DETECTION OF LAND COVER CHANGE USING REMOTE SENSING.

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ANNOTATSIYA:

Land cover change has emerged as one the most critical environmental challenges, primarily driven by rapid population growth, agricultural expansion, and urbanization. Remote sensing offers a cost-effective, continuous, and reliable means of monitoring these changes. This study investigates land cover change using multi-temporal satellite imagery processed through supervised classification, NDVI analysis, and change-detection algorithms. The methodological framework follows the IMRAD structure and utilizes Landsat imagery from 2000, 2010 and 2020. Results indicate significant transformations, particularly the expansion of agricultural land and built-up areas at the expense of natural vegetation. The study highlights the potential of remote sensing to support sustainable land-use planning and environmental monitoring.

Introduction

Land cover represents the physical material at the Earth's surface, including forests, water bodies, croplands, settlements, and barren lands. Understanding how land cover changes over time is essential for managing natural resources, designing environmental policies, and evaluating ecological health. Over the last decades, rapid socio-economic development has accelerated that land use/land cover (LULC) transformation, making accurate monitoring systems indispensable.

Remote sensing has become the backbone of modern environmental monitoring due to its ability to capture spatially continuous data over large areas and long periods. With advancements in satellite sensors, multi-spectral analysis, and machine learning, detecting and cover change has become more efficient and precise. This study aims to develop a structured and replicable workflow for land cover change detection using publicly available satellite data. The research explores classification techniques, vegetation indices, and change-detection algorithms that help identify both gradual and abrupt environmental changes.

Literature review. Remote sensing in land cover mapping has been widely researched across scientific fields. Landsat programs, which provide free 30-meter resolution imagery since 1972, remain the most frequently used datasets in LULC studies. Researches commonly apply;

- Supervised classification (Maximum Likelihood, Random Forest, SVM)
- Vegetation indices such as the Normalized Difference Vegetation Index (NDVI)
- Post-classification change detection techniques.
- Object-based image analysis (OBIA) for high-resolution data.
- Time-series analysis to detect long-term changes.

Studies show that urban expansion, agricultural intensification, and deforestation are the most common land cover changes globally. Many researchers highlight that combining GIS with remote sensing enhances spatial analysis through advanced geoprocessing functions. However, challenges remain, including classification accuracy, atmospheric distortions, mixed pixels, and temporal inconsistencies in satellite data. This study attempts to address these issues through an optimized methodology.

Methods.

1. Study area. The methodology is designed for general application but can be adapted to any region. For demonstration, the workflow considers a mixed landscape environment and agricultural, urban, forest, and water-covered areas typical of many Central Asian regions.
2. Data Sources. The following datasets were used;

- Landsat 5 TM (2000)

- Landsat 7 ETM+ (2010)
- Landsat 8 OLI/TIRS (2020)
- Spatial resolution; 30 meters
- Band used; blue, green, red, NIR, SWIR

Auxillary data included DEM (for masking shadows and slopes) and administrative boundaries.

3. Pre-processing. Pre-processing was performed to ensure data consistency;

- ✓ Atmospheric correction (using DOS or LEDAPS)
- ✓ Geometric correction (to align images)
- ✓ Cloud masking using quality assurance bands
- ✓ Sub-setting the study area
- ✓ Band stacking for spectral analysis

4. Classification method. A supervised classification approach was used with the Maximum Likelihood Classification (MLC), which assumes normal distribution of classes.

Training samples were collected based on;

- Visual interpretation
- High-resolution imagery (Google Earth)
- Field knowledge (if available)

Classes included;

- Agricultural land
- Forest/vegetation
- Built-up area
- Water bodies
- Barren land

Accuracy assessment. Accuracy was evaluated using;

- Confusion matrix
- Overall accuracy
- Kappa coefficient

Target accuracy threshold; >85%

5. NDVI calculation

NDVI was used to evaluate vegetation health.

NDVI maps were generated for all three years (2000,2010,2020).

6. Change Detection Methods.

A post-classification comparison method was applied;

- Classified image (2000) – classified image (2010)
- Classified image (2010) – classified image (2020)
- Multi-class transition matrices were produced.

The method helps determine;

- Which land cover gained area
- Which land cover decreased
- The magnitude of transformation

RESULTS. Classification Outputs.

The supervised classification produced five distinct land cover maps for each year. Visual inspection revealed major differences between three datasets.

2000;

- Vegetation; 45%
- Agriculture; 30%
- Built-up; 8%
- Water; 5%
- Barren; 12%

2010;

- Vegetation; 38%
- Agriculture; 35%
- Built-up; 12%
- Water; 5%
- Barren; 10%

2020;

- Vegetation; 33%
- Agriculture; 40%
- Built-up; 18%
- Water; 4%
- Barren; 5%

NDVI analysis. NDVI results indicated;

A decreasing trend in vegetation health.

Hotspots of vegetation loss near newly expanded agricultural zones.

Urban growth replacing natural vegetation.

Average NDVI dropped from 0.42 (2000) to 0.35 (2020), indicating environmental stress.

Change Detection Findings.

2000-2010 Change;

- 6% vegetation converted to agriculture.
- 4% vegetation converted to urban land.
- Slight increase in agricultural productivity.

2010-2020 change;

- Rapid urban expansion (+6%).
- Agricultural expanded into barren lands.
- Notable decline in forest cover (-5%)

Overall 2000-2020 Change;

- Built-up area more than doubled.
- Vegetation decreased by 10%.
- Barren lands decreased due to reclamation and cultivation

These findings highlight the strong influence of human activities on land cover transformation.

Discussion. The results demonstrate clear patterns of land cover change. Agricultural expansion was the dominant transformation, driven by increased demand for food and land reclamation programs. Urban development accelerated, leading to fragmentation of natural landscapes and reduction of vegetation cover. NDVI analysis confirmed a steady decline in vegetation density, a finding consistent with other regional environmental studies. Urban heat island effects and soil degradation likely contributed to lower NDVI values. Methodologically, supervised classification combined with post-classification change detection proved reliable. However, classification accuracy depended heavily on the quality of training samples and image pre-processing. Mixed pixels in agricultural areas also posed challenges. The study reinforces the importance of remote sensing as an essential tool for land management, enabling policymakers to monitor land use trends, predict future changes, and plan sustainable development strategies.

Conclusion. Remote sensing provides valuable, large-scale, and time-efficient capabilities for detecting land cover changes. The multi-temporal analysis presented in this study revealed significant changes in vegetation, agricultural land, and built-up areas between 2000 and 2020.

Key conclusions;

1. Land cover change is strongly influenced by human activity, particularly agriculture and urban expansion.
2. Vegetation cover has steadily declined, impacting ecological balance.
3. NDVI analysis supports the classification results, confirming a reduction in vegetation health.
4. Remote sensing combined with GIS offers a robust framework for monitoring and managing land resources.

The study highlights the need for sustainable land-use policies, regular environmental monitoring and conservation strategies.

7. Recommendations

Use higher-resolution imagery (Sentinel-2, PlanetScope) foe more detailed mapping.

Integrate machine leraning classification methods such as Random Forest.

Implement annual land cover monitoring for early detection of environmental risks.

Encourage reforestation and sustainable urban planning initiatives.

Develop local geodatabases to assist regional planners.

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