Land Degradation (UN SDG 15.3.1) and Urban Expansion in Lucknow Using MODIS and Landsat (2001-2020)

Zahra Rizvi, Sophia Rizvi, Susan Zehra

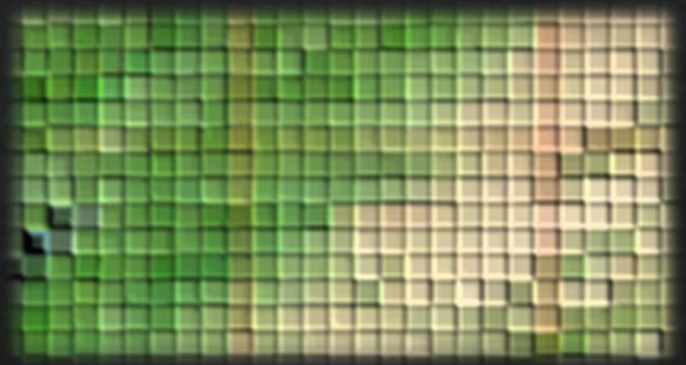
Problem & Motivation

- Land degradation + rapid urban expansion = critical challenges for SDG 15.3.1.
- Lucknow, India: population ↑ from 2.3M (2001) → 3.7M (2020).
- Need reproducible, open workflow to monitor land change.

Fig. 1: Location of Lucknow within Uttar Pradesh, India.

Data Sources

- MODIS MCD12Q1 (500m, annual, IGBP classes).
- Landsat 7/8 (30m, NDVI composites).
- Study Area: Lucknow, Uttar Pradesh.
- Time frame: 2001 vs. 2020.



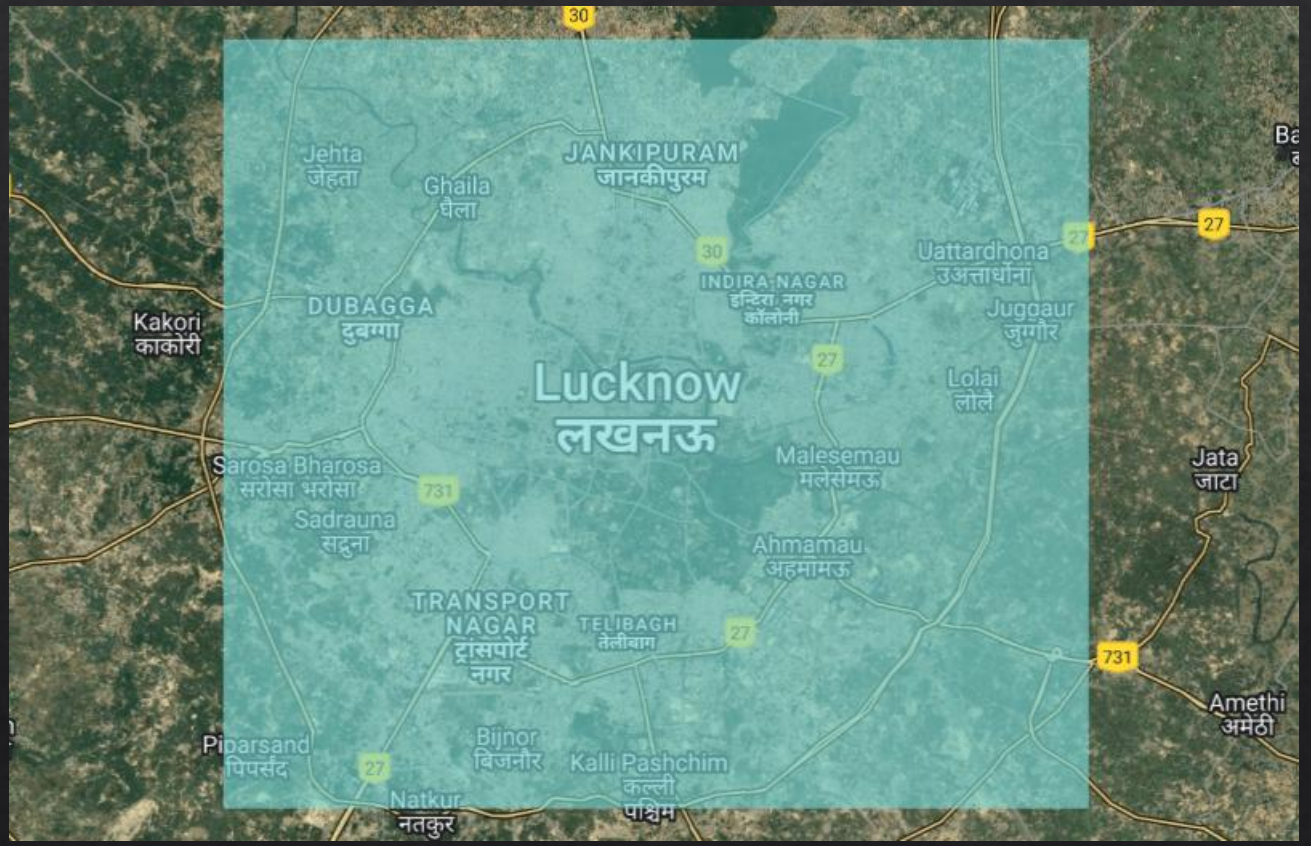


Fig. 2: Area of interest (From GEE).

Workflow / Methodology

Built entirely on Google Earth Engine. Steps involved:

- MODIS land-cover pixel counts (2001, 2020).
- Landsat NDVI composites & statistics.
- Merge + sample 1,000 points for NDVI–land-cover analysis.
- Validation with zoning maps & high-res imagery.
- Open-Source Code: https://github.com/rizvizahra/lucknow_sdg_15_3_1/

Algorithm 1 Land Cover and NDVI Analysis in Lucknow

1: **Define Study Area:** Set geographic bounding box for Lucknow (Lat: 26.72–26.96, Lon: 80.80–81.10)
2: **Select Years of Interest:** Define years to compare
3: **Load MODIS Land Cover Data:** Import MODIS MCD12Q1 product and extract IGBP classes
4: **Load and Preprocess Landsat Data:**
- Import Landsat 7 and 8 collections
- Apply cloud and shadow masking
- Normalize reflectance and compute NDVI
- Generate annual median composites

5: **Reproject and Merge Datasets:** Align Landsat and MODIS resolutions (500 m) and combine NDVI with land cover labels
6: **Generate Sample Data:** Randomly sample 1000 pixels for training and NDVI analysis
7: **Visualize Results:**
- Plot histograms of land cover class distributions
- Create bar charts comparing pixel counts per class
- Display NDVI histogram and scatter plot of NDVI vs. land cover class

8: **Compute Summary Tables:**
- Count pixels per IGBP class for each year
- Compute NDVI statistics (mean, min, max) per year

9: **Export Results:** Print land cover and NDVI statistics

Results: Land Cover Change

- Cropland ↓ 13.9% (Class 12).
- Urban ↑ 17% (Class 13).
- Grassland + Savanna ↑ in peri-urban zones.

Table I: Land–cover class counts for selected classes.

Class	Description	Count 2001	Count 2020	Δ
9	Savanna	4	52	+48
10	Grassland	24	169	+145
12	Croplands	2,357.77	2,029.85	–327.92
13	Urban	791.31	925.31	+134.00
14	Cropland	0	0.92	+0.92

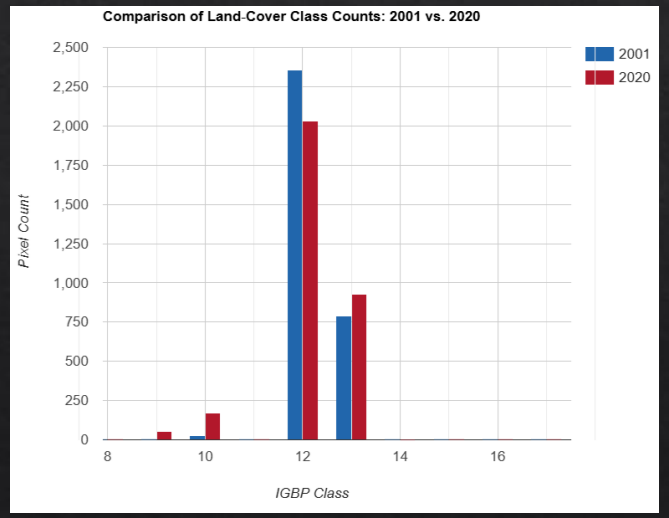


Fig. 3: Comparison of IGBP land–cover class pixel counts between 2001 and 2020, based on MODIS MCD12Q1 data.

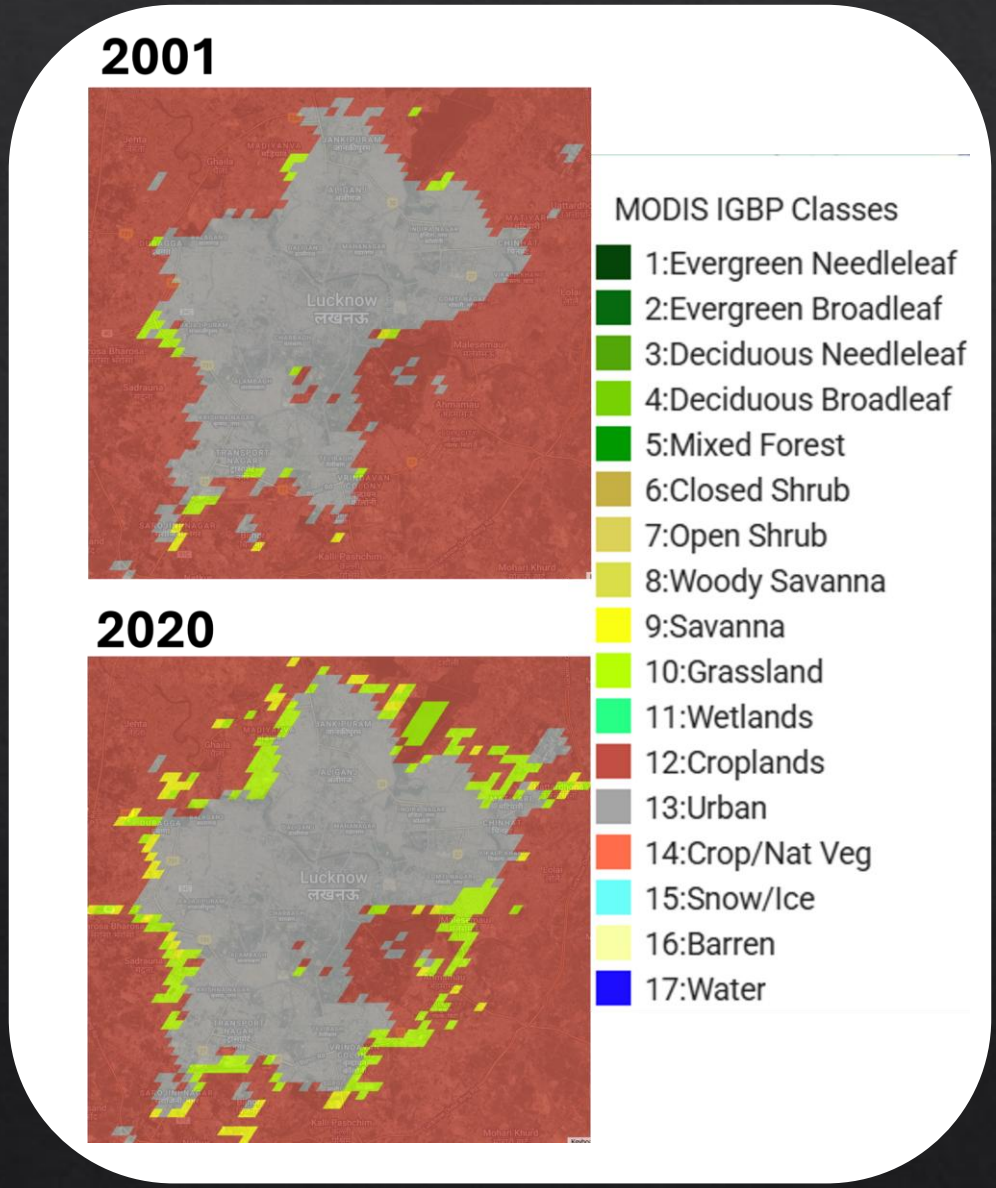


Fig. 4: Expansion of the urban area over time.

Results: Vegetation & ML Pilot

- NDVI mean declined by –0.0315 (weaker vegetation health).
- High NDVI patches = irrigated fields, parks.
- Logistic regression (proof of concept): 82% accuracy (urban vs cropland vs grassland).

Fig. 5: Scatter of NDVI vs. IGBP Class (2020).

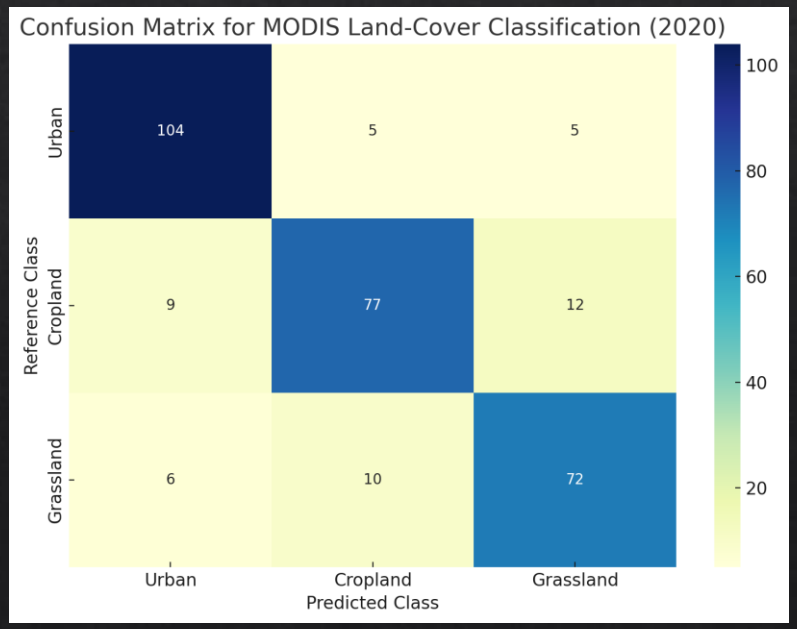


Fig. 6: Confusion matrix for MODIS land-cover classification (2020), derived from stratified validation using 300 visually verified reference points.

Impact & Future Directions

- Supports urban planners & humanitarian practice (heat stress, food security).
- Reproducible, open workflow for SDG monitoring.
- Future: multi-seasonal composites + socioeconomic integration + ML classifiers.
- Public repo link https://github.com/rizvizahra/lucknow_sdg_15_3_1/

References:

1. NASA LP DAAC. MODIS Land Cover Type (MCD12Q1) Version 6 [Data set]. NASA EOSDIS Land Processes DAAC. https://doi.org/10.5067/MODIS/MCD12Q1.006
2. U.S. Geological Survey (USGS). Landsat Collection 2 Level-2 Surface Reflectance Products [Data set]. https://doi.org/10.5066/P9C7I13B
3. Google Earth Engine. A planetary-scale platform for Earth science data & analysis. https://earthengine.google.com/