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DETECTION OF LAND USE AND LAND COVER CHANGE AT THE NAINI INDUSTRIAL SITE IN PRAYAGRAJ

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ABSTRACT

The goal of this research is to examine the impact of industrialization and urban expansion on the Naini Industrial Site in Prayagraj, Uttar Pradesh, India using remotely sensed data. The study will focus on the spatial and temporal effects of these developments. The Land Use Land Cover Change detection potentiality of the remotely sensed dataset with competent Geographic Information Systems (GIS) techniques was utilized to capture and analyze land use and land cover of the region. The findings reveal substantial changes in land use and land cover within the Naini Industrial Site significantly influenced by urban expansion, industrial development, and changes in agricultural practices as the primary drivers of these changes. The results provide valuable information for urban planning, environmental management, and decision-making processes. This study contributes to the understanding of land use and land cover dynamics in industrial sites, highlighting the need for sustainable land management practices in rapidly developing regions. The outcomes can support policymakers, urban planners, and environmental agencies in formulating effective strategies for balanced development and environmental preservation.

Keywords: Land use, Land cover, Change detection, Remote sensing, GIS, Naini Industrial Site, Prayagraj.

INTRODUCTION

Global studies have extensively explored Land Use/Land Cover (LU/LC), analyzing changes in settlements, forests, water bodies, and agriculture, driven by Geographic Information Systems (GIS) and remote sensing technologies (Fen et al. 2019; Kogo et al. 2019; Langat et al. 2019). Satellite imagery availability enables accurate analysis of landscape changes (Dissanayake et al. 2019; Sarif et al. 2017). India's rapid transformation has spurred LU/LC research in cities like Kolkata, Delhi, Mumbai, Bengaluru, Chennai, Raipur, and others, revealing evolving spatial patterns (Sharma et al. 2015; Chakraborty et al. 2015; Samant & Subramanyan, 1998; Govind & Ramesh, 2019; Aithal & Ramachandra, 2016). These studies provide insights into intricate land change dynamics across India.

Our study employs multispectral Landsat 8 Operational Land Image sensor (OLI) data. The Landsat satellite has the best ground resolution and spectral bands for effectively tracking land use and recording land changes brought on by climate change, urbanization, drought, wildfire, biomass changes, and a wide range of other natural and human-caused changes. The Landsat 8 OLI collects data in the visible, near-infrared, and shortwave infrared regions of the spectrum between 433-2300 nm. Along with a 185 km swath, a15- meter panchromatic and 30 meters multi spectral spatial resolution, makes it suitable for our study work.

Prayagraj City (formerly Allahabad City), a significant urban center in Uttar Pradesh, has been designated as a Smart City under India's Smart Cities Mission (MoHUA, 2015). Previous studies on Prayagraj's Land Use/Land Cover (LU/LC) changes (Chaturvedi, 2014; Kumar & Agrawal, 2019; Singh et al. 2013; Srivastava & Gupta, 2003) lack comprehensive insights. These studies suffer from various limitations such as inadequate transition analysis, error matrix explanation, and long multi-temporal gaps. The research gap highlights the need for a detailed study that examines LU/LC dynamics over time and its impact on urban planning for Prayagraj's development as a Smart City. The current study employs multi-temporal Landsat datasets from 2014 & 2023 of the Industrial area of Naini to extract LU/LC maps. The research aims to assess periodic changes, examine transitions among LU/LC classes, and explore transformation consequences on the urban planning of Naini. This study addresses the gaps in previous research and offers valuable insights for effective policy-making and sustainable development of Prayagraj City.

STUDY AREA

Naini, located in the district of Prayagraj, Uttar Pradesh, is situated at 25.371085°N latitude and 81.858737°E longitude. The city is nestled along the confluence of the Ganga and the Yamuna Rivers. While Naini encompasses a vast area, our study focuses on a specific region within Naini, covering approximately 19.227 sq km. Although tourism and agriculture are significant contributors to the city's economic status, the industries located in Naini also play a noteworthy role. Additionally, Naini is renowned for its ashrams that attract devotees throughout the world. These ashrams serve as accommodations and cater to thousands of devotees during events such as the Kumbh Mela. During the Magh and Kumbh Mela, millions of people flock to the Naini railway station, as it serves as a staging area for the holy dip in the sacred waters. Our

study area encompasses the Arail area, which connects various major industries, as well as the Choennki region. Fig 1 & 2. Describes the study area with inset maps of Uttar Pradesh state and Prayagraj City.

Figs 1 (a-e). Different types of Land use/Land covers in the study area.

a. Water Body

b. Dense Vegitation

c. Industry

d. Built-up area

e. Grass Land

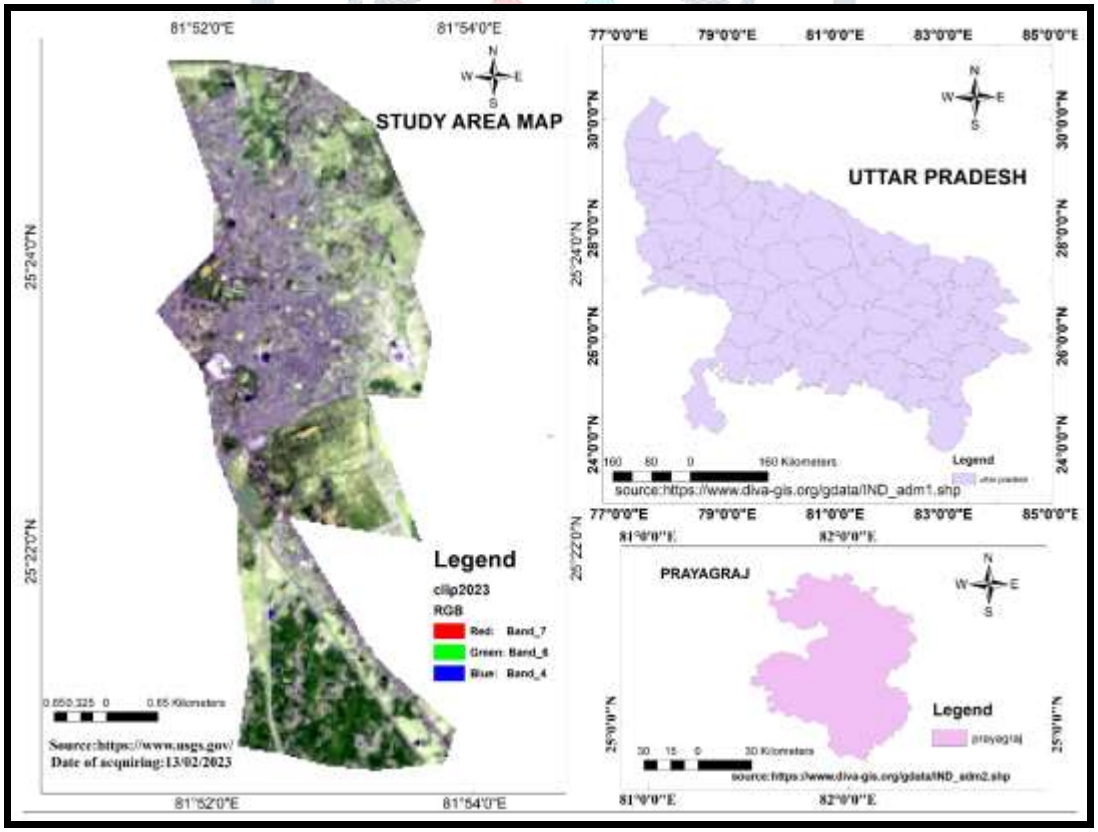

Fig. 2. Study area with inset maps of Uttar Pradesh state and Prayagraj City.

MATERIALS AND METHODS

The land use and land cover analysis was conducted using satellite images obtained from the USGS earth explorer portal for two different years, namely 2014 and 2023. Ground truthing was performed to validate the accuracy of the dataset. Data referencing was performed on the Satellite imageries of Landsat 8 OLI retrieved for the years 2014 and 2023 from the USGS Earth Explorer website. The Crucial examination of cloud cover, spectral and geometric resolution properties, and local seasonal variations was considered prior to the selection of the satellite dataset. Additionally, the administrative boundary shapefile of Prayagraj district was procured through the Diva GIS (https://www.diva-gis.org/gdata) portal. The satellite image was then clipped to the desired administrative boundary using survey points of the study area. A False Color Composite (FCC) image was created for the same using SWIR-2 (band 7), SWIR-1 (band 6), and RED (band 4) bands. This false composite shows vegetation in shades of green, darker vegetation in darker green shades, water in dark blue, built up in light blue or light purple, and industry in yellow and white. Then a supervised image classification is performed wherein the end user provides labeled training samples for each class and the classifier uses the samples to learn the characteristics of various classes and successfully implements them to classify the image.

INSTRUMENTATION AND SOFTWARES

The GARMIN Etrex 10 GPS device with precision of ±10 m was used to determine the precise geographical coordinates of the study area. Flag points marked with GPS devices were later transferred to a laptop for further analysis. ArcGIS 10.8.2 was utilized for creating composite images, performing land use and land cover classification, and change detection analysis using various inbuilt tools of the software. Microsoft Excel was employed for data assimilations, statistical derivations, and graphical representations of the derived composite datasets via ArcGIS 10.8.2. Furthermore, the Level II Classification scheme of the National Remote Sensing Centre (NRSC) Land Use Classification was adopted for the study.

RESULTS

Brief results of Land use and land cover analysis based on multi-temporal satellite images are presented in Table 1 & Fig 2. which displays graphically the Land Use Land Cover Analysis of 2014. The table provides valuable insights into the changes observed in different land cover categories over the period from 2014 to 2023. The analysis reveals that the water body area decreased significantly from 0.112 sq. km in 2014 to 0.052 sq. km in 2023, representing a decrease of approximately 53%. Similarly, the dense vegetation experienced a decrease from 5.766 sq. km to 3.942 sq. km, which accounts for a decrease of around 31%. Further, the grassland area saw a considerable decrease, declining from 6.298sq.km to 4.743 sq. km, indicating a decrease of about 24%. In contrast, the built-up area witnessed a significant increase from 6.642 sq. km in 2014 to 10.069 sq. km in 2023, representing an increase of approximately 51%. This increase in the built-up area shows the highest change among the analyzed categories. Table 2 provides detailed information on the change detection, showing which land cover category transformed into another category and the corresponding area of change. Fig. 3 & 4 displays the Land Use Land Cover Analysis of 2014 &

2023. Further, Fig.5 shows the Land Use Land Cover Change Detection between 2014- 2023. The numerical change between the years is summarized in Table 2 as Categorical Change detection from 2014 to 2023.

Table 1 Statistical Change detection in various land use land cover classes from 2014 to 2023.

LULC Class	Area 2014 (in sqkm)	Area 2023 (in sqkm)	% of the increase (↑) or decrease (↓)	Percentage Area 2014	Percentage Area 2023
Waterbody	0.112	0.052	53%↓	0.58	0.27
Dense vegetation	5.766	3.942	31%↓	29.98	20.5
Grassland	6.298	4.743	24%↓	32.78	24.66
Built-up	6.642	10.069	51%↑	34.54	52.36
Industry	0.409	0.421	25%↑	2.12	2.21
Total	19.227	19.227		100	100

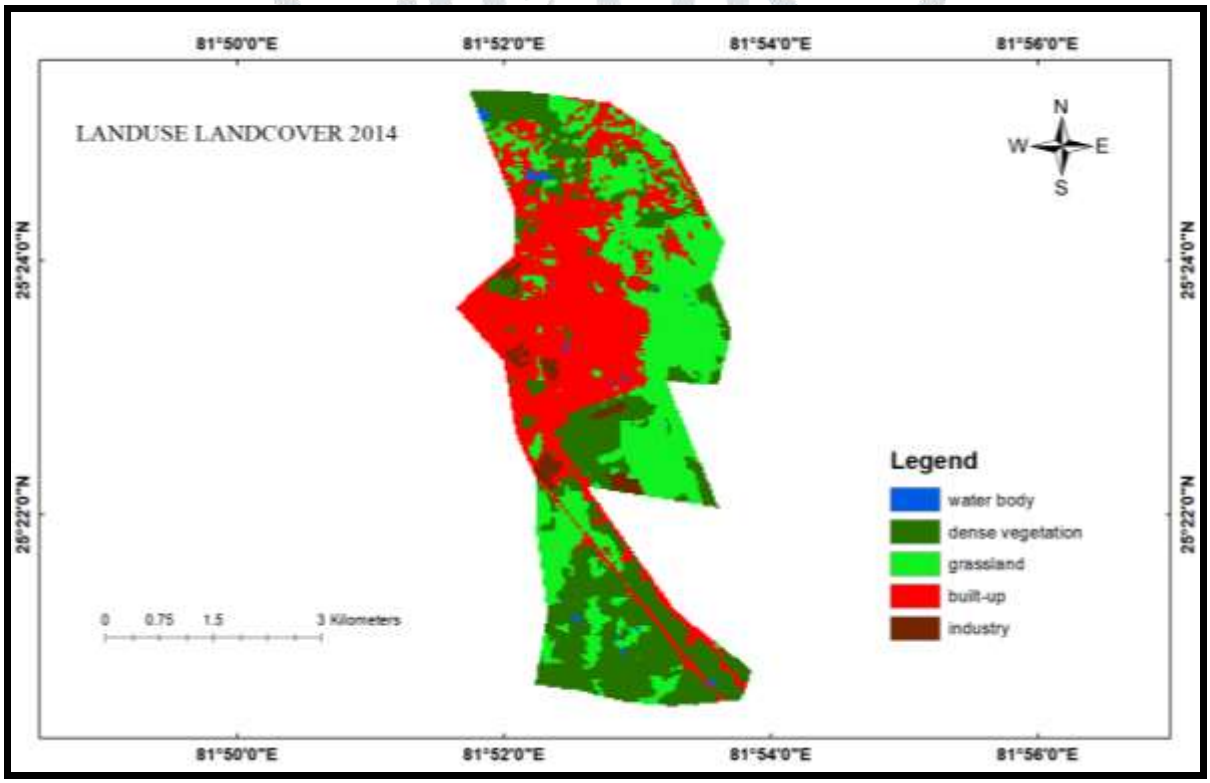

Fig.3. Land Use Land Cover Analysis of 2014

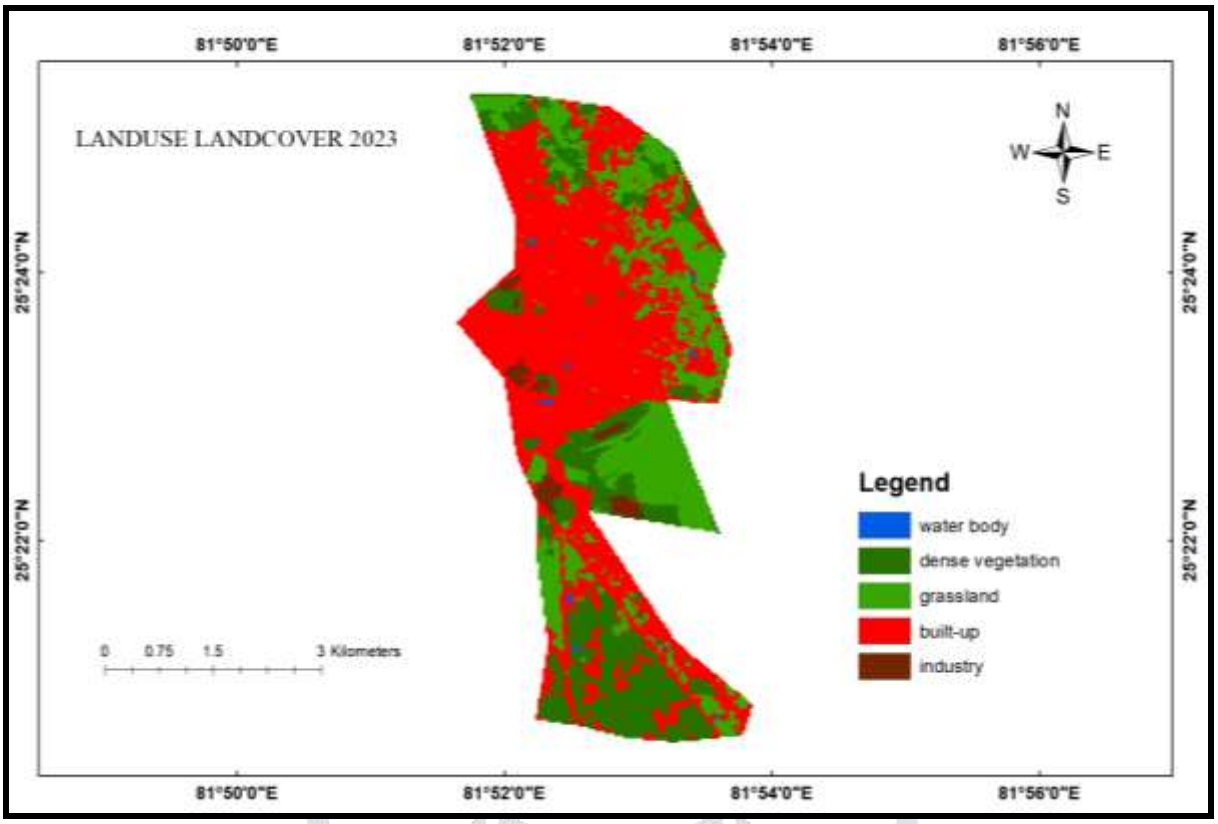

Fig. 4. Land Use Land Cover Analysis of 2023

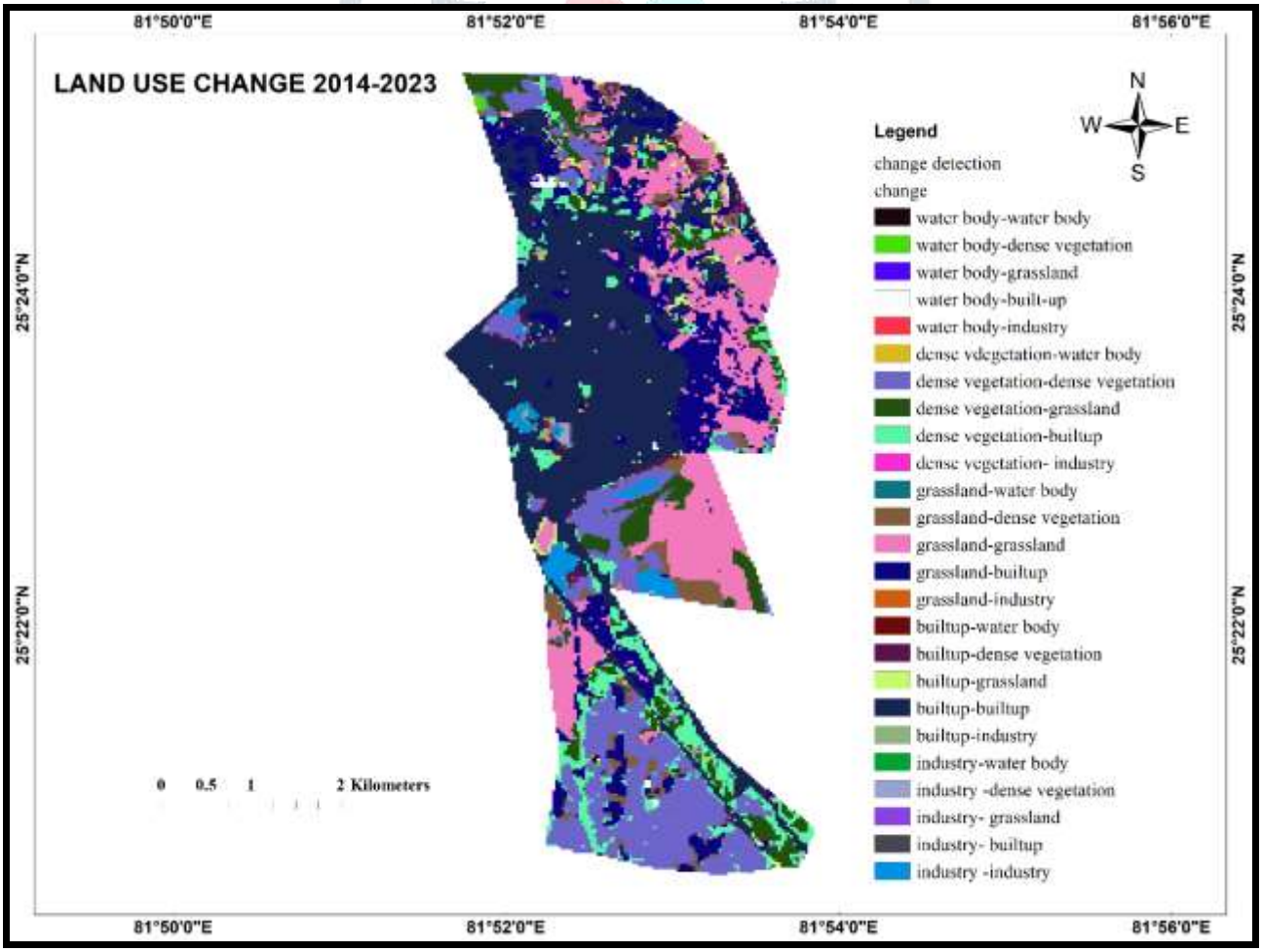

Fig.5. Land Use Land Cover Change Detection between 2014- 2023

The analysis of Table 1, and Table 2, reveals interesting findings. In 2014, the water body accounted for 0.58 % of the total area, which reduced to 0.27% in 2023. Similarly, dense vegetation decreased from 29.98 % in 2014 to 20.50% in 2023. The grassland category, similarly experienced a decline, with its percentage decreasing from 32.78 % in 2014 to 24.66 % in 2023. On the other hand, the built-up area expanded significantly, increasing from 34.54 % in 2014 to 52.36% in 2023. The industrial category witnessed a slight increase, from 2.12% in 2014 to 2.21% in 2023. These findings highlight the changing dynamics of land cover and land use in the study area over the examined period, emphasizing the transformation of natural areas into built-up regions.

Table 2 Categorical Change Detection from 2014 to 2023

S.NO.	Class Change Category	Area (sq km)
1	water body-water body	0.012
2	water body-dense vegetation	0.031
3	water body-grassland	0.017
4	water body-built-up	0.084
5	water body-industry	0
21	industry-water body	0
22	industry -dense vegetation	0.048
23	industry- grassland	0
24	industry- built up	0.02
25	industry -industry	0.355
11	grassland-water body	0.011
12	grassland-dense vegetation	0.604
13	grassland-grassland	3.177
14	grassland-built up	2.481
15	grassland-industry	0.012
16	dense vegetation-water body	0.016
7	dense vegetation-dense vegetation	2.999
8	dense vegetation-grassland	1.302
9	dense vegetation-built up	1.418
10	dense vegetation- industry	0.011
16	built up-water body	0.011
17	built up-dense vegetation	0.276
18	built up-grassland	0.235
19	built up-built up	6.066
20	built up-industry	0.041
		19.227

DISCUSSION

Over the period from 2014 to 2023, the Naini Industrial Site in Prayagraj has undergone substantial changes, particularly with a remarkable increase of 51% in the built-up area. The surge in construction activities attributed to rapid urbanization has led to the establishment of multistory apartments, high-tech city projects, and township developments. Notable examples include Saraswati High-Tech City, Omax Shiva, and Narayan Smart City. The area has become a hub for employment opportunities, offering a range of facilities such as hospitals, transportation services, quality educational institutions, banks, and a railway station. As a result, the growing population demands more residential and commercial spaces, driving the increase in built-up areas. The demand for land for construction purposes has necessitated the clearance of vegetation and grassland areas, resulting in a 31% decrease in dense vegetation and a 24 % decrease in grassland. While the majority of this change can be attributed to built-up activities, shifts from other land cover categories have also contributed to the decline (Deka et al. 2019; Xu et al. 2019)

Water bodies in the form of ponds and wetlands have also experienced a decrease in size (53% decrease). Some of these water bodies may have undergone succession, transforming into dense vegetation

and grassland areas. Additionally, a portion of water bodies has been covered by the expansion of built-up areas.

Most of the industries in the Naini Industrial Site have either shut down or experienced a significant slowdown. Prominent industrial establishments like Triveni Structural Limited (TSL), Bharat Pumps and Compressors Limited (BPCL), Indian Telephone Industry (ITI), Hindustan Cables, Swadeshi Cotton Mill, AREVA, LIPTON, and others, which once contributed to the area's reputation as an industrial hub in the eastern region, are now defunct. The closure of these industries has not only affected the industrial climate in the city but has also forced workers to seek alternative employment opportunities.

In the case of AREVA, the company has been sold to a new entity called SSEL (formerly T and D), resulting in its revival under new ownership. Furthermore, the Naini Industrial Site is also home to the Naini 80 MLD (Million Liters per Day) sewage plant, employing the activated sludge process, and a 5MW solar power plant operated by EMC Limited in collaboration with NTPC Vidyut Vyapar Nigam. The solar power plant is the first of its kind in the state of Uttar Pradesh. These facilities were present both in 2014 and 2023. Despite witnessing rapid urbanization, construction activities, and various developmental projects, the area has struggled to revive its declining industries. So far, the government has not implemented any measures to address this issue. In a developing nation like India, the function and significance of industries are very vital for exterminating poverty, creating employment opportunities, developing rural areas, and maintaining a balance in the promotion and growth of various activities. Companies like TSL, SHAIL, Champion Cycles, BPCL, ITI, Cotton Mill, Raymond, and LIPTON made all these commodities be produced inside the country, reducing imports and also promoting export which not only improved domestic productivity but also helped in increasing foreign reserves and reducing pressure on countries balance of payment (Kapoor, D., & Pandey, N. 2019) Moreover, Industrial organizations that anticipate and prepare for a sustainable future are more likely to endure into the next generation, thus providing chance for systematic and sustainable revival of these industries and contribute to development (Prakasam. C 2010)

CONCLUSION

Through the application of remote sensing techniques and conducting change detection studies, valuable insights about the Naini Industrial site have been obtained. The area has experienced rapid development, with the establishment of residential projects, improved transportation infrastructure, and easier connectivity to Allahabad city, making it an attractive destination for a larger population. The population growth can be attributed to the ongoing construction activities, as a growing population requires housing and office spaces.

However, the increasing demand for land has come at the expense of green spaces, leading to a decline in dense vegetation, grassland, and water bodies. This decline has been observed at a rapid rate, serving as a warning sign for potential future environmental issues. To mitigate these challenges, adopting sustainable urban planning methods is crucial to strike a balance between development and environmental conservation.

One major concern in the Naini area is the fate of its industrial hub. Many industries now have dilapidated buildings, presenting an unsightly and underutilized space. Reviving these industries or repurposing the land

holds significant potential for creating employment opportunities in the area. Giving priority to these industries would address the issue of unemployment and contribute to sustainable industrial development by incorporating environmentally friendly technologies.

To ensure the overall well-being of the city, the government and development authorities need to plan land use in a manner that considers human needs, socioeconomic factors, and environmental preservation. Balancing development with environmental sustainability and prioritizing industries that promote job creation and income generation, while embracing technologies that prioritize environmental safety, will pave the way for a thriving city with immense potential.

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