Automatic extraction of economically important forest tree species using deep learning and image processing techniques

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Trees are crucial for the structure and functioning of forests and play a significant ecological and economic role. Certain tree species in forests have a key economic impact by providing timber and non-timber forest products (NTFPs) and contributing to the economic productivity and the livelihood of forest-dependent communities. Therefore, it is vital to accurately identify and quantify these economically important species to prioritise resource allocation and support rural livelihoods. While previous studies have focused on identifying tree species in more uniform temperate forest regions, few studies have concentrated on tropical, heterogeneous forests. Trees like *Madhuca longifolia* (Mahua), *Dendrocalamus strictus* (Bamboo), *Tectona grandis* (Teak), and *Hardwickia binata* (Anjan) are widely found in the Central regions of India. This study aimed to automatically identify economically important tree species using object-based image processing techniques, such as segmentation, object-based image classification, graphic analysis of spectral reflectance curve, and deep learning methods applied to Pléiades Neo Satellite data. Trees possess specific crown characteristics, tone, texture, pattern and shadows, which produce distinctive spectral and spatial signatures. The study automatically extracted the targeted trees from India's highly diverse tropical forests, achieving an intersection over union (IoU) of 0.806. The Kappa coefficient turned out to be 0.81321, with omission error of 3% and commission error of 8%.

Keywords: Deep learning, machine learning, NTFP, OBIA, Pléiades, timber trees.

grandis (teak) and *Hardwickia binata* (Anjan) are prominent in this region. Even though these species are classified as NTFPs trees and timber trees, they can sometimes be used for both purposes. It is essential to establish effective due diligence systems and implementation mechanisms to sustain the use of these economically important species. It is well established that NTFPs contribute in various ways to the well-being of many rural and urban households and populations worldwide, especially tribal people[1,2]. NTFPs are critical natural resources as far as tribal welfare and sustainable development are concerned. Tribal groups are dependent on these natural resources to sustain their livelihood. Thus, the automatic extraction of NTFP trees will be of great use to tribal welfare departments for assessing the potential of each forest land and planning the utilisation of the resources. One of the major lacunae that tribal welfare departments in India face is the absence of accurate data regarding the availability of NTFPs in their jurisdiction. High-resolution remote sensing data can be utilised to automatically extract economically important tree species in a timely and cost-effective way. Several studies have explored using remote sensing images for mapping and identifying trees. These approaches include identifying tree crowns from satellite images by aligning images with maps, utilising convolutional neural networks (CNN) to classify tree species based on low-cost unmanned aerial vehicle (UAV)–red, green and blue (RGB) image data[3], employing low-cost machine vision systems for tree identification using UAV–RGB images[4], using faster R-CNN for automated tree-crown detection,