Synopsis of Thesis

Tree Species Diversity Estimates of Selected Forest Covers of India: AVIRIS-NG Approach

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By
Ms. Amrita N. Chaurasia

Guided by
Prof. N. S. R. Krishnayya

Ecology Laboratory

Department of Botany

Faculty of Science

The Maharaja Sayajirao University of Baroda

Vadodara – 390 002

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Tropical forest are known for its rich, diverse and complex terrestrial ecosystem. One of the world's most diversified nations, India supports a great floral diversity resulting from various climatic conditions such as rainfall and temperature. The majority of the forests in India are tropical moist deciduous and tropical dry deciduous. Tree species contributes to larger proportion in building the structure and function of any ecosystem and thus its study is clearly important to aid conservation efforts.

Field methods are commonly used to estimate tree diversity in great detail at small spatial extents. However, these methods can be costly, time consuming and difficult to scale up to larger spatial extents. Remote sensing provides an efficient and potentially cost effective way to study and monitor changes over larger areas. It is a technique used to obtain information at larger spatial extents in the form of image without being in physical contact with the object. These images are in raster format as it contain pixels of different land surface structures having unique reflectance values. Thus, each features has its own unique spectral signatures which are used to classify the objects at broader or narrower scales from land cover types to single tree species level. Field data and remote sensing data are linked to effectively assess spatial and temporal distributions of tree species diversity and developing detail and accurate forest maps. Many studies have been carried out to measure various indicators of species diversity such as normalized difference vegetation index (NDVI), biomass, and land cover types. Several researchers have been able to estimate species diversity and chemical diversity using remote sensed data. It has been noted that measurements of variance in a remotely sensed image's spectral properties are connected to species richness. The variety in plant community assemblages and environmental gradients have both been connected to the observed spectral heterogeneity, which can be used as a proxy for species diversity. As tree species plays a

dominant role in maintaining rich floristic diversity in tropical forests, its identification, distribution and response to climate change have become important in the application of forestry to understand different processes.

Types of imagery plays an important role in remote sensing based tree species identification and classification studies. Images obtained by remote sensors are basically multispectral and hyperspectral. Multispectral images are of low spectral and spatial resolution in contrast to advance hyperspectral images where hundreds of bands present providing detail information about objects on earth. Recent advancement in the technology of remote sensing led to development of hyperspectral Airborne Visible/InfraRed Imaging Spectrometer Next Generation (AVIRIS-NG) sensor. High spatial and spectral resolution of this sensor provides an opportunity to directly measure tree species diversity through species level characteristics. Increase in spatial and spectral resolution makes it easy to detect individual crowns of trees. Ample of research work done for tree species classification using hyperspectral data in temperate, coniferous and few for tropical forest but in India such studies are limited using AVIRIS-NG datasets. So present study was proposed to advance the understanding about target forest covers of India using AVIRIS-NG datasets with following objectives,

1. To develop tree species map of selected forest covers of India.
2. To estimate how tree species diversity is correlated with spectral diversity in different spectral regions of AVIRIS-NG spectra.

The **study area** includes Shoolpaneshwar Wildlife Sanctuary (SWS) and Vansda National Park (VNP) in Gujarat, Mudumalai Tiger Reserve (MTR) in Tamil Nadu. These are protected areas with rich and diverse vegetation with significant amount of human activities. Plantation of Tectona grandis and Dendrocalamus strictus were common in all the three protected areas along with few other species. The climatic factor in the three protected areas forms a gradient. At the time of AVIRIS-NG data acquisition mean annual rainfall recorded

was minimum at SWS and maximum at MTR ranging from 978.75 – 1486.28 mm. Similar gradient were also observed in temperature which was maximum at SWS and minimum at MTR. Topographic difference were also observed in the three zones. These forest covers represent dry deciduous to moist deciduous to evergreen forests. The trees species found in SWS and VNP are mostly deciduous with few evergreens whereas, MTR supports more evergreen species than deciduous ones.

Field visits were carried out at the three protected areas matching with time window of AVIRIS-NG acquisition dates ((date of image data acquisition: MTR – 5/01/2016, SWS – 8/02/2016 and VNP – 9/02/2016). Randomly 8*8 m quadrates were laid down and its location using Global Positioning system (GPS) were marked. The density and diversity of the species in the quadrates were recorded. The biophysical parameters such as diameter at breast height (dbh), canopy spread and height were measured for each species present in the quadrat. Along with this GPS location of large crown single trees (>4 m) were also marked. Subsequent field visit were carried out to generate detail species inventories.

The **climate data** used in the study are rainfall and temperature. Rainfall data were obtained from Climate Hazards Infrared Precipitation with Station data (CHIRPS) and temperature from European ReAnalysis-Interim (ERA-Interim). The spatial resolution of CHIRPS rainfall data is 5.12 km (0.05º) and 12.5 km (0.125º) for ERA-Interim temperature data. The 1984–2016 meteorological data showed a spatial gradient in rainfall from MTR (wetter) through VNP to SWS (lesser wetter, more arid). At the three protected areas, annual, decadal, and long-term mean minimum and maximum temperatures showed minor variations. Compared to SWS decadal mean rainfall and temperature at MTR are ~40% higher and ~4% lower respectively.

AVIRIS-NG datasets were available as a part of joint campaign between the Indian Space Research Organization (ISRO) and the National Aeronautics and Space Administration

(NASA) in 2016 for the forest covers of India. It is a new generation NASA's Earth science airborne sensor developed by Jet propulsion laboratory. It has high spatial resolution of 3 to 4 m. Spectral resolution is of 5 nm with 425 spectral bands ranging from 380 nm to 2510 nm wavelength. Standard topographic and bidirectional reflectance distribution function (BRDF) corrected images of the three protected areas were used for mosaicking, removing noisy and water absorption bands using ENVI 5.3 software resulted in spectral subset of 366 usable bands. Non forest areas were masked using normalized difference vegetation index (NDVI) values. Further brightness normalization and dimension reduction transformation techniques were applied. This transformed data were linked with field data and further analysis were carried out using R software.

The **results** of the study showed potential of AVIRIS-NG datasets for classifying tree species of forest covers of India with a fair overall accuracy ranging from 76.92 to 81.04% with 0.76 – 0.80 kappa coefficient. Certain spectral features were found to be more useful for estimating tree species diversity. The climate gradient shown to impact species spread and distribution in the three protected areas. Detailed results and interpretation will be included in the thesis. Thesis will also take an account of appropriate statistical analysis and relevant current literature.

Date: 19th January, 2023
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(Amrita N. Chaurasia)

Guide

(Prof. N.S.R. Krishnayya)
Professor
Dept. of Botany
Faculty of Science
The Maharaja Sayajirao University of Baroda
Vadodara - 390002

Head,
Department of Botany

HEAD
DEPT. OF BOTANY

Dean,
Faculty of Science

Dean
Faculty of Science
The M. S. Uni. of Baroda.

List of publications

1. Chaurasia, A.N.; Dave, M.G.; Parmar, R.M.; Bhattacharya, B.; Marpu, P.R.; Singh, A.; Krishnayya, N.S.R. Inferring Species Diversity and Variability over Climatic Gradient with Spectral Diversity Metrics. Remote Sens. 2020, 12, 2130. (IF: 4.509)

2. Chaurasia, A. N., Parmar, R. M., Dave, M. G., Mehta, N., Kallaje, R., Sahu, A., Murthy, K. I., Singh, C. P., & Krishnayya, N. S. R., Syncing tree phenology phase and canopy spectral reflectance of common tree species of four forest covers. Current Science, 2020. (IF: 0.848)

3. Parmar, R. M., Chaurasia, A. N., Dave, M. G., Goroshi, S., & Krishnayya, N. S. R. (2022). Importance of AVIRIS-NG data in assessing the assemblage of guilds of tropical trees over a contrasting climate. Advances in Space Research. (IF: 2.611)

List of Papers presented and published in Conference Proceedings

1. Chaurasia, A., Dave, M., Parmar, R., N. S. R., Krishnayya, ed. (B. K. Bhattacharya and C. P. Singh), 2017, Deciduous forest species discrimination, In: Spectrum of India, ISRO, Ahmedabad, pp. (26), ISBN NO. 9789382760290.

2. Oral presentation on "Tree diversity and density mapping of Mudumalai Tiger Reserve utilizing imaging spectroscopy data" at 11th International Conference on Ecological Informatics (ICEI 2020+1) organized virtually by the school of Informatics, Kerala University of Digital Sciences, Innovation and Technology (Digital University Kerala) from 9 – 13 November 2021.

3. Participated as coauthor of presented research paper "Importance of AVIRIS-NG data in assessing the assemblage of guilds of tropical tree over a climate gradient" during the 2nd International conference on Biodiversity and Climate Change 2021 (IConBaCC2021) on September 23-24, 2021 organized virtually by Misamis University, Ozamiz City, Philippines.