

SPATIAL ESTIMATION OF VEGETATION INDEXES IN ANAIYUR CATCHMENT USING LANDSAT 8 IMAGE

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Abstract: The objective of this paper is to estimate three vegetation indexes for Anaiyur catchment of Kamuthyaluk, Ramanathapuram 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 Operational Land Imager (OLI) Sensor and Thermal Infrared Sensor (TRIS) was used. Two Landsat Image of April 2017 and August 2019 belonging two different seasons was downloaded from the USGS website and used in calculation of the three indexes. The Normalized Difference Vegetation Index of Anaiyur Catchment for April, 2017 varies between 0.001 and 0.42 and for August, 2019 varies between 0.04 and 0.48. The Leaf Area Index of Anaiyur Catchment for April, 2017 ranges from -0.40 to 1.89 and for August, 2019 ranges from 0.27 to 2.82. The predicted value of Soil Adjusted Vegetation Index of Anaiyur Catchment for April, 2017 ranges from 0.002 to 0.63 and for August, 2019 ranges from 0.068 to 0.72. These vegetation attributes can be used in various study related to surface albedo, photosynthesis, carbon budgets, water balance, rainwater harvesting potential and related processes.

Keywords: Landsat Image, Remote Sensing, Vegetation Indexes

INTRODUCTION

The state of plant health can be identified based on how the plant reflects light at certain frequencies (some waves are absorbed and others are reflected). Chlorophyll (a health indicator) strongly absorbs visible light, and the cellular structure of the leaves strongly reflect near-infrared light (Lillesand et al., 2008). NDVI is a measure of surface reflectance and gives a quantitative estimation of vegetation growth and biomass. This index was introduced by Tucker (1979) and varies between -1 and 1 in which the values less than zero during the growing season indicate no vegetation cover, such as desert, bare earth, cloud, snow, icepack, water body, and glacier; while values more than zero in the growing season describe available vegetation cover. 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.

The satellite imageries have wider application in agricultural crop related studies around the Globe and also in India. Koshal and Kumar (2015) made the decadal analysis of total cereal crops area and production with climatic factors viz. temperature and rainfall of India and suggested that the seasonal time

series remote sensing SPOT VGT data is useful for understand changing of land use coverage in India.

Thavorn tamand Tantemsapya (2013) investigated the seasonal variation of vegetation greenness based on the Normalized Difference Vegetation Index (NDVI) in major land cover types in the Northeast Thailand. In Northeast Thailand, the climate change has resulted in erratic rainfall and temperature patterns. The results showed a decreasing trend in NDVI values for both deciduous and evergreen forests. The highest productivity and biomass were observed in dry evergreen forests and the lowest in paddy fields. Mazzarino and Finn (2016) performed a Landsat 5-TM derived normalized difference vegetation index (NDVI) analysis in a semi-arid watershed (2700 km²) in the Andes of southern Peru from 1985 to 2010. Xiao-sheng Lin et al. (2016) studied the seasonal variation of vegetation greenness and dynamics based on the Normalized Difference Vegetation Index (NDVI) in major land cover types in the Liao River basin in Jilin Province, China. The results showed a general increasing trend in NDVI value in the region, while 34.63 % of the region showed degradation. Ramachandran et al. (2019) has done greenness modeling of different crops in Lalgudi block using Landsat 8 image. From the Landsat 8 satellite images, three vegetation indexes for different crops were estimated in Lalgudi Block.

With this background, the objective of this paper is to estimate three vegetation indexes via Normalized Difference Vegetation Index (NDVI), Soil Adjusted Vegetation Index (SAVI), and Leaf Area Index (LAI) for Anaiyur catchment of Kamuthyaluk, Ramanathapuram District, Tamil Nadu.

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MATERIALS AND METHODS

The study was conducted in Anaiyur catchment of Kamuthyaluk, Ramanathapuram District, Tamil Nadu. Landsat 8 images were downloaded from the USGS Earth Explorer website. Landsat 8 was the most recently launched satellite of Landsat series. Landsat 8 satellite images have two different sets of images that are from Operational Land Imager (OLI) Sensor with nine bands (band 1 to 9) and Thermal Infrared Sensor (TRIS) with two bands (band 10 and 11) (Roy et al., 2015). The models used for vegetation indexes estimation is presented in the following section.

Normalized Difference Vegetation Index (NDVI)

NDVI is the normalized difference in reflectivity of near-infrared (NIR) band and red band which is given by

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

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 was obtained.

Soil Adjusted Vegetation Index (SAVI)

Empirically derived NDVI products was unstable and varying with soil color, soil moisture, and saturation effects from high density vegetation. Huete (1988) developed a vegetation index for differential red and near-infrared extinction through the vegetation canopy to improve NDVI. It minimizes soil brightness influences from NDVI. The SAVI subtracts the effects of background soil from NDVI. The impacts of soil wetness were reduced in this index. It is given by

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

where L is a canopy background adjustment factor. An L value of 0.5 in reflectance space was found to minimize soil brightness variations and eliminate the need for additional calibration for different soils.

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 indicates biomass and canopy resistance. LAI was computed using the following empirical equation:

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

where; SAVI is calculated from Equation of SAVI using a value 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 NDVI, SAVI and LAI index estimated for Anaiyur Catchment area is shown in Fig. 1 to 6 respectively for April 2017 and August 2019 Landsat Images. The Normalized Difference Vegetation Index of Anaiyur Catchment for April, 2017 varies between 0.001 and 0.42 and for August, 2019 varies between 0.04 and 0.48. The maximum value of NDVI is noted in southern part of the study area which indicates the presence of vegetation. Ramachandran et al. (2019) also reported that NDVI for different crops varied between 0.3 from 0.5. The seasonal changes of vegetation in the study area is revealed by the changes in NDVI values for the April 2017 and August 2019 Landsat Images which can be well noted in few pixels of north western part.

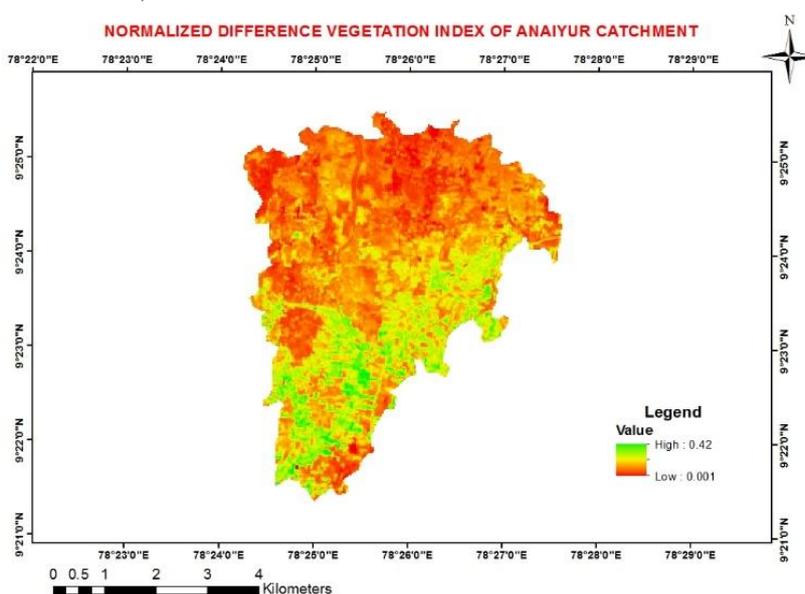


Figure 1. Normalized Difference Vegetation Index of Anaiyur Catchment- April, 2017

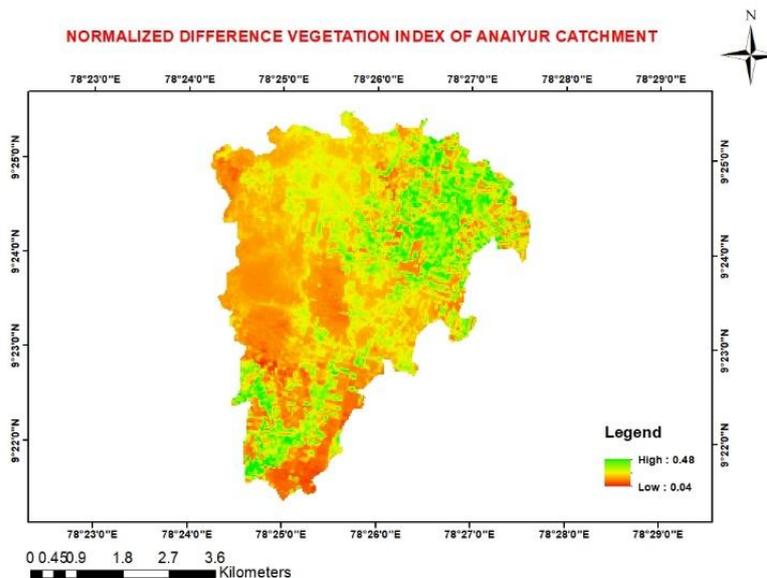


Figure 2. Normalized Difference Vegetation Index of Anaiyur Catchment - August, 2019

The Leaf Area Index of Anaiyur Catchment for April, 2017 ranges from -0.40 to 1.89 and for August, 2019 ranges from 0.27 to 2.82. The predicted value of Soil Adjusted Vegetation Index of Anaiyur Catchment for April, 2017 ranges from 0.002 to 0.63 and for August, 2019 ranges from 0.068 to 0.72.

The negative values of NDVI, SAI and LAI were obtained in the Northern part of the study area which is due to the presence of barren land and settlements. Similarly Ramachandran et al. (2019) also reported that settlements and barren land also exhibited negative or comparatively lower values of all vegetation indexes. The waterbodies within the catchment area had negative value of NDVI.

Thavorntamand Tantemsapya (2013) reported that vegetation indexes could be used to observe the change in vegetation greenness and dynamics affected by temperature and rainfall. Mazzarino and Finn (2016) pointed out that the changes in land management in some locations can be studied using the vegetation indexes estimated from remote sensing images. Xiao-sheng Lin et al. (2016) indicated that the seasonal variation of vegetation greenness and dynamics based on vegetation index provided important data for the environmental protection of the basin area. This kind of spatial estimation of vegetation indexes helps in further study of crop behavior, crop monitoring and planning.

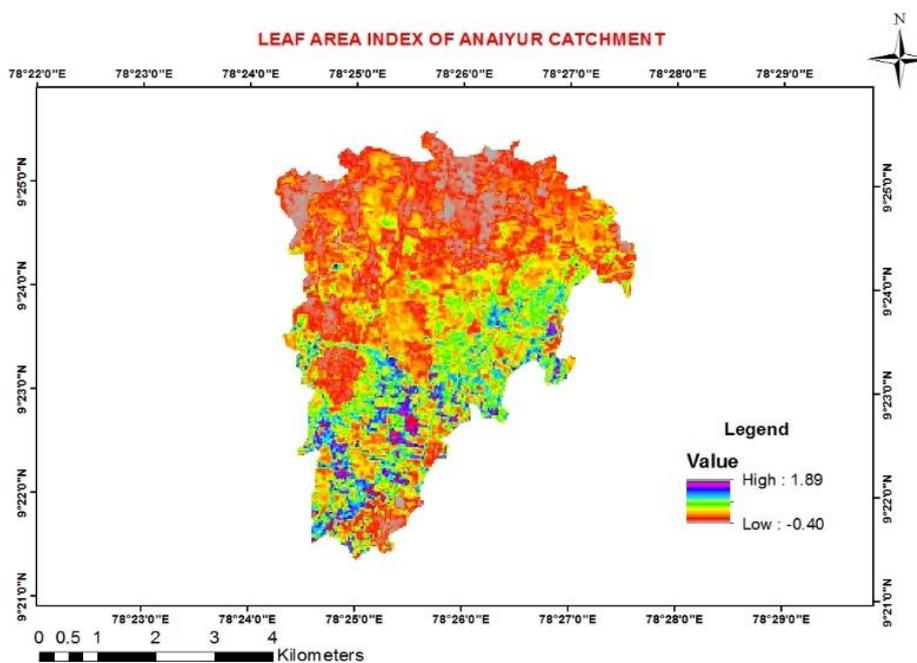


Figure 3. Leaf Area Index of Anaiyur Catchment- April, 2017

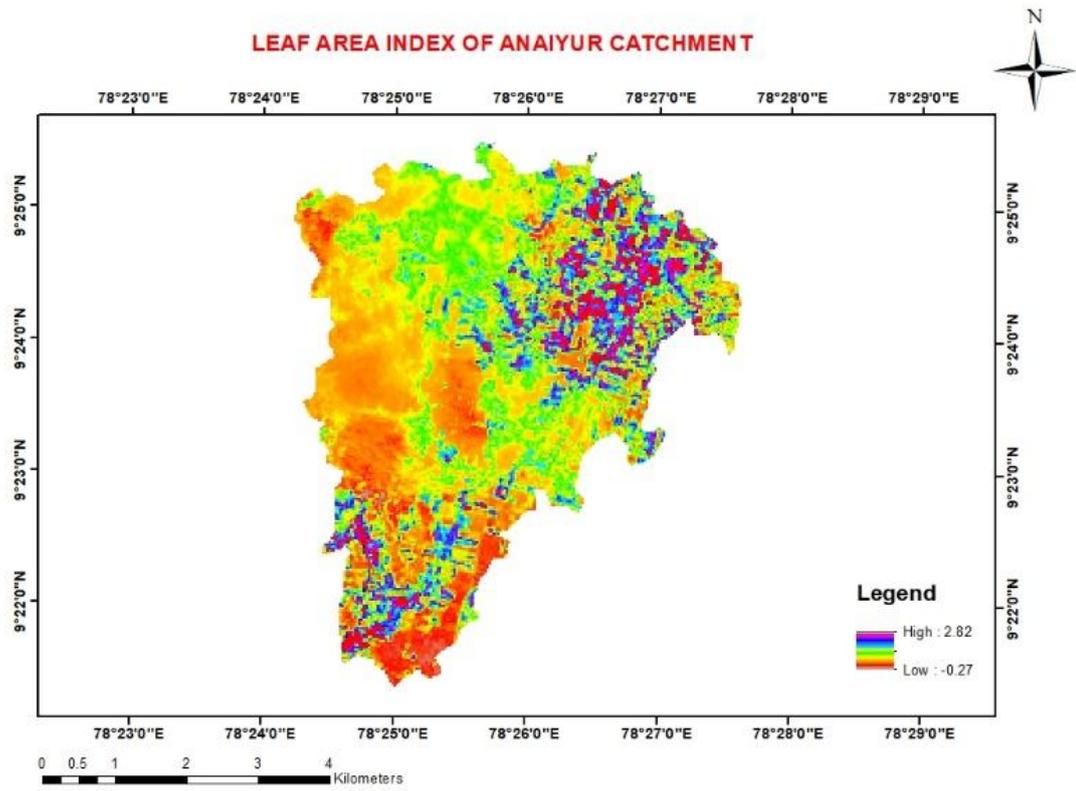


Figure 4. Leaf Area Index of Anaiyur Catchment - August, 2019

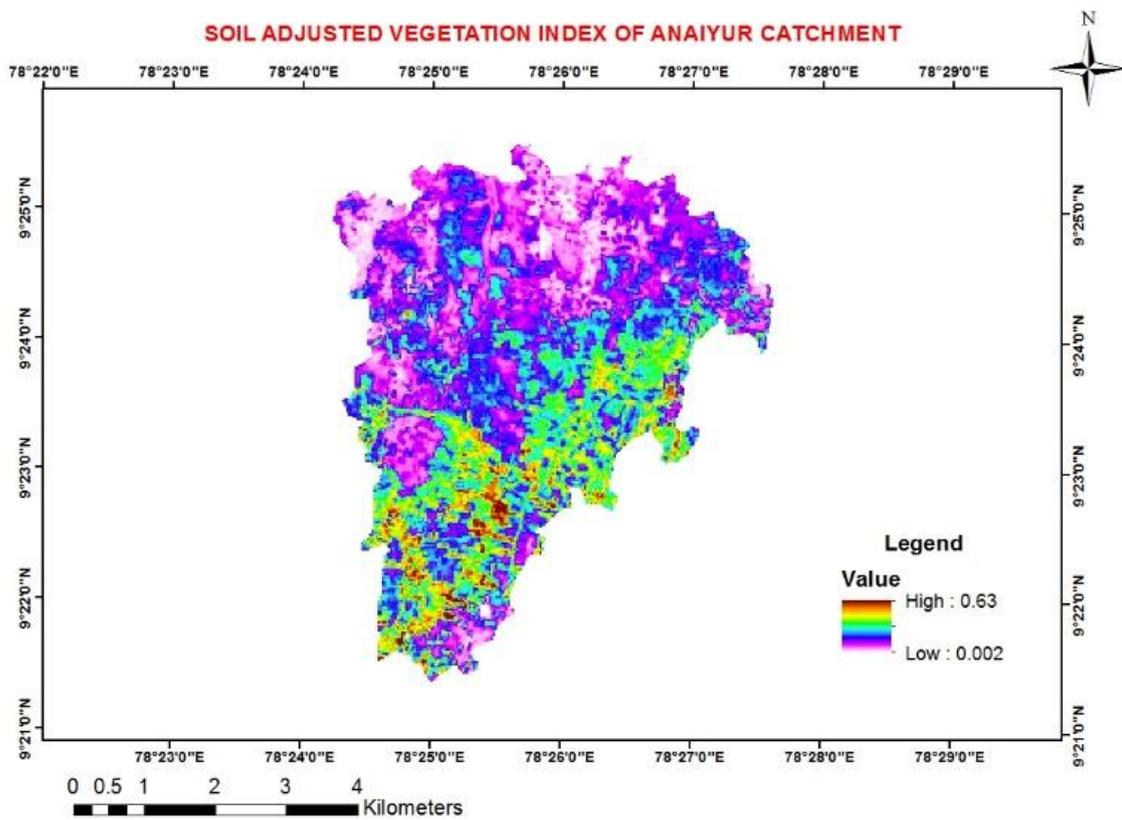


Figure 5. Soil Adjusted Vegetation Index of Anaiyur Catchment-April, 2017

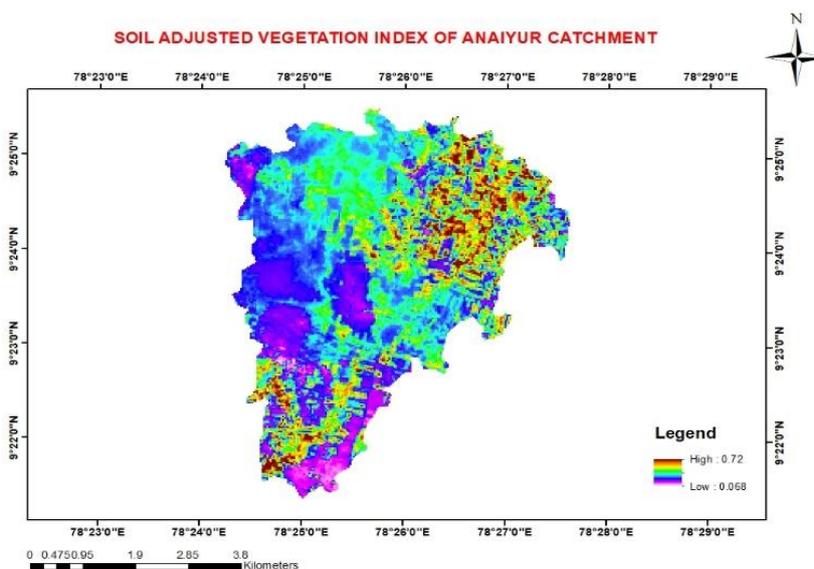


Figure 6. Soil Adjusted Vegetation Index of Anaiyur Catchment - August, 2019

CONCLUSION

The values of NDVI, SAVI and LAI of Anaiyur catchment were estimated using the Landsat 8 images. The Normalized Difference Vegetation Index of Anaiyur Catchment for April, 2017 varies between 0.001 and 0.42 and for August, 2019 varies between 0.04 and 0.48. The Leaf Area Index of Anaiyur Catchment for April, 2017 ranges from -0.40 to 1.89 and for August, 2019 ranges from 0.27 to 2.82. The predicted value of Soil Adjusted Vegetation Index of Anaiyur Catchment for April, 2017 ranges from 0.002 to 0.63 and for August, 2019 ranges from 0.068 to 0.72. This outcome represents a fundamental tool for biomass estimation, crop water requirement and crop management practices, sustainable land use planning, protecting the land from water-related soil erosion processes, and gully erosion hazard mitigation in the study area.

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