ISSN 2063-5346

LAND USE / LAND COVER CHANGE DETECTION BY MULTI-TEMPORAL REMOTE SENSING IMAGERIES: TALWARA BLOCK OF PUNJAB, INDIA

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Article History: Received: 01.02.2023 **Revised:** 07.03.2023 **Accepted:** 10.04.2023

Abstract

The world's natural ecosystems are impacted by changes in land use and land cover (LULC), which are a dynamic, pervasive, and accelerating process primarily driven by anthropogenic activities and natural disasters. One of the objectives of landscape ecology is change detection. This study's primary goal is to prepare land use, land cover, and their change detections utilising GIS and remote sensing techniques. The changes in Talwara Block's land use and land cover between 2001 and 2021 are shown in this study. Landsat5 & Landsat8 imagery from 2001, 2011 and 2021 was used for the investigation. With the application of remote sensing and GIS technology, categorization maps for land use and land cover were created. The results indicate that there was a significant increasing trend in built up land and decreasing trend in agricultural Land and forest cover.

KEYWORDS: Land Use, Land Cover, Talwara District, Landsat, Remote Sensing

INTRODUCTION

Land use / Land cover exhibits the physical and economic situation of any region. Land-use refers to the way land has been used by humans and their habitats, usually with an emphasis on the functional role of land for economic activities. Land cover pertains to the physical attributes of the Earth's surface, ascertained through the dispersion of flora, aqueous bodies, earth, and other topographical characteristics of the terrain, including those constructed purely through human endeavours such as habitation. Data on alterations in land use and land cover have a significant part to perform in local and regional, as well as large-scale, preparation. Changes in land cover develop naturally and progressively, although there are instances when it occurs rapidly and abruptly due to human activities.

Remote sensing data with high resolution and various temporal intervals is crucial in the assessment of the rate and causative agents of transformations. Therefore, it plays an essential role in local planning across different spatial and temporal scales. The utilization of Geographic Information System (GIS) and Global Positioning System (GPS) in conjunction with spatial and temporal analytical technologies can facilitate the maintenance of current land-use dynamics information. This results in a sound plan and cost-effective decision-making process.

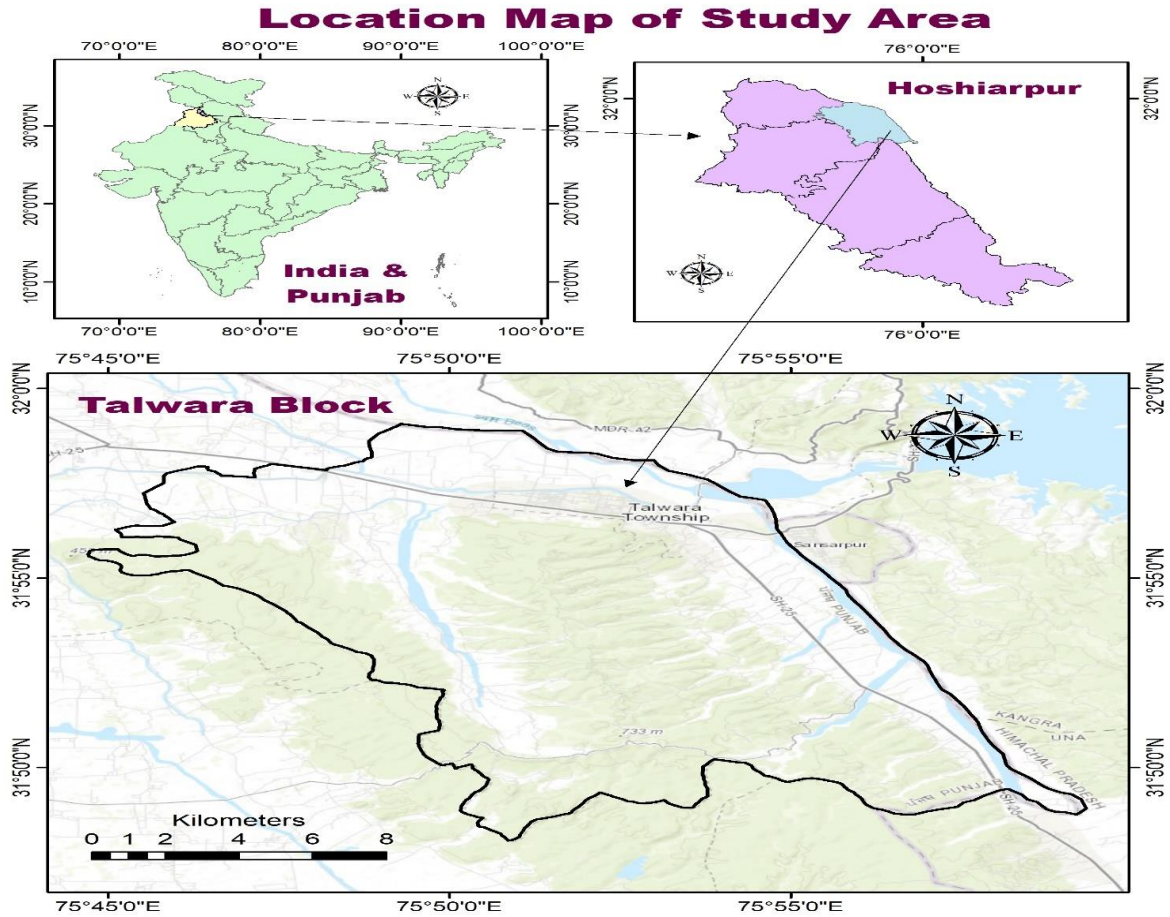
OBJECTIVES

The main objective of the study is to detect and analyse land use/land cover changes in Talwara block of Punjab, India using multi-temporal remote sensing imagery.

More specifically, the study aims to:

1. Generate land use/land cover maps for Talwara block for different time periods using satellite imagery.
2. Quantify the changes in land use/land cover patterns over time.
3. Identify the major drivers of land use/land cover change in the study area.
4. Evaluate the accuracy of the land use/land cover maps generated through remote sensing techniques.
5. Provide useful information and insights to local policymakers and stakeholders for sustainable land use planning and management in the study area.

STUDY AREA



The study area for the research is the Talwara block. Talwara is a block in the district of Hoshiarpur in the state of Punjab, India it lies on the Longitude: 75.9565° E to 76.2235° E and Latitude: 31.4727° N to 31.7191° N. It is located in the north-eastern part of the district, bordering the state of Himachal Pradesh. The block has a total area of 95.68 square kilometres and is home to a population of around 30,000 people, according to the 2011 census. The Talwara block is primarily an agricultural area, with a significant portion of the land being used for cultivation of crops such as wheat, rice, and sugarcane. The block is also home to a number of small villages, and the terrain is characterized by rolling hills and valleys. The study of land use/land

cover change in this area is important for understanding the impacts of human activities on the environment and for developing strategies for sustainable land use and management.

METHODOLOGY

Three subsets of false colour composite (FCC) images derived from Landsat 5 TM and Landsat 8 OLI, dated respectively in the years 2001, 2011, and 2021, have been employed in the present study to cover an area of 225.6 Sq km in Talwara Block. Different interpretation strategies have been adopted based on the interpretation of satellite images and their morphological and physical features, such as colour, texture, and structure.

To ensure comparable resolution and projection with other datasets, the Landsat images have been geometrically corrected through geo-referencing, with a first-order transformation (affine transformation) utilized for the purpose of the correction. An image-to-image model has been employed for the correction of the remaining images. A comprehensive GIS analysis has been conducted to analyse and recalculate the alterations.

Data Acquisition: Remote The process of arranging pixels into distinct categories is known as image classification. To identify the digital values of various land-use and land-cover (LULC) categories, satellite data were analysed using spectral and spatial profiles. ISODATA (Iterative Self-Organizing Data Analysis Technique) algorithm was used for unsupervised classification. The study region was able to identify five different land cover classes: built-up land, agricultural land, water bodies, barren land, and forests. Figure 1 illustrates the approach employed for thematic data extraction from the satellite images.

Table 1: Details of Satellite Imageries Used

Sl No	Satellites	Sensors	Date	Resolution	No of Bands	Path	Row
1	Landsat 5	TM	23- March-2001	30 m	5	148	38
2	Landsat 5	TM	22-April-2011	30 m	5	148	38
3	Landsat 8	OLI	17-April-2021	30 m	5	148	38

Image Classification: The process of arranging pixels into distinct categories is known as image classification. To identify the digital values of various land-use and land-cover (LULC) categories, satellite data were analysed using spectral and spatial profiles. ISODATA (Iterative Self-Organizing Data Analysis Technique) algorithm was used for unsupervised classification. The study region was able to identify five different land cover classes: built-up land, agricultural land, water bodies, barren land, and forests. Figure 1 illustrates the approach employed for thematic data extraction from the satellite images.

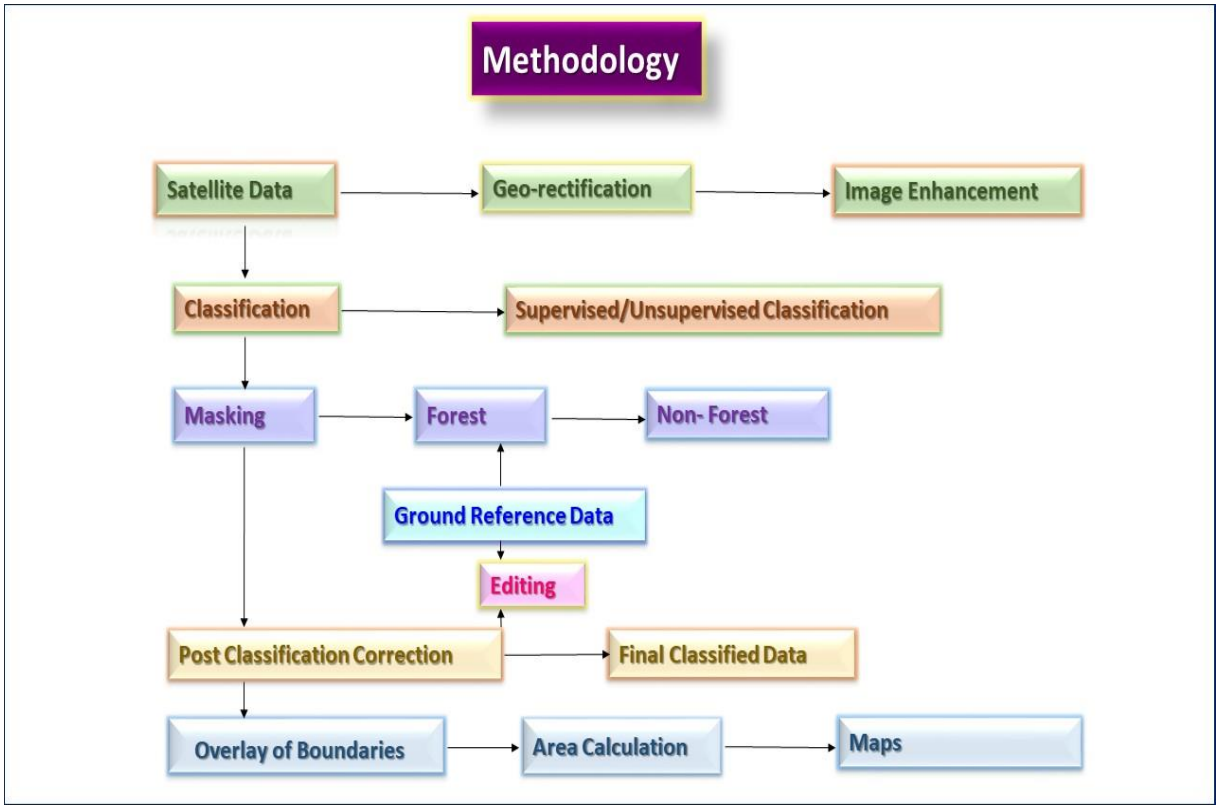


Figure 1: Flow Chart Illustrating the Methodology of Digital Image Processing

RESULTS AND DISCUSSIONS

Land use/land cover analysis with remote sensing data

The different land use/land cover classes interpreted in the study area include built-up land, agricultural land (cropland and fallow land), forest (dense and degraded forest, and plantation).water bodies and Barren land (barren rocky areas), which are shown in table 2 along with graphical representation (fig 2). Detailed accounts of these Land Use / Land Cover classes of the study area are described in the following sections shown in Maps from 2001 to 2021 (Figure 3, 4,5).

Talwara Block, located in Hoshiarpur has experienced significant changes in land use and land cover over the years. The region's rich natural resources, diverse vegetation, and unique topography have played a crucial role in shaping its landscape. As we delve into the historical context of land use and land cover change in Talwara Block, we uncover several intriguing trends.

Agricultural Expansion

Agriculture has been the primary land use in Talwara Block for decades. The fertile soil and favourable climatic conditions have supported various agricultural practices, including the cultivation of crops such as wheat, rice, maize, and sugarcane. However, over the years, we have witnessed a significant expansion in agricultural lands in Talwara Block, driven by increased demand for food and changing socio-economic factors. This expansion has resulted in the conversion of forests, grasslands, and other natural habitats into agricultural lands, leading to changes in land cover and its associated impacts on the local ecosystem.

Urbanization and Infrastructure Development

Urbanization and infrastructure development have also contributed to land use and land cover change in Talwara Block. With the growing population and increasing urbanization, there has been a rise in demand for housing, industries, and

infrastructure facilities. As a result, we have witnessed the conversion of agricultural lands, forests, and other natural habitats into urban and industrial areas. This rapid urbanization has had significant implications for the region's land use and land cover, including changes in vegetation cover, loss of wildlife habitat, and alterations in hydrological patterns.

Mining and Industrial Activities

Mining and industrial activities have been another key driver of land use and land cover change in Talwara Block. The region is rich in mineral resources, and mining activities, including coal mining, have been prevalent in the area for several years. These activities have resulted in changes in land use, including the conversion of agricultural lands and forests into mining areas, which have significant environmental and social impacts. Furthermore, the establishment of industrial facilities has also contributed to land cover change, with the construction of roads, buildings, and other infrastructure altering the landscape of Talwara Block.

Environmental effects of land use and land cover change

The changes in land use and land cover in Talwara Block have had significant environmental impacts, with far-reaching consequences for the region's natural resources, biodiversity, and local communities. Let's take a closer look at some of the key environmental impacts of land use and land cover change in Talwara Block.

Deforestation and Loss of Biodiversity

The conversion of forests and other natural habitats into agricultural lands, urban areas, and mining sites has resulted in deforestation and loss of biodiversity in Talwara Block. Forests are crucial for maintaining ecological balance, providing habitat for wildlife, and supporting local livelihoods. However, deforestation has led to the loss of vegetation cover, fragmentation of wildlife habitats, and depletion of natural resources, adversely impacting the region's biodiversity and ecological integrity.

Changes in Hydrological Patterns

Land use and land cover change in Talwara Block have also altered hydrological patterns, affecting water availability and quality in the region. Deforestation and changes in vegetation cover have resulted in changes to the water cycle, impacting the local hydrological patterns. The loss of vegetation cover can disrupt the natural process of water absorption, leading to increased runoff, soil erosion, and changes in groundwater recharge. This, in turn, can have adverse effects on water availability, water quality, and overall water security in Talwara Block.

Air and Water Pollution

The expansion of urban areas, industrial activities, and mining operations has also led to air and water pollution in Talwara Block. Increased vehicular emissions, industrial emissions, and discharge of untreated waste into water bodies have contributed to air and water pollution, posing risks to human health, wildlife, and aquatic ecosystems. The degradation of air and water quality can have severe consequences for the local environment, including impacts on vegetation, wildlife, and public health.

Socio-economic Impacts

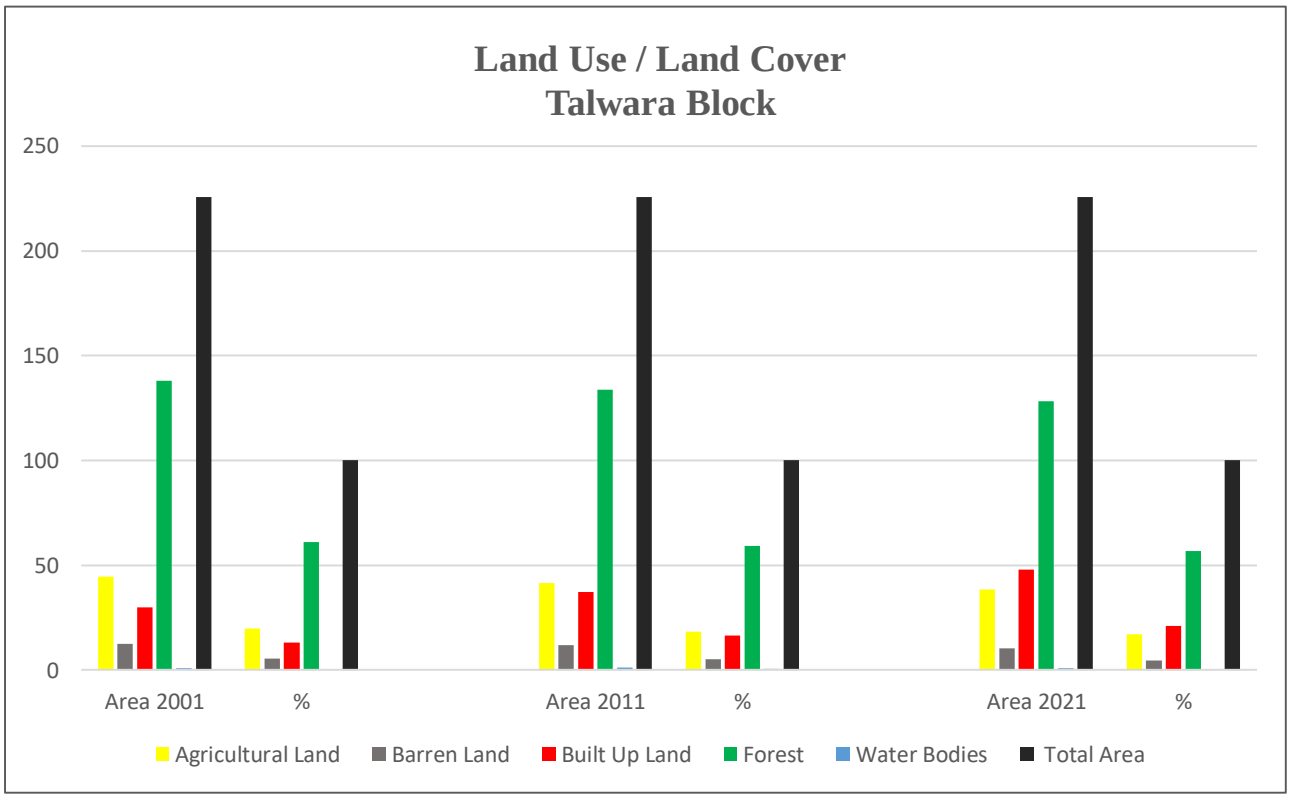
The changes in land use and land cover in Talwara Block have not only environmental impacts but also socio-economic implications. The conversion of agricultural lands into non-agricultural uses can affect the livelihoods of local farmers, disrupt traditional farming practices, and

alter local economies. Additionally, changes in land cover, such as deforestation, can affect the availability of forest-based resources, disrupt traditional practices, and impact the cultural heritage of local communities. It is crucial to consider the socio-economic impacts of land use and land cover change in Talwara Block for sustainable development planning and decision-making.

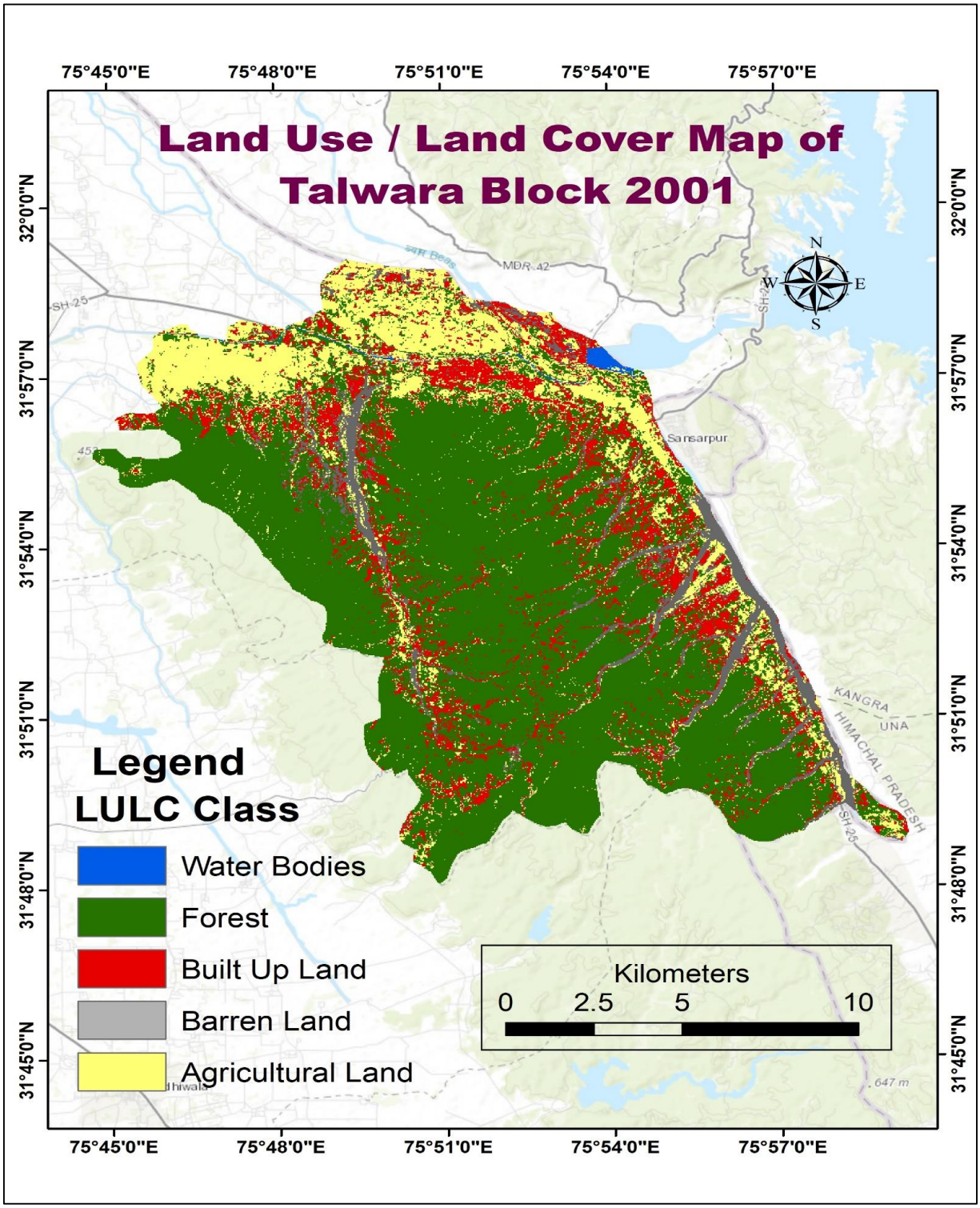
Table 2: Areas of Land use/ Land Cover Classes in the Study Area

LANDUSE TYPE	Area 2001	% Area	Area 2011	% Area	Area 2021	% Area
Agricultural Land	44.671	19.79356	41.6291	18.44692254	38.4153	17.0221354
Barren Land	12.38	5.485532	11.907	5.27629727	10.4017	4.60907882
Built Up Land	29.791	13.20028	37.1563	16.46491008	47.8251	21.1916952
Forest	137.955	61.12735	133.892	59.33098128	128.209	56.8104624
Water Bodies	0.887563	0.393276	1.08522	0.480888832	0.827401	0.36662819
Total Area	225.684563	100	225.66962	100	225.6785	100

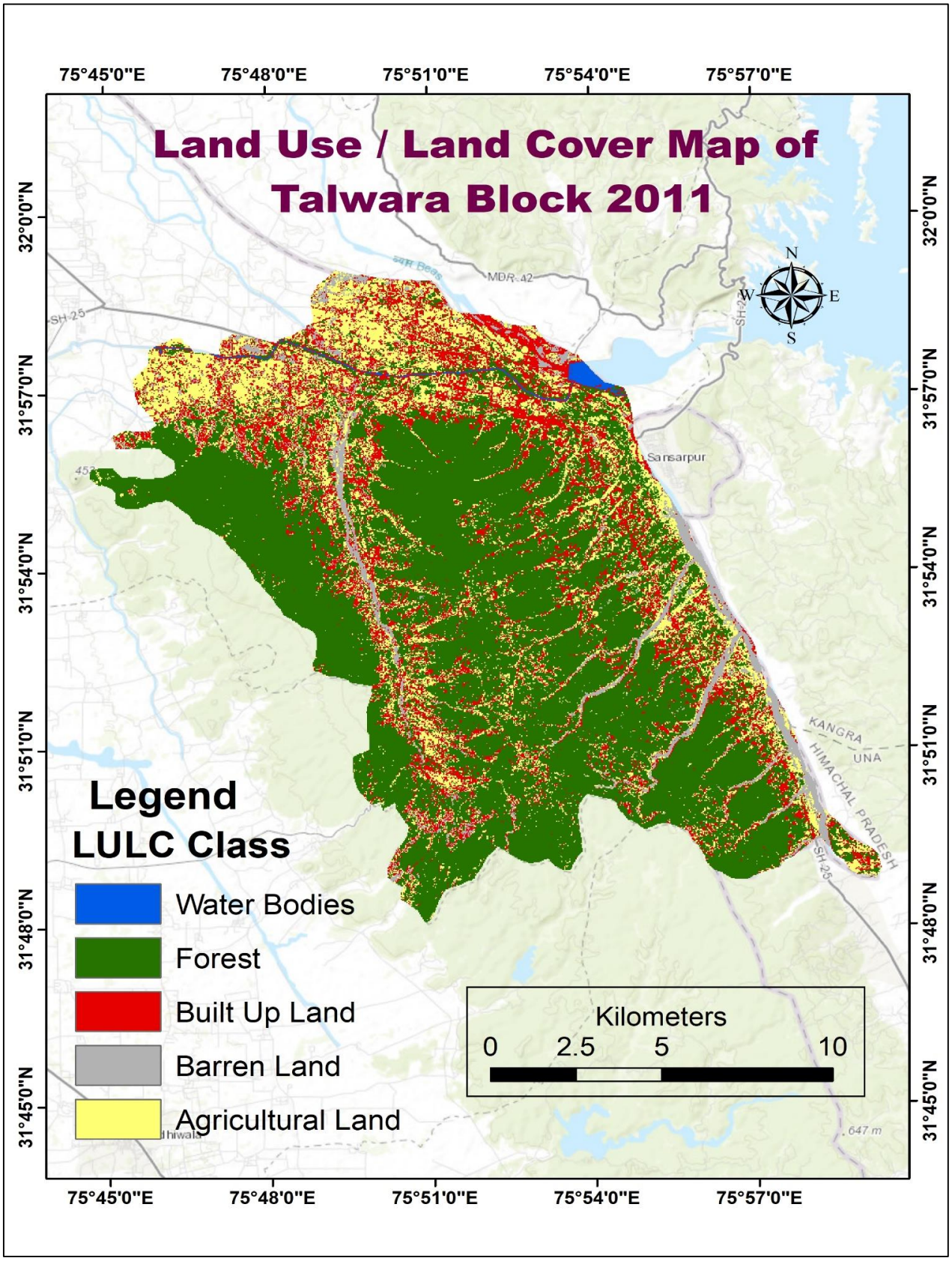
Fig. 2 Land use land cover 2001 ,2011 and 2021 Talwara Block



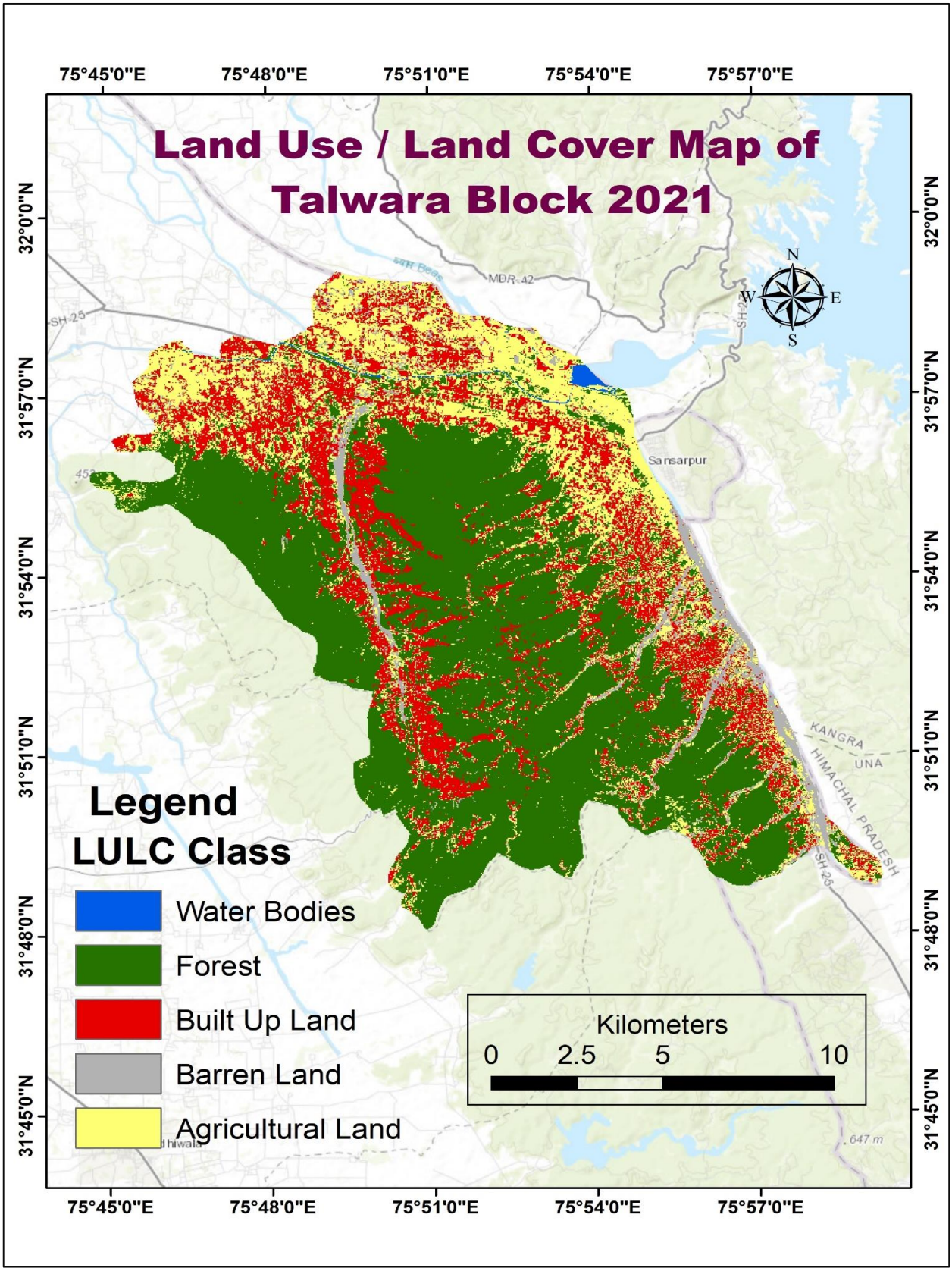
Landuse/Land Cover Pattern of Study Area from 2001 to 2021



LANDSAT 5 TM (2001) FIG -3



LANDSAT 5 TM (2011) FIG -4



LANDSAT 8 0LI (2021) Figure 5

Table 3. Land-Use Changes in Talwara Block

Magnitude and percentage of LULC change from 2001 – 2021.						
Land Use Type	2001 Area	% Area	2021 Area	% Area	Magnitude of change	Percentage of change
Agricultural Land	44.671	19.7935558	38.4153	17.0221354	-6.2557	-2.7714204
Barren Land	12.38	5.48553248	10.4017	4.60907882	-1.9783	-0.8764537
Built Up Land	29.791	13.2002826	47.8251	21.1916952	18.0341	7.99141262
Forest	137.955	61.1273532	128.209	56.8104624	-9.746	-4.3168908
Water Bodies	0.887563	0.3932759	0.827401	0.36662819	-0.060162	-0.0266477
Total Area	225.684563	100	225.678501	100		

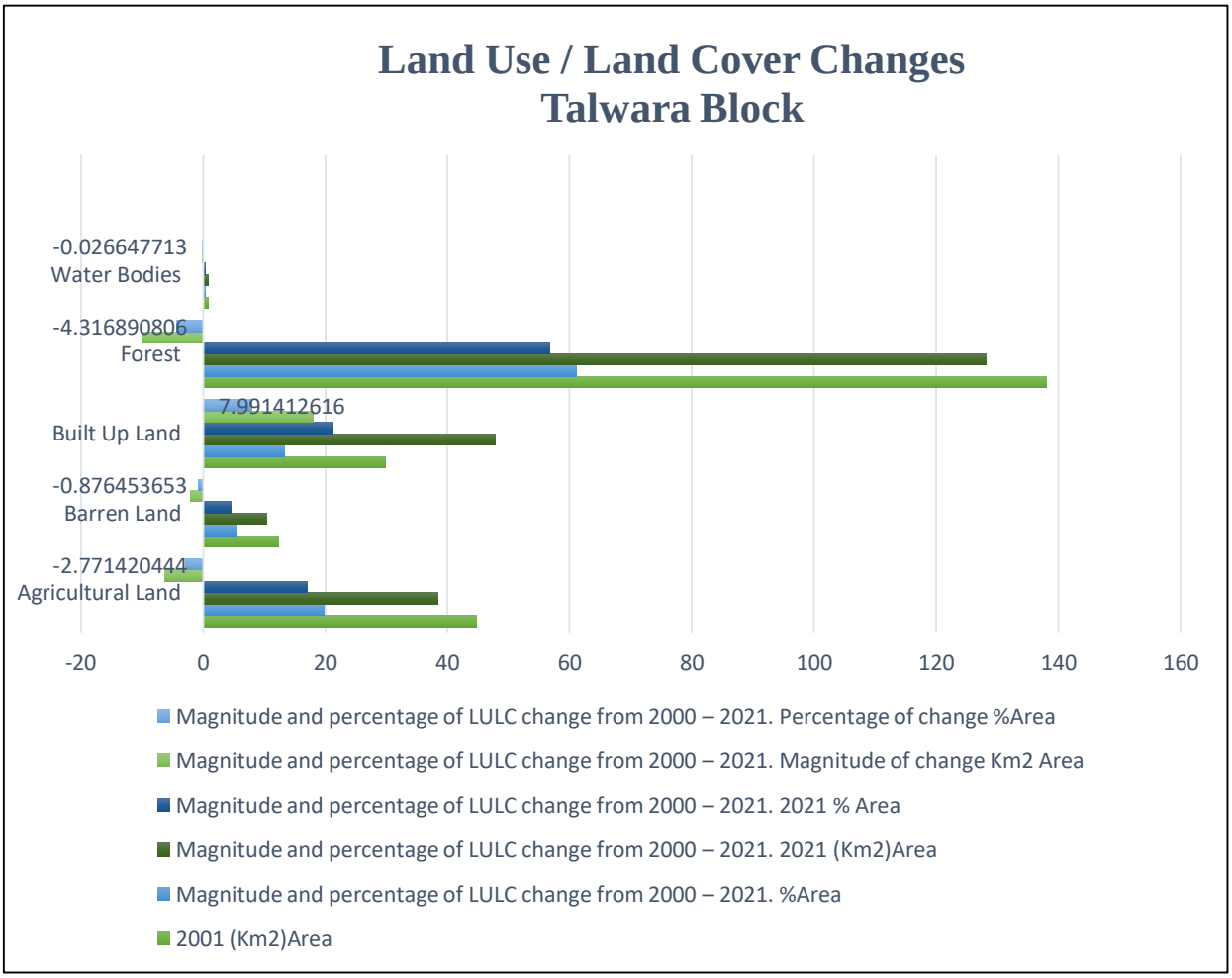


Fig .6 land use land cover changes

Strategies for Sustainable Land Use and Land Cover Management

Given the significant environmental and socio-economic impacts of land use and land cover change in Talwara Block, it is crucial to adopt strategies for sustainable land use and land cover management. Here are some key strategies that can be implemented:

1. Promoting Sustainable Agriculture

Promoting sustainable agricultural practices, such as conservation agriculture, organic farming, and agroforestry, can help reduce the negative impacts of agricultural expansion on land use and land cover in Talwara Block. Sustainable agriculture practices can improve soil health, reduce the use of chemicals, and promote biodiversity-friendly farming, contributing to sustainable land use management.

2. Implementing Land Use Planning and Zoning

Adopting comprehensive land use planning and zoning strategies can help manage land use change in Talwara Block. This can involve identifying suitable areas for different land uses, such as agriculture, urban development, and mining, and regulating land use changes accordingly. This can help ensure that land use changes are planned, controlled, and sustainable.

3. Promoting Forest Conservation and Restoration

Conserving and restoring forests in Talwara Block is crucial for maintaining biodiversity, protecting water resources, and mitigating climate change. Implementing measures such as afforestation, reforestation, and forest protection can help reduce deforestation, restore degraded lands, and promote sustainable land cover management.

4. Strengthening Environmental Regulations and Enforcement

Enforcing strict environmental regulations, such as those related to air and water pollution, can help mitigate the negative impacts of industrial activities and mining on land use and land cover in Talwara Block. This can involve monitoring and regulating emissions, waste disposal, and other environmental impacts of human activities, and imposing penalties for non-compliance.

5. Engaging Local Communities and Stakeholders

Engaging local communities and stakeholders in decision-making processes related to land use and land cover management is essential for sustainable outcomes. This can involve consulting with local farmers, residents, and indigenous communities to understand their perspectives, needs, and traditional practices, and incorporating them into land use planning and management strategies.

Conclusion

In conclusion, land use and land cover change in Talwara Block have significant environmental and socio-economic impacts. The expansion of agriculture, urbanization and industrial activities, deforestation, and mining operations have led to degradation of land cover, loss of biodiversity, changes in hydrological patterns, air and water pollution, and socio-economic disruptions. To address these challenges, sustainable land use and land cover management strategies need to be implemented. By promoting sustainable agricultural practices, implementing effective land use planning and zoning, conserving and restoring forests, strengthening environmental regulations and enforcement, and engaging local communities and stakeholders, Talwara Block can move towards more sustainable land use and land cover management. These strategies can help mitigate the

negative impacts of land use and land cover change, protect the environment, and ensure socio-economic well-being for local communities.

Additionally, raising awareness about the importance of sustainable land use and land cover management among the local population, policymakers, and other stakeholders is crucial. Educational campaigns, training programs, and capacity building initiatives can help build knowledge and skills related to sustainable land use and land cover management, encouraging informed decision-making and responsible actions as sustainable land use and land cover management are critical for mitigating the environmental and socio-economic impacts of land use change in Talwara Block. By adopting strategies that promote sustainable agriculture, effective land use planning, forest conservation and restoration, environmental regulations and enforcement, and community engagement, Talwara Block can achieve sustainable development outcomes and ensure a healthier and more resilient environment for present and future generations.

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