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# Impacts of Land Use Land Cover Changes on Water Resources of Noida and Nava Raipur Using Geo- Spatial Technology

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**Abstract** The study represents a comprehensive study on data collection and methodology used for analysing land use and land cover (LULC) changes in Noida and Nava Raipur between 2013 and 2022. The study incorporates remote sensing data and GIS techniques to assess urbanization, vegetation, water bodies, and barren land. The methodology involves satellite image acquisition, pre-processing, supervised classification, and digitization of water bodies from Google Earth Pro Imageries. In Noida, urbanization is evident with an increase in built-up land, while the proportion of barren land decreased. Vegetation remained stable, and water bodies saw a slight increase. The city's efforts to balance growth with ecological preservation are highlighted. In Nava Raipur, significant urbanization is observed with a decrease in barren land and substantial increase in built-up land. Vegetation increased as well, demonstrating efforts towards sustainability. Water body area increased slightly, indicating attention to water resource management. Both cities showcase the importance of maintaining a balance between urbanization, environmental preservation, and water resource management. The study underscores the need for informed decision-making and continuous monitoring to ensure sustainable city planning in the face of urban expansion and climate change challenges.

***Keywords:*** *land use and land cover (LULC) changes in Noida and Nava Raipur, GIS techniques to assess urbanization, vegetation, water bodies, and barren land*

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## 1. Introduction

Urbanization is a process of population concentration in the cities [1]. The urbanization refers to the changes in the infrastructure and land use patterns in urban space. The infrastructure in the villages and cities differ. The sky scrapers are absent the villages but not in the cities. The land use pattern also changes in the urban and rural areas. The industrialization led to the urbanization that we have learned. The number of industries would be higher in the urban land that needs more space. To work in these industries, we need people. The people need housing and other necessary infrastructures like schools for their children, colleges, hospitals, service centres, railway stations, connectivity networks and all and all. These need more space. So, in order to build these infrastructures, we need to compromise on the arable lands, wetlands, water bodies, hills, mountains etc. this would disrupt the harmony of nature and further lead to disasters. Climate change is an evident disaster that happens in front of our eyes. The water bodies play an important role in maintaining the whole climate of a region. The disturbance in the hydrological cycle would affect the climate of the area and thereby the people too. The rapid pace of urbanization is reshaping the world as we know it. As populations increase and economies evolve, cities are becoming hubs of innovation, opportunity, and diversity. This transition presents both promise and challenge. On one hand, urban centres offer improved access to education, healthcare, and employment opportunities. On the other, they strain under the weight of inadequate infrastructure, housing shortages, and environmental issues. India, with its vast population and cultural tapestry, exemplifies this urban transformation. As the nation's cities experience unprecedented growth, they bridge ancient traditions with modern aspirations. This complex interplay fuels the emergence of novel challenges and prospects. The government's initiatives, such as the Smart Cities Mission and Clean India Campaign, underscore a commitment to sustainable urban development and improved living standards for all. As we navigate this urban journey, striking a balance between growth and sustainability is paramount. The success of our cities will define the quality of life for billions and set a precedent for global urbanization. It is a journey that requires collective effort, innovative solutions, and a deep understanding of the intricate dynamics that mould our urban landscapes.

India is a country with full of agricultural lands. India is mostly of plateaus and plains. That makes it suitable for the agriculture. These agricultural lands are transformed to urban lands to forms the nodes of the nation. The arable lands and water bodies are get filled and there the cities are established. This will affect the cities as well as the nation adversely.

Urban land use changes can have profound effects on water bodies and their associated ecosystems. The conversion of natural landscapes into urban areas often results in increased runoff, elevated flooding risks, and disrupted hydrological cycles due to the proliferation of impervious surfaces. This alteration of land cover contributes to the degradation of water quality through the transportation of pollutants such as heavy metals, pesticides, and sediment into water bodies. The loss of natural habitats, including wetlands and riparian zones, poses a threat to biodiversity and the intricate balance of aquatic ecosystems. Concurrently, shifts in species composition and the proliferation of invasive species become prevalent. Nutrient loading from urban areas leads to eutrophication, creating oxygen-depleted zones detrimental to aquatic organisms. Urbanization also drives stream channelization, causing changes in flow dynamics and habitat degradation. Mitigating these impacts necessitates the implementation of green infrastructure, stormwater management systems, and preservation zones, all aimed at replicating natural processes, curbing runoff, enhancing water quality, and safeguarding urban aquatic environments.

NOIDA and NAVA RAIPUR are the two cities taken as study area. The Noida is an example of brown field planning and the Nava Raipur is an example of green field planning. Both cities are in its phase of sustainable development. This means it give more importance to the nature and the physical environment and try to plan according to the nature. This will revive the ecosystem of both cities. The study focuses particularly on how the urban land use changes affect the water bodies of both cities. For that we have took a geospatial approach. The satellite imageries are taken to understand, calculate and analyse the urban land use changes and its impacts over the water resources. here the surface water is given more importance. The increase in the area of water bodies will definitely make the city more drought resilient, flood resilient and even climate resilient and the decrease in the water bodies will reverse the situation.

## 2. Literature Review

India, a country with a large rural population, is transitioning slowly but steadily and broadly towards urbanisation. In 2011, there were 7,935 cities and megacities, up from 5,161 in 2010. According to UN estimates, 600 million people, or 15% of the global urban population, would reside in Indian cities by the year 2031. The effects of this rise in urban population on the environment, ecology, and sustainability will show up in the demand for urban services and management of the urban ecosystem. Urbanisation also creates a great deal of conflict with regard to biodiversity, protected areas, natural ecosystems, land use, and other ecosystem services essential to human well-being [2].

Urbanisation in India is becoming more and more noticeable, with far-reaching effects on physical landscapes around the nation. The land cover, natural habitats, biodiversity, and ecosystem services that support human well-being will all be impacted by these changes [3]. Wetlands are crucial for replenishing aquifers and stabilising the urban eco-system. Wetlands improve water quality, provide home for various species of flora and wildlife, and mitigate severe floods by storing water. Consequently, wetlands are essential to urban ecology. Many of the water bodies have been lost and some are completely polluted as a result of the fast urbanisation. Urban sprawl, which places a greater demand on natural resources and is consequently linked to the loss of wetlands, is the main driver of environmental degradation. On several of these lakes, medium and high-rise structures have sprouted up, demonstrating the deterioration in the natural catchment flow and lowering the water quality. Unplanned urbanisation and construction activities have had a significant negative impact on these wetlands and significantly reduced the aquifers' ability to store water [4].As growth and development are concentrated in the urban centres of towns and cities, India's urbanisation phenomenon over the past few decades has resulted in a rural-urban movement.

Urban water bodies must be recognised in planning laws and procedures since urban growth and development are frequently haphazard or unplanned, making it important to preserve and revitalise this priceless resource [5]. Rapid and unplanned urbanisation is responsible for the exponential growth of Indian cities. The management of surface water is severely hampered by the exceptional rate of increase. Urban planners and policymakers view the decrease of surface water bodies as a crucial factor [6]. An area with more urban growth had a higher chance of seeing an increase in yearly surface runoff. Areas that are heavily populated were more likely to flood. Urbanisation reduced the maximum amount of storage possible, which led to higher runoff coefficient values [7]. This is a major problem in cities. The Indian cities become flood prone and drought prone too. The quality of water also gets affected by the concentrated built-up area of the urban spaces [8].

Here is an attempt to study how the urban land use changes impact the water bodies of two cities, NOIDA and NAVA RAIPUR, with the help of geospatial technologies, remote sensing and geographic information system. This study focuses on how the urban land use changed from 2013 to 2022. How the change affected the water bodies of both cities. Give some suggestions to build a sustainable city without harming the environment.

## 3. Study Area

The NOIDA and NAVA RAIPUR are the two cities taken as the study area

Noida is located in the state of Uttar Pradesh at the fringes of Delhi, the national capital. Located at the doorstep of Delhi, NOIDA is only 14 Kms. away from

Connaught Place. Noida belongs to Delhi-NCR. The 550 metre long, eight lane NOIDA Toll Bridge across Yamuna connecting Maharani Bagh in Delhi to NOIDA has further reduced the distance, time and cost of commuting to and from Delhi-NOIDA. Noida lies between 28°34′47″ N Latitude and 77°19′47″ E Longitude. It has all the key advantages of Delhi without having its disadvantages. The development area encompasses about 20, 316 hectares of land consisting of 81 villages of district Gautam Buddha Nagar. Noida is bounded by NH-24 Bye-Pass in the North beyond which the Ghaziabad Development Area exists, in the East by River Hindon beyond which Greater Noida Industrial Development Area exists, in the West by River Yamuna, beyond which are the States of Delhi and Haryana and in the South is the meeting point of the rivers Yamuna and Hindon. Noida, an acronym for New Okhla Industrial Development Authority, traces back to the 1960s when the need for planned urban expansion to accommodate the burgeoning industrialization near Delhi was recognized. The New Okhla Industrial Development Authority (NOIDA) was established in 1976 under the Uttar Pradesh Industrial Area Development Act, with a primary focus on fostering industrial growth and providing a well-structured industrial environment. Over the ensuing decades, Noida witnessed remarkable progress and transformation.

Noida's history underscores its dedication to modern infrastructure, organized sectors, and the attraction of industries and enterprises. Its journey has been steered by careful urban planning and the development of a diverse array of residential and commercial spaces. Presently, Noida stands as a significant satellite city of Delhi, playing a pivotal role in the region's economic advancement and urban expansion, all while conscientiously balancing industrialization with the principles of sustainable urban living. Now, the urban planning gave more importance to the physical environment too. This paved way for the sustainable development in the cities. The Noida is in its initial phase of sustainable development. The changes are evident. The study also focuses on how the brown field urban planning make a way to sustainable development by protecting the nature.

Nava Raipur Atal Nagar, as the name suggests, is the new upcoming state capital of Chhattisgarh. It lies between the coordinates of 21° 9' 53.9748" N and 81°8'15.307" E. Nava Raipur is a plain area located in the central part of India. Raipur is also called the “Rice Bowl of India” because hundreds of varieties of rice are grown here. Nava Raipur Atal Nagar came into existence as a much-required project when the governance sought the requirement of a completely redesigned and planned capital city for this newly formed state. The metropolitan aims in bringing together a conglomerate of the latest real estate development trends to ensure a fruitful progression of this integrated smart city project of India. It all began on the dawn of 1st Nov 2000, when India got its 17th most populated state named after its 36 Forts (Chhattisgarh) and Raipur became the honorary capital of this new state.

However, within a few years of its progression, Chhattisgarh realized the need for a dedicated and modern administrative block. So, in an attempt to embrace innovation and gift the state a new capital, the development plan for an integrated smart city came to the surface. Situated 17 km to the South-East of the old urbanite, Nava Raipur Atal Nagar started gaining shape through the hands of NRANVP (Nava Raipur Atal Nagar Vikas Pradhikaran).

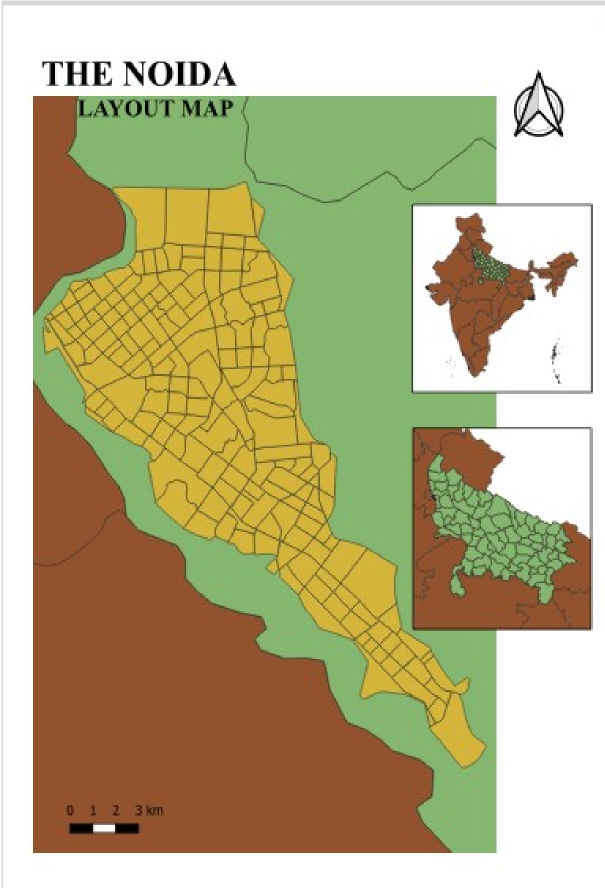


**Figure 1.** Study area of Noida

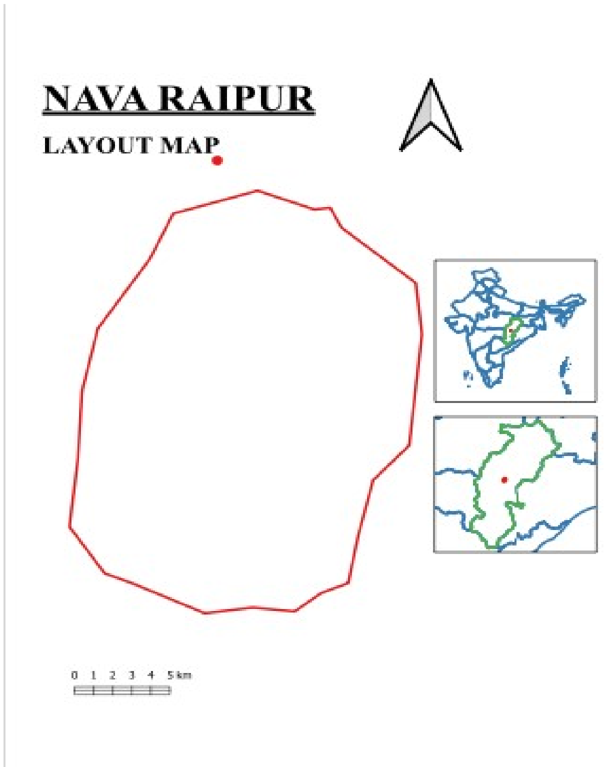


**Figure 2.** Study area of Nava Raipur

NRANVP or Nava Raipur Atal Nagar Vikas Pradhikaran embraced plan 2031 comprising of a wholesome metropolitan development. It comprises of 41 villages under its jurisdiction which consists of 3 layers of smart city development. One is 95 sq. km comprising of a dedicated green belt. second, a peripheral region covering 130 sq. km. and third, another 12 sq. km comprising Raipur and Nava Raipur Atal Nagar's international airport. This city justifies its green field tag by adopting a green, cross connected walking belt that runs across the length and breadth of the city. Moreover, a linear design facilitates the construction of an urban transport project including Nava Raipur Atal Nagar's BRTS as well. In this respect, this green field smart city brings together the following development approaches which justify its name as the first integrated smart city of India. In an attempt to make Nava Raipur Atal Nagar one of the finest smart cities in India, NRANVP opts for a CBD concept. This Central Business District approach provides the following amenities: -Dedicated commercial hubs in each sector ensuring easy access, Smart LED lighting saving power considerably and ultra planned and state-of-the-art roads. The biggest aspect of incorporating a CBD approach is the establishment of a dedicated IT hub. NRANVP aims at inviting all major MNC and IT sectors from around the globe. NRANVP has developed Nava Raipur Atal Nagar keeping in mind a number of aspects which make it an apt selection over others when concerning a residential area. The city opts for compete underground drainage system to keep away wastes from surfacing this metropolitan.24 hours water supply is available to this integrated smart city project of India owing to the SCADA distribution system.

The standard communication facilities include a proposed train line connecting Nava Raipur Atal Nagar to Mumbai and associated regions, BRTS system joining the old city to its new counterpart. State-of-the-art medical amenities assuring complete protection and health services to its residents. So, residing in one of the planned and ultra-modern blocks of Nava Raipur Atal Nagar can be your contribution to the sustainable future. This integrated smart city project of India is sure to fulfil all your expectations (official website Nava Raipur Atal Nagar). Both cities are satellite towns developed nearby the biggest cities of the state. Both have the responsibility to provide better amenities to their people without compromising on the nature. This led to the need of eco-friendly and sustainable cities. The study emphasizes on how the urban development changed the land use pattern of these cities and how those changes influence the water bodies of the cities. This is an attempt to show the impacts of land use changes on the water resources.

## 4. Data Collection and Methodology

Multi-spectral LANDSAT TM for the year 2013 and 2022 and manually digitized water bodies of Noida and Nava Raipur of 2013and 2022 from google earth pro is considered for the study. Water body features were extracted from Google Earth Pro which represent the geological features of the earth. It is published by the Maxar technologies. The water bodies of the study area are extracted by manual digitization. The data of 2013 and 2022 are collected. Land sat satellite images were downloaded from the United States Geological Survey (USGS) Earth Explorer a public domain that provides topographic and geographic maps of the required region in GeoTIFF format. These data sets were used for the land use and land cover (LULC) classification.

**Table 1. Data Collected For the Study**

| Sl. No | Type Of Data Used | Scale/ Resolution | Path And Row | Date Of Acquisition |
|---|---|---|---|---|
| 1 | Landsat 8 Oli/Tris C2 Level - 2 | 30 M | Nava Raipur: 142 And 045 Noida: 146 And 040 | 2013/05/02 |
| 2 | Landsat 8 Oli/Tris C2 Level - 2 | 30 M | Nava Raipur: 142 And 045 Noida: 146 And 040 | 2022/05/01 |
| 3 | Google Earth Pro | 1 M | | 2013/05 |
| 4 | Google Earth Pro | 1 M | | 2022/05 |

Geographical information systems (GIS) together with remote sensing data are used for monitoring the emerging urbanization of the cities using digital satellite images. The LANDSAT 8-9 Operational Land Imager (OLI) - Thermal Infrared Sensor (TIRS) Collection 2 (C2) Level 2 (L2) data is acquired from the USGS Earth Explorer platform. LANDSAT is an Earth observation satellite program formulated, implemented, and operated by the National Aeronautics and Space Administration (NASA) and the Department of the Interior (DOI) U.S. Geological Survey (USGS). Land sat's ongoing record of data focuses on medium-resolution remote sensing of Earth's land surfaces. The goal of LANDSAT is to continue the collection, archive, and distribution of multispectral imagery affording global, synoptic, and repetitive coverage of land surfaces at a scale where natural and human-induced changes can be detected, differentiated, characterized, and monitored over time. The mission's programmatic goals are stated in the United States Code, Title 15 Chapter 82 "Land Remote Sensing Policy" (derived from the Land Remote Sensing Policy Act of 1992). This policy requires the LANDSAT program to provide data into the future that are sufficiently consistent with previous LANDSAT data, allowing the detection and quantitative characterization of changes in or on the Earth's surface. The highly successful LANDSAT series of missions has provided satellite coverage since 1972. The data from these missions constitute the longest continuous record of Earth's surface as seen from space.

Level 2 Output Files Overview the standard L2SP is a Digital Number (DN) product stored in a 16-bit unsigned integer format. Refer to LSDS-1747 LANDSAT 8-9 Calibration and Validation (Cal/Val) Algorithm Description Document (ADD) for a description of the atmospheric auxiliary data pre-processing, the SR algorithm, and the Single Channel algorithm for ST. SR bands approximate what a field spectro-radiometer sensor held just above the Earth's surface would measure. Coarse

Resolution Water Vapour and Ozone datasets from the Moderate Resolution Imaging Spectrometer (MODIS) instrument on NASA's Terra and/or Aqua satellites are used in the SR algorithm. SR bands require Top of Atmosphere (TOA) reflectance bands corrected for per-pixel sun angles. SR bands are generated only for scenes with the Solar Zenith Angle (SZA) less than 76°. The SZA is 90° minus the sun elevation angle. Most L2 products are from scenes between 65 degrees north and 65 degrees south latitude. Table 3 lists specifications for the SR bands. The values output from Land Surface Reflectance Code (LaSRC) are scaled to fit in unsigned integers for the files named in the values for FILE_NAME_BAND_X; where X = [1,7]. The range of values output by LaSRC in conjunction with the values for REFLECTANCE_MULT_BAND_X and REFLECTANCE_ADD_BAND_X limit the value in the named files to 65455. SR might have noticeable errors for scenes captured greater than 10 degrees off-nadir. The ST band provides the temperature of the Earth's surface in Kelvin (K). The emissivity auxiliary data, used by the ST algorithm for Thermal Infrared Sensor (TIRS), is obtained from the Advanced Space borne Thermal Emission and Reflection Radiometer Global Emissivity Dataset (ASTER GED) by Land Processes Distributed Active Archive Centre (LP DAAC). Goddard Earth Observing System Model, Version 5 (GEOS-5) Forward Process for Instrument Teams (FP-IT) data are used in the Single Channel algorithm for atmospheric correction.

The L2SP image data are atmospherically corrected and available as COG files. Table 2 shows the band identification. If ST cannot be produced, an SR-only product is attempted. Atmospheric auxiliary data used in processing a L1 product into the L2 product are described in LSDS-1329 LANDSAT Atmospheric Auxiliary Data Format Control Book (DFCB). Seven ST intermediate bands are included in the L2SP when the Single Channel algorithm is used to generate ST. These ST intermediate bands consist of a thermal band converted to radiance, up welled radiance, down welled radiance, atmospheric transmittance, emissivity estimated from ASTER GED, emissivity standard deviation, and pixel distance to cloud.

For example, the downloaded SR Image Files for Nava Raipur are:

LC08_L2SP_142045_20130501_20200913_02_T1_SR_B1
LC08_L2SP_142045_20130501_20200913_02_T1_SR_B2
LC08_L2SP_142045_20130501_20200913_02_T1_SR_B3
LC08_L2SP_142045_20130501_20200913_02_T1_SR_B4
LC08_L2SP_142045_20130501_20200913_02_T1_SR_B5
LC08_L2SP_142045_20130501_20200913_02_T1_SR_B6
LC08_L2SP_142045_20130501_20200913_02_T1_SR_B7

Satellite images are needed to be pre-processed to obtain clear pixels in an image to perform image classification algorithms. ArcMap 10.8 software is used to make LULC maps of the study area. The data of both 2013 and 2022 are calculated. The supervised classification is used to make the Land Use Land Cover maps. The first level classification is made for the study. The study needed 7 bands of LANDSAT 8-9 OLI/TRIS C2 Level 2 data. The 7 bands were merged together to get a composite bend. The near infrared (OLI, 5with band width of 851 -879) red (OLI, 4with band width of 636 – 673) and green (OLI, 3 with band width of 533 - 590) layers were made visible. This made a map of FCC, i.e., false Colour Composite satellite imagery. The Maximum Likelihood classification is used to perform on the set of raster bands and creates a classified raster as output. The classes were made as built-up land, vegetation, water body and barren land. From the classified images the urban land features are extracted from raster to vector format. Then the raster images are converted to vector format as polygons. These polygons are calculated to find the area of the classes.

**Table 2. Band Reference Table**

| Band Number | Band Description | Band Range (nm) |
|---|---|---|
| 1 | Coastal Aerosol (Operational Land imager - OLI) | 435 - 451 |
| 2 | Blue OLI | 452 - 512 |
| 3 | Green OLI | 533 – 590 |
| 4 | Red OLI | 636 - 673 |
| 5 | Near Infrared –NIR, (OLI) | 851 - 879 |
| 6 | Short wave length Infrared (SWIR 1) (OLI) | 1566 – 1651 |
| 7 | SWIR 2 (OLI) | 2107 - 2294 |
| 10. | Thermal Infrared Sensor (TIRS) 1 | 10600 - 11190 |

**Table 3. Specifications of OLI SR bands**

| Band Number | Identifier FT | Units | Valid Range | Fill Value |
|---|---|---|---|---|
| 1 | SR_B1 | Unit less | 1 through 65455 | 0 (No Data) |
| 2 | SR_B2 | Unit less | 1 through 65455 | 0 (No Data) |
| 3 | SR_B3 | Unit less | 1 through 65455 | 0 (No Data) |
| 4 | SR_B4 | Unit less | 1 through 65455 | 0 (No Data) |
| 5 | SR_B5 | Unit less | 1 through 65455 | 0 (No Data) |
| 6 | SR_B6 | Unit less | 1 through 65455 | 0 (No Data) |
| 7 | SR_B7 | Unit less | 1 through 65455 | 0 (No Data) |

Google Earth Pro are considered for abstracting surface water body features. Manual digitization is done. The data of 2013 and 2022 are extracted from the google earth pro, published by Maxar technologies. Those are the data from LANDSAT, Copernicus etc. For the analysis of urbanization impacts on surface water bodies, the area of extracted water bodies is compared with the data of previous year and came into a conclusion by understanding the change in the area of water bodies. This is performed in the ArcMap 10.8 Software. The KML files of google earth pro are converted into a layer with the use of ArcMap 10.8 and made calculations. The methodology involves quantifying the extent of each category in terms of area and calculating the percentage contribution to the total land area.

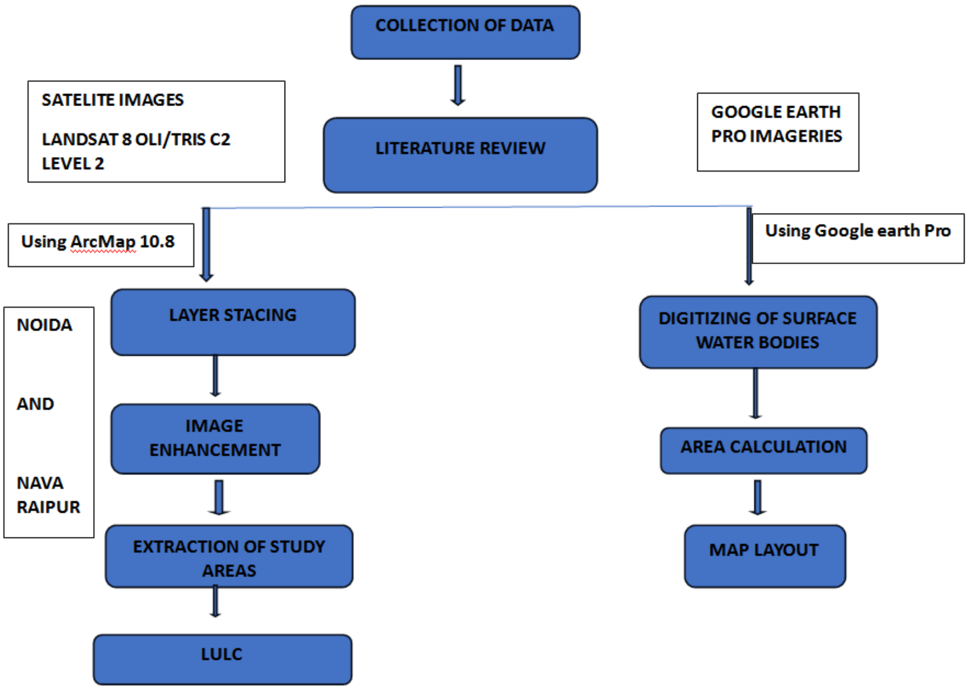


**Figure 3.** Flowchart of Methodology

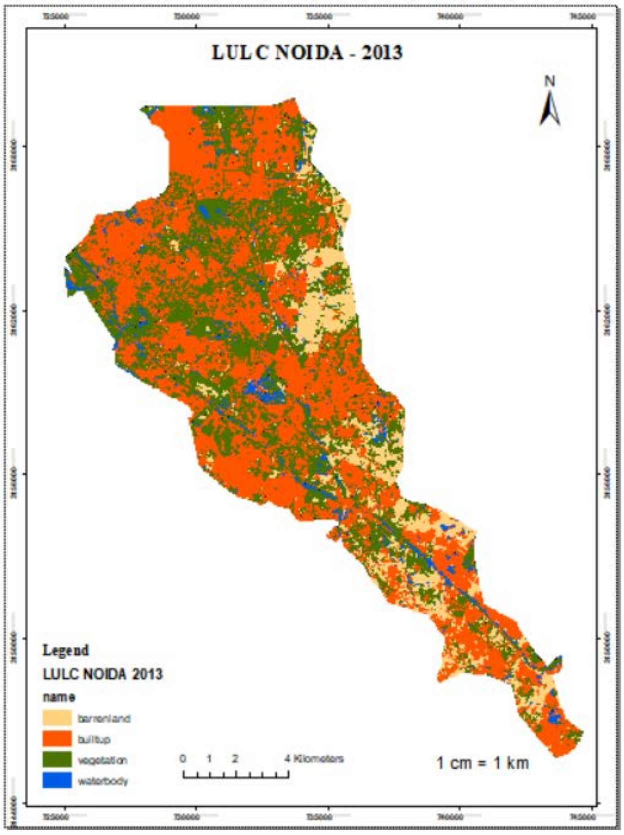


**Figure 4.** LULC of Noida (2013)

## 5. Results and Discussion

The satellite image of the study area is classified into various classes such as water body, urban built up, vegetation and barren land. The results of these classifications are shown below. The water body features are extracted from geo-referenced Google Earth Pro imageries. The Land use and land cover classifications are done by a supervised classification for the satellite images.

## 6. LULC Classification of Noida 2013

The Landsat satellite image of 2013 is clipped using the shape file of Noida. The clipped satellite image corresponding to the study region is classified using a supervised classification method. The classification was carried out for four land use categories such as water body, urban, vegetation and barren. The classified image is shown in Figure 4.

The Land use Land Cover of Noida in 2013 represent as follows:

**Table 4. LULC of Noida 2013**

| LAND USE | AREA (sq.km) | PERCENTAGE |
|---|---|---|
| Barren Land | 18.27125844 | 12% |
| Built Up land | 73.62306645 | 49% |
| Vegetation | 52.37933112 | 35% |
| Water Body | 6.316057495 | 4% |
| Grand Total | 150.5897135 | 100% |

The area occupied by each land use class is given in the Table 4. The urban built-up land occupies almost 73.6 sq.km., this contributes to the 49% of the total study area of Noida. The level of urbanization happened in 2013 on Noida comparatively less than 2022.

Barren Land (12%): The findings reveal that approximately 18.27 sq.km of NOIDA's land area is categorized as Barren Land, indicating regions with minimal vegetation or development. This category encompasses rocky terrains, uncultivable land, and areas with limited productivity.

Built-Up Land (49%): The analysis demonstrates a significant urbanization trend, with 73.62 sq.km designated as Built-Up Land. This classification encompasses residential, commercial, and industrial zones, showcasing the city's dynamic growth and infrastructure expansion.

Vegetation (35%): A noteworthy 52.38 sq.km is characterized as Vegetation, highlighting the presence of natural ecosystems, green spaces, and various forms of flora. This percentage underscores the city's efforts to preserve ecological balance amidst rapid urban development. This is by the collective efforts people and government.

Water Body (4%): Water Bodies, covering approximately 6.32 sq.km, constitute a crucial aspect of the landscape. This category encompasses rivers, lakes, and ponds, serving as vital components of aquatic ecosystems and water resource reservoirs. The share of water bodies is less in Noida because of the unscientific planning happened in the 1990s. after the Paris agreement of 2015, every nation gave importance to the climate change and made measures to cope. Preserving the water bodies would be the easiest way to cope climate change. The water is the major force which influence the climate.

# 7. LULC Classification of Noida 2022

The Landsat satellite image of 2022 is clipped using the shapefile of Noida. The clipped satellite image corresponding to the study region is classified using a supervised classification method. The classification was carried out for four land use categories such as waterbody, urban, vegetation and barren. The classified image is shown in Figure 5.

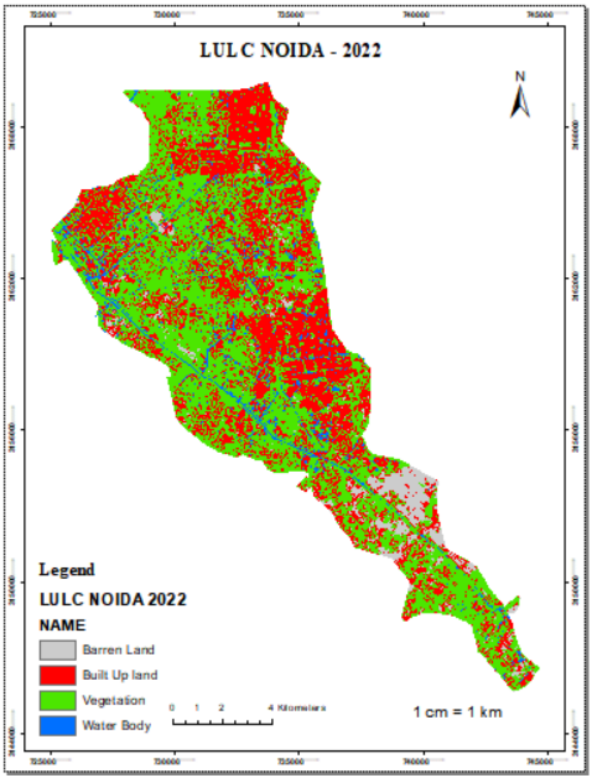


**Figure 5.** LULC of Noida 2022

The data is divided into four categories: Barren Land, Built Up Land, Vegetation, and Water Body.

The barren land occupies an area of 7.800142786 sq.km. Barren land refers to areas with minimal or no vegetation cover, typically consisting of rocky, sandy, or gravelly surfaces. Noida has a relatively small proportion of barren land, occupying 5% of the total area.

**Table 5. LULC of Noida 2022**

| Name | Area (sq.km) | Percentage |
|---|---|---|
| Barren Land | 7.800142786 | 5% |
| Built Up land | 75.71578275 | 50% |
| Vegetation | 59.76313445 | 40% |
| Water Body | 7.307984706 | 5% |
| Grand Total | 150.5870447 | 100% |

The urban Built-Up Land occupies an area of 75.71578275 sq.km. Built-up land includes urban infrastructure, residential, commercial, and industrial areas. This is the largest land category, covering a significant portion (50%) of Noida's total area. This indicates urbanization and economic development.

The Vegetation is given more importance in nowadays. But it is hard to maintain and improve a brown field with is already planned unscientifically without giving prior importance to the nature. But in this case Noida being a brown field successfully maintained and improved its share of vegetation in terms of area. Even the percentage remains the same the share of area got increased in last decade. The area of 59.76313445 sq.km is occupied by vegetation cover or green belt. The Vegetation refers to areas covered by trees, shrubs, grass, and other forms of plant life. With 40% of the area covered by vegetation, Noida seems to have a substantial green cover, which contributes to environmental health, aesthetics and even for the mental health of human beings.

Water Body is the other significant feature that need to protected and maintained for the sake of healthy natural environment. Without water nothing can survive. The Indian cities have been built-up on the wetlands and arable lands [10]. After Paris Agreement the world got aware of the climate change. This made the nations to rethink and go for climate resilient cities with its full bunch of water bodies which can collect, store water and decrease the runoff and helps in percolation and maintain the hydrological cycle, which will be a great save from the climate change. The share of water bodies in Noida in the year 2022 is 7.307984706 sq.km. Water bodies include rivers, lakes, ponds, and reservoirs. Noida's water bodies cover 5% of the total area, providing important natural resources and recreational spaces.

The majority of Noida's land is divided between Built Up Land (50%) and Vegetation (40%). This balance suggests that while urbanization and development are significant, efforts have been made to maintain a substantial green cover. The presence of 5% barren land indicates some areas might be less conducive to vegetation growth due to natural or human-induced factors. The presence of water bodies (5%) signifies the importance of water resources within the city's landscape. The distribution of land categories is relatively balanced, indicating that urban development has taken into account ecological considerations. It would be important for urban planners and policymakers to ensure sustainable development practices that maintain this balance between urbanization, green cover, and water resources. As Noida continues to grow and evolve, monitoring changes in these land categories over time will be crucial to understanding the city's environmental health and urban development trajectory.

## 8. Comparison of LULC 2013 and 2022 of Noida

Barren Land (12% to 5%): Between 2013 and 2022, the area of Barren Land experienced a reduction from 18.27 sq.km to 7.80 sq.km, decreasing its share from 12 to 5 percent. This suggests that the extent of non-vegetated, unproductive land was filled with vegetation and some built-ups over the period. The percentage of Barren Land increased and the spatial distribution of unproductive land got changed from the central part to the southern side.

Built-Up Land (49% to 50%): The Built-Up Land category expanded by 2.10 sq.km, increasing from 73.62 sq.km to 75.72 sq.km. Despite this increase, the percentage got a 1 percent of increase, indicating the continuation of urbanization trends. The expansion of Built-Up Land aligns with ongoing urban development trends and underscores the importance of managing urban growth sustainably. The built-up increased by occupying the barren land with no use into a productive one. The sustainable growth of Noida city is highlighted here.

Vegetation (35% to 40%): Vegetation area increased significantly from 52.38 sq.km to 59.76 sq.km, contributing to 35% to 40%, a consistent growth can be seen here. This demonstrates a concerted effort to preserve and expand natural ecosystems within the urban landscape. The eco-friendly approach of the city is seen well. The increased percentage of Vegetation highlights the city's commitment to balancing urbanization with ecological preservation by turning up the barren land of no use into productive areas of vegetation.

Water Body (4% to 5%): Water Body area experienced a marginal increase, growing from 6.32 Sq.km to 7.31 Sq.km. The percentage increased from 4% to 5%, indicating that water bodies increased their proportion within the landscape. The modest increase in Water Body area indicates that aquatic ecosystems continue to be managed effectively. The effort of maintaining the water bodies in a brown field is definitely a herculean task. The area also got increased; even a slight change is a good sign towards a climate resilient city.

## 9. LULC Classification of Nava Raipur 2013

The Landsat satellite image of 2013 is clipped using the shape file of Nava Raipur. The clipped satellite image corresponding to the study region is classified using a supervised classification method. The classification was carried out for four land use categories such as water body, urban, vegetation and barren. The classified image is shown in Figure 6.

Nava Raipur is divided into various categories based on the land use types, and the data presents the area in square kilometres (sq.km) and the percentage of the total area that each land use type occupies.

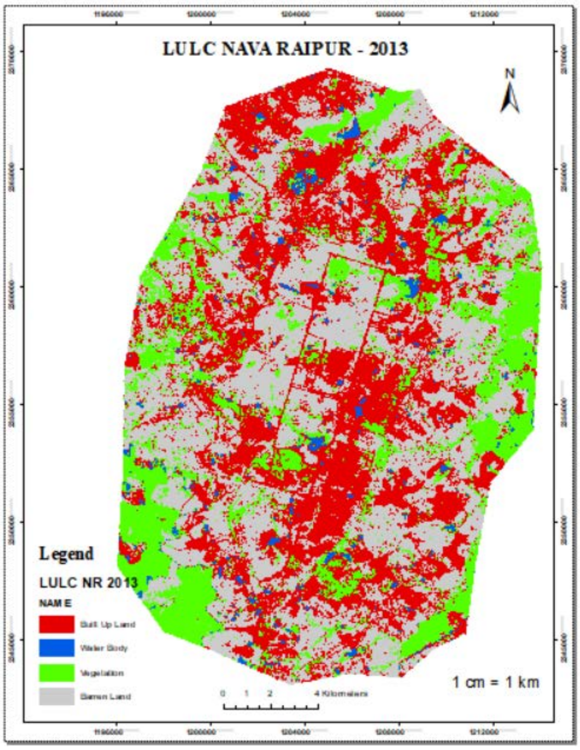


**Figure 6.** LULC of Nava Raipur 2013

**Table 6. LULC of Nava Raipur 2013**

| LAND USE | AREA (SQ.KM) | PERCENTAGE |
|---|---|---|
| Barren Land | 150.6091399 | 42% |
| Built Up Land | 128.9848224 | 36% |
| Vegetation | 73.84475574 | 20% |
| Water Body | 7.983884336 | 2% |
| Grand Total | 361.4226024 | 100% |

Barren Land (42%): Barren land comprises the largest portion of the area, occupying approximately 42% of the total land. Barren land typically refers to areas that have limited or no vegetation cover and is devoid of significant human activity. This could include rocky terrains, deserts, in arable land and areas with little to no plant growth.

Built Up Land (36%): Built-up land covers around 36% of the total area. This category includes areas with infrastructure development, such as residential, commercial, and industrial buildings, roads, and other urban structures. The relatively high percentage indicates significant urbanization and human settlement in Nava Raipur. The

Vegetation (20%): Vegetation covers about 20% of the total area. This category represents areas with plant growth, which could include forests, grasslands, parks, and other green spaces. The presence of vegetation is essential for maintaining ecological balance and providing natural habitats. But the region is of little vegetation compared to the barren land. This is a central region of India which is dominated by the plains and plateaus. Even though, the inadequate water supply is the reason for the less vegetation. It is evident that the built-up area never caused harm for the vegetation directly filling up but indirectly by the unscientific planning.

Water Body (2%): Water bodies cover rivers, lakes, and ponds, account for approximately 2% of the total area. While this is a relatively small percentage, water bodies play a crucial role in the environment, supporting biodiversity and providing water resources for various purposes.

The analysis of the data suggests that Nava Raipur in 2013 had a significant proportion of barren land, followed by built-up areas, vegetation, and water bodies. As a green field, this distribution reflects a mix of urban development, natural landscapes, and water resources in the region. The data highlights the importance of managing urban expansion while also considering the preservation of natural ecosystems and water sources. The plan for an integrated city rises after this year.

## 10. LULC Classification of Nava Raipur 2022

The Landsat satellite image of 2013 is clipped using the shape file of Nava Raipur. The clipped satellite image corresponding to the study region is classified using a supervised classification method. The classification was carried out for four land use categories such as water body, urban, vegetation and barren. The classified image is shown in Figure 7.

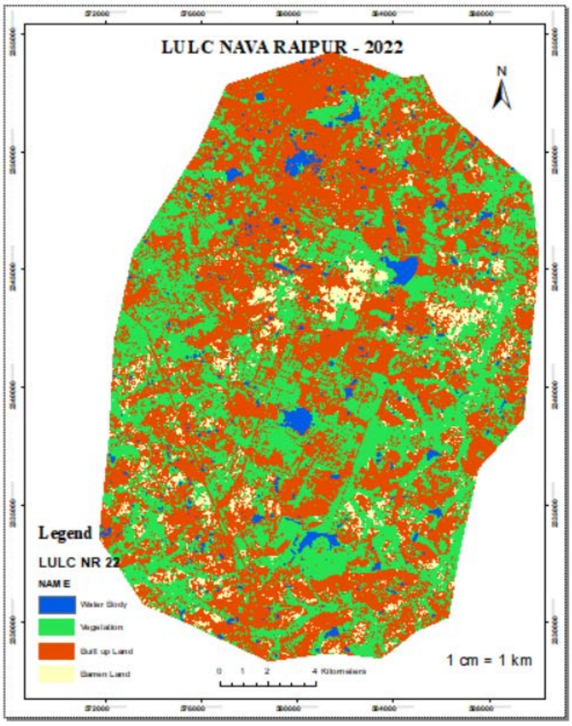


**Figure 7.** LULC of Nava Raipur 2022

**Table 7. LULC of Nava Raipur 2022**

| LAND USE | AREA (SQ.KM) | PERCENTAGE |
|---|---|---|
| Barren Land | 19.22393051 | 5% |
| Built up Land | 191.7096849 | 53% |
| Vegetation | 139.8193339 | 39% |
| Water Body | 10.65509089 | 3% |
| Grand Total | 361.4080402 | 100% |

The provided data represents the land use distribution in Nava Raipur for the year 2022. Let's analyse this data in detail:

Barren Land occupies 19.22393051 sq.km of the total area. The barren land got concentrated over the central part of the city. Barren land refers to areas that are devoid of vegetation and have minimal or no human development. These areas might include rocky terrain, desert-like landscapes, and similar environments. In Nava Raipur, barren land occupies a relatively small portion of the total area, constituting 5% of the total land.

Urban Built-up Land occupies 191.7096849 sq.km of the total area. The urban infrastructures are spatially distributed evenly. The northern part of the city seems very concentrated with the built-up lands. Towards the middle or centre the build up land gets sparser compared to the outer edges. This is because of the administrative buildings and all. Even the water bodies are also concentrated in this part make the city planners to leave those sites and enhance the natural ecosystem of the city.

Built-up land refers to areas that are urbanized or developed, including residential, commercial, industrial, and infrastructure zones. This category includes buildings, roads, and other man-made structures. In Nava Raipur, built-up land occupies the largest portion of the total area, comprising 53% of the land.

Vegetation occupies an area of 139.8193339 Sq.km. The vegetation is evenly distributed in the city. Vegetation refers to areas covered by plants, trees, and other forms of natural greenery. It includes forests, parks, gardens, and agricultural land. Vegetation is vital for ecological balance, air quality, and aesthetics. In Nava Raipur, vegetation covers a significant portion of the total area, accounting for 39%. The vegetation includes public parks and all. These plays a very important in the stressful life or urban people. These give a smoothening effect from the urban busy life.

Water Body occupies a portion of 10.65509089 Sq.km in Nava Raipur. Water bodies encompass all types of water features, such as lakes, ponds, and reservoirs. These areas contribute to the overall ecosystem health, provide habitats for various species, and offer recreational opportunities. In Nava Raipur, water bodies cover a relatively small proportion of the total area, making up 3%. The new master plan of 2031 emphasizes on increasing and protecting the water bodies as a sponge city strategy. But as a green field, it needs more care to build an integrated sponge city for collect and store water and replenish the riparian areas and wetlands. These are the pillars for the conservation of water resources.

In summary, Nava Raipur's land use in 2022 is dominated by built-up land, indicating significant urban development. Vegetation also covers a substantial portion, contributing to the ecological balance and aesthetic value of the region. Water bodies and barren land are present but occupy relatively smaller portions of the total area. This analysis showcases the spatial distribution of different land use types and their relative significance in Nava Raipur.

## 11. Comparison of LULC of 2013 and 2022 (Nava Raipur)

Let's compare the land use data for Nava Raipur between the years 2013 and 2022 to identify the changes and trends:

Barren Land:

- 2013: 42% of the total area (150.61 sq.km)
- 2022: 5% of the total area (19.22 sq.km)
- Change: There is a significant decrease of 37% in the proportion of barren land. This suggests that efforts have been made to reclaim or repurpose barren land for other uses, due to urbanization and land development projects. These projects include the rejuvenation of water bodies and make the first integrated sponge city.

Built Up Land:

- 2013: 36% of the total area (128.98 sq.km)
- 2022: 53% of the total area (191.71 sq.km)
- Change: There is a notable increase of 17% in the proportion of built-up land. This indicates rapid urbanization and expansion of infrastructure in Nava Raipur, with a substantial increase in residential, commercial, and industrial areas.

Vegetation:

- 2013: 20% of the total area (73.84 sq.km)
- 2022: 39% of the total area (139.82 sq.km)
- Change: There is a significant increase of 19% in the proportion of vegetation. This suggests that there have been efforts to preserve or enhance natural ecosystems, green spaces, and parks amidst urban development. This makes a sustainable way of development incorporating the preservation of natural environment.

Water Body:

- 2013: 2% of the total area (7.98 sq.km)
- 2022: 3% of the total area (10.66 sq.km)
- Change: There is a slight increase of 1% in the proportion of water bodies. While the percentage increase is small, it indicates that there has been some attention given to maintaining or possibly even creating water bodies, which are crucial for the environment and water resources. This initiative is begun as apart of their master pan 2031. The city is also growing as the first integrated sponge city of India. 'Sponge cities'' are emerging as a new trend and pathway for the sustainable development and management of water in cities. The term "sponge cities" is used to describe urban areas with abundant natural areas such as trees, lakes, parks, or other good artificial designs intended to infiltrate the stormwater and recharge the groundwater. This will reduce the overflow of the stormwater into the streams and all, which further causes the overflow of rivers and again causes floods and inundations.

The comparative analysis between 2013 and 2022 reveals several significant trends:

- Urbanization: The increase in built-up land indicates a strong trend towards urbanization and development of infrastructure, including residential, commercial, and industrial areas.
- Vegetation: The increase in vegetation suggests that efforts have been made to balance urban expansion with the preservation of natural ecosystems and green spaces.
- Barren Land: The substantial decrease in barren land indicates successful initiatives to repurpose or reclaim these areas for more productive use.
- Water Bodies: The slight increase in water body coverage indicates attention to maintaining or possibly creating water resources, although this remains a relatively small change.

Overall, the data highlights a dynamic process of urban development and environmental management in Nava Raipur, with efforts to balance economic growth with ecological sustainability.

## 12. Surface Water Body Extraction from Google Earth Pro

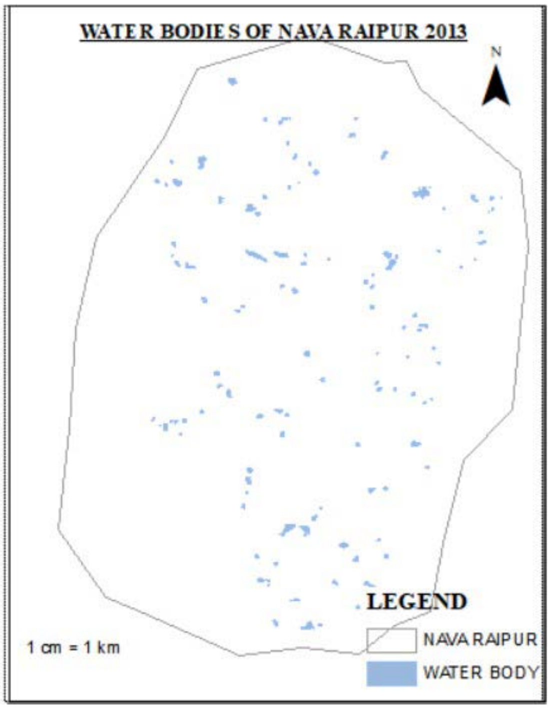


**Figure 8.** spatial extension of water bodies 2013

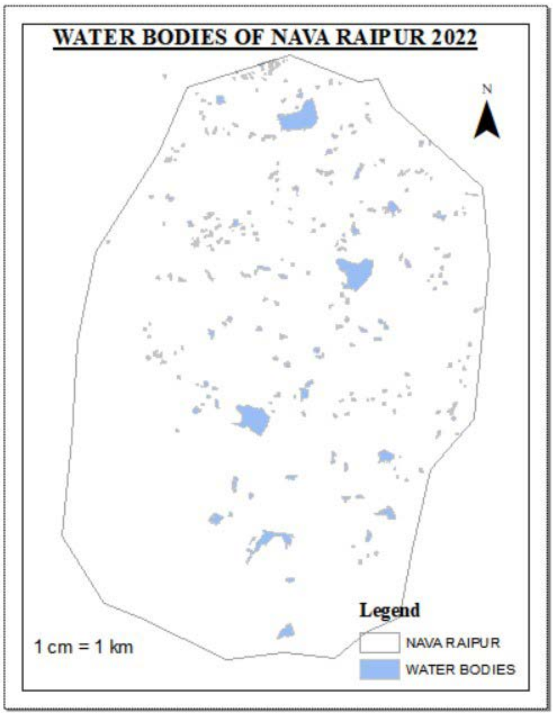


**Figure 9.** Spatial extension of water bodies 2022

The spatial extent of surface water bodies such as lakes and ponds in the study region, Nava Raipur is determined by digitizing the lakes and ponds from the Google Earth Pro of 2013 and 2022. The digitized water bodies are represented in Figure 8 and 9. The digitized spatial boundary represents the region designated for lakes and ponds as per the 2013 and 2022 Google Earth Pro satellite imageries. The digitized water bodies have a surface area of 2.05198514536312 Sq.km in 2013 and 12.11501316 sq.km in 2022 which is considered for the study. The total surface area covered by the surface water bodies (LULC) in the study region is 7.983884336 Sq.km in 2013 and 10.65509089 sq.km in 2022 which includes all the water bodies in the digitized surface area. Here we can see an increase of 3 Sq.km in the total area of water bodies. Since the area of water bodies in LULC depicts the area covered by all the water bodies and not that of designated lakes and ponds, the data was not used for the analysis.

Only Nava Raipur is taken into account for the extraction of surface water bodies. The change in Noida is very less and unable represent diagrammatically. So, for that reason only Nava Raipur's surface water bodies are digitized and represented. The figures 8 and 9 evidently show the increase in the area of water bodies as well as its spatial distribution too. The concentration of water bodies is high in the central part of the city. There we have the administrative building and all kind of major service providing infrastructure. The well maintenance is a reason for the improved area of water bodies. And it is necessary to ensure that the city won't get drowned especially the administrative buildings. So, in order collect the storm water and store in the aquifers the water act as a natural barrier for flood and drought.

## 13. Conclusion

In conclusion, the analysis of land use and land cover (LULC) data for both Noida and Nava Raipur between the years 2013 and 2022 provides valuable insights into the changing landscape and urban development trends in these regions.

For Noida:

- The land use distribution in Noida in 2013 and 2022 shows a significant increase in built-up land, indicating ongoing urbanization and infrastructure development.
- The proportion of barren land decreased, while the proportion of vegetation increased relatively.
- The water body area experienced a modest increase, suggesting some level of attention to water resource management.
- The comparison between the two years reflects Noida's efforts to balance urban growth with ecological preservation, with an emphasis on sustainable development practices.

For Nava Raipur:

- The data reveals a dramatic decrease in barren land and a substantial increase in built-up land, signifying rapid urbanization and infrastructure expansion.
- The proportion of vegetation also increased notably, indicating an effort to balance urban development with ecological sustainability.
- The slight increase in water body area highlights the importance of water resource management and its role in urban planning.
- Nava Raipur's shift towards a more balanced distribution of land use categories suggests a growing commitment to integrated and sustainable urban development.

This study helps to raise concerns for the protection and improvement of surface water resources for our present and future demands. The urban planning and urban governance play a crucial role in building up the cities. The study reveals the need for management of water resources as well as environment for the climate resilient cities. Noida and Nava Raipur are the two satellite cities outgrown to the stage of integrated sponge cities. In both cases, the analysis underscores the importance of maintaining a balance between urbanization, environmental conservation, and water resource management. The data reveals how cities are striving to integrate development with nature, preserve natural ecosystems, and adapt to the challenges posed by climate change and urban expansion. The trends observed in these two cities serve as valuable examples for other urban centres aiming to achieve a harmonious coexistence between human activities and the environment. Continuous monitoring of these changes is essential for informed decision-making and sustainable city planning in the future. An integrative and proactive land use planning and management system at regional strategic level and local action level is considered to be essential if surface water systems are to be conserved and improved. Increased recognition of their societal and ecological value should be reflected in more detailed attention to the spatial requirements of water bodies and riparian areas in urban planning policies [9]. There is possibility for further researches on this area of study. Future research could delve into the specific policies, regulations, and initiatives that contributed to the observed trends, offering a more nuanced understanding of Noida's urbanization journey as well as Nava Raipur's. Additionally, historical data from more years would enable a more comprehensive long-term trend analysis.

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