

Morphological Assessment of Land Use and Land Cover in Gurugram City (2001)

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ABSTRACT

This study provides a comprehensive morphological assessment of land use and land cover (LULC) in Gurugram City as of 2001, focusing on the signs of urban transformations that began during the early stages of urbanization. Once primarily an agrarian district, Gurugram has evolved into a dynamic urban center, a shift driven by rapid industrialization and economic growth. Utilizing geospatial data sources, including Google Earth imagery and historical town planning documents, the research analyzes the spatial distribution and classification of various land use types. Key objectives include quantifying the extent of transformation from agricultural land to urban spaces. The findings reveal that, in 2001, agricultural land constituted 33.21% of the total area, indicating a still-prevalent rural character, while open areas accounted for 29.31%, highlighting significant undeveloped land. Residential areas covered 14.30%, characterized by modest housing developments, while industrial zones and commercial areas were in their nascent phases, comprising only 3.28% and 1.72%, respectively. The study also notes a considerable vegetative cover (12.92%), although signs of deforestation were beginning to emerge due to urban encroachment. The analysis serves as a foundation for ongoing studies into the evolving urban landscape of Gurugram which is a prominent urban location among the rapidly urbanizing regions of India.

Keywords: Land Use and Land Cover (LULC), Urbanization, Gurugram, Geospatial Analysis, Urban Planning.

INTRODUCTION

Urban areas experience profound changes, particularly in their built environments primarily due to increasing population densities and ongoing infrastructure development (Pandit et al., 2017). This evolution necessitates a thorough examination of land use and land cover (LULC) within urban contexts, as it offers vital insights into the patterns of urbanization and their associated environmental repercussions. Gurugram, a satellite city in the state of Haryana and included in the National Capital Region has been experiencing rapid urbanization (Singh, 2007). The city was once a predominantly rural agrarian district that has undergone a remarkable transformation into a vibrant urban centre that has been largely propelled by rapid industrialization and urbanization (Yadav & Punia, 2014). This evolution began in the early years of India's economic liberalization when the establishment of industries marked the onset of significant economic change. Gurugram's economy transitioned from agriculture, which dominated in the early 1990s, to a diversified economy with strong industrial and service sectors (Majumder & Gururani, 2021). The city's strategic location near the national capital coupled with favourable state policies and infrastructure development attracted numerous multinational corporations and contributed to its emergence as a major hub for information technology and various service sectors (Gururani, 2023). This shift has significantly altered its economic structure, with a notable rise in the service and industrial sectors while also presenting challenges related to urban planning and sustainability (Singh, 2015). This economic metamorphosis has not only catalysed Gurugram's emergence as a major economic centre but has also exposed critical challenges in urban planning, including infrastructure development, housing shortages and environmental sustainability. The uneven process of land acquisition and the conversion of rural landscapes into urban settlements underscore the complexities of managing such growth (Chadchan & Shankar, 2012). Furthermore, this transformation has led to population surges and intensified demands on resources, posing risks to ecological balance and necessitating sustainable urban management strategies (Roy, 2019). Gurugram exemplifies both the opportunities and challenges of urbanization in rapidly developing regions, necessitating innovative approaches to ensure balanced growth and sustainability. On the other hand, the urban expansion has raised concerns about environmental degradation particularly in areas near the Aravalli hills, where development pressures threaten ecological balance (Jain et al., 2017; Rajagopalan & Tabarrok, 2014). In this context, the study aims to assess the morphological change in land use and land cover in Gurugram City as of 2001 that noted the early transformation of agricultural land into urban spaces.

Study Area

Gurugram is a prominent city located in the northern Indian state of Haryana and is situated approximately 30 kilometers southwest of New Delhi. Covering an area of about 332.50 square kilometers, Gurugram's population was recorded at approximately 876,969 in the 2011 census. The city is characterized by a diverse landscape that includes urban centers, industrial zones, and green spaces (Narain,2009). Its elevation averages around 217 meters above sea level, contributing to its distinct climate, which ranges from hot summers to cool winters with a monsoon season. The city has experienced rapid urbanization and economic growth since the 1970s, particularly following the establishment of several multinational corporations and IT hubs. Gurugram is part of national capital region, and is well connected to Delhi and major cities like Faridabad, Jhajjar and Nuh. National highway 48 passes through the city which connects Rajasthan to Delhi. Gurugram is 20 kms to International Airport and connected with Gujratand Rajasthan through broad meter gauge railway line.

Objectives

- To analyse the spatial distribution and classification of land use and land cover types in Gurugram City as of 2001.
- To analyse the transformation from agricultural land to urban spaces and to quantify the extent of these changes.

DATABASE & METHODOLOGY

The study of Land Use and Land Cover (LULC) changes is pivotal for understanding the dynamics of urban growth, including the extension of built-up areas and the implications of urban sprawl (Gaur & Singh,2023). In this context, the database and methodology utilized in the research on Gurugram city are crucial for capturing the spatial-temporal variations that characterize its urban landscape. The database for the study primarily relied on various geospatial data sources. One of the key components has been the use of Google Earth imagery, specifically from the year 2001. These images are sourced through Google Earth Explorer (USGS) and served as a foundational dataset for analyzing the extent of urban expansion in Gurugram. In addition to satellite imagery, the study incorporated essential information from town and country planning documents, including the city's master plan and historical records that provided context and baseline data necessary for a comprehensive analysis of land use changes over time. Furthermore, the research utilized topographical maps from the Survey of India, specifically at a scale of 1:50,000. The maps along with municipal boundary maps obtained from the Municipal Corporation have been used to extract and validate the land use data.

Table 1: Land-use/land-cover classification method at three levels

| LEVEL – I | | LEVEL –II | | LEVEL –III | |
|-----------|------------------------|-----------|-------------------------|------------|-------------|
| 1 | Built-Up | 1.1 | Built-Up (Urban) | 1.1.1 | Residential |
| | | | 1.1.2 | Industrial | |
| 1.1.3 | Mixed Built-Up Area | | | | |
| 1.1.4 | Recreational | | | | |
| 1.1.5 | Public and Semi-Public | | | | |
| 1.1.6 | Commercial | | | | |
| 1.1.7 | Transportation | | | | |
| 1.1.8 | Reclaimed Land | | | | |
| 1.1.9 | Vacant Land | | | | |
| 1.1.10 | Vegetated Area | | | | |
| | 1.2 Built-Up (Rural) | | | | |
| 2 | Agriculture | 2.1 | Cropland | | |
| | 2.2 Fallow Land | | | | |
| | 2.3 Plantation | | | | |
| 3 | Forest | 3.1 | Dense Forest | | |
| | | 3.2 | Open | | |
| | | 3.3 | Plantations | | |
| | | 3.4 | Mangroves | | |
| 4. | Grazing Land | | | | |
| 5. | Waste Lands | 5.1 | Salt-Affected | | |
| | | 5.2 | Gullied Ravinous | | |
| | | 5.3 | Land With/Without Scrub | | |
| | | 5.4 | Barren/Rocky | | |
| | | 5.5 | Sandy Area | | |
| 6. | Wet Lands | 6.1 | Marshy/Swampy | | |
| | | 6.2 | Mudflats | | |
| | | 6.3 | Water Logged | | |

| | | | |
|----|--------------|-----|-------------------------------|
| | | 6.4 | Salt Pans |
| 7. | Water Bodies | 7.1 | Rivers |
| | | 7.2 | Canal |
| | | 7.3 | Reservoirs |
| | | 7.4 | Tanks |
| | | 7.5 | Cooling Pond/ Cooling Pond |
| | | 7.6 | Abandoned Quarries with Water |
| 8. | Others | 8.1 | Quarry/ Brick Kilns |
| | | 8.2 | Dam/Barrage |
| | | 8.3 | Coral Reef/Atoll |

Source: NUIS, 2006

The study incorporated geospatial technologies and systematic classification techniques. Key software tools included ERDAS IMAGINE for image processing and ArcGIS for geographic information system (GIS) analysis. These tools facilitated the creation of various thematic layers that are essential for understanding land use changes in Gurugram. A critical aspect of the methodology was the geo-referencing of the Google Earth images. The images were imported as tiles into ERDAS IMAGINE, where they underwent geo-referencing to ensure spatial accuracy. Following this, the images were digitized in ArcGIS, which allowed for precise identification and classification of different land use types across the urban landscape. The classification of land use was based on the National Urban Information System (NUIS) classification scheme established by the Ministry of Urban Affairs in 2006. This classification framework organizes land use into five hierarchical levels, allowing for a structured approach to mapping. The first three levels of classification include categories such as Built-Up, Agriculture, Forest, Grazing Land, Waste Lands, Wet Lands, Water Bodies, and Others (Table 1). Each of these categories is further divided into subcategories, providing a detailed view of land use types, such as distinguishing between urban and rural built-up areas, various agricultural practices, and different forest types. Data analysis involved comparing the processed images from 2001 with historical data to identify and assess changes in land use and cover over time. This comparative analysis aimed to reveal patterns of urban expansion and assess the implications of such changes for urban planning and development in Gurugram. The results have been visualized through thematic maps generated in ArcGIS, which illustrated the spatial distribution of various land use types and highlighted areas of significant transformation.

RESULT & DISCUSSION

Classification Land Use/Land Cover of Gurugram City, 2001

The land use and land cover in Gurugram during 2001 were markedly different from today, showcasing a predominantly rural and less developed landscape. Agriculture and open land dominated the region with extensive farmland characterizing much of the area. Rural settlements were still common and the urban footprint was limited to a few concentrated zones around the city centre and major roads. Although some forest cover and natural vegetation remained, these had diminished over the years due to gradual deforestation. Industrial and commercial areas were beginning to emerge, particularly with the establishment of industrial zones, but they were not yet widespread (Jain et al., 2011). Infrastructure, including roads and highways, was starting to expand, setting the groundwork for future urban growth. Additionally, significant portions of barren and uncultivated land remained, highlighting the early stages of Gurugram's transformation into an urban hub.

The residential areas in the city during 2001 were relatively modest compared to the extensive urban sprawl observed today. The housing landscape primarily featured low-rise buildings, small independent homes and rural settlements, reflecting a simpler, less developed character (Narain, 2018). While residential colonies were starting to emerge, particularly in older parts of the city and near newly established industrial zones, they had yet to reach the city's outskirts. The large, organized residential complexes that now characterize Gurugram were still in their early stages, with only a few gated communities and apartment buildings in existence. Traditional villages remained prevalent where agrarian lifestyles were more widespread. Recreational spaces in Gurugram were limited, lacking the numerous malls, parks, and entertainment venues that define the city today. Parks and public gardens were few, and most leisure activities took place in small community parks or open fields. The overall recreational infrastructure was modest, with residents often relying on informal spaces for recreation marking a stark contrast to the vibrant urban environment that would develop in the following years.

During the time, the vegetation cover in Gurugram was also more prominent than it is today, with significant patches of green still visible amid the early signs of urbanization. Agricultural lands, trees, and small forests contributed to a richer natural landscape, while green belts surrounding the city acted as vital buffers between rural and urban areas. These stretches of farmland and natural vegetation played an essential role in supporting the local ecosystem. However, the onset of deforestation and the gradual clearing of land for real estate and infrastructure projects marked the beginning of significant environmental changes. Open spaces, including barren and uncultivated lands, were prevalent throughout Gurugram, with large portions remaining undeveloped. These expanses created informal gathering spots for local communities and held potential for future development, reflecting a transitional phase in the city's evolution. This

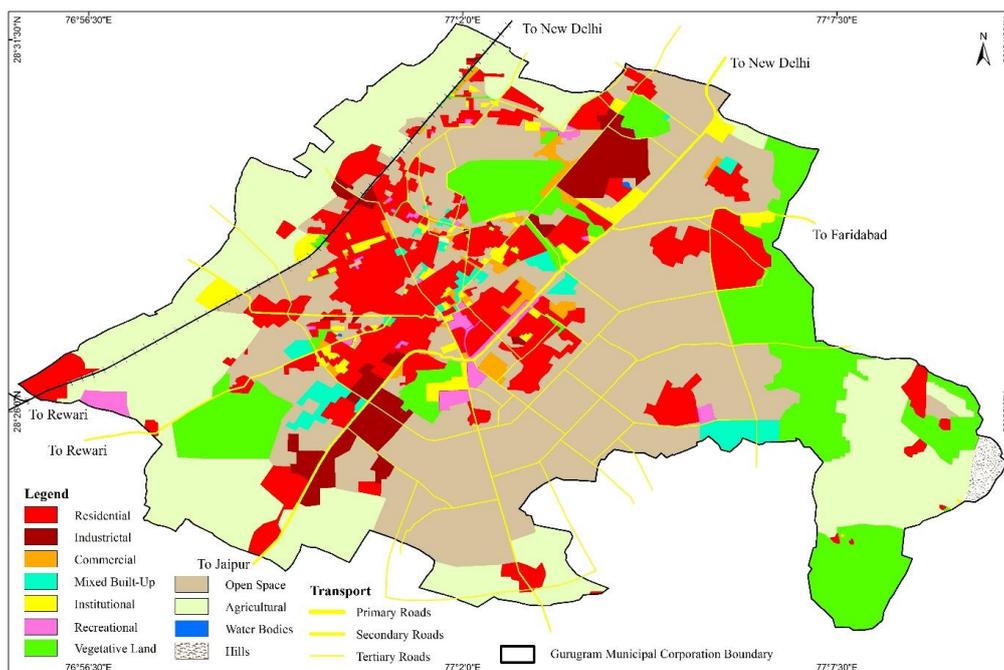
balance between nature and the encroaching urban environment highlighted the complexities of Gurugram’s growth, foreshadowing the challenges that would arise as the city continued to expand (Chatterji,2016).Although infrastructure like roads and highways had begun expanding, open spaces still dominated much of the landscape, indicating a city on the verge of rapid transformation but not yet fully urbanized. The distribution of land use and land cover as of 2001 in Gurugram City revealed several important trends that showed the developing city. The residential zones accounted for 14.30% of the total land area that is equivalent to 32.98 square kilometers (Table 1). This significant portion highlighted the city’s commitment to housing development in response to a rising population, illustrating the urban expansion taking place during that time. In contrast, industrial zones comprised only 3.28% of the land, or 7.57 square kilometers, indicating a focus on economic growth and industrialization, albeit at a nascent stage. The relatively small size of these industrial areas suggested that Gurugram was still in the early phases of its industrial evolution. Additionally, commercial zones made up 1.72% (3.97 square kilometers) and mixed-use areas accounted for 1.58% (3.65 square kilometers) of the land, reflecting a limited presenceof business activities and a mixed development stage.

Table 1: Classification of Land Use/ Land Cover of Gurugram City, 2001

| Sr. No. | Land Use/Land Cover: 2001 | Area (Sq. km) | Area (in %) |
|--------------|---------------------------|---------------|-------------|
| 1. | Residential Area | 32.98 | 14.30 |
| 2. | Industrial Area | 7.57 | 3.28 |
| 3. | Commercial Area | 3.97 | 1.72 |
| 4. | Mixed Area | 3.65 | 1.58 |
| 5. | Institutional Area | 4.18 | 1.81 |
| 6. | Recreational area | 2.33 | 1.01 |
| 7. | Open Area | 67.59 | 29.31 |
| 8. | Agicultural Land | 76.58 | 33.21 |
| 9. | Vegetative Land | 29.79 | 12.92 |
| 10. | Water Bodies | 0.03 | 0.01 |
| 11. | Hills | 1.94 | 0.84 |
| Total | | 230.60 | 100 |

Source: Computed by Researcher based on Google Earth Images, 2001

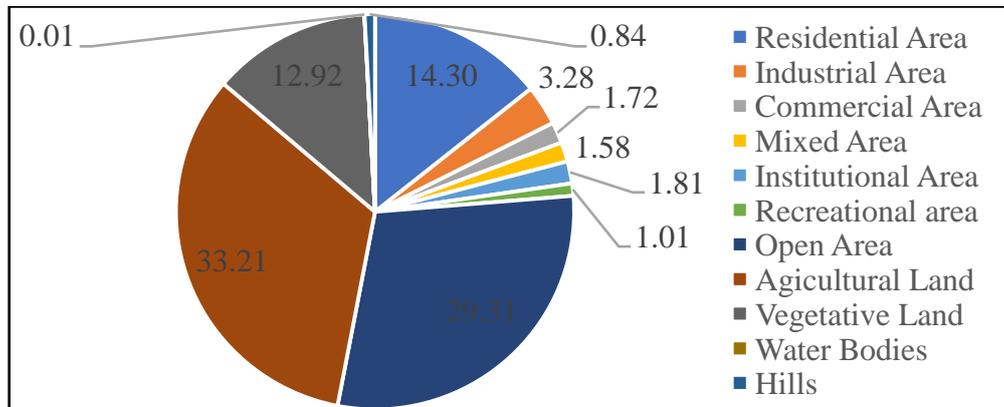
Map 1: Land use/land cover change of Gurugram city, 2001



Source: Prepared by Researcher Based on the Google Earth Images, 2001

The institutional areas in the city accounted for 1.81% of the total land, which is approximately 4.18 square kilometers and included facilities for educational and public services. While this percentage may seem modest, it played a vital role in supporting the city's infrastructure and social services at the time. On the other hand, recreational spaces made up

only 1.01% of the land, or about 2.33 square kilometers which shows a scarcity of public areas designated for recreational activities. Notably, a considerable portion of land that comprised of 29.31%, or 67.59 square kilometers came under open area which was basically undeveloped plots or land showing that a significant part of Gurugram remained in its natural state or was reserved for prospective development initiatives.



Source: Based on the table 1

Figure 1: Classification of Land Use/ Land Cover of Gurugram City, 2001

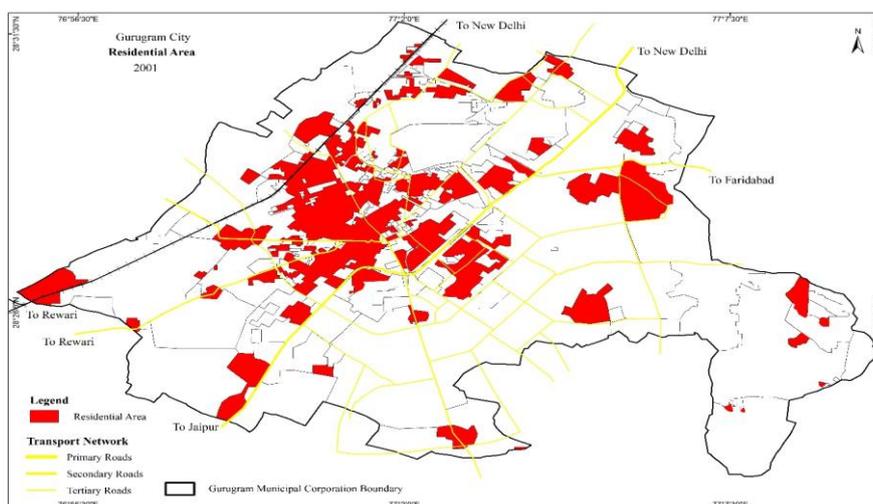
The presence of considerable portion of agricultural land which had made up 33.21% (76.58 sq. km) showed the prevalence of farming in the region during 2001 and the significance of agriculture in Gurugram’s economy. Similarly, there were significant area under vegetative land that covered 12.92% (29.79 sq. km) of the city area (Table 1). Water bodies, covering just 0.01% (0.03 sq. km), and hills, at 0.84% (1.94 sq. km), had represented the minimal natural features within the city’s landscape. Overall, Gurugram had illustrated a city in transition, balancing between urban expansion, industrial growth, and the continuation of agricultural sector in the city.

LAND USE AND LAND COVER ANALYSIS OF THE CITY, 2001

Residential Area in Gurugram City, 2001

As of 2001, the residential sector in Gurugram was markedly different from the extensive urban sprawl it exhibits today. The area predominantly featured modest housing colonies interspersed with traditional rural communities and emerging urban neighbourhoods. Established residential sectors like Sector 14 and Sector 15 were characterized by independent homes and smaller apartment complexes. Meanwhile, DLF Phase 1 and DLF Phase 2 were beginning to develop into upscale residential regions, appealing to early waves of professionals and middle-class families. Despite these developments, the city was still in its formative stages; the towering high-rise apartments and gated communities that now dominate Gurugram's skyline had yet to materialize. Many residents continued to inhabit village-like environments, particularly in areas such as Palam Vihar and Sushant Lok, which were gradually evolving into organized urban housing zones (Map 2).

Map 2: Distribution of Residential Area of Gurugram city, 2001



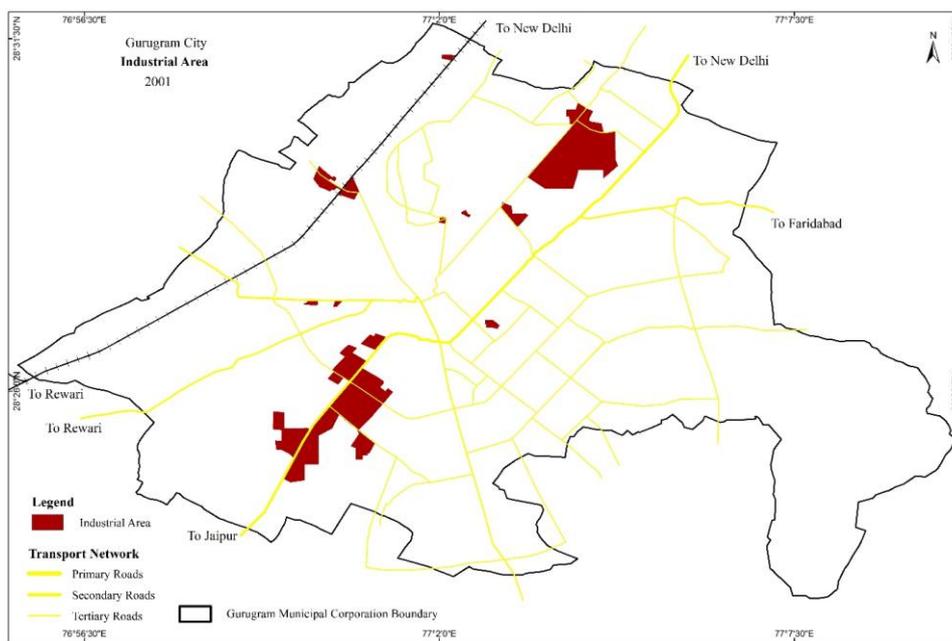
Source: Prepared by Researcher Based on the Google Earth Images, 2001

Gurugram was beginning to evolve in 2001 with several significant residential neighborhoods as part of its initial urban expansion. DLF Phase 3 was emerging as another important residential area, joining DLF Phases 1 and 2, although it was still in the early phases of development. Established sectors such as Sector 4, Sector 9, and Sector 10 were already providing housing options for government employees and middle-class families. At that time, Uniworld City had just commenced, but it had yet to develop into the expansive community it is known as today. South City 1 and South City 2 were also on the rise, catering to a burgeoning population of professionals looking for modern living spaces. Alongside these newer developments, traditional village areas like Jharsa and Wazirabad denoted a blend of Gurugram's rural heritage with its urbanizing trajectory.

Industrial Area in Gurugram City, 2001

The industrial sector in Gurugram recorded expansion as an important economic center, although it had not yet achieved the extensive scale of industrial growth that characterizes the area today. One of the pivotal industrial regions at that time was Udyog Vihar which hosted a variety of factories, manufacturing facilities, and corporate offices (Map 3).

Map 3: Distribution of Industrial Area of Gurugram city, 2001



Source: Prepared by Researcher Based on the Google Earth Images, 2001

During the time period, the industrial sector in Gurugram was beginning to take shape with significant expansion of operations from companies like Maruti Suzuki, which established manufacturing facilities in the area. This influx played a crucial role in boosting the local economy and creating job opportunities.

Udyog Vihar emerged as a central industrial zone, housing numerous factories and corporate offices. Meanwhile, the IMT Manesar area was in its nascent stages but had started to attract various industries, setting the foundation for what would later develop into a substantial industrial cluster.

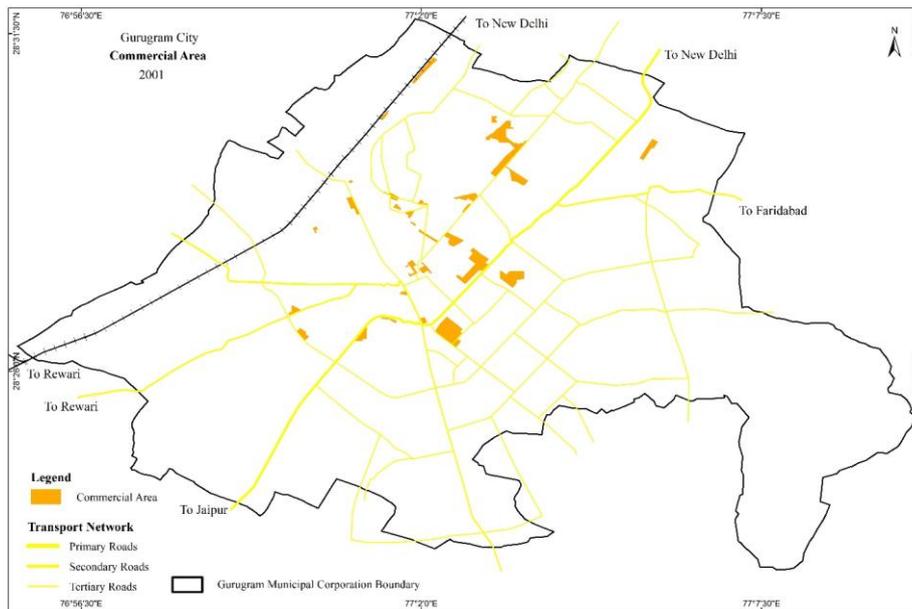
The industrial landscape at that time was characterized by a focus on automobile production, textiles, and small-scale manufacturing operations. Sectors such as Sector 18 and Sector 34 were already witnessing the establishment of industrial estates. Overall, these developments marked a significant transformation for Gurugram, transforming it from a predominantly agrarian society to one driven by industrial growth.

Commercial Areas in Gurugram City, 2001

The commercial areas of Gurugram had been in the early stages of development although several key locations had begun to establish themselves as significant business hubs. Local markets and small enterprises had dominated the commercial landscape, with Sector 14 and Sector 17 being well-known for shopping and daily necessities.

Mehrauli-Gurgaon (MG) Road had started to undergo transformation into a commercial hotspot, but the large malls and office complexes that it is recognized for today had not yet been fully developed (Map 4). Overall, the groundwork for future commercial growth had already been laid.

Map 4: Commercial Area of Gurugram City, 2001



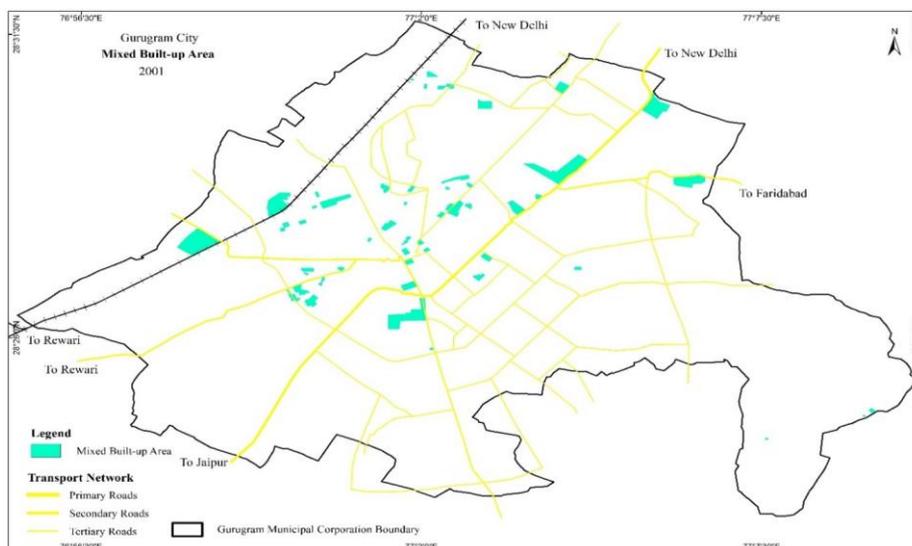
Source: Prepared by Researcher Based on the Google Earth Images, 2001

By that time, DLF City Centre had been under construction and would eventually emerge as a landmark of Gurugram's commercial expansion. Udyog Vihar had also started to develop into a prominent business district, accommodating numerous corporate offices and factories. Meanwhile, Cyber City had remained in its early stages, with many of the skyscrapers and multinational offices that characterize it today still yet to be constructed. Overall, these developments were laying the foundation for Gurugram's future growth as a commercial hub.

Mixed Built-up Area in Gurugram City, 2001

The mixed built-up areas of Gurugram had been gradually developing as of 2001 that was characterized by a combination of residential, commercial and industrial spaces existing side by side. Neighborhoods such as Sushant Lok and Palam Vihar had begun to take shape as mixed-use regions, integrating homes, small businesses, and offices. DLF Phase 1 and DLF Phase 2 had also evolved into mixed-use areas, featuring upscale residences alongside local markets, shops, and office spaces. South City 1 had transformed and accommodated both residential properties and small commercial enterprises. Meanwhile, traditional village areas like Sikanderpur and Jharsa also recorded significant changes where older homes were giving way to modern buildings, offices and shopping centers. The expansion of mixed built-up areas denoted the early stages of Gurugram's growth, as urbanization had started to merge various land uses.

Map 5: Mixed Built-up Area of Gurugram City, 2001



Source: Prepared by Researcher Based on the Google Earth Images, 2001

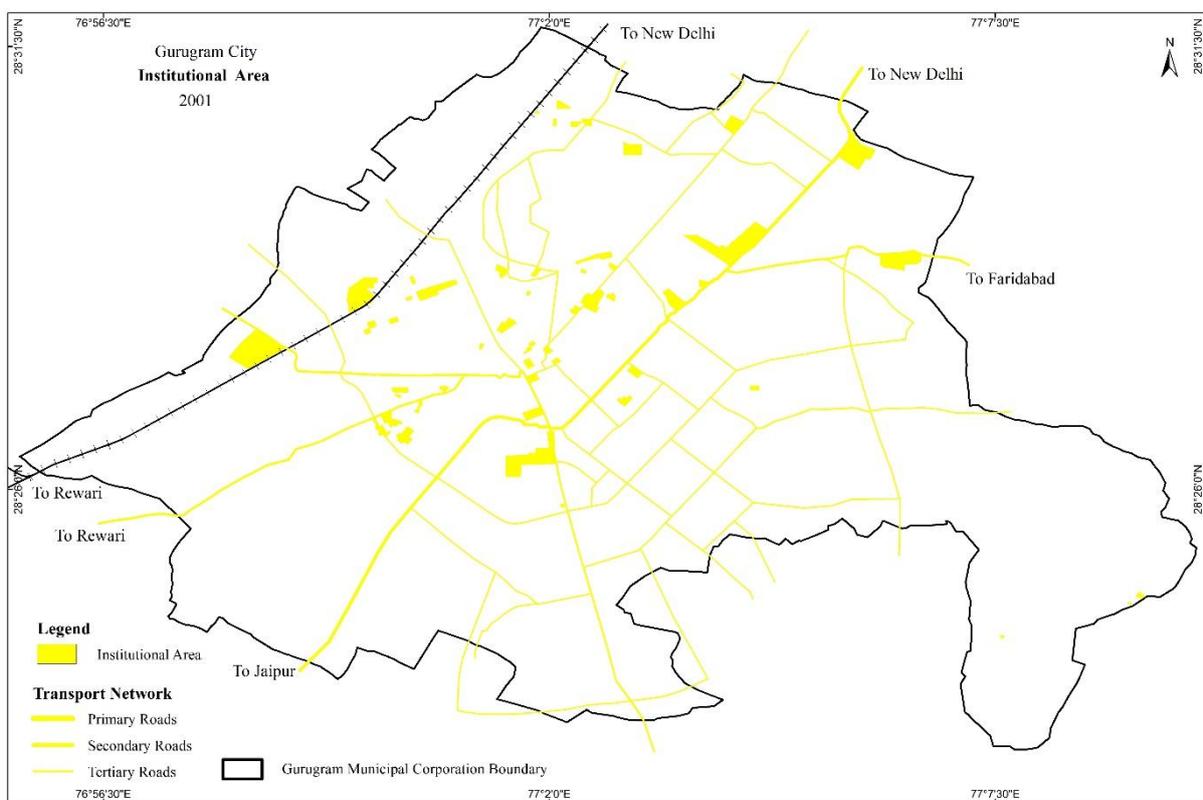
Institutional Area in Gurugram City, 2001

The institutional area of Gurugram had been relatively limited in 2001 but it had begun to establish important educational and administrative institutions. The campus of the Indian Institute of Corporate Affairs (IICA) had been in its formative stages, with plans already set for it to become a prominent center for professional education and training. In Sector 14, the Government College had been well-established, serving as a vital educational institution for the local community.

Additionally, the Haryana State Industrial and Infrastructure Development Corporation (HSIIDC) had been actively involved in planning and developing infrastructure to support various administrative functions.

While many larger institutions and specialized educational centers were still under development at that time, these early establishments had played a crucial role in laying the foundation for Gurugram's future as an educational and institutional hub. Delhi Public School (DPS) in Sector 45 had gained recognition for its strong academic programs (Map 6).

Map 6: Institutional Area of Gurugram City, 2001



Source: Prepared by Researcher Based on the Google Earth Images, 2001

The Heritage School in Sector 62 had emerged as a prominent institution while the Army Public School in Sector 37 had been dedicated to serving the children of defense personnel, featuring a robust curriculum tailored to their needs. The higher education also expanded with the Government College in Sector 14 being established.

Simultaneously, the K.R. Mangalam University in Sector 43 had begun to position itself as an emerging center for higher education. Additionally, training centers like NIIT in Sector 14 had gained recognition for their IT education and professional training programs, while Aptech in Sector 15 provided a variety of computer and IT courses.

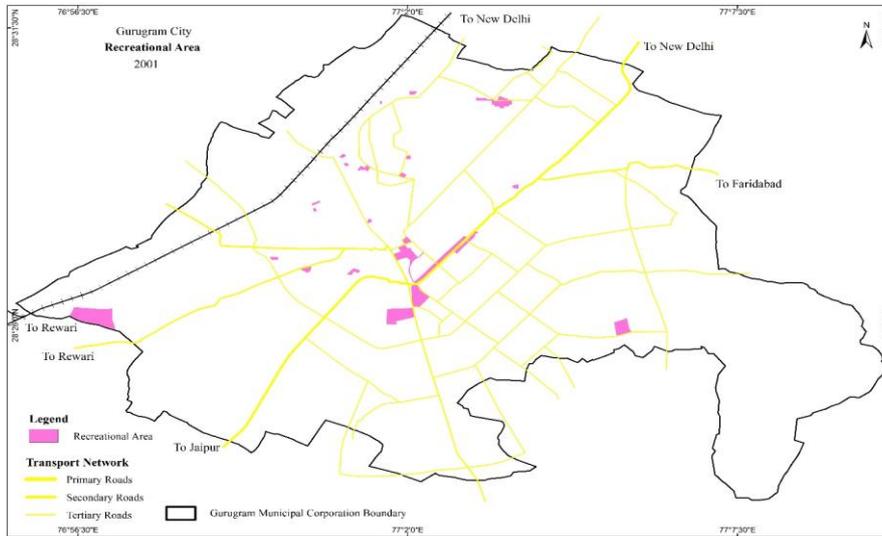
Collectively, these institutions played a critical role in enhancing the educational infrastructure in Gurugram that recorded expansion as of 2001.

Recreational Area in Gurugram City, 2001

During 2001, the recreational areas also began developing gradually featuring several notable locations that offered leisure activities for the community.

DLF City Centre Mall had recently opened, becoming one of the earliest shopping destinations in the city and providing a variety of dining and shopping experiences.

Map 7: Recreational Area of Gurugram City, 2001



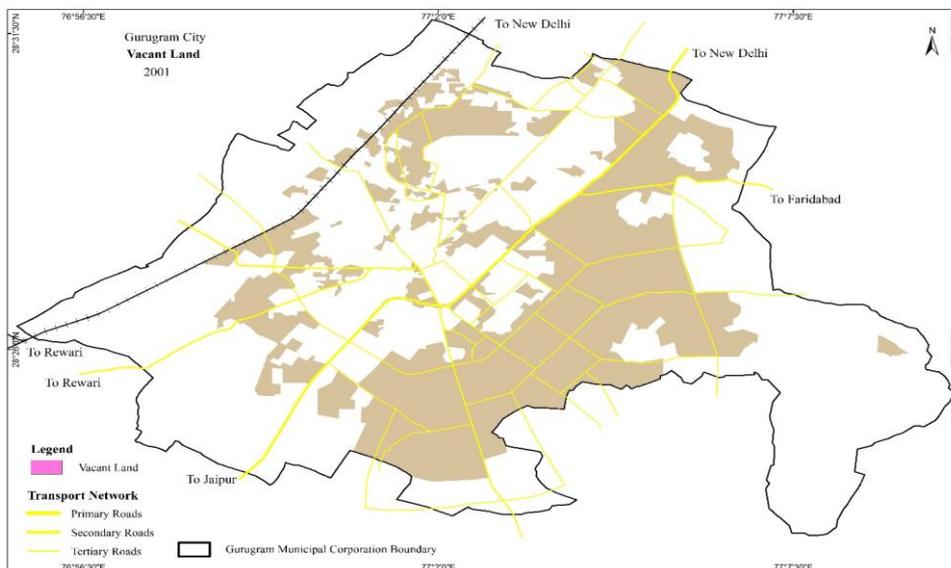
Source: Prepared by Researcher Based on the Google Earth Images, 2001

At the same time, public parks such as Tau Devi Lal Park and Leisure Valley Park had gained popularity among residents for outdoor activities and family outings, serving as essential spaces for recreation and community gatherings. The Kingdom of Dreams had been in its early planning stages with plans to become a major entertainment hub that promised a unique combination of theatrical performances and leisure options. Despite the ongoing urbanization, these recreational sites played a crucial role in offering residents places for relaxation and social interaction which forms an important aspect of any urban area (Map 7).

Vacant Land in Gurugram City, 2001

Vacant land had remained a notable characteristic of the city especially in the outskirts of the city. Regions such as Manesar and Jharsa featured large tracts of agricultural fields and open spaces that dominated the scenery. Similarly, significant stretches of undeveloped land surrounded Udyog Vihar and Sushant Lok while Sectors 67 and 68 had substantial areas of vacant land, which were in the early stages of development and would eventually evolve into important residential and commercial zones. These open spaces were transitional areas between rural and urban environments that enabled the shift from a predominantly agrarian region to a vibrant city (Map 8).

Map 8: Vacant Land of Gurugram City, 2001

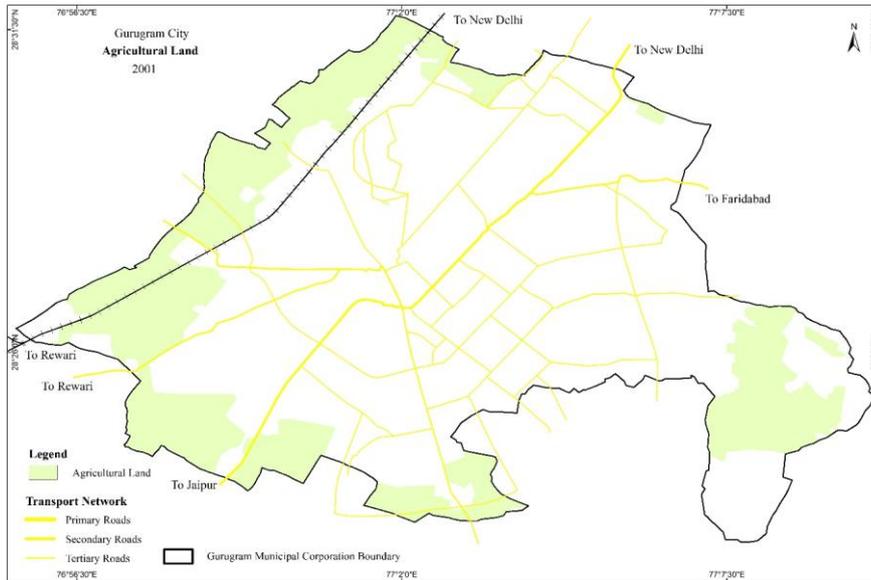


Source: Prepared by Researcher Based on the Google Earth Images, 2001

Agricultural Land in Gurugram City, 2001

Agricultural land had remained prevalent within the jurisdiction of the Gurugram Municipal Corporation, particularly in the city's peripheral areas. Extensive farmland had characterized regions such as Jharsa, Wazirabad, and Sikanderpur, where traditional farming practices were still actively pursued. The landscape around Manesar had been defined by vast agricultural fields, with crops and rural scenery dominating the region. In these areas, agriculture had been the primary activity, with expansive fields of wheat, rice, and other crops. Although the transition from agricultural land to urban development had commenced, much of the region had still retained its rural character at that time (Map 9).

Map 9: Agricultural Land of Gurugram City, 2001

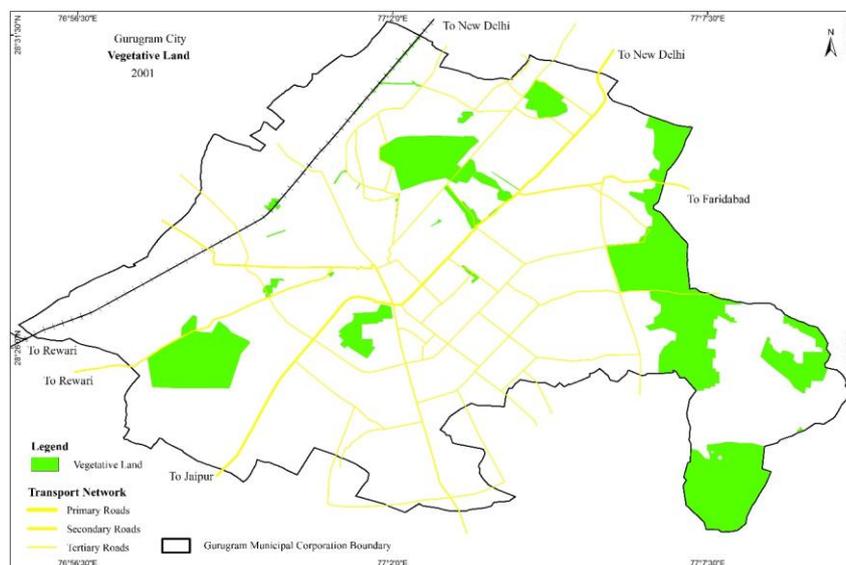


Source: Prepared by Researcher Based on the Google Earth Images, 2001

Vegetative Land in Gurugram City, 2001

The vegetative land within the Gurugram Municipal Corporation included several significant green spaces and areas of natural vegetation. Regions such as Sikanderpur and Wazirabad had featured substantial coverage of trees and shrubs offering essential green zones amidst the expanding urban landscape. Tau Devi Lal Park had been established as a major public park, showcasing extensive lawns and wooded areas that served as important recreational and ecological spaces. Similarly, the areas surrounding Leisure Valley Park had included well-maintained gardens and patches of natural vegetation, contributing to the city's limited green cover. Additionally, forest areas had been present around Jharsa and Manesar, acting as a buffer against the encroaching urban development. These vegetative lands had played a crucial role in maintaining ecological balance while providing leisure spaces for residents (Map 10).

Map 10: Vegetative Land of Gurugram City, 2001



Source: Prepared by Researcher Based on the Google Earth Images, 2001

Hilly Areas in Gurugram City, 2001

The Gurugram Municipal Corporation did not have any significant hilly terrain, as the region was mainly characterized by flatlands and gentle slopes. However, some fringe areas, particularly in Manesar and near the borders of the Aravalli Hills, do have slight elevations and undulating landscapes that appeared hilly compared to the surrounding flat regions. During 2001, these areas had not been heavily developed and preserved some natural characteristics, including rugged terrain and sparse vegetation. The Aravalli Range, which extended into the broader region surrounding Gurugram was visible from the city's outskirts adding to the area's diverse topography. While the more prominent hilly regions are located in neighboring districts, the gently elevated areas near Gurugram contributed to a subtle diverse topography to the city's predominantly flat landscape.

Therefore, based on the analysis of the land use and land cover of Gurugram in 2001 it could be said that the time period marked a transitional phase with significant changes due to urbanization and industrialization. Agricultural land still dominated the landscape, particularly in peripheral areas such as Jharsa, Wazirabad, and Sikanderpur, where traditional farming practices were evident.

However, the encroachment of urban development had begun to reduce the extent of agricultural land, which had decreased from approximately 81 percent in 1971 to around 50.67 percent by 1993, and further to 26.5 percent by 2002. Regions like Manesar exhibited slight elevations and undulating terrains, contributing to the area's varied topography. While vacant land remained prevalent, especially in newly developing sectors such as Sector 67 and Sector 68, the presence of parks like Tau Devi Lal Park and Leisure Valley Park provided essential green spaces amidst the growing urban sprawl. The gradual transformation of these agricultural areas into residential, commercial, and industrial zones indicated Gurugram's shift from a predominantly agrarian society towards a more urbanized environment, setting the stage for its rapid growth in subsequent years.

CONCLUSION

The assessment of land use and land cover in Gurugram City as of 2001 denotes a pivotal phase in the city's evolution from a predominantly agrarian landscape to a developing urban centre. The time period has been marked by significant land use changes that show signs of urbanization and industrialization. The agricultural land accounted for 33.21% of the total area that denoted the earlier agriculture-based economy whereas the open areas comprising 29.31% of the landscape, highlighted the presence of undeveloped land that served as a buffer during this early stage of urban growth. Residential development, although modest at 14.30%, indicated the city's initial responses to increasing population densities and the demand for housing. The presence of low-rise buildings and small colonies outlined the nascent stages of urban planning, foreshadowing the extensive residential complexes and high-rises that would later dominate the skyline. Industrial areas, while only occupying 3.28% of the land paved the beginning of economic diversification, laying the groundwork for future industrial hubs that would significantly contribute to the local economy. In conclusion, the city's land use and land cover dynamics of 2001 serve as a critical case study for understanding the morphological transformation brought about by rapid urbanization and industrialization.

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