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Assessment of Land Use Land Cover Changes Using Remote Sensing and GIS in Sargur Taluk of Mysuru District, Karnataka, India

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Land use and land cover (LULC) dynamics are a major source of environmental change, impacting biodiversity, water, carbon, and ecosystem services (Foley *et al.*, 2005; Lambin and Geist, 2006; Turner *et al.*, 2007). Precise mapping and assessment of LULC change are the first steps towards sustainable land use (Verburg *et al.,* 2015). Remote sensing technologies coupled with Geographic Information Systems (GIS) have proven to be the most efficient method of multi-temporal LULC mapping on a large scale (DeFries *et al.*, 2010; Jain *et al.*, 2018). Supervised classification techniques, especially the Support Vector Machine (SVM) algorithm, have been proven to be more accurate for classifying LULC using Sentinel-2 data due to their ability to deal with non-linear, high-dimensional spectral information (Mahendra *et al.*, 2022; Kumar *et al.*, 2021). Post-classification comparison and vegetation indices-based change detection techniques accurately quantify LULC changes (Singh *et al.*, 2020). LULC change and associated drainage alterations due to land-use intensification can have profound effects on stability (George *et al.*, 2021).

In India, LULC changes are influenced by population growth, agricultural activities, urbanization and policies (Roy *et al.*, 2015; Sharma *et al.*, 2018). Over the last 20 years, Karnataka has undergone rapid urbanization and industrialization, leading to substantial changes in LULC (Bhagwat S.A. *et al.*, 2019; Krishnaswamy *et al.*, 2020). Karnataka has effectively used remote sensing and GIS to map deforestation, agricultural expansion and assess ecosystem services (Nagendra *et al.*, 2013; Gokarneshan *et al.*, 2018). Combined remote sensing and GIS approaches also work well for groundwater potential mapping (Varade *et al.*, 2019) and drainage morphometric studies (Kamble *et al.*, 2019).

While LULC change has been studied in the larger Mysuru region (Murali *et al.*, 2019), a comprehensive, multi-temporal analysis of Sargur Taluk using a machine-learning classifier has not been undertaken. This study fills this gap by producing Sentinel-2-based LULC maps for 2018, 2021 and 2024, mapping the change patterns, assessing the influence of geomorphology on land-cover patterns, and delivering validated results useful for land-resource management and conservation.

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Study Area

The Sargur Taluk of Mysuru District, Karnataka, India is located between 11°43′ N to 12°12′ N latitude and 76°10′ E to 76°32′ E longitude and covers an area of about 1,575 km² (Survey of India, Toposheets) (Fig. 1; Census of India, 2011). It is part of the physiographic transition zone between the Western Ghats mountain ranges to the west and the Deccan Plateau to the east (Geological Survey of India, 2011). Major drainage is by the Kabini River and its tributary the Nugu River (Central Water Commission, 2014). The climate type is tropical semi-humid, with a mean annual rainfall of about 900 mm, mainly received during the south-west monsoon (June - September) (India Meteorological Department, Climatological Normals). Elevations span from 595 m to 1,021 m above mean sea level, with a mean elevation of 742 m amsl.

Geology

The basin is underlain by the Archaean Peninsular Gneissic Complex (>3.0 Ga), which is followed by the metavolcanics, chlorite schists and ferruginous quartzites of the Dharwar Supergroup (2.5-3.0 Ga) (Naqvi and Rogers, 1987; Geological Survey of India, 2011; Fig. 2). Recent formations such as laterites, alluvium and sandstone-shales are found in the eastern flood plains of the Kabini River system (Central Ground Water Board, 2013; Fig. 2). North of the taluk, gneiss constitutes 58-62%, schist belts 18-22%, and younger sedimentary and alluvial deposits 15-20% of the area, which suggests that the taluk is dominated by hard crystalline rocks. Mapping of lineaments revealed 27 major and 64 minor lineaments that have N-S and NE-SW trend, which are the tectonic controls of drainage and groundwater recharge (Geological Survey of India, 2011; National Remote Sensing Centre 2016, 2019).

The denudational hills are dominant in the study area which

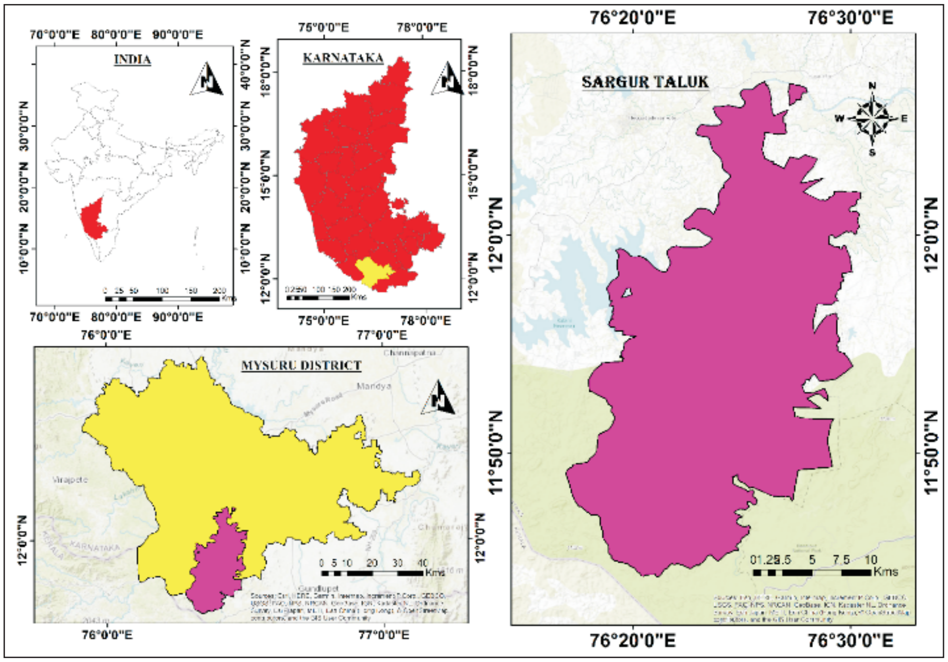

Fig. 1. Study area map of Sargur

means that many processes of weathering and erosion of the underlying hard rock landscape occurred (Geological Survey of India, 2011; Fig. 3). The structural hills are linear to sub-linear ridges that stand for the influence of geological structures, such as joints, faults and foliations (Geological Survey of India, 2011). The pediplains are the most common landforms in the taluk and represent the gently undulating surfaces that have been formed by long-term erosion due to the semi-arid to sub-humid climatic conditions (Geological Survey of India, 2011; Fig. 3). The floodplains are confined to the major rivers, particularly the Kabini River and the Nugu River, which indicate the sites of active fluvial deposition and seasonal inundation (Central Water Commission, 2014).

Sargur Taluk has a wide variety of soil due to different lithology and topography (Fig. 4). Western Ghats uplands are dominated by lateritic and red soils with iron oxide enrichment that form well-drained, loamy soils, and are used for coffee and other plantations (Geological Survey of India, 2011). The eastern and central lowlands consist of fertile alluvial soils deposited by Kabini and Nugu rivers (Geological Survey of India, 2011).

Materials and Methods

A systematic approach was followed to map LULC in Sargur Taluk. Sentinel-2 Level-2A (surface reflectance) images were

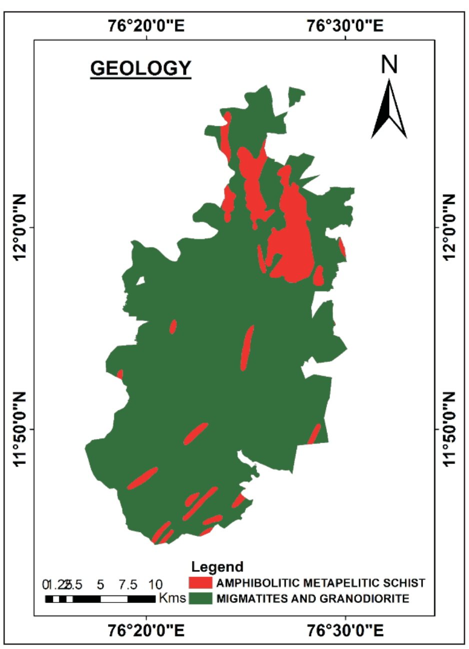

Fig. 2. Geology map of Sargur

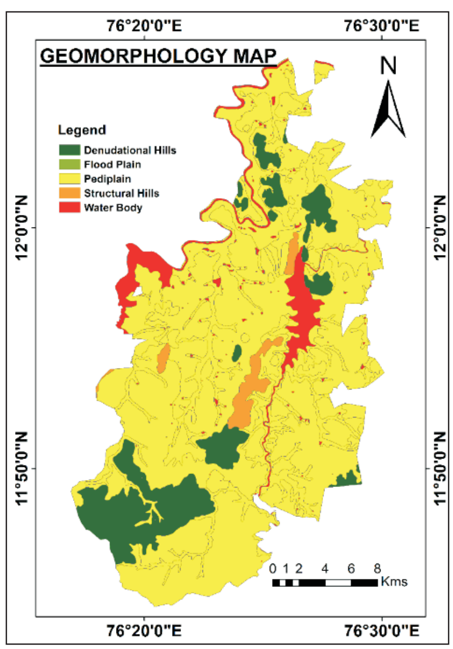

Fig. 3. Geomorphology map of Sargur

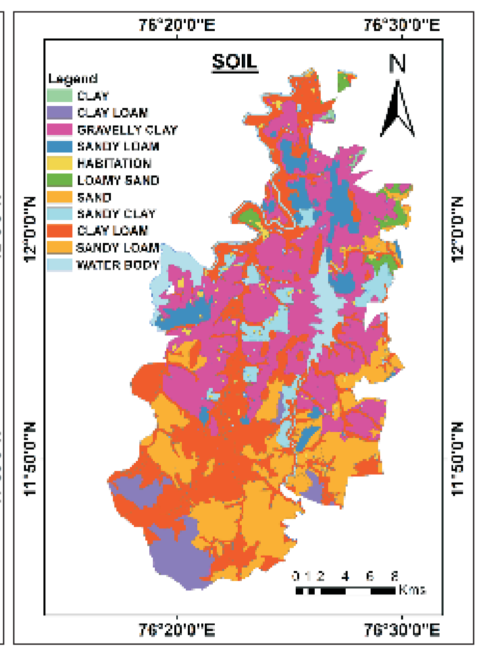

Fig. 4. Soil map of Sargur

obtained from the Sentinel Open Access Hub for three benchmark years 2018, 2021 and 2024 with cloud cover less than 5%. Images were acquired during the dry season (November - January) to reduce phenological effects.

Processing

The major pre-processing procedures are radiometric correction in conjunction with atmospheric correction and geometric correction that deliver improved quality images with consistent positions. The pre-processing method compensates for atmospheric effects by correcting distortions and provides a consistent outcome in several staging phases for valid comparison.

Support Vector Machines

SVM classifier based on the kernel architecture, Radial Basis Function (RBF), was implemented on top of a kernel to classify Sentinel-2 multispectral data into five LULC classes: dense forest, cultivated agricultural land, open water surfaces, human settlement areas, and bare terrain (Thanh Noi and Kappas, 2018). Post-classification change detection was used to map and measure changes in LULC between 2018-2021 and 2021-2024 (Yousefi *et al.*, 2022).

The accuracy of classification was assessed independently through stratified random sampling of field-corroborated validation points per epoch in time, and error matrices formed using these points produced error statistics of the accuracy in general and Cohen Kappa coefficients (Congalton, 1991).

Five land-cover classes with 505 training samples (Forest - 215, Crops - 160, Barren land - 95, Water bodies - 15 and Settlement - 15) were employed. The Support Vector Machine (SVM) kernel used for this analysis is Radial Basis Function (RBF) which is effective in non-linear spectral separability (Mountrakis *et al.*, 2011; Yang, 2011). The SVM parameters include C = 10, Gamma = 0.045 and Tolerance = 0.001. The features used as input are the Sentinel-2 multispectral (Red, NIR, SWIR) bands, vegetation and water indices like NDVI, NDWI and SAVI (Srivastava *et al.*, 2012).

Result and Discussions

LULC Classification

Using Sentinel-2 data and SVM classifier, multi-temporal LULC classification maps were created for Sargur Taluk for 2018, 2021 and 2024 (Fig. 5-9). The classification identified five classes - water bodies, forest, cropland, settlements and barren land. The area and percentage coverage of each class for the three years are given in Table 1.

LULC Assessment and Change Detection Analysis

Agricultural land accounted for 36% of the taluk's total area in 2018, while forests made up 34% (Fig. 5-6). Twenty-five percent of it was waste. The Nugu Reservoir, Kabini backwater, and water canals were among the aquatic bodies that made up 3% of the zone. Sargur town and other rural communities made up the majority of the 2% of human settlements. 2018's classification accuracy was 83.14% (Kappa = 0.745; Table 2).

Field-based accuracy validation used GPS-recorded

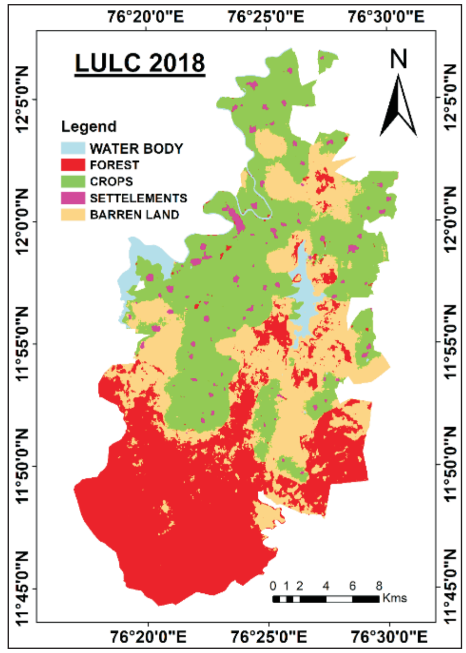

Fig. 5. LULC Map of Sargur during 2018

reference points for each LULC class: forest (11.8938°N, 76.2102°E), cropland (11.8753°N, 76.2447°E), barren land (11.8640°N, 76.1965°E), water bodies (11.9014°N, 76.2263°E), and settlements (11.8836°N, 76.2341°E); overall accuracy was 78.6% (Kappa = 0.69) for the 2024 classification based on 120 validation points. Geographical analysis revealed that the majority of forest recovery (2018–2024) took place in schist hill regions and gneissic uplands with steep slopes and thin soils unsuitable for farming. On the other hand, agricultural development was mostly concentrated in the productive alluvial. The increasing conversion of laterite-capped hillslopes into plantation regions reduced the amount of barren land, plains, and lateritic pediplains.

Cropland increased from 36% to 41% and forest cover from 34% to 41% between 2018 and 2021, taking into consideration 82% of the taluk area in 2021 (Fig. 7-8). Natural reforestation, forest plantations, improved agriculture, and more irrigation are the causes of this expansion. The region of barren land considerably dropped from 25% to 12%, indicating effective vegetation management and land rehabilitation. In 2021, the classification accuracy was 83.56% (Kappa = 0.768; Table 3).

Forests and agriculture covered 88% of the taluk area in 2024 (forest: 45%, crops: 43%; Fig. 9-10). Due to extensive land

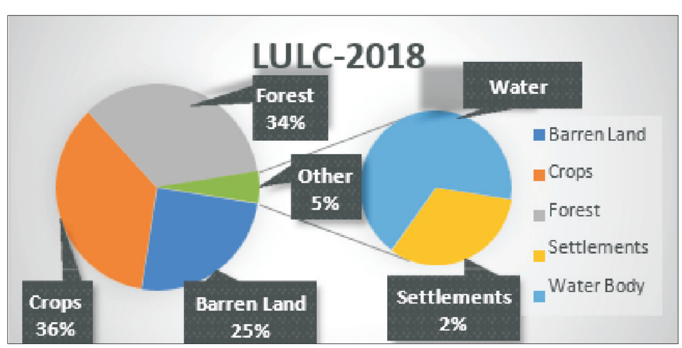

Fig. 6. Shows the LULC area distribution during 2018

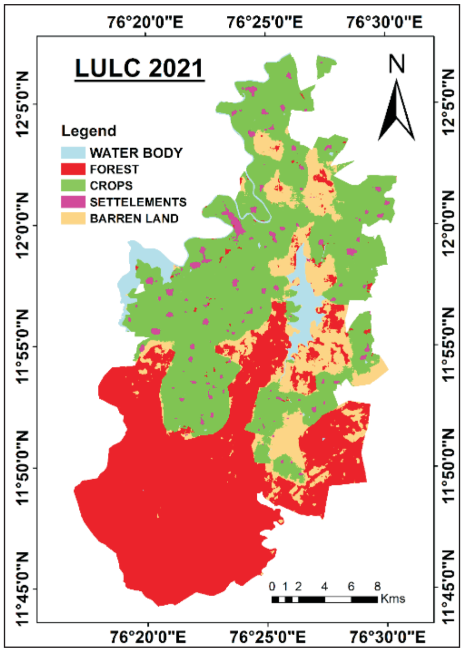

Fig. 7. LULC Map of Sargur during 2021

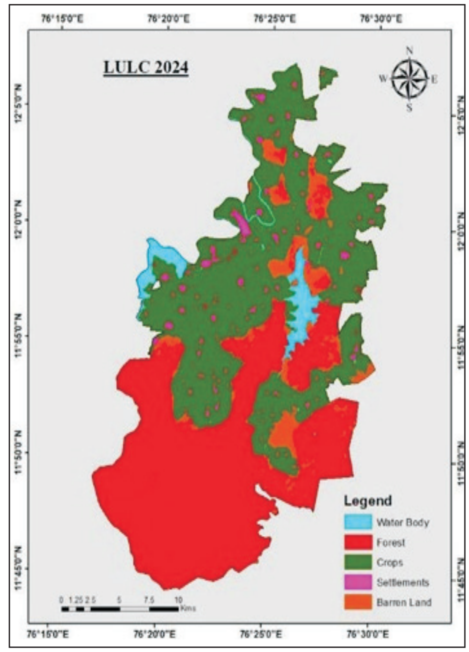

Fig. 9. Shows LULC Map of Sargur during 2024

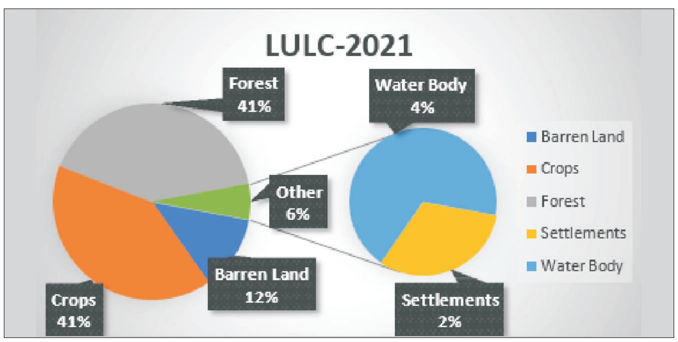

Fig. 8. Shows the LULC area distribution during 2021

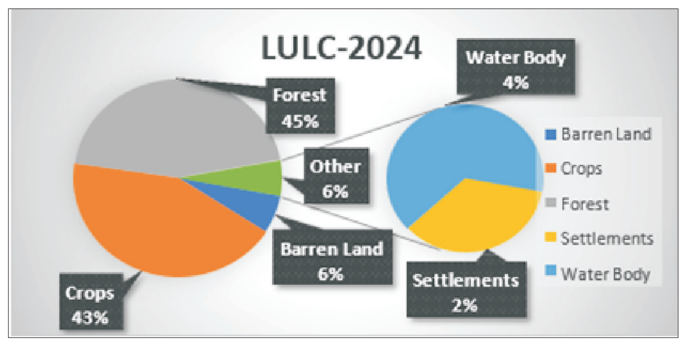

Fig. 10. Shows the LULC area distribution during 2024

reclamation and reforestation over the previous six years, the percentage of barren land was at least 6%. The water bodies' area was constant at about settlements at 2%, and 4%. The taluk's land management appears to have improved, as seen by the declining trend of barren area and the corresponding rise in productive land cover. In 2024, the classification accuracy was 84.12% (Kappa = 0.763; Table 4).

Accuracy Assessment

Confusion matrices were used to assess classification accuracy using 120 field-validated reference points annually. From 83.14% in 2018 (Kappa = 0.745; Table 2) to 83.56% in 2021 (Kappa = 0.768; Table 3) and 84.12% in 2022, overall accuracy gradually increased (Table 4; Kappa = 0.763). The validity of the methodological framework is confirmed by the corresponding accuracy levels, which are comparable to and even higher than those of recent SVM-based LULC classification systems using Sentinel-2 data in comparable tropical semi-humid settings (Talukdar *et al.*, 2020; Thanh Noi and Kappas, 2018; Sheykhmousa

Table 1: Showing LULC assessment of Sargur Taluk for 2018, 2021, and 2024

Class	2018 (%)	2018 (km²)	2021 (%)	2021 (km²)	2024 (%)	2024 (km²)
Water Body	3	18	4	24	4	24
Forest	34	204	41	246	45	270
Crops	36	236	41	246	43	258
Barren Land	25	150	12	72	6	36
Settlements	2	12	2	12	2	12

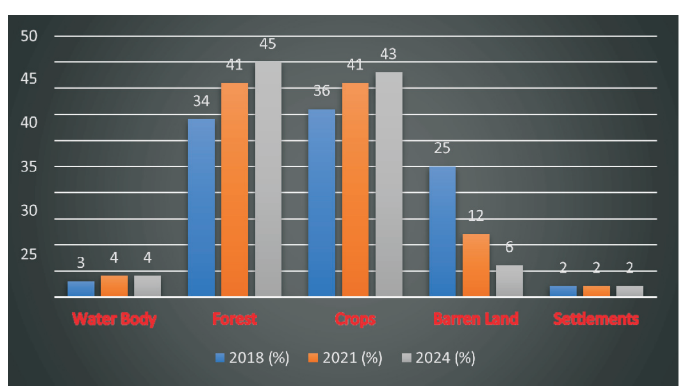

Fig. 11. Showing Land Use/Land Cover Change in Sargur Taluk (2018–2024)

Table 2: Confusion matrix for a classified map of 2018

Classified Data		Reference Data				
Class	Number of samples	Water Body	Forest	Crops	Settle-ments	Barren Land
Water Body	15	0	5	0	0	10
Forest	215	200	10	0	5	0
Crops	160	20	120	5	10	5
Settlements	15	10	0	5	0	0
Barren Land	95	10	5	80	0	0
Overall Accuracy = 81 %		Cohen's Kappa≈0.72				

Table 3: Confusion matrix for a classified map of 2021

Classified Data		Reference Data				
Class	Number of samples	Water Body	Forest	Crops	Settle-ments	Barren Land
Water Body	15	0	5	0	0	10
Forest	215	200	10	0	0	5
Crops	160	20	120	5	5	10
Settlements	15	10	0	5	5	0
Barren Land	95	10	5	0	0	80
Overall Accuracy = 81 %		Cohen's Kappa≈0.72				

et al., 2020). Cropland and forest classes consistently had the highest user accuracy due to their unique signatures in Sentinel-2 bands. A lower accuracy was recorded for settlements because it was misclassified with barren land, which is a scope for further improvement by including the Normalized Difference Built-up Index (NDBI). The revisions show the consistent approach to monitor water, forest, crop and barren land changes over time but further work is needed to identify built-up areas. The temporal assessment provides critical information for urban and ecosystem planners, economic developers and environmental monitoring personnel in Sargur Taluk.

Table 4: Confusion matrix for a classified map of 2024

Classified Data		Reference Data				
Class	Number of samples	Water Body	Forest	Crops	Settle-ments	Barren Land
Water Body	15	0	7	0	0	8
Forest	215	195	10	5	5	0
Crops	160	19	121	5	9	6
Settlements	15	6	4	5	0	0
BarrenLand	95	18	5	72	0	0
Overall Accuracy = 78.69 %		Cohen's Kappa≈0.69				

Conclusions

This study provides a thorough multi-temporal LULC analysis of Sargur Taluk, Mysuru District, Karnataka in 2018, 2021, and 2024 using SVM classification and Sentinel-2 data. Agriculture increased from 36% to 43%, and forest area increased from 34% to 45% with a significant drop in barren land from 25% to 6% in six years. These changes are driven by natural forest regeneration, reforestation initiatives, better crop management and successful land reclamation. The geomorphological setting largely controls the spatial distribution of LULC, with forest growth on steep gneissic hills and cultivation on alluvial plains that are fertile. The SVM classification method is validated by the classification accuracy of 83.14% to 84.12% (Kappa 0.745 to 0.768). Quantitative proof of sustainable land is provided by the LULC maps. solutions for resource management and conservation in the ecologically vulnerable Western Ghats. For longer-term and more thorough studies, future work should incorporate object-based classification, higher resolution remote sensing, and forecast land use modelling.

Authors' Contributions

MK: Data curation, Writing- Original Draft Preparation, Software, Validation. **DN**: Methodology, Supervision, Reviewing and Editing. **VA**: Visualisation, Investigation, Formal Analysis. **KL**: Conceptualisation, Writing- Reviewing and Editing. **PN:** Supervision, Reviewing and Editing.

Conflict of Interests

The authors declare that they have no conflict of interest related to this study. The research was conducted without any commercial or financial relationships that could be considered as a potential conflict of interest.

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