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Change in Land Use Pattern: Change Scenario of Urban Features, A case study of korba city

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Introduction:

According to Patel et al. (2019), land-use change refers to modifications made to the way humans utilize or deal with a specific piece of land, while land-cover change refers to changes made to certain continuous aspects of the land, such as the kind of flora, the characteristics of the soil, and so forth. This has to do with how urbanization has changed the natural landscape. It is noteworthy to note that a variety of local and global repercussions, such as the loss of habitat and ecosystem services, as well as the loss of biodiversity and the health effects that go along with it, are caused by this change (Patel et al., 2019). Even though sprawl is seen as a necessary and concurrent result of fast urbanization, there is debate and misunderstanding surrounding the term in urban geography, particularly with regard to land use and planning (Maier et al., 2006). The occurrence and management of sprawl are complicated by a number of related phenomena, including conceptual ambiguity and misunderstanding about origins and consequences, as well as urban expansion, suburbanization, outgrowth, and a lack of consistent, precise, and scientific measures. Urban sprawl is a key dynamic phenomenon associated to urban space, however because of its enigmatic character, the existing research lacks consensus definitions and measurement techniques (Barnes et al., 2001; Clifton et al., 2008; Liu et al., 2018). From a conceptual standpoint, it is the encroachment of urban boundaries onto other land classifications, such as open spaces, aquatic bodies, and agricultural and vegetated areas (Sharma & Kumar, 2023; Zhang, 2004). It is a low-density, heterogeneous region with key urban characteristics that was created on the outskirts of a well-established urban center and is encircled by either agricultural land or open space (Saini & Tiwari, 2020). Urban sprawl is, to put it simply, the word used to describe the incorrect pattern and inconsistency of rapid development in sub-urban areas or the periphery of developed areas (Cheng, 2003).

Land use Pattern of Korba City

Korba city, located in Chhattisgarh, exhibits a distinct land use pattern influenced primarily by its industrial activities, particularly coal mining and power generation, as well as urbanization (Dewangan et al., 2020). Korba is one of India's largest coal-producing regions, dominated by open-cast coal mines. A significant portion of land is dedicated to mining operations, coal processing, and associated industrial infrastructure. Large tracts of land are occupied by thermal power plants (e.g., NTPC, Korba Super Thermal Power Plant), which consume considerable space for energy production and related facilities. The presence of industries like Bharat Aluminum Company (BALCO) contributes to a substantial industrial footprint. Rapid industrialization has led to the growth of urban settlements. Residential, commercial, and institutional areas have expanded significantly, especially in the vicinity of industrial zones. Roads, highways, railways, and utility corridors crisscross the city, connecting industrial zones with urban residential areas.

Traditional agricultural land exists on the outskirts of the city, though these areas are shrinking as urban and industrial zones expand. Rice, maize, and pulses are some of the key crops grown. The encroachment of agricultural land by industrial projects has reduced the overall farming area. Korba is surrounded by dense forests, particularly in the northern and northeastern regions. These forested areas are critical for the region's biodiversity and act as catchment zones for rivers like Hasdeo. Mining and urban sprawl have led to deforestation, reducing forest cover and affecting wildlife habitats.

The Hasdeo River is a major water body flowing through Korba. Reservoirs and small lakes serve as important water sources but face pollution from industrial runoff (Dheeraj et al., 2023). The construction of industrial water intake and discharge systems has impacted natural water bodies, leading to pollution and changes in hydrological patterns. Areas around coal mines are characterized by spoil heaps and waste dumps, which occupy significant land and contribute to landscape degradation. The city has several zones of degraded land, mainly due to mining activities and deforestation, leading to reduced land productivity.

1. Materials & Methods

This study made use of Sentinel 2 (path 142, row 44) and Landsat OLI (Figure 1). Sentinal 2 (2020) was supplied by a commercial data supplier (Figure 2), whereas the Landsat OLI images (2000 and 2010) were obtained from the USGS Earth Resources Observation Systems data center. we tried to keep the dates of the two photos as near to the same season as feasible. Using a spatial resolution of 15 meters for panchromatic, 30 meters for multispectral, and 30 meters for thermal infrared sensor (TIRS), Landsat 8 OLI satellite pictures were obtained for the research region. For spectral characteristics, Landsat 8 uses an 11-band combination. In 2015, the multispectral Sentinel-2 sensor was introduced. Sentinel-2 contains 13 bands with a spatial resolution of 10, 20, and 60 m, covering the VNIR region with 8 bands and the SWIR zone with 2 bands. The swath is 290 kilometers wide. Sentinel-2 photos are supplied at the radiometrically and geometrically corrected L1C level.

2. Results

2.1. Year-wise LULC change analysis

The land use and land cover map (LULC) were created using the supervised classification method since it provides more accurate and better information, although training site selection must be done carefully to reduce error. A change estimate for LU/LC was made from 2000 to 2020, and the research area is 227 km^2. Table 1 summarizes the individual class area and change statistics for the three years. Classification maps were created for each of the three years (Figures 3, 4, and 5).

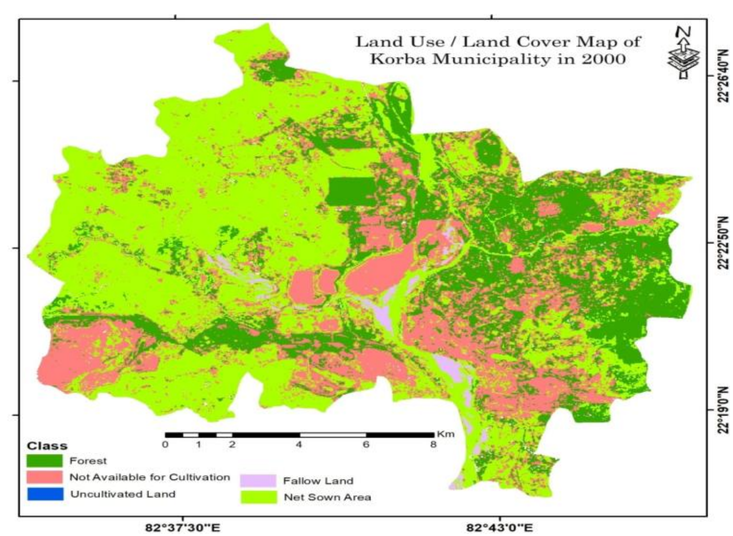

Figure 1: Land use land cover characteristics of Korba city in 2000

In the study area, most of the land is covered by arable land and natural vegetation cover, distributed mostly in the east and west of the stud area. Industrial centre and mining area are observed in south and small pockets of central part of the city. The built-up area is mostly observed in the central and south-east of the Korba city.

Table 1 makes it clear that between 2000 and 2010, net sown area and forest saw the largest LULC changes. Uncultivated Land has steadily decreased, shrinking from 13.38 sq. km in 2000 (5.88%) to 9.19 sq. km in 2010 (4.04%), and further down to 6.94 sq. km in 2020 (3.05%). This downward trend suggests increasing pressure to convert previously unused land into productive or developed uses, possibly due to population growth or economic development.

Forest area has also seen a consistent decline, dropping from 87.65 sq. km in 2000 (38.5%) to 82.21 sq. km in 2010 (36.11%), and reaching 71.69 sq. km by 2020 (31.49%). This represents a loss of over 15 sq. km of forest cover in 20 years, likely driven by deforestation for agriculture, infrastructure expansion, or urbanization. This trend raises concerns about biodiversity loss, carbon sequestration capacity, and ecosystem health.

In contrast, land classified as Not Available for Cultivation has significantly increased—from 29.58 sq. km (12.99%) in 2000 to 49.39 sq. km (21.70%) in 2010, and then to 69.76 sq. km (30.64%) in 2020. This indicates a growing segment of land being repurposed for non-agricultural uses such as settlements, industries, roads, and other infrastructure. The sharp rise suggests accelerating urban expansion and potentially the degradation of arable lands.

The Net Sown Area, representing land actively used for crop cultivation, has declined from 95.67 sq. km in 2000 (42.03%) to 82.76 sq. km in 2010 (36.35%), and further to 75.04 sq. km in 2020 (32.96%). This reduction reflects a shift away from traditional agriculture, possibly due to changes in rural livelihoods, declining groundwater levels, land degradation, or conversion of farmland for non-agricultural purposes.

Finally, Fallow Land—land left uncultivated for a period to restore its fertility—has seen a marked increase from just 1.36 sq. km (0.60%) in 2000 to 4.10 sq. km (1.80%) in 2010, and 4.23 sq. km (1.86%) in 2020. While still a relatively small proportion of the total land, this rise could reflect

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either improved agricultural practices that include crop rotation and fallowing or an indicator of declining interest or capacity in farming activities.

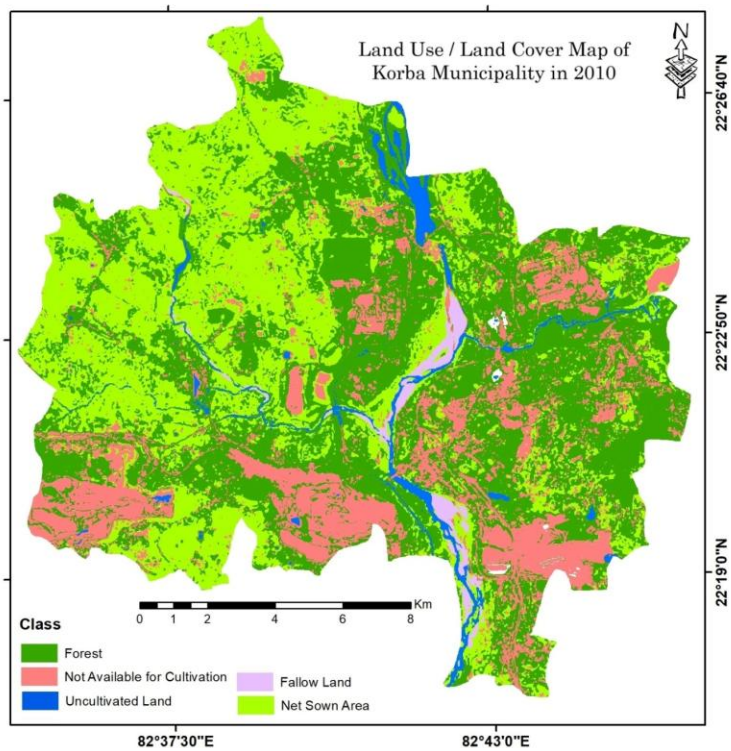

Figure 2: Land use land cover characteristics of Korba city in 2010

Table 1: Areal distribution of land use / land cover characteristics in the study area

Class	**Sub-Class**	**2000 (sq km)**	**Percent**	**2010 (sq km)**	**Percent**	**2020 (sq km)**	**Percent**
Forest	Forest	87.65	38.5	82.2	36.11	71.67	31.49
Not Available for Cultivation	Built up	11.69	5.14	23.39	10.27	36.45	16.01
	Industry	17.89	7.85	26	11.42	33.31	14.63
Uncultivated Land	Uncultivated Land	13.38	5.88	9.19	4.04	6.94	3.05
Fallow Land	Fallow Land	1.36	0.6	4.1	1.8	4.23	1.86
Net Sown Area	Net Sown Area	95.67	42.03	82.76	36.35	75.04	32.96
Total		227.64	100	227.64	100	227.64	100

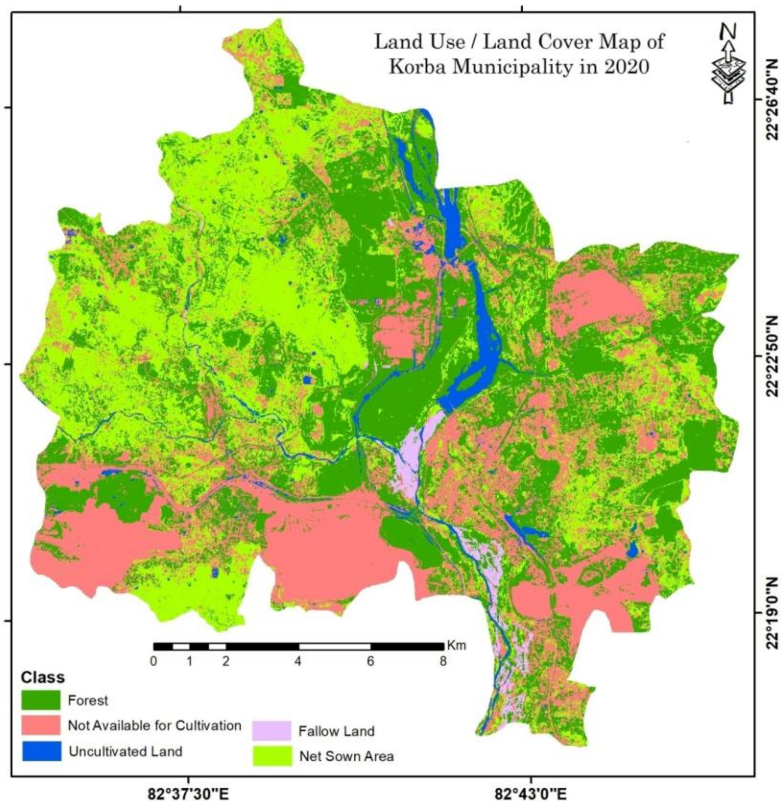

Figure 3: Land use land cover characteristics of Korba city in 2020

The Land Use and Land Cover (LULC) change analysis over three-time intervals—2000–2010, 2010–2020, and 2000–2020—provides valuable insights into the dynamic transformations occurring in land use patterns across the region (Table 2).

Between 2000 and 2010, the Uncultivated Land category reduced by 4.19 sq. km, equivalent to a 1.84% decrease. This trend continued, albeit at a slower rate, with a further reduction of 2.25 sq. km (0.99%) between 2010 and 2020. Over the two-decade span, a total decrease of 6.44 sq. km (2.83%) was observed, indicating a consistent conversion of uncultivated lands into other land use categories, possibly for cultivation, construction, or industrial purposes.

Table 2: Areal changes of Land use / land cover characteristics of Korba district during the period between 2000 and 2020

Class	Sub-Class	2000 - 2010 (sq km)	Percent	2010 - 2020 (sq km)	Percent	2000 - 2020 (sq km)	Percent
Forest	Forest	-5.44	-2.39	-10.52	-4.62	-15.96	-7.01
Not Available for Cultivation	Built up	11.7	5.13	13.06	5.74	24.76	10.87
	Industry	8.11	3.57	7.31	3.21	15.42	6.78
Uncultivated Land	Uncultivated Land	-4.19	-1.84	-2.25	-0.99	-6.44	-2.83
Fallow Land	Fallow Land	2.74	1.2	0.13	0.06	2.87	1.26
Net Sown Area	Net Sown Area	-12.91	-5.67	-7.72	-3.39	-20.63	-9.07

(-) indicate negative growth; (+) indicates positive growth

The Forest class experienced the most significant decline among all categories. From 2000 to 2010, forest cover shrank by 5.44 sq. km (2.39%), accelerating further in the following decade with a loss of 10.52 sq. km (4.62%). The cumulative reduction over 20 years was a substantial 15.96 sq. km (7.01%). This pronounced decline highlights serious environmental implications, including deforestation, habitat loss, and reduced carbon sinks—likely driven by increasing pressure from agriculture, urban expansion, and infrastructure development.

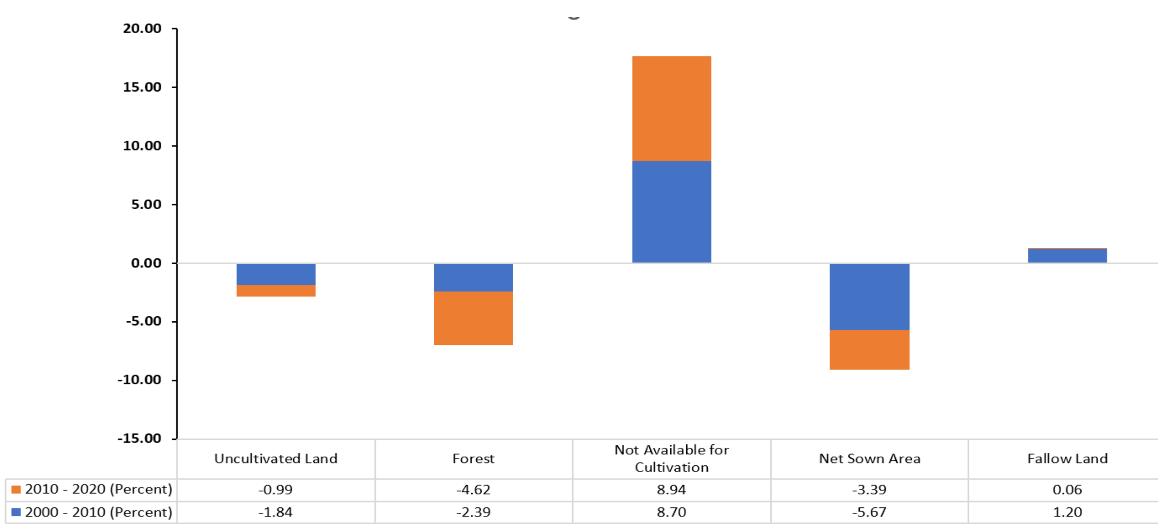

Figure 4: Positive and negative growth of LULC classes in the Korba municipality during the period between 2000 and 2020

In stark contrast, the area classified as Not Available for Cultivation rose dramatically. It increased by 19.81 sq. km (8.70%) from 2000 to 2010 and by another 20.37 sq. km (8.94%) from 2010 to 2020, marking a total rise of 40.18 sq. km (17.65%) over two decades. This surge signifies a rapid transformation of land into built-up, infrastructural, or otherwise non-agricultural usage, indicating urban sprawl and industrialization as key drivers (Figure 6).

The Net Sown Area, representing actively cultivated land, declined sharply—first by 12.91 sq. km (5.67%) between 2000 and 2010, and then by another 7.72 sq. km (3.39%) in the next decade. The cumulative loss of 20.63 sq. km (9.07%) over 20 years reflects a persistent contraction of agricultural land, potentially due to declining farm viability, land degradation, or a shift in occupational patterns away from agriculture.

Fallow Land exhibited a contrary trend, increasing by 2.74 sq. km (1.20%) during the first decade, with only a marginal addition of 0.13 sq. km (0.06%) from 2010 to 2020. Over the full 20-year period, this class grew by 2.87 sq. km (1.26%). This moderate growth suggests that while some land is being temporarily rested from cultivation, it may also point to an increasing number of agricultural plots left unused due to economic or agronomic challenges.

LULC Class wise change detection analysis

In the year 2000, uncultivated land covered an area of 13.38 sq. km, accounting for 5.88% of the total municipal area. This suggests that at the turn of the century, a moderate portion of the municipality's land remained unused for agriculture or development—possibly due to terrain limitations, ownership issues, or lack of infrastructural development.By 2010, this uncultivated area had reduced sharply to 9.19 sq. km, or 4.04% of the total land area. This decline of approximately 4.19 sq. km (a 1.84% reduction in percentage terms) over a decade suggests active land conversion efforts. The driving factors could include increasing urbanization, industrialization (especially in a mineral-rich region like Korba), and growing demand for land for residential, commercial, and infrastructural development.The trend continued into 2020, where uncultivated land further declined to 6.94 sq. km, constituting only 3.05% of the total municipal land. This represents an additional loss of 2.25 sq. km (or 0.99%) over the second decade. Overall, from 2000 to 2020, Korba witnessed a total reduction of 6.44 sq. km of uncultivated land—

equivalent to a 2.83% decline over 20 years.This consistent shrinkage of uncultivated land highlights an ongoing process of land use intensification in Korba Municipality. The pressure to accommodate urban growth, industrial expansion (given Korba's role as a power and mining hub), and possibly the conversion of idle land into productive or infrastructural assets are key contributors to this pattern. While such transitions are often linked with economic development, they also raise important questions about sustainable land management, ecological balance, and the preservation of open or green spaces within the urban fabric.

The forest land within Korba Municipality has experienced a steady and concerning decline over the two decades from 2000 to 2020, indicating significant environmental transformation, likely due to urban expansion, industrial activities, and land use conversion.In the year 2000, forest land accounted for 87.65 sq. km, which represented approximately 38.50% of the total municipal area. This high percentage indicates that forest cover once constituted a major portion of Korba's landscape, providing vital ecosystem services such as biodiversity preservation, climate regulation, and watershed protection.By 2010, the forest area had decreased to 82.21 sq. km, reducing its share to 36.11% of the municipal territory. This loss of 5.44 sq. km (a 2.39 percentage point drop) over a decade signal growing developmental pressures on forested areas. During this period, Korba witnessed a phase of industrialization and urban growth, particularly in energy and mining sectors, which likely contributed to deforestation and encroachment on green cover.The trend further intensified between 2010 and 2020, when forest cover declined more sharply to 71.69 sq. km, comprising only 31.49% of the total area. This represents a more significant reduction of 10.52 sq. km in just ten years—almost double the forest loss compared to the previous decade. The corresponding decline of 4.62 percentage points reflects accelerating land use conversion, possibly due to infrastructure development, coal mining, and expanding residential or commercial zones (Figure 7).Overall, from 2000 to 2020, Korba Municipality lost a total of 15.96 sq. km of forest area, shrinking its forest cover by 7.01 percentage points. This 18% reduction in forest extent over two decades is not only environmentally alarming but also highlights the need for immediate policy intervention. Loss of forest cover can lead to severe consequences such as soil erosion, reduced air quality, loss of wildlife habitats, and vulnerability to climate change impacts.

The Not Available for Cultivation (NAC) land category in Korba Municipality has witnessed a significant and consistent increase over the two-decade period from 2000 to 2020, both in absolute area and proportional coverage. In the year 2000, NAC land covered approximately 29.58 sq. km, which constituted about 12.99% of the municipality’s total area. By 2010, this figure rose sharply to 49.39 sq. km, making up 21.70%, and continued to grow, reaching 69.76 sq. km by 2020, which corresponds to a substantial 30.64% of the total land area.This upward trend indicates a notable shift in land use patterns, reflecting increasing areas being rendered unsuitable or intentionally allocated for purposes other than cultivation, such as infrastructure development, urban expansion, mining, industrialization, or permanent settlements. The steep rise, particularly between 2000 and 2020, suggests accelerating pressure on agricultural land due to socioeconomic and developmental factors. The increase of 40.18 sq. km over two decades signifies a major transformation in land use, highlighting the need for strategic land management and planning to balance development with food security and environmental sustainability in the region (Figure 7).

The Net Sown Area (NSA) in Korba Municipality has shown a steady decline over the two-decade period from 2000 to 2020, both in absolute area (sq km) and as a percentage of total land use. In the year 2000, the Net Sown Area was approximately 95.67 sq km, which constituted around 42.03% of the municipality's total land area. This reflects a period when agriculture was a dominant land use, likely supported by sufficient availability of arable land, water resources, and a population heavily dependent on farming.By 2010, the Net Sown Area had decreased to 82.76 sq km, amounting to 36.35% of the total land use. This decline of about 12.91 sq km (or roughly 5.68%) over the decade could be attributed to various factors such as urban expansion, land degradation, conversion of agricultural land for infrastructure development, or shifting livelihood patterns.The trend continued into 2020, with the Net Sown Area further reducing to 75.04 sq km, representing just 32.96% of the total land area. This marks a total reduction of over 20.63 sq km (approximately 9.07%) in Net Sown Area between 2000 and 2020. Such a consistent decline suggests long-term transformations in land use practices, potentially driven by factors such as increasing pressure from urbanization, changing climatic conditions affecting crop viability, or declining interest in agriculture among the local population.

The analysis of Fallow Land in Korba Municipality across the three decadal time points—2000, 2010, and 2020—shows a notable upward trend in both areal extent and percentage share within the overall Land Use and Land Cover (LULC) distribution. In the year 2000, fallow land constituted approximately 1.36 square kilometers, accounting for 0.60% of the total geographical area. This relatively small share suggests that land left uncultivated temporarily was minimal at the turn of the century, possibly due to higher utilization of agricultural land or lower agricultural stress.However, by 2010, fallow land increased sharply to 4.10 sq km, representing 1.80% of the total area. This significant rise—more than threefold in area and percentage—could indicate a combination of factors such as soil fertility decline, water scarcity, changes in land ownership, or socio-economic shifts leading to a reduction in active agricultural practices. It may also reflect a transition phase where land was being temporarily abandoned or repurposed.In 2020, the area under fallow land further increased slightly to 4.23 sq km, with a marginal rise in percentage to 1.86%. While the growth rate slowed compared to the previous decade, the continuous upward trend over 20 years suggests a gradual but consistent pattern of agricultural land being left unused, either due to environmental constraints or structural changes in local agriculture and land management. This trend underscores the need for targeted land reclamation strategies, agricultural revitalization, or sustainable land use planning to mitigate the prolonged underutilization of cultivable areas.

3. Discussion

Understanding land use and cover is now crucial to addressing issues with biogeochemical cycles, biodiversity, declining ecosystems, degradation of the environment, loss of agricultural land, devastation of wetlands, and loss of habitat for fish and wildlife (Mallupattu et al., 2013). Rapid population expansion, rural-to-urban migration, reclassification of rural areas as urban areas, poverty, ignorance of biophysical limitations, and the usage of ecologically incompatible technologies are the main causes of the LULC shifts (Torahi and Rai, 2011).We employed cutting-edge technologies, such as remote sensing and GIS, to measure LULC because various data sets were involved. Our classification of the research area has been based on the analysis of remote sensing data, field surveys, and current conditions. The categories include arable land, built-up area, natural vegetation, industry, waterbodies, and sand bar area.In summary, the obtained results, which are now being examined and analyzed, demonstrate that the study's goals and purposes have been met. There are five classifications for land use change detection for each year between 2000 and 2020.

The Land Use and Land Cover (LULC) change in Korba city, Chhattisgarh, has primarily resulted from rapid urbanization and industrialization, particularly in coal mining and thermal power sectors (Yang and Lo, 2002). This has led to significant loss of arable land and forest cover, along with degradation of surface water bodies due to pollution and encroachment. Conversely, there has been notable growth in built-up areas and industrial zones, contributing to economic development but also necessitating sustainable planning to mitigate environmental impacts.The built-up area in Korba city, Chhattisgarh, has undergone significant changes due to rapid urbanization and industrialization. This expansion has transformed previously agricultural and forested lands into residential, commercial, and industrial spaces (Wiatkowska et al., 2021). The growth is particularly pronounced near coal mining and thermal power plants, which have attracted infrastructure development. This trend reflects the city's economic growth but also raises concerns about environmental sustainability and the need for effective urban planning to mitigate negative impacts on natural resources.

The mining and industrial areas in Korba city, Chhattisgarh, have expanded significantly, driven by the presence of coal reserves and thermal power plants. This growth has led to the establishment of various industrial facilities, increasing land use for mining operations. The area around these facilities has seen infrastructural development, impacted local ecosystems and reduced arable land (Pal and Ziaul, 2017). The changes underscore the balance between economic growth and environmental sustainability, necessitating effective land management strategies to mitigate adverse effects on natural resources and communities.Natural vegetation and forest cover in Korba city, Chhattisgarh, have significantly decreased due to industrialization and urban expansion, primarily driven by coal mining activities (Potapov et al., 2022). Deforestation has led to habitat loss and reduced biodiversity, impacting local ecosystems. As industrial areas and infrastructure expand, the remaining forest cover becomes fragmented, exacerbating environmental challenges.

Conservation efforts and sustainable land management practices are essential to mitigate these impacts and restore ecological balance in the region.

The area of surface water bodies in Korba city, Chhattisgarh, has decreased significantly due to urbanization and industrial activities. Encroachment, pollution, and changes in land use have negatively affected the quality and quantity of water resources. Key water bodies have been impacted by the expansion of industrial zones, leading to habitat loss and diminished water quality. Efforts to monitor and manage these water resources are essential to mitigate further degradation and support sustainable urban development. The sand bar areas in Korba city, Chhattisgarh, have experienced changes primarily due to alterations in river dynamics caused by mining and urban development. These changes can lead to sedimentation and shifting landforms, impacting local ecosystems and water flow. As urbanization increases, natural sand bars may be affected by encroachment and environmental degradation, emphasizing the need for monitoring and management strategies to preserve these dynamic areas and maintain ecological balance.

Across all three assessments, classification accuracy improved progressively from 86% to 90%, reflecting refinement in methodology and better class separability. The Net Sown Area and Fallow Land consistently showed high producer accuracy, indicating that agricultural features were well recognized in classification. However, some classes like Forest and Area Not Used for Cultivation saw occasional misclassifications, as shown by slightly lower user accuracies. The results indicate a robust and reliable LULC classification effort, with most classes being consistently well represented in the classified maps. Further enhancement can focus on improving class separability and addressing overlap between similar land cover types.At the overall level, the Kappa statistic for all classes combined was 0.8463 in 2000, decreased slightly to 0.8207 in 2010, and then increased to a high of 0.8714 in 2020. These overall values indicate that while classification quality remained strong throughout the period, 2020 witnessed the highest level of agreement between classified outputs and actual ground conditions. This progression suggests continual improvement in classification techniques or data sources used in the latter stages of the study.

4. Summary

This Study combines GIS and remote sensing data to examine changes in land use and land cover (LULC) in the urban region of Korba municipality, Chhattisgarh. Our findings unequivocally demonstrate that between 2000 and 2020, there were notable variations in LU/LC. There has been a noticeable increase in the built-up area. However, the areas of arable land, water spread, and natural vegetation are decreasing.The substantial influence of population growth and related development activities on LULC change is amply demonstrated by this study. This study demonstrates that using remote sensing and GIS together is a useful tool for managing and planning metropolitan areas. In order to improve public understanding and aid environmental management groups and policy makers, the quantification of LU/LC variations in the Korba Municipal region is highly helpful.

In this study, validation data were collected from various ground truth points and visually interpreted high-resolution imagery. The confusion matrix generated from this data was used to compute all accuracy metrics, ensuring a statistically sound and methodologically consistent evaluation of the LULC classification performance across different years.The LULC trends from 2000 to 2020 show a clear transition from agriculture and forests toward non-cultivable and developed land uses, accompanied by a decline in natural and cultivated land covers. These patterns underscore the need for sustainable land management and policy interventions to balance development with environmental conservation. The data reflect a clear shift from natural and agricultural land classes toward non-cultivable and developed land uses. The decline in forest and sown areas combined with a surge in non-cultivable land underscores growing developmental pressures and possible ecological degradation, emphasizing the urgent need for integrated land use planning and sustainable resource management.The forest land change in Korba Municipality over the past 20 years underscores a critical transition from a green, forest-dominated landscape to a more urbanized and industrial terrain. Strategic urban planning, afforestation initiatives, and stricter enforcement of forest protection laws are essential to mitigate further degradation and ensure ecological sustainability. Across all three assessments, classification accuracy improved progressively from 86% to 90%, reflecting refinement in methodology and better class separability. The Net Sown Area and Fallow Land consistently showed high producer accuracy, indicating that agricultural features were well recognized in classification. However, some classes like Forest and Area Not Used for Cultivation saw occasional misclassifications, as shown by slightly lower user accuracies. The Kappa statistics analysis highlights a generally high level of classification accuracy for LULC in Korba Municipality, with the best performance recorded in 2020. The data supports the reliability of the classification outcomes and validates the use of the methodology for monitoring long-term land use changes. This data highlights a significant shrinking of agricultural land in Korba Municipality, underlining the need for integrated land use planning and sustainable agriculture promotion strategies to protect remaining cultivable land and ensure food security and rural livelihoods

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