Assessment of Land Use Land Cover Accuracy Using Geospatial Technology

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1. Introduction

The conversion of natural land cover to human-dominated land use systems impacts the environment, and satellite imagery provides essential data for assessing these changes (Hill et al., 2008). Land use classification supports policy-making, business, and environmental protection (Rwanga and Ndambuki, 2017). Geospatial technologies like Remote Sensing (RS) and GIS are crucial for modeling forest variables and spectral reflectance (Das and Singh, 2016). Accuracy assessment, comparing classified images with ground truth data, ensures data quality (Congalton, 1991). Metrics such as Producer's and User's Accuracy, and Kappa coefficient are used to evaluate classification accuracy (Foody, 2002). This study aimed to classify LULC and assess classification accuracy.

2. Materials and Methods:

This paper covers the analysis of LULC classification and mapping and accuracy assessment.

2.1 Study Area:

Dakshina Kannada, located in Karnataka, India, is a coastal district spanning an area of 4,845.6 km², with geographical coordinates between 12°27'28.798"N to 13°11'16.437"N latitude and 74°46'40.689"E to 75°40'19.386"E longitude (Figure 1).

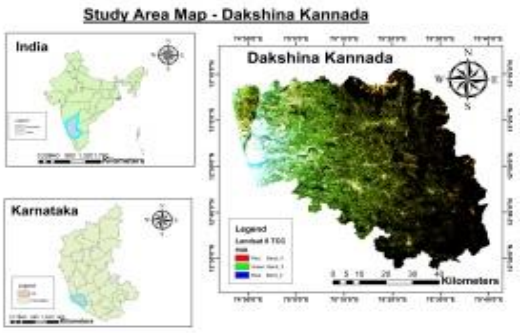

Figure 1: Study area map of Dakshina Kannada (Landsat image).

The district has an elevation range from 0.0 m to 1,115 m above mean sea level, bordered by the Western Ghats to the east and the coastline to the west. The climate is hot and dry in the

summer, with heavy rainfall of 4,030 mm during the monsoon, and mildly temperate and humid in the winter (Naik et al., 2023).

2.2 Data collection, Image Pre-Processing and Image Processing:

Classification process and analysis of the different LULC classes were done using Landsat 8 OLI-TIRS satellite images acquired on 2020 from United States Geological Survey (USGS) Earth Explorer (https://earthexplorer.usgs.gov/) (Table 1). Each Landsat image was georeferenced to the WGS84 datum and Universal Transverse Mercator Zone 43 North coordinate system (Aber *et al.*, 2019).An intensive pre-processing such as geo-referencing with the reference to SOI toposheets (scale 1:50,000) and mosaicking were carried out in order to Ortho-rectify the satellite images. The study area was extracted by layer stacking and the image was then enhanced with false color composition (FCC), true color composition (TCC) and principle component analysis (PCA) in ArcGIS 10.8 software (Asare *et al.*, 2020).

Table 1: Data specification

Satellite	Sensor	Path/Row	Spatial resolution (m)	Acquisition Date	Cloud Cover (%)	Source
Landsat 8	OLI-TIRS	145/51 146/51	30 30	03/02/2020 26/12/2020	<20 <20	USGS Earth Explorer

2.3 Analysis and Assessment of LULC Classification and LULC Accuracy:

2.3.1 LULC Classification: The pre-processed 2020 satellite image was classified using the Supervised Maximum Likelihood Classification (MLC) algorithm in ArcGIS 10.8, based on training signature files (Richards & Richards, 2022). Considering the spatial resolution of the satellite sensors six LULC classes were identified: built-up, barren land, forest, sand, agricultural land and water bodies.

2.3.2 **Accuracy Assessment:** The overall accuracy is calculated using simple descriptive statistics by dividing the sum of the principal diagonal by the total pixels in the confusion matrix. Kappa analysis, a multivariate technique, provides the Khat statistic to measure agreement or accuracy (Güler et al., 2007). The Overall Accuracy and Khat statistic is computed as:

Overall accuracy = $\frac{\sum_{i=1}^{r} x_{ii}}{x}$, Where x_{ii} is the diagonal numbers in the confusion matrix and x is the total number of samples

Khat statistic, $K = \frac{N(\sum_{i=1}^{r} x_{ii}) - (\sum_{i=1}^{r} (x_{i+}.x_{+i}))}{N^2 - \sum_{i=1}^{r} (x_{i+}.x_{+i})}$, Where; r = number of rows and columns in the error matrix, N = total number of observations (pixels) included in matrix, x_{ii} = number of observations in row i and column I (on the major diagonal), x_{i+} = marginal total of observations in row i, and x_{+i} = marginal total of observations in column i.

3. Results and Discussion

3.1 LULC Status of Dakshina Kannada in 2020:

Six major LULC types are classified for the year 2020 and the simple statistics about the percentage and areal coverage of each LULC for the year 2020 which is derived based on the classification results are summarized in Table 2.The classification results of Dakshina Kannada for the year 2020 obtained from Landsat image is represented in Figure 2. In 2020, the greatest share of LULC, from all classes was forest and agriculture land, which covers an area of 2154.7 Km^2 and 1525.2 Km^2 each accounting for 44.47% and 31.47% of total land of the district respectively. Followed by water body with an area 506.68 Km^2 (10.46%) and built up area with 384.59 Km^2 (7.93%) and least covered with sand and barren land accounted each for 3.80% and 1.87% with an area of 184.24 Km^2 and 90.2 Km^2 respectively.

Table 2: Summary of area statistics for the map of 2020 in Dakshina Kannada District.

Category	Land cover in 2020	
	Area (Km2)	%
Forest	2154.7	44.47
Agriculture land	1525.2	31.47
Built up land	384.59	7.93
Water body	506.68	10.46
Barren land	90.2	1.87
Sand	184.24	3.80
Total	4845.6	100

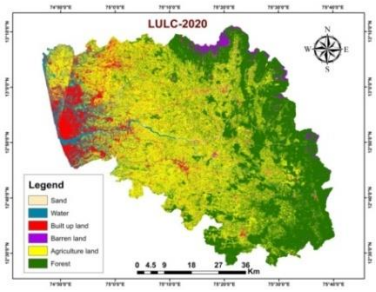

Figure 2: LULC classification map of Dakshina Kannada using Landsat 8 OLI-TIRS 2020.

3.2 Accuracy Assessment of LULC Thematic Map 2020:

The 2020 LULC map achieved an overall accuracy of 92% and a kappa coefficient of 0.88,

with producer's accuracy exceeding 85% for all classes except barren land (67%). User's accuracy was over 90% for all classes, except for sand and barren land, which showed significant confusion due to their similar reflection values (Table 3).

Table 3: Summary of the error matrix of the accuracy assessment of the LULC map.

Classified	Reference						Total	User Accuracy (%)	Kappa (K)
	Sand	Water body	Built up land	Barren land	Agriculture land	Forest			
Sand	7	0	5	3	4	0	19	37	0
Water body	0	53	1	0	3	0	57	93	0
Built up land	0	0	37	0	1	0	38	97	0
Barren land	0	0	0	6	1	1	8	75	0
Agriculture land	0	0	0	0	157	11	168	93	0
Forest	0	0	0	0	11	199	210	95	0
Total	7	53	43	9	177	211	500	0	0
Producer Accuracy (%)	100	100	86	67	89	94	0	92	0
Kappa (K)	0	0	0	0	0	0	0	0	0.880183

4. Conclusion and Recommendation:

The study successfully mapped and quantified the Land Use and Land Cover (LULC) distribution in the study area using remote sensing and GIS, identifying forest and agricultural land as the dominant land covers. The Maximum Likelihood Classification (MLC) algorithm applied in ArcGIS 10.8 achieved a high overall accuracy of 92% and a Kappa coefficient of 0.88, indicating reliable classification results. These findings provide valuable insights for informed decision-making, aiding sustainable land use management and environmental conservation efforts in the region.

References

1. Aber, J. S., Marzolff, I., Ries, J. B., & Aber, S. E. (2019). Digital image processing and analysis In small-format aerial photography and UAS imagery: principles, techniques, and geoscience applications. *Academic Press, Second Edition*, 191-196. https://doi.org/10.1016/B978-0-12-812942-5.00011-2.
2. Asare, Y. M., Forkuo, E. K., Forkuor, G., & Thiel, M. (2020). Evaluation of gap-filling methods for Landsat 7 ETM+ SLC-off image for LULC classification in a heterogeneous

landscape of West Africa. *International journal of remote sensing*, *Vol.41*, 2544-2564. https://doi.org/10.1080/01431161.2019.1693076.

3. Congalton, R.G. (1991). A Review of Assessing the Accuracy of Classifications of Remotely Sensed Data. *Remote Sensing of Environment*, *Vol.37*, 35-46. https://doi.org/10.1016/0034-4257(91)90048-B.
4. Das, S., & Singh, T. P. (2016). Forest type, diversity and biomass estimation in tropical forests of Western Ghat of Maharashtra using geospatial techniques. *Small-scale forestry*, *Vol.15*, 517-532. https://doi.org/10.1007/s11842-016-9337-y.
5. Foody, G. M. (2002). Status of land cover classification accuracy assessment. *Remote sensing of environment*, *Vol.80*, 185-201. https://doi.org/10.1016/S0034-4257(01)00295-4.
6. Güler, M., Yomralıoğlu, T., & Reis, S. (2007). Using landsat data to determine land use/land cover changes in Samsun, Turkey. *Environmental monitoring and assessment*, *Vol.127*, 155-167. https://doi.org/10.1007/s10661-006-9270-1.
7. Hill, J., Stellmes, M., Udelhoven, T., Röder, A., & Sommer, S. (2008). Mediterranean desertification and land degradation: Mapping related land use change syndromes based on satellite observations. *Global and Planetary Change*, *Vol.64*, 146-157. https://doi.org/10.1016/j.gloplacha.2008.10.005.
8. Naik, N., Chandrasekaran, K., Sundaram, V. M., Panneer, P., 2023. Dual attention guided deep encoder-decoder network for change analysis in land use/land cover for Dakshina Kannada District, Karnataka, India. *Environmental Earth Sciences*. *Vol.82*, 33. https://doi.org/10.1007/s12665-022-10713-1.
9. Rwanga, S. S., & Ndambuki, J. M. (2017). Accuracy assessment of land use/land cover classification using remote sensing and GIS. *International Journal of Geosciences*, *Vol.8*, 611. https://doi.org/10.4236/ijg.2017.84033.
10. Stehman, S. V., & Foody, G. M. (2019). Key issues in rigorous accuracy assessment of land cover products. *Remote Sensing of Environment*, *Vol.231*, 111199. https://doi.org/10.1016/j.rse.2019.05.018.

Reference to a book (ISBN):

1. Richards, J. A., & Richards, J. A. (2022). *Remote sensing digital image analysis* (Sixth edition, Vol. 5, pp. 256-258). Berlin/Heidelberg, Germany: springer. https://doi.org/10.1007/978-3-030-82327-6.