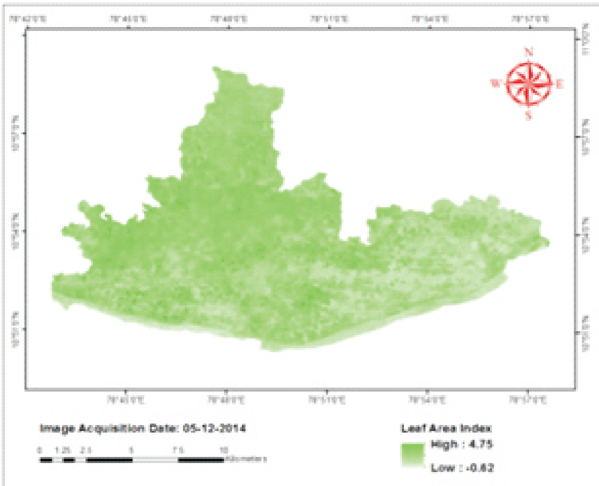
f) SAVI - Jan 2015



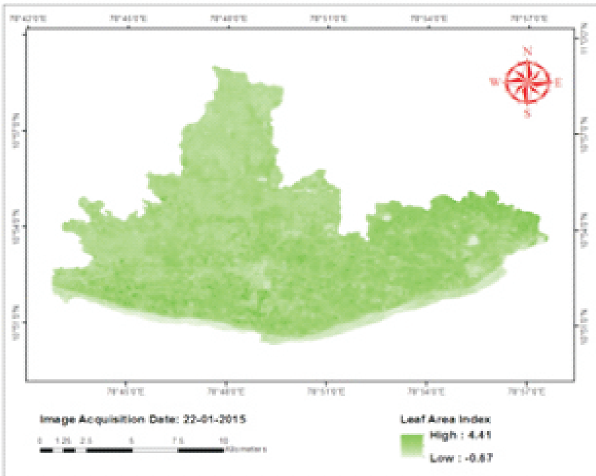
g) SAVI - Dec 2017



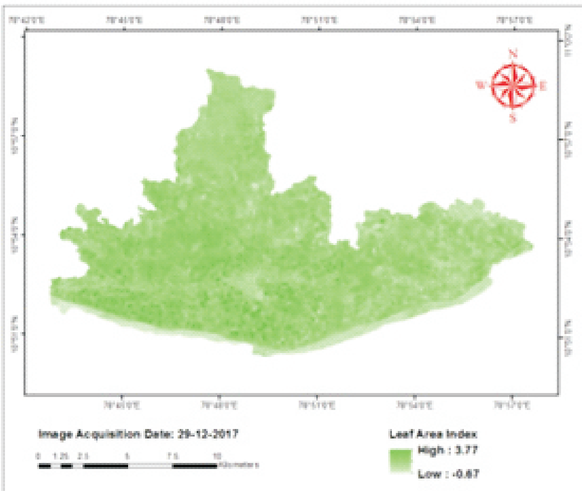
h) SAVI - Jan 2018



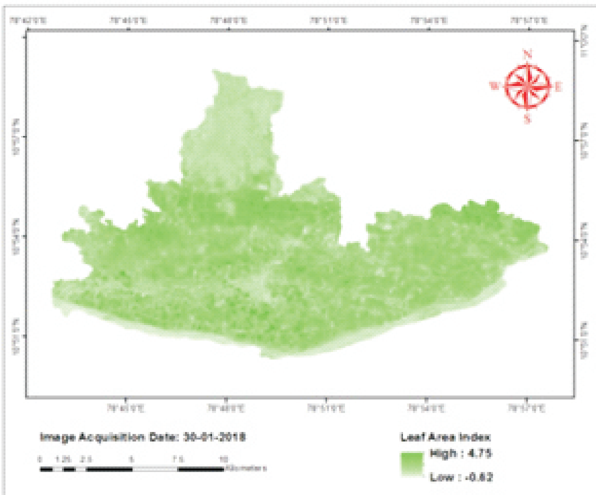
i) LAI - Dec 2014



j) LAI - Jan 2015



k) LAI - Dec2017



l) LAI - Jan 2018

Fig. 2. Spatio-Temporal Variation of Vegetation Indexes in Lalgudi Block

The average NDVI values for sugarcane and banana fields varied from 0.3 to 0.4 in all the scenes. The average LAI values of sugarcane and banana was observed to be 1.4 which is similar to the values obtained by da Silva *et al.* (2017) for sugarcane in second regrowth. Normally in Lalgudi block, second regrowth is practiced for banana and sugarcane. It was also observed that, for fields having newly planted banana plants, the LAI was very low (0.0256). By this way, the spatial variation of three vegetation indexes were estimated from Landsat 8 images.

The values of NDVI, SAVI and LAI were estimated for different crops using the Landsat 8 images. Results showed that NDVI for different crops varied between 0.3 to 0.5. The LAI of paddy was 3.77 m^2 m^{-2} during active tillering stage, 4.75 m^2 m^{-2}during panicle initiation stage and 4.41 m^2 m^{-2}during the dough stage.The LAI value for banana and sugarcane during the second regrowth was 1.4 m^2 m^{-2}. A linear relationship was found between SAVI and LAI. The settlements, waterbodies and sand bed exhibited relatively lesser or negative values for vegetation indexes. Taking the satellite imagery into account for modelling greenness of different crops, would pave a roadmap for several spatial and temporal studies like biomass estimation, crop water requirement and crop management practices.

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