Monitoring Land Use and Land Change (Lulc) In High Altitude Landscape Using Remote Sensing and Gis: A Case Study of Kishtwar (Jammu and Kashmir), India

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***Abstract*—Land is a fundamental natural resource that supports biodiversity, sustains livelihoods, and forms the basis for all economic and ecological systems. Monitoring changes in land use and land cover (LULC) is essential for assessing the impacts of urban expansion and guiding sustainable land management practices. This study investigates LULC dynamics in Kishtwar, a high-altitude landscape in Jammu and Kashmir, India, over the past 15 years using remote sensing and Geographic Information System (GIS) techniques. The results reveal significant transformations in land use patterns, particularly an increase in built-up areas at the expense of agricultural land. The application of geospatial technologies proved instrumental in detecting, visualizing, and quantifying these changes, offering valuable insights for environmental planning and resource management in mountainous regions.**

***Index Terms*—GIS, Land use and Land cover, landscape dynamics, Remote Sensing, Urban Sprawl,**

1. INTRODUCTION

Land is a vital natural resource that supports life, serves as a habitat, and underpins major economic activities (du Plessis, 2022). With rapid population growth and intensified anthropogenic pressures, the demand for land for agriculture, habitation, industry, and infrastructure has grown exponentially (Maja and Ayano, 2021). Accordingly, land is classified into two key concepts—land use and land cover. *Land use* refers to the human purpose applied to land, such as agriculture, settlements, or recreation (Roy *et al*., 2010), whereas *land cover* denotes the physical material present on the surface, including vegetation, water bodies, built-up areas, or bare soil (Roy *et al*., 2010; Ellis, 2007). Over time, land has been increasingly overexploited due to unregulated human activities (Hooke *et al*., 2012). This has led to significant alterations in land use and cover patterns, with serious consequences for ecological sustainability, food security, and climate change (Roy *et al*., 2010; Govinda Prasad *et al*., 2014). The conversion of prime agricultural lands into non-agricultural uses—such as urban expansion and industrial development—poses a critical threat to sustainable development (Miljkovic *et al*., 2012). Thus, comprehensive land use planning is essential to balance developmental needs and environmental integrity.

Traditionally, land use and land cover (LULC) changes were assessed through field surveys, which were often time-consuming and spatially limited. The advent of remote sensing technologies and Geographic Information Systems (GIS) in the 1980s revolutionized landscape monitoring. These tools enable multi-temporal, synoptic, and high-resolution assessment of Earth's surface, making them indispensable for detecting LULC changes (Rawat *et al*., 2015; Selçuk *et al*., 2003).

A substantial body of international research has utilized these technologies to monitor LULC dynamics. For example, Traore *et al.* (2021) examined the influence of LULC change on urban temperature in Bangui, while Gondwe *et al.* (2021) studied LULC transformations in Blantyre, China, over two decades. In India, Sharma *et al.* (2013) reported an increase in settlement and plantation areas alongside a decrease in agricultural and fallow lands in Jammu District between 2001 and 2011. Similarly, Mishra *et al.* (2020) documented a significant increase in dense forests and built-up areas in Sikkim Himalaya, using geospatial analysis over 29 years.

Despite these advances, high-altitude urban landscapes such as Kishtwar remain underexplored in LULC studies. Kishtwar, located in the western Himalayas, is ecologically and economically significant. The region is known for producing high-quality saffron—locally called *Kishtwari Saffron*—grown in the fertile Karewa soils of the Poochal area. However, increasing urbanization and land conversion have reduced the area under saffron cultivation and agriculture in general.

This study aims to map and analyse the spatio-temporal changes in LULC of Kishtwar city from 2005 to 2020, focusing on the declining trend in agricultural land, including saffron fields. The findings are expected to support evidence-based urban planning, resource management, and agricultural policy development for this high-altitude Himalayan city.

2. MATERIALS AND METHOD

METHODOLOGY

The present study aims to analyse the temporal dynamics of land use and land cover (LULC) in the high-altitude landscape of kishtwar, Jammu and Kashmir through the application of Remote Sensing (RS) and Geographic Information System (GIS). The study was conducted using satellite images (Landsat 7 & Landsat 8). The digitization was done in GIS environment by visual interpretation (Fig 2) using QGIS software in the form of polygons reflecting different land use categories (Fig 3). Land use maps were generated and Land use changes were observed using Post Classification Comparison Technique (Lu et al., 2004). Land use categories include- water body, open forest and dense forest, pastures, agricultural land, educational institutes and built-up area. An overlay of maps of 2005 & 2020 was created to quantify the changes (Fig 4) which are shown in the comparison chart (Fig 5).

a. Study Area

The study is focused on the Kishtwar region, located in the high-altitude zone of Jammu and Kashmir, India. Characterized by rugged topography, forested landscapes, and alpine pastures, the area is ecologically sensitive and socio-economically important. Kishtwar district falls in Jammu Division of recently created J&K UT, India (Fig 1). Kishtwar is located on 33°19` Northern latitude and 75°48` Eastern longitude with an area of 163845 hectare. Kishtwar comes under sub-tropical temperate transitional zone representing mid to high altitude. The population was 190843 (Census 2001) which increased to 230696 (Census 2011). Kishtwar is famous for Saffron, Sapphire and Kishtwar High Altitude National Park. District Kishtwar is famous its rich source of forests in Jammu and Kashmir, located on hilly mountainous region. The Kishtwar District lies in the South-East of Jammu and Kashmir touching border of Himachal Pradesh on Northern side, District Anantnag of Kashmir on Western side, Ladakh on North-Eastern side, Zanskar on Northern side and District Doda on Southern side. Kishtwar branches off in Marwah Valley, Warwan Valley, Padder Valley, Chatroo Valley and is surrounded by lofty Himalayas on all sides. The district is connected with rest of the country by all-weather road National Highway 1-B.

Fig. 1 Location map of Kishtwar city

b. Data Acquisition

Multi-temporal satellite imagery from the Landsat program was utilized for the years 2005 and 2020:

- Landsat 7 Enhanced Thematic Mapper Plus (ETM+) for the year 2005
- Landsat 8 Operational Land Imager (OLI) for the year 2020

These images were obtained from the United States Geological Survey (USGS) Earth Explorer portal. Cloud-free scenes covering the study area and captured during similar seasonal windows were selected to minimize atmospheric and phenological differences.

c. Image Preprocessing

The downloaded satellite images underwent standard preprocessing steps, including:

- Geometric correction to align images using a common coordinate reference system (WGS 84/UTM Zone 43N).
- Radiometric correction to standardize the pixel values.
- Image subset creation to clip the images to the extent of the study area using QGIS software.

d. Visual Interpretation and Digitization

Visual interpretation was employed for LULC mapping, utilizing tone, texture, shape, size, and context as guiding elements. Digitization was carried out in a GIS environment (QGIS 3.x) by creating polygon features representing different land use categories (Fig. 2 and Fig. 3).

e. Land Use and Land Cover Classification

Based on visual interpretation and ancillary data, the LULC classes were categorized as follows:

- Water Bodies
- Dense Forest
- Open Forest
- Pastures
- Agricultural Land
- Built-up Areas
- Educational Institutes

A separate LULC map was generated for each reference year (2005 and 2020). Attribute data were assigned to each polygon accordingly.

f. Change Detection Analysis

To assess the changes in LULC over the 15-year period, the Post Classification Comparison (PCC) technique was employed (Lu et al., 2004). This method involves:

- Comparing classified images from two different years
- Creating an overlay to detect transitions between land use classes
- Quantifying the gains, losses, and net changes within each LULC category (Fig. 4)

The spatial overlays of the two classified maps were analyzed using QGIS's spatial analysis tools to determine the area and direction of change. A comparison chart was generated to visually summarize the LULC transitions (Fig. 5).

g. Accuracy Assessment

Ground truth data collected during field visits and high-resolution Google Earth imagery were used to validate the classification outputs. An error matrix was created, and overall accuracy and Kappa coefficient values were calculated for each classified map.

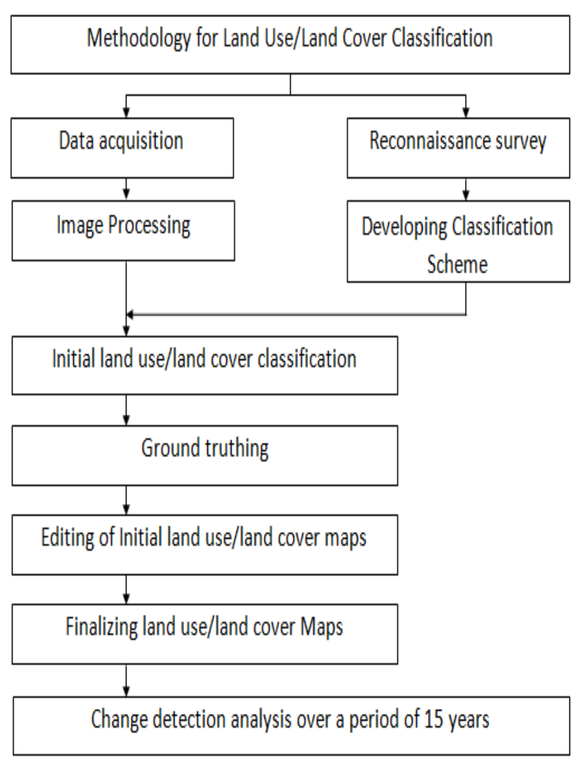

Fig. 2 Flow chart depicting methodology of LULC

3. RESULT AND DISCUSSION

Land use and land cover (LULC) changes are predominantly driven by anthropogenic activities, with population growth acting as a primary catalyst (Seema Rani, 2014; Ganaie *et al*., 2021). As the population increases, so does the demand for infrastructure development, including housing, transportation networks, educational institutions, and administrative buildings. In the present study, significant LULC transformations have been observed both within the core urban areas and the peripheral zones of Kishtwar.

The analysis revealed a notable shift in the land use pattern, particularly with respect to built-up and agricultural land categories (Phukan *et al*., 2013; Naikoo *et al*., 2020; Chen *et al*., 2014; Kleemann *et al*., 2017). Between 2005 and the current assessment period, the built-up area expanded by 221.96 hectares. In 2005, built-up land constituted approximately 11.91% (672.66 ha) of the total study area, which has increased to 15.84% (894.62 ha). This urban expansion has primarily occurred at the expense of agricultural land, resulting in a 3.93% (221.96 ha) decline in the area under cultivation (Kotoky *et al*., 2012). The pattern of expansion appears to be radial, with new constructions predominantly emerging along major roadways (Wani *et al*., 2011).

In contrast, categories such as forest cover, water bodies, pasturelands, and institutional areas exhibited minimal to no observable changes during the study period. Forested areas surrounding the city have remained stable, likely due to their proximity to the district headquarters and continuous monitoring by forest protection agencies. The central pastureland, locally known as *Chowgan*, remains intact owing to fencing and regulatory restrictions. Likewise, the Chenab River (*Chandrabhaga*), the major water body adjacent to Kishtwar, displayed no significant changes in extent or morphology over the study duration.

Overall, the study underscores a clear trend of urban sprawl at the cost of agricultural land, with potential implications for food security, ecosystem services, and urban planning. These findings can inform future land management strategies and sustainable development policies for Kishtwar and similar Himalayan towns experiencing rapid urbanization.

Table 1 Absolute changes in land use/land cover classes of the study area

Land use/Land cover classes	2005 (in ha)	2020 (in ha)	Change (ha)
Agriculture	2127 (37.67%)	1905.04 (33.74%)	-221.96 (3.93%)
Built-up	672.66 (11.91%)	894.62 (15.84%)	+221.96 (3.93%)
Pasture	32.19 (0.57%)	32.19 (0.57%)	No Visible Change
Educational Institutes	6.21 (0.1%)	6.21 (0.1%)	No Visible Change
Open Forest	2164.82 (38.34%)	2164.82 (38.34%)	No Visible Change
Dense Forest	607.71 (10.76%)	607.71 (10.76%)	No Visible Change
Water Body	35.58 (0.65%)	35.58 (0.65%)	No Visible Change
Total	5646.17	5646.17	

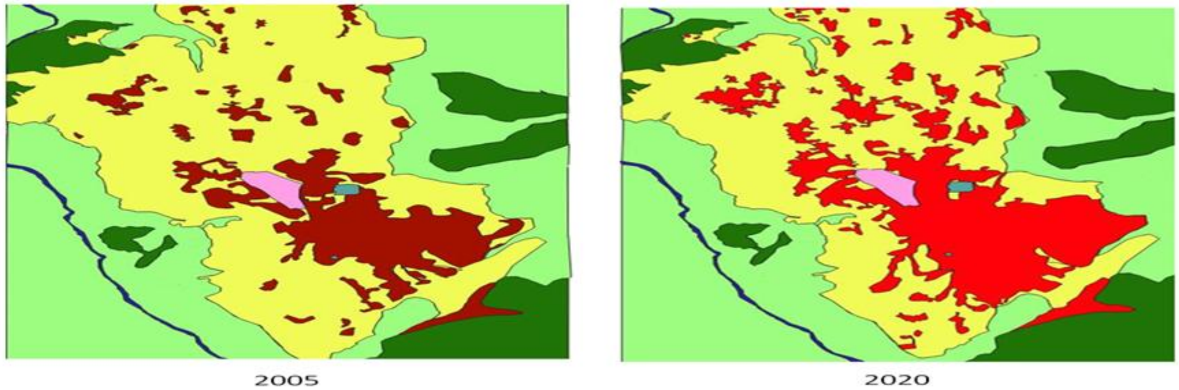

Fig. 3 LULC map of Kishtwar city for the year 2005 and 2020

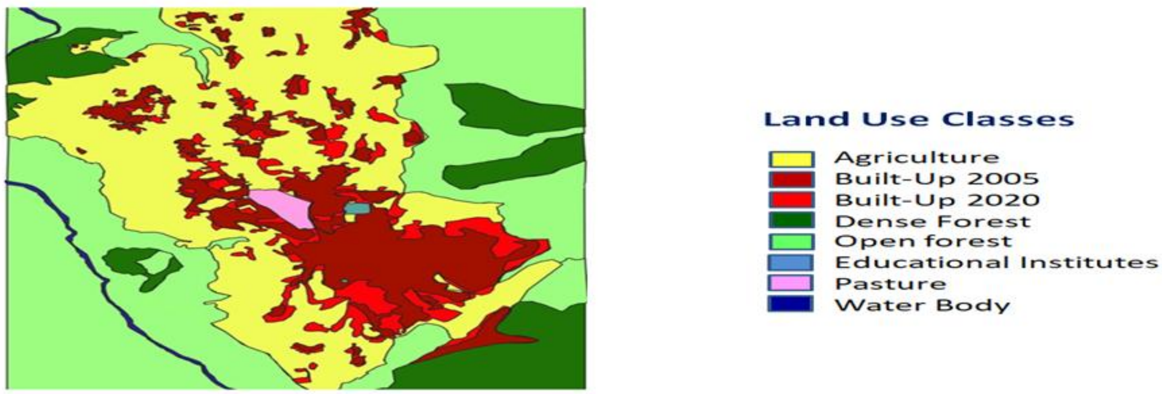

Fig. 4 Overlay of LULC Map of Kishtwar city for the year 2005 and 2020.

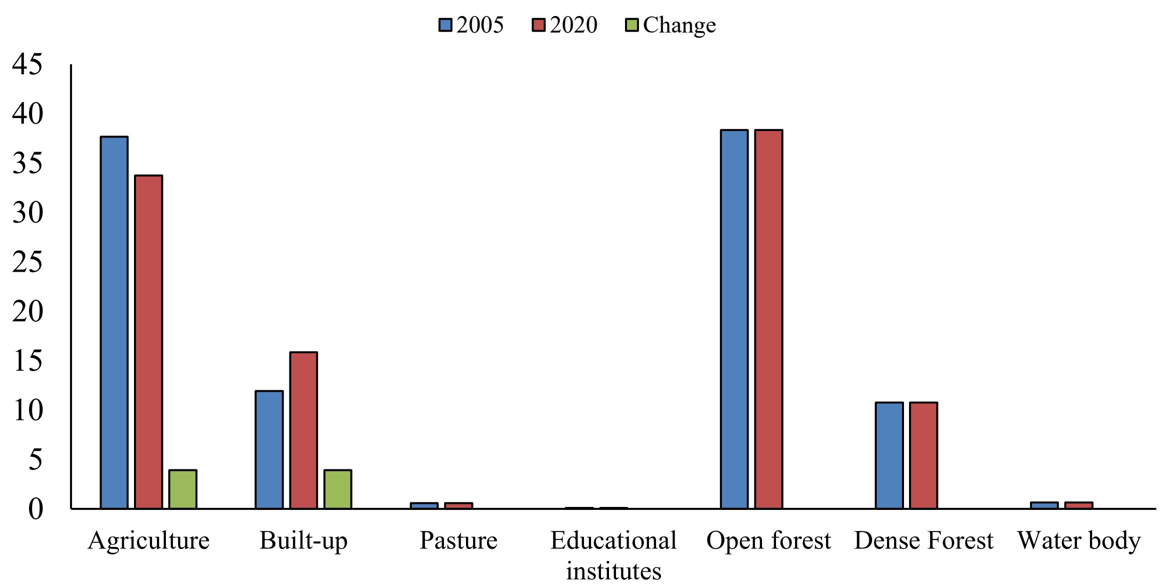

Fig. 5 Comparison chart of LULC pattern (2005-2020)

4. CONCLUSION

In quantifying the changes across various Land Use and Land Cover (LULC) classes, remote sensing has proven to be an invaluable tool for observation and mapping—capabilities that are often challenging to achieve through conventional ground surveys. Comparative analysis of LULC maps from 2005 and

2020 reveals a notable increase in built-up area, expanding from 672.66 ha to 894.62 ha**,** primarily at the expense of agricultural land. This shift in land use, particularly the growth of built-up areas, contributes to elevated surface temperatures and potentially accelerates localized climate change (Sresto *et al.*, 2022). In contrast, forested areas, pastures, and water bodies exhibited minimal changes, likely due to consistent monitoring and conservation efforts by relevant authorities. However, agricultural zones, especially those located on ecologically sensitive Karewa soils, necessitate stringent monitoring and well-defined policies to mitigate environmental externalities and ensure sustainable development. This study represents the first documented attempt to evaluate LULC dynamics in the city of Kishtwar and is expected to serve as a foundational reference for future research on land cover transformations in the region

5. CONFLICT OF INTEREST

All authors declared that there is no conflict of interest regarding the said paper.

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