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Land Use and Land Cover Analysis and Prediction Using Machine Learning Approach: A Case Study of Gaibandha District, Bangladesh

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INTRODUCTION & AIM

Land use and land cover (LULC) change analysis is at the core of analyzing a region's landscape dynamics and informs sustainable environmental decision-making and policy planning. For Bangladesh, with its urbanization and expansion of agricultural cover, these problems have a considerable influence on natural resources and ecosystems, necessitating the analysis of LULC change to map out future development plans. The study focuses on Gaibandha district, Bangladesh, using Google Earth Engine (GEE) and a machine learning approach in exploring LULC changes between 2019 and 2022, with projections to 2025. Utilizing ESRI Global Land Cover data and combining elevation data from SRTM, the study builds a Random Forest classifier to predict land cover changes, identifying nine distinct LULC classes, e.g., water, trees, flooded vegetation, crops, built-up, bare ground, snow/ice, clouds, and rangeland [1–3]. The result, as empirically tested for accuracy, reveals extensive landscape transformations, particularly agricultural-to-built-up area conversion, pointing to the operating forces of urbanization. Second, the research employs Shannon's diversity index and transition matrix analysis in assessing and interpreting landscape heterogeneity and change patterns. The 2025 forecasts show that urban expansion and agricultural land conversion will continue to be major environmental concerns. This research identifies the potential of cloud-based remote sensing platforms like GEE to monitor LULC change at regional scales and aid data-informed decision-making for regional development and climate change resilience planning.

METHOD

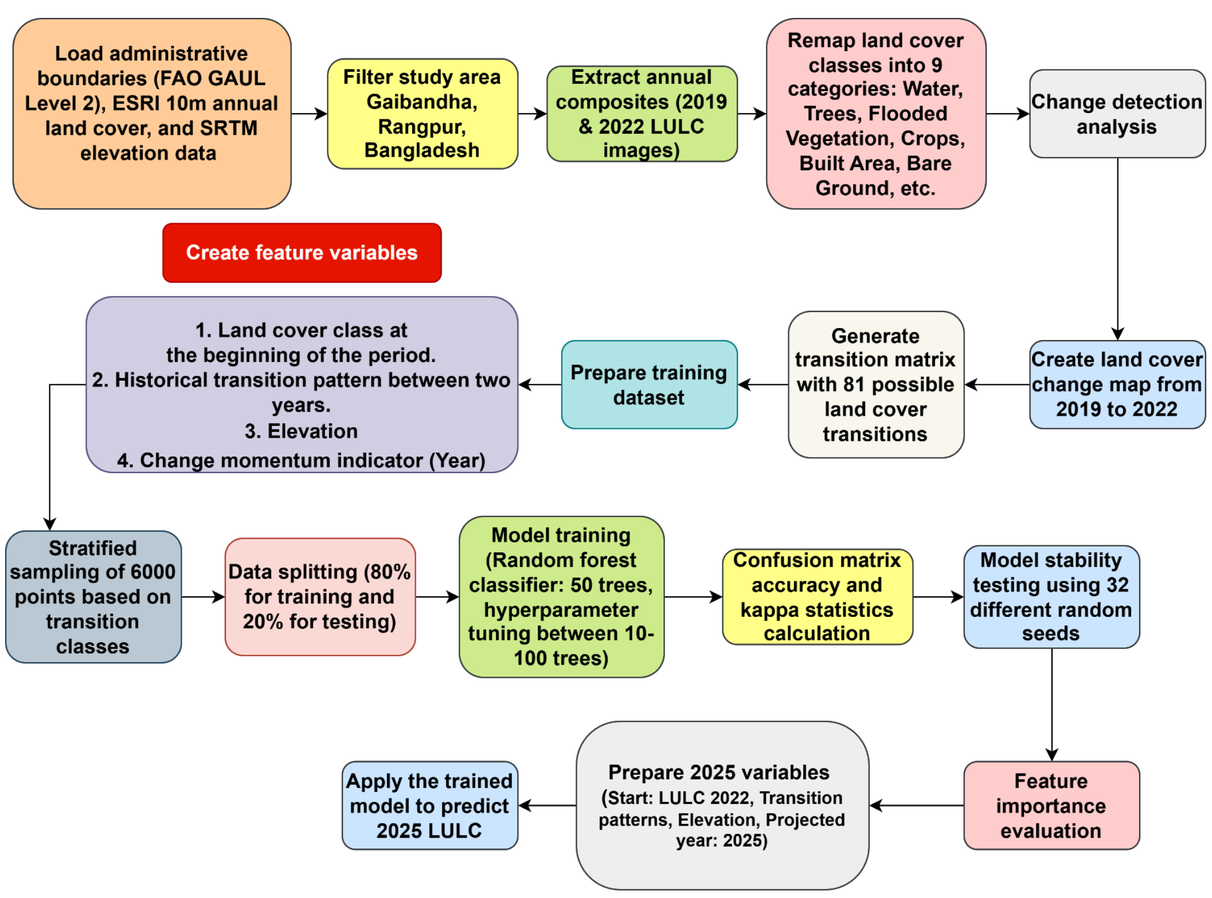


Figure 1. Methodological flowchart.

STUDY AREA

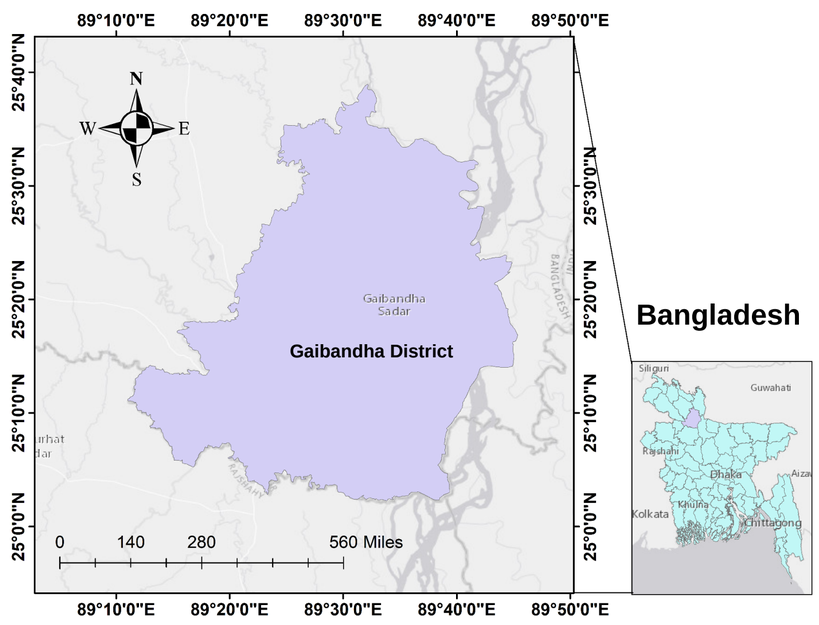
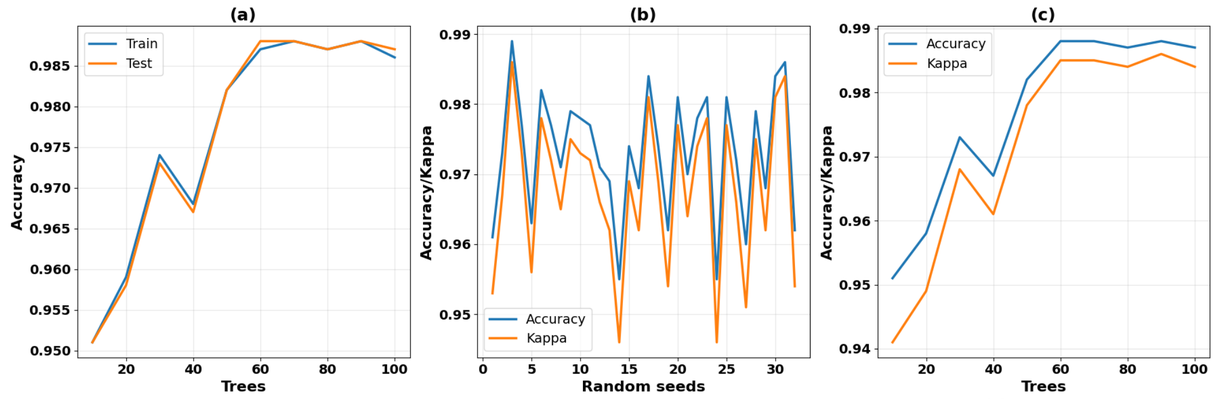


Figure 2. Study area.

RESULTS & DISCUSSION



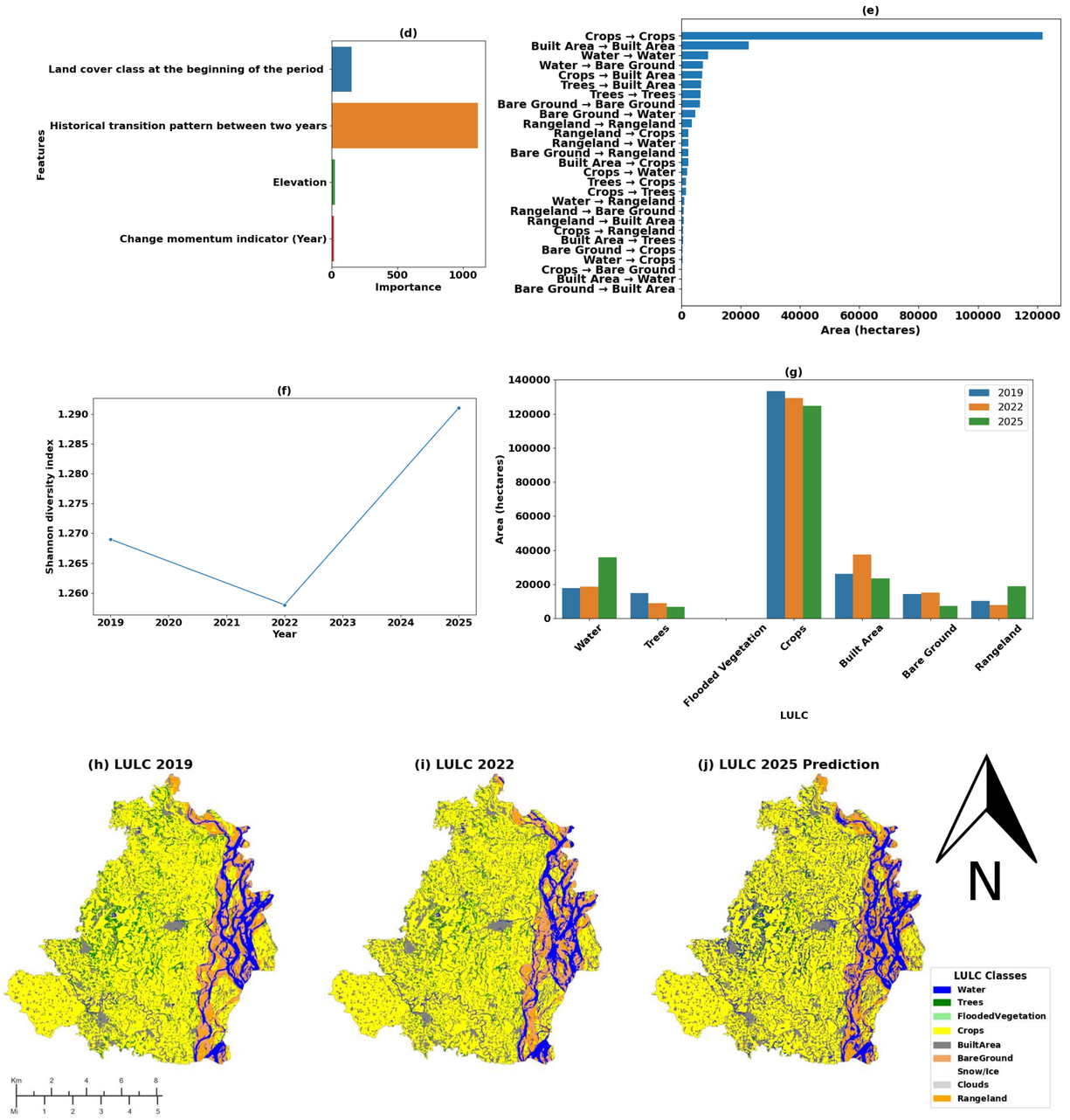


Figure 3. Model performance evaluation and land cover change analysis: (a) Overfitting analysis showing train vs. test accuracy, (b) Model stability across different random seeds, (c) Learning Curve: Accuracy vs. number of trees, (d) Feature importance in Random Forest classification, (e) Significant land cover transitions (2019 to 2022), (f) Shannon diversity index temporal variation, and (g) Land cover distribution by class across years (2019, 2022, 2025), LULC maps for (h) 2019, (i) 2022, and (j) 2025 prediction.

CONCLUSION & FUTURE WORK

Future work would involve incorporating higher-resolution satellite images and other data sources, i.e., socio-economic variables, into the models to enhance the accuracy of LULC predictions. Including time-series analysis to capture more detailed temporal patterns and expanding the analysis to other parts of Bangladesh would provide a broader understanding of LULC processes. Also, the incorporation of deep learning techniques would help the model detect small land cover variations and improve its predictive capability. Lastly, field validation would render the predictions more trustworthy and help in policy-making more effectively.

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