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RESEARCH PAPER

Assessment of land use and vegetation in Yellapur forest division, Uttara Kannada district, Karnataka

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Abstract: The study Land use land cover classification of different forest types was conducted in the Yellapur forest division of Uttara Kannada district, geographically positioned between 74° 25' to 75° 6' East longitudes and 14° 44' to 15° 7' North latitudes. The 2023 Land Use Land Cover (LULC) analysis, based on Landsat-8 data, provides valuable insights into the condition and distribution of vegetation across various land categories through Google Earth Engine. The Normalized Difference Vegetation Index (NDVI) values ranged from -0.07 to +0.70, reflecting diverse levels of vegetation health. Higher NDVI values indicate healthier vegetation, while lower values correspond to non-vegetated areas, such as water bodies. Vegetation, including forests, plantations, and other green spaces, covers 1,61,976 hectares (81.68%) and is crucial for supporting biodiversity and maintaining ecological balance. In contrast, built-up areas cover 17,413 hectares (8.83%) of the land, signalling ongoing urban expansion and infrastructure development. The overall accuracy of the Land Use Land Cover (LULC) analysis reached 95.45 per cent, with a Kappa coefficient of 0.94, indicating a high level of precision and reliability in classifying land cover types.

Key words: Kappa coefficient, Land use Land Cover (LULC), Normalized Vegetation Index

Introduction

Forests are widely acknowledged as one of Earth's invaluable natural resources. They play a crucial role in supporting life by offering various goods and services. Forests serve numerous ecological, economic and social functions, such as facilitating nutrient cycles, conserving soil, fostering species and genetic diversity and regulating greenhouse gases (Rao and Pant, 2001). Economically, forests provide timber, fuelwood, and non-timber forest products such as fruits, nuts, resins, and medicinal plants. Socially, forests are integral to cultural and spiritual practices. Many indigenous communities consider forests sacred and rely on them for traditional rituals and ceremonies. Forests provide recreational spaces and aesthetic beauty, enhancing society's overall well-being. Their diverse contributions make forests essential to livelihoods, supplying a wide range of resources (Zewdie, 2002).

Land, a finite and vital resource for the economic advancement of nations, faces increasing strain due to population growth. The dynamic condition of land requires immediate attention. Understanding both land use and land cover is paramount for grasping the connection between human actions and the environment, which is crucial for preventing forest degradation (Dimyati *et al*., 1996). Land use reflects the interaction of societal values, governmental policies and the land's capacity to support human activities. Conversely, land cover describes the physical attributes of the land surface. Recognizing these disparities is crucial for effective planning and management to meet societal needs while alleviating human-induced pressures on land. Land use defines the function or purpose of land, guiding its management to fulfil human requirements (Skole,*et al*1994).

Land use/land cover change is recognized as the primary driver of ecosystem transformation and its associated services. The fundamental goal of studying such changes is to comprehend their underlying causes and take appropriate measures to minimize negative impacts while optimizing land utilization (Das, 2015). Spatial and temporal analyses of land provide policymakers with valuable insights for crafting efficient management strategies. Land use and land cover changes are intricately linked, with impacts that influence each other reciprocally. Whether driven by natural processes or human activities, such changes disrupt environmental stability (Lu *et al.,* 2004). Change detection involves identifying differences in the state of an object or phenomenon over time and is essential for understanding the dynamic relationship between human societies and nature (Rwanga and Ndambuki, 2017).

Material and methods

Study area

The present study was focused on various forest types within the Yellapur Forest Division in Uttara Kannada District. Located in the eastern part of the district, the Yellapur Forest Division covers a total area of 168,986.66 hectares, including Betta lands (protected forests), which represents 86.97% of the division's geographical area (1,902.28 km²). The division is bounded by longitudes 74°25' to 75°6' East and latitudes 14°44' to 15°7' North. The study area is depicted in Fig 1. The Yellapur Forest Division encompasses three distinct forest types viz dry deciduous, moist deciduous and semi-evergreen (Fig. 2).

Sentinel-2 is an Earth observation mission from the Copernicus Programme that systematically acquires optical imagery at high spatial resolution (10 m) over the study area.

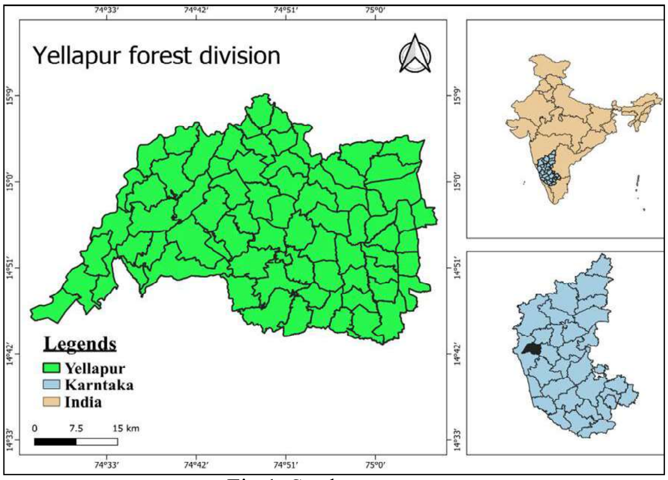

Fig.1. Study area map

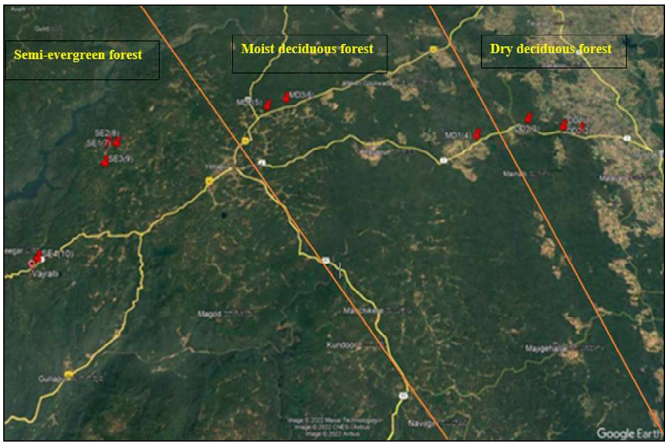

Fig. 2. Location of different forest types in the Yellapur forest division

Multi-spectral data with 13 bands in the visible, near-infrared and short-wave infrared part of the spectrum. The algorithm used was the maximum likelihood (Table 1).

Software

Google Earth Engine and QGIS is a platform for scientific analysis and visualization of geospatial datasets.

Experimental details

For conducting the experiment, satellite images of the Yellapur area for different years were used. The ground truth data was collected based on the forest density classes. Forest inventory was done for biomass and carbon studies.

Table 1. Details of Landsat 8 sattellite data

Launch date	Feb 2013
Swath width	185 km
Repeat cycle	16 days
Scene size	185 kilometres cross track by 180 km long
Resolution (m)	Panchromatic band: 15 metersVisible (VIS), near-infrared (NIR), and shortwave infrared (SWIR): 30 metersThermal nfrared: 100 meters
Sensor	Operational land Imager (OLI) and the Thermal Infrared Sensor (TIRS)

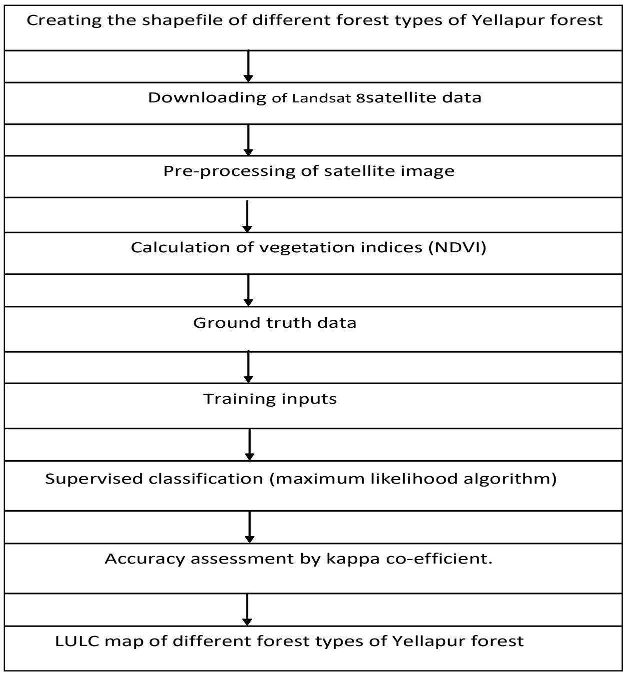

Fig. 3. Methodology for LULC map of Yellapur forest division

Creating the shapefile of different forest types of Yellapur forest

A shapefile is a geospatial vector data format used in Geographic Information System (GIS) software. It contains information about the geometry (location and shape) and attributes (data) of spatial features. This step involves defining and digitising the boundaries of different forest types within the Yellapur forest area.

Pre-processing of satellite image

This involves correcting the raw satellite data for atmospheric effects, sensor noise, geometric distortions and other imperfections. Pre-processing ensures that the satellite images are accurate and ready for analysis.

Radiometric correction

Radiometric correction for all the satellite images was done to remove the undesirable haze and noise. It was done to rectify variations in pixel digital numbers that are not caused due to image or scene being scanned. It was used for correcting the malfunctioning of the detectors, topographic and atmospheric effects and for adjusting the brightness value of the pixel in the image. Scan line error for sentinel-2 images was removed by focal analysis.

Geometric correction

Geometric correction was done for the Sentinel 2 images. The satellite image was geo-referenced and projected to UTM projection.

Calculation of vegetation index (NDVI):

Normalized Difference Vegetation Index (NDVI) is used to quantify vegetation health and cover. NDVI is calculated using the red and near-infrared bands of the spectrum of a multispectral sensor of Sentinel-2. The Normalized Difference Vegetation Index (NDVI) is a widely used vegetation index that is calculated using the red and near-infrared (NIR) bands of satellite imagery. The formula for NDVI is:

NDVI =(NIR-RED)/(NIR + RED) = (B8 - B4) / (B8 + B4)

Ground truth data

Ground truthing involves collecting data on the ground to validate and calibrate the satellite image analysis. This can include direct observations, measurements, or photos taken at various locations within the study area

Training inputs

Training inputs refer to the data used to train a classification algorithm. This includes samples of known land cover types that are used to teach the algorithm how to recognize these classes in satellite imagery.

Supervised classification (maximum likelihood algorithm)

Supervised classification is a process in which the algorithm assigns each pixel in the satellite image to a specific land cover class based on the training inputs. The maximum likelihood algorithm is a statistical method that calculates the probability of a pixel belonging to each class and assigns it to the class with the highest probability.

Accuracy assessment by Kappa coefficient

Accuracy assessment evaluates the performance of the classification algorithm. The kappa coefficient is a statistical measure that compares the observed accuracy with the expected accuracy (random chance) and provides a value between-1 and 1, where 1 indicates perfect agreement and values ≤0 indicates no agreement.

$K = (ND - P)/(N^2 - P)$

K= kappa coefficient

D= Sum of correctly classified class pixels

P= Sum of product of row total and column total

N= Total number of pixels

Area calculation

Area calculation After reclassification of each image into four classes, the area calculation for each land use land classes was done in Google Earth Engine. The area for different land use classes is tabulated in excel and the area was calculated in per cent.

LULC map of different forest types of Yellapur forest

The final output is a Land Use Land Cover (LULC) map that visually represents the spatial distribution of different land use classes within the Yellapur forest. This map is created based on classified satellite imagery and is useful for forest management, conservation and planning purposes.

Results and discussion

The NDVI values for 2023 range from -0.07 to +0.70 (Fig. 4), representing varying levels of vegetation health and density across the study area. Higher NDVI values, closer to +0.70, indicate healthier and denser vegetation, while lower values, around -0.07, correspond to areas such as water bodies with little to no vegetation. These variations in vegetation cover are influenced by factors such as urban expansion, deforestation, and agricultural activities, which impact the overall landscape and ecological balance.

The area under different land use land cover Classes of Yellapur forest division for the year 2023

The Land Use Land Cover (LULC) analysis provides a detailed breakdown of land categories, reflecting how the landscape is shaped by both natural processes and human activities. Vegetation, which covers the majority of the area, extends over 1,61,018 hectares (81.68%). This includes forests, plantations, and other forms of greenery, all of which play a critical role in maintaining the region's biodiversity, regulating local climate, and ensuring ecological balance. The vast expanse of vegetation serves as a carbon sink and supports numerous species, making it an essential component of the environment (Fig. 5).

Agricultural land occupies 16,976 hectares (8.61%), indicating the importance of farming in the region's economy and livelihood. These areas are used for the cultivation of crops and the management of agroforestry systems, which not only provide food and resources but also shape the cultural and

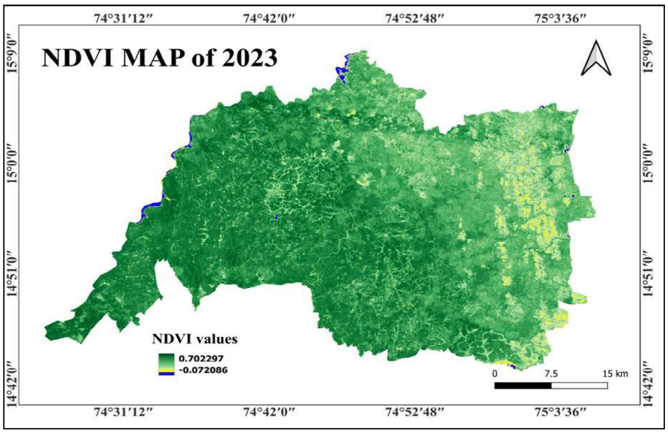

Fig. 4. NDVI map of Yellapur forest division for the year 2023

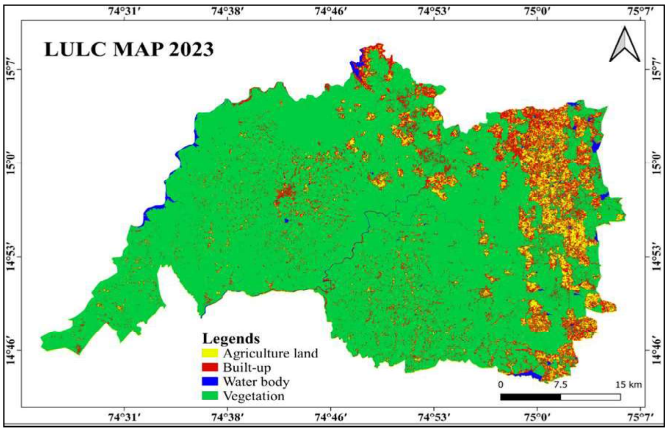

Fig. 5. LULC map of Yellapur forest division for the year 2023

economic fabric of the local population. The presence of agriculture reflects the balance between land use for production and the need to maintain natural habitats.

Built-up areas, covering 17,413 hectares (8.83%), demonstrate the ongoing expansion of urban infrastructure, housing, and industrial activities. This growth reflects the increasing demands of urbanization and economic development, leading to the conversion of natural landscapes into residential and commercial spaces. While built-up areas support human needs and economic activities, they also add pressure on the environment by reducing natural habitats and increasing demands for resources such as water and energy.

Water bodies, though limited in size, span 1,721 hectares (0.87%). These lakes, ponds, and reservoirs play an important role in the region's hydrology, supporting aquatic biodiversity, providing water for agriculture and domestic use, and helping regulate the local climate. Despite occupying a small portion of the land, water bodies are crucial for sustaining life and balancing ecosystems (Table 2).

The total land area analysed amounts to 1,97,130 hectares, offering a comprehensive view of the region's land use patterns. This analysis emphasizes the importance of managing both natural resources and human activities in a way that supports sustainable development while conserving vital ecosystems. The diverse land use categories showcase the interconnectedness between environmental health, economic development, and societal well-being (Fig. 6).

In 2023, the accuracy evaluation was carried out in Google Earth Engine using the.Confusion Matrix() function resulted in an overall accuracy of 95.45 percent, with a Kappa coefficient of 0.94. These values indicate a high level of classification accuracy and agreement.

Table 2. The area under different land use and land cover classes of Yellapur forest division for the year 2023

LULC CLASSES	Area (ha)	Area(%)
Agriculture land	16,976	8.61
Built-ups	17,413	8.83
Waterbody	1,721	0.87
Vegetation	1,61,018	81.68
Total	1,97,130	100

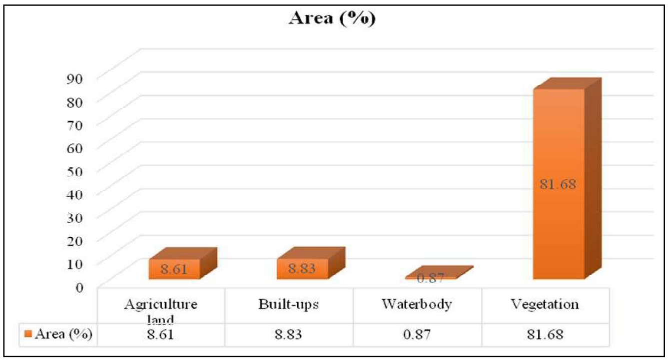

Fig. 6. The area under different land use and land cover classes of the Yellapur forest division

Nath and Acharjee (2013) employed NDVI to differentiate between vegetation-covered areas and non-vegetated regions, recording values of 0.1 and 0.6. The higher value in this range reflects greater photosynthetic activity and a denser canopy, indicating more robust vegetation. Lunetta *et al*. (2022) utilized pixel-wise Normalized Difference Vegetation Index (NDVI) to distinguish between various land use classes. the Yellapur Forest Division has experienced significant vegetation loss primarily due to urbanization, agricultural expansion and infrastructure development. Rapid population growth and economic activities in the region have led to the encroachment of forested areas for the development of built-up zones, particularly for residential and industrial purposes (Gupta and Roy, 2012). A considerable portion of the forest cover has been cleared to make way for agricultural land as farmers seek to meet the rising demand for food production (Santosh *et al*., 2019). Infrastructure projects such as road construction and the establishment of power lines have further fragmented the forest landscape contributing to the degradation of natural habitats. Resource extraction including logging and the collection of non-timber forest products has also played a role in reducing forest cover. Bhat *et al*. (2017) conducted a similar study and highlighted the significant environmental impacts of current urban growth trends on surrounding ecosystems. The rapid expansion of urban and built-up areas has led to dramatic shifts in land use and land cover marked by sharp declines in vegetation. Mallupattu *et al*. (2013) demonstrate that land use and land cover (LULC) changes were substantial between 1976 and 2003. The study highlights a notable increase in built-up areas, while agricultural land, water bodies and forested areas have all decreased. The findings underscore the significant influence of population growth and development activities on LULC changes. The research also confirms that integrating GIS and remote sensing technologies is a valuable approach to urban planning and management by Bisht and Kothyari (2001). The quantification of LULC changes in the Tirupati region provides valuable insights for environmental management groups, policymakers and the public, enhancing their understanding of the area's dynamics (Srimani and Prasad, 2013).

Conclusion

Remote sensing and GIS technologies offer an efficient and reliable approach for assessing land cover categories and monitoring changes in forest cover over time. In this study, the Yellapur forest division was classified into four key LULC categories: vegetation, built-up areas, agricultural land, and water bodies. NDVI values derived from Landsat 7 imagery in 2023 ranged from -0.07 to +0.70, providing insights into vegetation health and density across the landscape.

According to Landsat-8 data for 2023, vegetation, which includes forests and other green spaces, covered a substantial 1,61,976 hectares (81.68%) of the total area, emphasizing its ecological importance in maintaining biodiversity and carbon sequestration. Built-up areas, reflecting urban development and infrastructure, accounted for 17,413 hectares (8.83%), while agricultural land covered 16,976 hectares (8.61%), highlighting the role of farming in shaping the region's land use. Water bodies were limited to 1,721 hectares (0.87%), playing a crucial role in local hydrological cycles and providing essential resources for both ecosystems and human activities. The total land area of the Yellapur forest division was calculated to be 1,97,130 hectares, underscoring the diversity of land uses and the need for balanced land management to support both environmental sustainability and economic development.

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