

Morphological Assessment of Land Use and Land Cover in Gurugram City (2021)

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ABSTRACT

This study presents a comprehensive morphological assessment of land use and land cover (LULC) in Gurugram City as of 2021, highlighting the significant transformations induced by rapid urbanization and economic development. Over the past few decades, Gurugram has evolved from a predominantly agricultural landscape into an urban center. The research employs high-resolution satellite imagery and Geographic Information Systems (GIS) to analyze LULC patterns and quantify the extent of changes across various land cover types. Key findings indicate a dramatic decline in agricultural land, which has plummeted to just 0.23% of the total area, underscoring the pressures of urban expansion on food security and traditional farming practices. In contrast, residential areas have surged, constituting 40.73% of the land cover, driven by an influx of professionals attracted to Gurugram's burgeoning IT and corporate sectors. Industrial zones, covering 6.88% of the area, remain vital to the local economy, with significant concentrations in Udyog Vihar and Manesar, yet they face increasing encroachment from expanding residential and commercial developments. Commercial areas account for 3.79% of the city's land, particularly concentrated around Cyber City and MG Road, which have become key business hubs within the National Capital Region. Additionally, the study identifies 26.33% of the city as vacant land, indicating potential for future urban growth while also raising concerns regarding unplanned expansion. The reduction of green spaces and water bodies, now limited to 7.82% and 0.02% respectively, poses significant environmental challenges, including increased urban heat islands and biodiversity loss. The findings signify the need for informed decision-making that prioritizes both economic development and environmental sustainability in the face of ongoing urban pressures.

Keywords: Urbanization, Land Use, Land Cover, Gurugram, Urban Development, Geographic Information Systems (GIS)

INTRODUCTION

Rapid urban growth, driven by population increase and economic development, has led to significant changes in land use patterns across Indian cities. Urbanization in India has significantly impacted land use patterns across its cities, leading to profound transformations in cities (Roy et al., 2022). As urban areas expand, the conversion of agricultural and natural lands into built environments has become a prominent trend. The most noticeable effect of urbanization is the dramatic increase in built-up land. For instance, studies have shown that in cities like Gurgaon, built-up areas have expanded rapidly, with agricultural land being converted into commercial and residential zones (Gandhi, 2024). In the case of Bengaluru, non-agricultural land uses grew significantly, with urban areas experiencing an increase from 42% to 56% of total geographical area between 2001 and 2016 (Harishkumar and Reddy, 2017). This trend reflects a broader national pattern where built-up spaces have increased from an average of 25.4% to 48% across various Indian cities from 1991 to 2017 (Sikarwar and Chattopadhyay, 2020). As urban areas expand, agricultural lands are increasingly being lost to development. The reduction of agricultural land is particularly stark in metropolitan regions; for example, Delhi saw a decrease in net sown area by approximately 16% between 1990 and 1997 due to urban pressures (Mohan et al., 2011). Similarly, studies indicate that agricultural land has declined significantly in cities like Jaipur and Ranchi as they adapt to urban growth demands. Urbanization has also led to a reduction in green spaces and open areas within cities. The average green space has decreased from about 16% to 12%, while open spaces have shrunk from 13% to 9% over the same period (Gupta, 2021). This loss impacts urban ecology, contributing to issues such as heat islands and reduced biodiversity.

The transformation of land use due to urbanization poses several environmental challenges. Increased built-up areas can exacerbate flooding by reducing natural drainage and increasing runoff (Suriya and Mudgal, 2012). Urban areas often impede rainwater percolation into the ground, leading to higher flood risks during monsoon seasons. Additionally, the loss of agricultural and forest lands can lead to biodiversity loss and changes in local climate patterns (Oliver and Morecroft, 2014). Urbanization not only alters physical features but also affects socio-economic dynamics. The demand

for housing and infrastructure drives up land prices, often leading to speculation and displacement of rural communities (Crisp et al., 2012). The shift from agricultural livelihoods to urban employment opportunities changes economic structures and social fabric within these regions (Muluneh, 2021).

The assessment of land use and land cover (LULC) in urban areas of India therefore plays a pivotal role in comprehending the dynamics of urbanization, resource management, and environmental sustainability. As one of the fastest urbanizing nations in the world, India faces significant challenges associated with rapid population growth, economic development, and the consequent transformation of a region (Sadashivam and Tabassum, 2016). Understanding LULC is essential for several reasons. Firstly, monitoring land use changes provides insights into the patterns and trends of urban expansion (Dadashpoor et al., 2019). Urban areas in India are often characterized by sprawling developments that consume agricultural land, forests, and other natural habitats. By systematically assessing LULC, researchers and policymakers can identify hotspots of urban growth, enabling them to develop strategies to manage urban sprawl effectively. This is crucial for ensuring that urbanization does not encroach excessively on agricultural lands, which are vital for food security. Secondly, effective resource management hinges on accurate LULC data. Urban areas require substantial resources, including water, energy, and land (Alawathugoda et al., 2024). By analyzing LULC, authorities can assess the availability and distribution of these resources, facilitating better planning and allocation. For instance, understanding the distribution of green spaces and water bodies within urban settings can inform strategies to enhance urban resilience, mitigate heat island effects, and maintain ecological balance. Moreover, environmental sustainability is increasingly becoming a priority in urban planning. LULC assessments help in evaluating the environmental impacts of urbanization, such as habitat loss, pollution, and changes in local climate patterns (Obeidat et al., 2019). By understanding how land cover types interact with urban ecosystems, planners can create policies that protect natural resources while accommodating growth. In addition, LULC assessments contribute to informed decision-making by providing a scientific basis for urban policies (Gaur and Singh, 2023). This ensures that urban development is not only economically viable but also socially equitable and environmentally responsible. Lastly, the integration of LULC data with modern technologies, such as Geographic Information Systems (GIS) and remote sensing, enhances the accuracy and efficiency of urban planning efforts (Herdini and Gamal, 2024). These technologies allow for real-time monitoring and analysis of land use changes, facilitating adaptive management in response to emerging urban challenges.

In this context, this study is an attempt to analyse the land use land cover of Gurugram city as of 2021. Gurugram has undergone rapid urbanization over the past few decades significantly transforming its land use patterns. Located near Delhi, the city has experienced explosive population growth increasing from 57,000 residents in 1971 to over 1 million by 2011. This surge has led to a dramatic decline in agricultural land which has declined from 81% in 1971 to just 26.5% in 2003, while built-up areas expanded from 11.36 square kilometers to 84.2 square kilometers during the same period. The city is now characterized by a mix of residential, commercial, and industrial zones, reflecting both the opportunities and challenges posed by rapid urbanization.

Study Area

Gurugram is located in the south-eastern part of Haryana, India and is a city characterized by its rapid urban development. The city is situated approximately 30 kilometers southwest of New Delhi and it serves as a significant industrial and financial hub within the National Capital Region (NCR). The city is marked by a combination of hills and depressions, primarily formed by the northern extension of the Aravalli mountain range. The city is bordered by two prominent ridges: the Delhi Ridge to the east and the Firozpur Jhirka-Delhi Ridge to the west. The average elevation of Gurugram is approximately 217 meters (712 feet) above sea level, with its total area measuring around 232 square kilometers (90 square miles) 35. The city comprises both urban and rural areas, with significant portions dedicated to industrial development. The Gurugram tehsil covers an area of 333 square kilometers, including 201.3 square kilometers of urban space. Over recent decades, Gurugram has transformed from a small town into a bustling metropolis often referred to as the "Millennium City." This rapid urbanization has been driven by significant investments in the IT and automobile industries since the early 1980s. The city's infrastructure has evolved to support its growing population and economic activities, leading to increased urban sprawl.

Objectives

- To analyse the transformation of land use in an urban setting in Gurgaon and to quantify the extent of these changes.
- To analyse the spatial distribution and classification of land use and land cover types in Gurugram City as of 2021.

DATABASE & METHODOLOGY

The study employed a multi-level land-use classification system, categorizing data into distinct levels to capture the complexity of land use in urban settings (Table 1). At Level I, broad classifications such as Built-Up, Agriculture, Forest, Grazing Land, Waste Lands, Wet Lands, Water Bodies, and Others were established. Level II provided further

granularity, breaking down Built-Up areas into urban and rural categories, while Level III offered the most detailed classification, specifying types such as Residential, Industrial, Commercial, and various land cover types.

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

Data were primarily sourced from high-resolution satellite imagery obtained through Google Earth, specifically focusing on the year 2021 to reflect the most current land use patterns. The imagery was analyzed to identify and quantify the extent of different land cover types across Gurugram. The study 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. The methodology involved overlaying the satellite images with GIS (Geographic Information System) tools to create accurate maps of land use patterns, allowing for spatial analysis of urban growth and distribution.

RESULT & DISCUSSION

In 2021, Gurugram's land use and land cover (LULC) underwent significant transformations due to rapid urbanization and infrastructure development. Large expanses of agricultural and barren land were converted into residential, commercial, and industrial zones, particularly in the southern parts of the city, such as Sohna Road and Sector 65, where high-rise apartment complexes and gated communities emerged to meet the increasing housing demand. Key commercial areas like Cyber City and Golf Course Road expanded further, replacing older industrial setups with modern office spaces, malls, and recreational facilities. Meanwhile, the northern and western outskirts, including regions near Manesar, retained some agricultural patches, although these were gradually being developed into industrial

parcs and logistics hubs. The Aravalli Hills along the eastern fringes remained one of the few natural features in the city, though they faced encroachment from real estate and mining activities. While green spaces such as parks existed, their extent had diminished compared to previous years due to relentless urban sprawl. Furthermore, the land use also experienced a notable shift towards infrastructure development, particularly in the construction of road networks and transportation hubs. The Dwarka Expressway, which connects the city to Delhi, played a crucial role in this transformation, with extensive stretches of land along the expressway being developed for new housing projects and commercial zones. Areas such as Sector 102 and 104, previously characterized by sparse populations and open fields, became focal points for large-scale real estate development. The expressway's construction, along with the proposed Delhi-Mumbai Industrial Corridor, further accelerated the conversion of agricultural land into urban use. Meanwhile, older parts of Gurugram, particularly around MG Road and Sushant Lok, experienced densification as multi-story commercial and residential buildings replaced older low-rise structures. This comprehensive infrastructure expansion reflects Gurugram's ongoing evolution into a major urban center.

The commercial area around MG Road in Gurugram has experienced a notable surge in shopping malls and entertainment facilities, contributing to the city's densification while simultaneously reducing open spaces and green areas in its core. Despite this trend, city officials have made efforts to establish urban green pockets, such as Leisure Valley Park and Aravali Biodiversity Park, although these areas are often encircled by dense urban development. In the outskirts, particularly near Sultanpur and Basai wetlands, there is a growing conflict between conservation initiatives and urban expansion. The wetlands, which support various bird species, face encroachment from nearby real estate projects and industrial growth, with the Basai wetland under significant pressure from development activities despite advocacy for its preservation by environmental groups. Additionally, historical water bodies in the region have been increasingly filled or diminished, often replaced by infrastructure projects or informal settlements.

During 2021, the city was significantly shaped by urban expansion, particularly in residential areas, which spanned approximately 93.93 square kilometers. Neighborhoods such as Sohna Road, Sector 55, and Sector 65 transformed into vibrant residential hubs filled with high-rise apartments and gated communities, driven by the influx of professionals attracted to nearby corporate centers. The industrial sector also played a vital role in the city's economy, covering around 15.86 square kilometers, with major concentrations in Udyog Vihar and Manesar. These industrial zones hosted numerous factories and corporate offices, including several prominent automobile manufacturers, underscoring Gurugram's status as an industrial powerhouse. The commercial areas in the city spanning approximately 8.74 square kilometers, is primarily centered around key districts such as Cyber City, MG Road, and Golf Course Road. Cyber City stands out as the epicenter of the city's corporate environment, hosting numerous multinational corporations within its office complexes. This area is characterized by a lively mix of shopping malls, entertainment venues, and workplaces, making it a bustling destination for both business and leisure activities. Additionally, mixed-use developments cover about 21.13 square kilometers in sectors like Sector 29 and Sikanderpur, where residential and commercial spaces are increasingly integrated. These regions are undergoing rapid transformation as older buildings give way to modern structures that combine living, working, and retail environments. Furthermore, institutional areas occupy around 6.83 square kilometers in sectors such as Sector 44 and Sector 32, where essential services like educational institutions, government offices, and hospitals are located, underscoring their importance to the community's infrastructure.

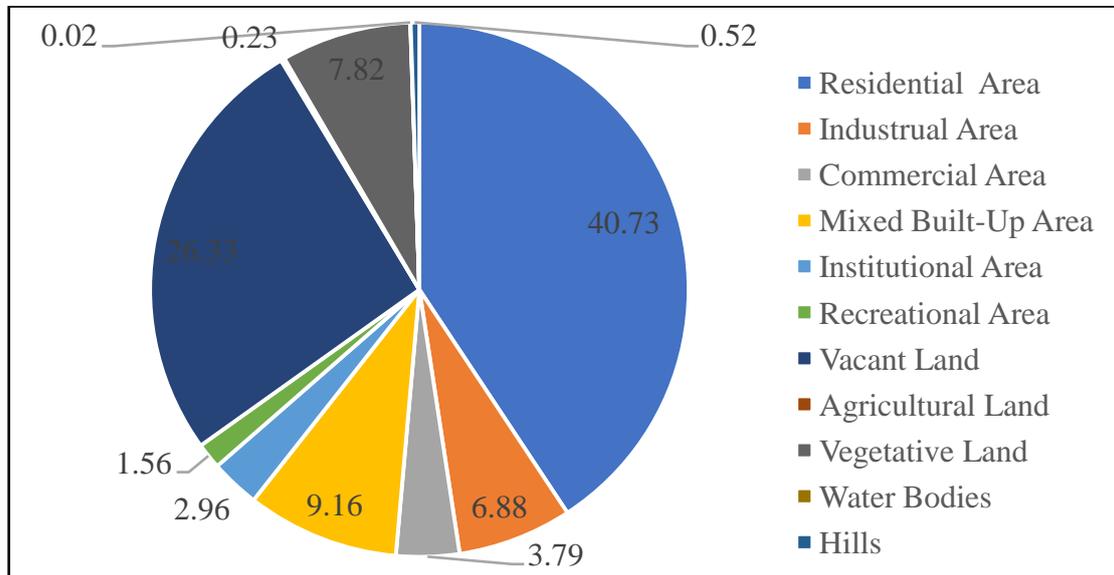
Table 1: Classification of Land Use/Land Cover of Gurugram City, 2021

Sr. No.	Land Use/Land Cover: 2021	Area (Km ²)	Area (In %)
1.	Residential Area	93.93	40.73
2.	Industrial Area	15.86	6.88
3.	Commercial Area	8.74	3.79
4.	Mixed Built-Up Area	21.13	9.16
5.	Institutional Area	6.83	2.96
6.	Recreational Area	3.61	1.56
7.	Vacant Land	60.71	26.33
8.	Agricultural Land	0.53	0.23
9.	Vegetative Land	18.04	7.82
10.	Water Bodies	0.04	0.02
11.	Hills	1.20	0.52
Total		230.60	100

Source: Computed by Researcher Based on the Google Earth Images, 2021

A considerable amount of land in Gurugram, approximately 60.71 square kilometers, remained vacant, particularly on the outskirts in areas such as Sector 102 and Sector 95, where future development plans are in place. This unused land

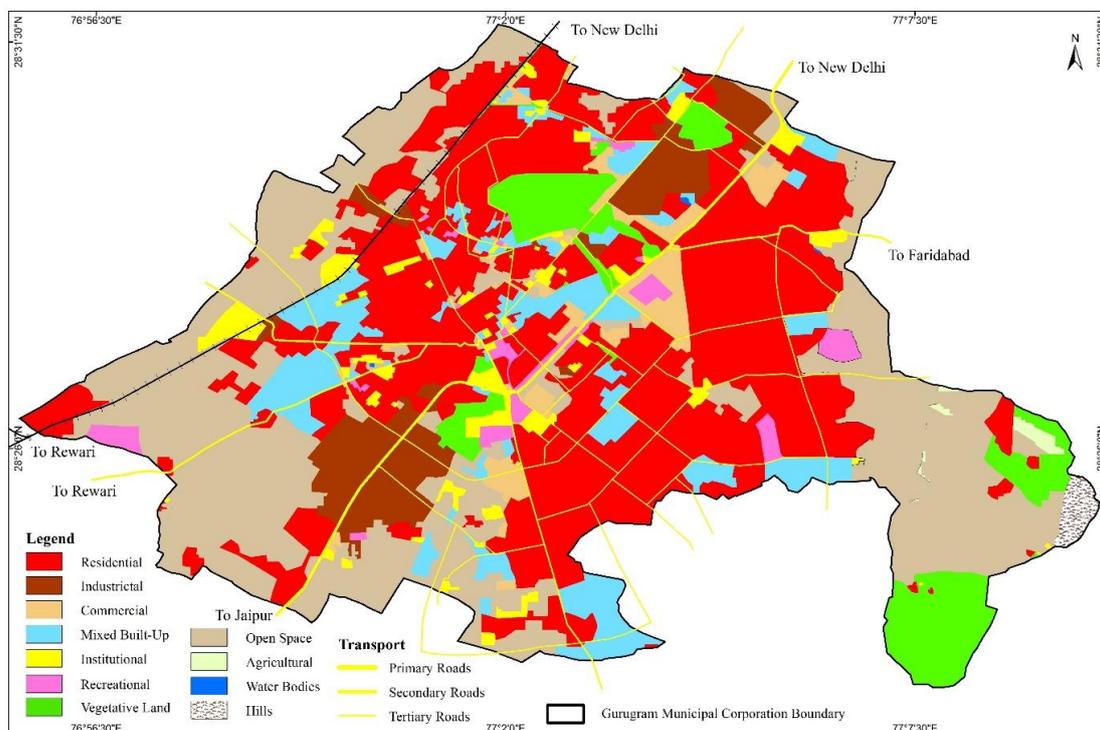
holds significant potential for further urban growth as large-scale projects are anticipated. In contrast, agricultural land has seen a dramatic decline, with only 0.53 square kilometers left, marking the transition away from extensive farming in what was once a largely rural area. Meanwhile, vegetative areas cover around 18.04 square kilometers, primarily located in green spaces like the Aravalli Biodiversity Park and the lush surroundings of Leisure Valley Park. These pockets of green were among the few remaining natural spaces in the city, which were struggling to survive amidst rapid development. The hills of the Aravalli Range, covering 1.20 sq. km, were also a natural feature that had persisted, but they were under threat from illegal mining and urban encroachment (Table 1).



Source: Based on the table 1

Figure 1: Classification of Land Use/Land Cover of Gurugram City, 2021

Map 1: Classification Land Use/Land Cover of Gurugram City, 2021



Source: Prepared by Researcher Based on the Google Earth Images, 2021

The water bodies in the city were notably scarce, encompassing just 0.04 square kilometers, with natural lakes and ponds having significantly dwindled over the years. Sultanpur Lake, located on the city's outskirts, stands out as one of the few remaining natural water features. In terms of recreational spaces, approximately 3.61 square kilometers were dedicated to parks and entertainment venues, with Leisure Valley and the Kingdom of Dreams serving as popular

destinations for relaxation and leisure activities. These areas play a crucial role in enhancing the quality of life for residents by providing essential green spaces amid the extensive urban development. Overall, by 2021, Gurugram had transformed dramatically, with urbanization overshadowing agriculture and natural environments. This shift was reflected in the proliferation of residential, industrial, and commercial zones, while the presence of vacant land suggested opportunities for further growth in the future.

The residential areas emerged as the predominant land use in Gurugram, comprising 40.73% of the city's total land area. Key neighborhoods such as Sohna Road, Sector 56, and Golf Course Extension Road became vibrant centers of residential development, featuring modern high-rise apartments and gated communities that appealed to professionals working in nearby corporate hubs. The continuous demand for housing in these regions reflected Gurugram's evolution into a major urban center. Industrial zones accounted for 6.88% of the city's land, with significant concentrations in Udyog Vihar and Manesar, which are crucial to the local economy due to their numerous factories and corporate offices. Manesar, in particular, has become a hub for several manufacturing units, especially in the automobile and electronics sectors. However, these industrial areas are increasingly facing encroachment from expanding commercial and residential developments.

The vacant land represented a notable aspect of Gurugram, comprising 26.33% of the city's total area. This unused land was primarily located on the outskirts, particularly in sectors such as 99A and 108, where numerous real estate projects were planned but had yet to be realized. These vacant parcels were designated for future residential and commercial developments, reflecting the city's ongoing rapid growth. Additionally, mixed-use areas made up 9.16% of the city area, especially in sectors like Sector 29 and Sikanderpur, where residential, commercial, and institutional facilities coexisted. These vibrant zones featured a blend of office buildings, shopping centers, and housing developments, driven by the increasing demand for integrated living and working environments.

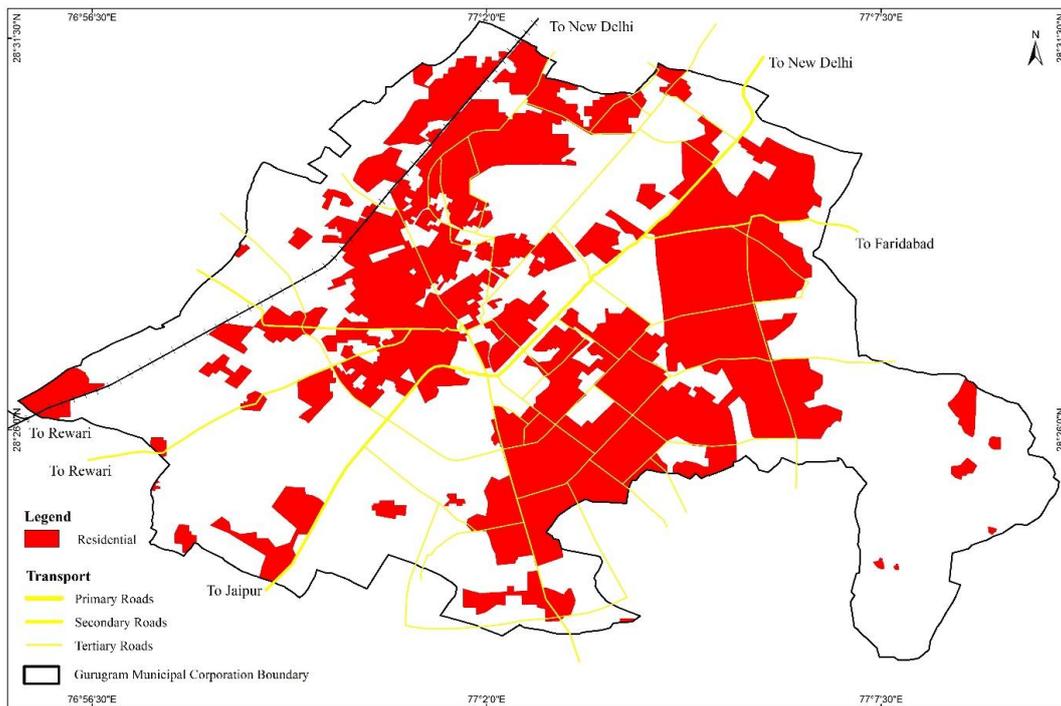
The vegetative land in Gurugram had dwindled to just 7.82%, yet essential green spaces like Aravalli Biodiversity Park and Leisure Valley Park continued to provide vital greenery and open areas for residents. Unfortunately, these natural spaces faced significant threats from ongoing urban encroachment. Institutional areas comprised 2.96% of the city's land, with sectors such as 32 and 44 housing important facilities like educational institutions, hospitals, and government offices, which are crucial for supporting the needs of the expanding population. Commercial zones were relatively small, accounting for only 3.79% of the area, with major business districts including Cyber City, MG Road, and Golf Course Road serving as hubs for corporate offices, shopping centers, and entertainment venues. Cyber City stood out as the leading commercial center, hosting the headquarters of numerous multinational corporations and solidifying its role as a key economic driver. Agricultural land, once a prominent feature of Gurugram city, had nearly vanished by this time, reduced to a mere 0.23%, with only small pockets of farmland remaining on the outskirts as urban development took precedence. Similarly, water bodies were scarce, covering only 0.02% of the total area; many natural lakes and ponds had been filled or diminished over the years, leaving Sultanpur Lake as one of the few remaining water features in the region.

The Aravalli Range, which occupies 0.52% of Gurugram, remains a prominent feature in the eastern part of the city, particularly near Faridabad Road. These hills are crucial to the region's natural setting but are increasingly threatened by illegal mining and urban development encroachment. Recreational spaces are limited as well, accounting for only 1.56% of the area, with attractions like Kingdom of Dreams and various sports complexes providing essential leisure options for both residents and visitors. Overall, Gurugram in 2021 was undergoing significant changes, characterized by urban expansion that encroached upon agricultural and natural lands. The growth of residential, commercial, and industrial sectors has dramatically altered the city with vacant plots indicating potential for further development. Despite this rapid urbanization, small green spaces and natural features such as the Aravalli hills and parks continue to exist within Gurugram's evolving environment.

Residential Area of Gurugram City, 2021

In 2021, residential areas dominated the city land use, comprising a substantial portion of the city and reflecting its rapid development. Key neighborhoods such as Sohna Road, Golf Course Extension, and Sector 56 emerged as prime residential destinations, evolving from open fields into vibrant hubs filled with high-rise apartments and luxury condominiums. The influx of professionals drawn to the city's thriving IT and corporate sectors fueled the demand for housing in these regions. Areas like Sushant Lok and DLF Phase V became particularly desirable due to their proximity to business centers, offering a harmonious balance of work and leisure. Meanwhile, affluent neighborhoods such as Palam Vihar and South City catered to wealthier residents with spacious villas, while mid-range housing options in sectors like 49 and 57 attracted middle-income families. Improved infrastructure, particularly along Sohna Road and Golf Course Road, further facilitated residential growth by enhancing accessibility and creating self-sufficient communities. Despite the rapid expansion, older sectors like DLF Phase I and Sector 14 retained their charm with green spaces and independent homes, providing a quieter alternative to the high-density developments characteristic of newer areas (Map 2).

Map 2: Distribution of Residential Area of Gurugram city, 2021

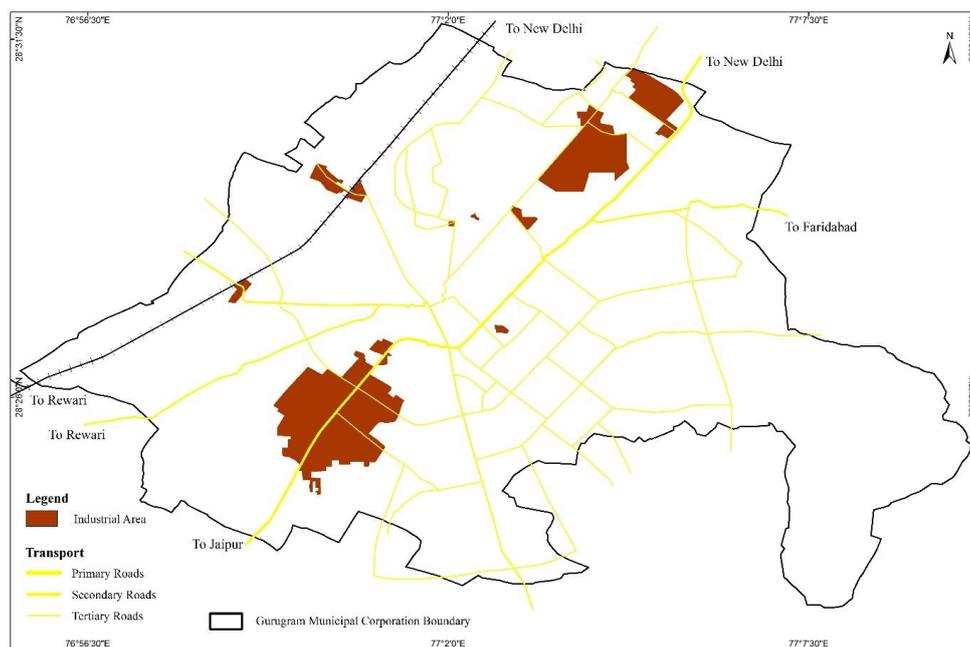


Source: Prepared by Researcher Based on the Google Earth Images, 2021

Industrial Area of Gurugram City, 2021

The industrial area of Gurugram City has played a crucial role in its economic growth, with Udyog Vihar serving as a prominent industrial hub that housed numerous factories and corporate offices across sectors like textiles, IT, and logistics. This area, vital for the city's industrial backbone, experienced significant expansion and activity, solidifying Gurugram's reputation as a key business center in North India. Manesar, located on the outskirts, transformed into a major industrial town, particularly in the automobile and electronics industries, with companies like Maruti Suzuki and Honda establishing factories there. The well-connected Manesar region also evolved into a residential and commercial hub to support its growing workforce. Additionally, Sector 37 catered to small and medium enterprises, focusing on machinery and textiles, while Pace City and IMT Manesar contributed to maintaining a balance between commercial and industrial growth.

Map 3: Distribution of Industrial Area of Gurugram city, 2021



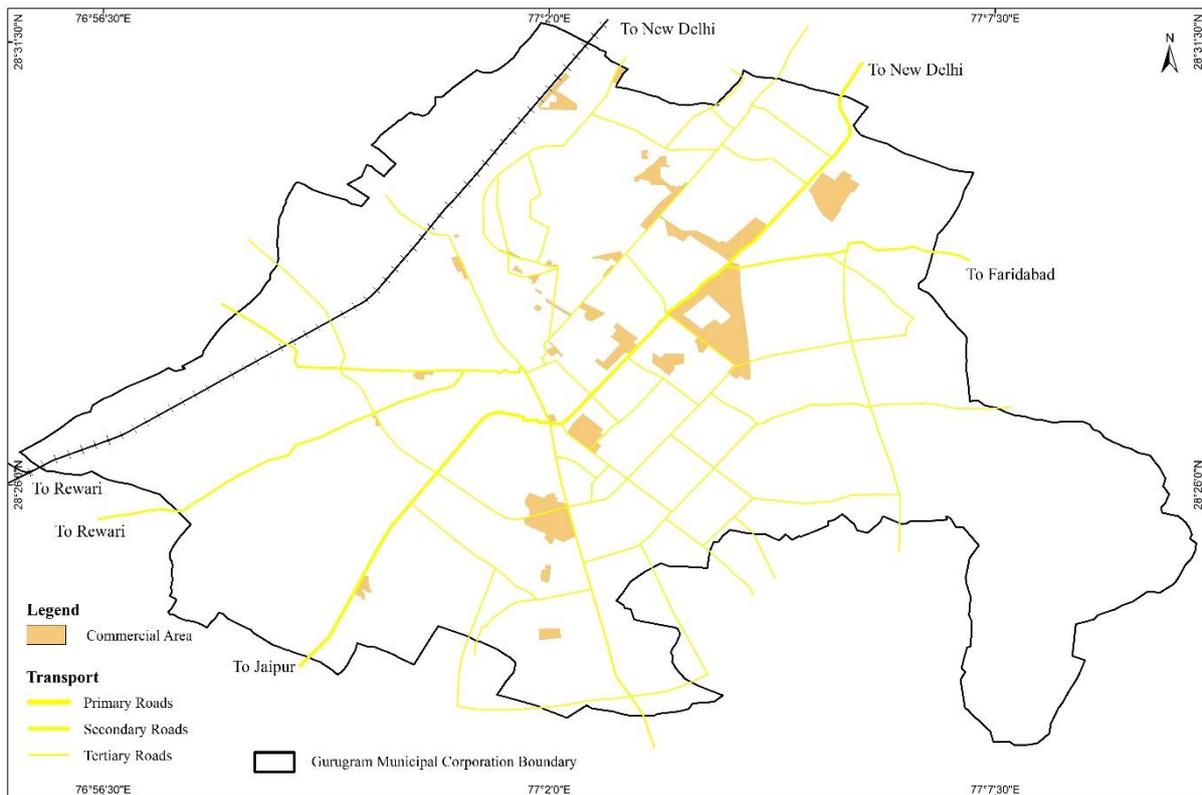
Source: Prepared by Researcher Based on the Google Earth Images, 2021

The growth of these regions, particularly Udyog Vihar and Manesar, solidified Gurugram’s position as one of India’s leading industrial cities. However, the expansion of residential and commercial sectors in close proximity to these industrial hubs raised concerns about sustainability and the impact on infrastructure, signaling the need for future planning and development. The industrial areas, covering 15.86 sq. km and comprising 6.88% of the city’s land, significantly impacted Gurugram’s economy, especially in Manesar, which housed major automobile and manufacturing companies. While these industrial zones remained vital to the city’s economic framework, they faced encroachment from expanding commercial and residential developments.

Commercial Area of Gurugram City, 2021

The commercial area in the city was characterized by its dynamic growth and status as a significant business hub in the National Capital Region, attracting both national and international enterprises. Key areas such as Cyber City and Udyog Vihar emerged as prominent landmarks, with Cyber City housing numerous multinational corporations in its high-rise office buildings and tech parks, making it the central node for business activities. Udyog Vihar contributed to the city’s economic vibrancy by accommodating various industrial and corporate offices. MG Road served as a bustling commercial artery filled with retail shops, restaurants, and entertainment venues, popular among professionals and shoppers due to its proximity to key business districts. Additionally, Sohna Road and Golf Course Road saw rapid expansion with new office spaces and commercial complexes to meet growing demand. Altogether, these commercial areas, covering 8.74 sq. km and accounting for 3.79% of the city’s total land, underscored Gurugram’s transformation into a modern business hub and solidified its pivotal role in the region’s economy.

Map 4: Commercial Area of Gurugram City, 2021

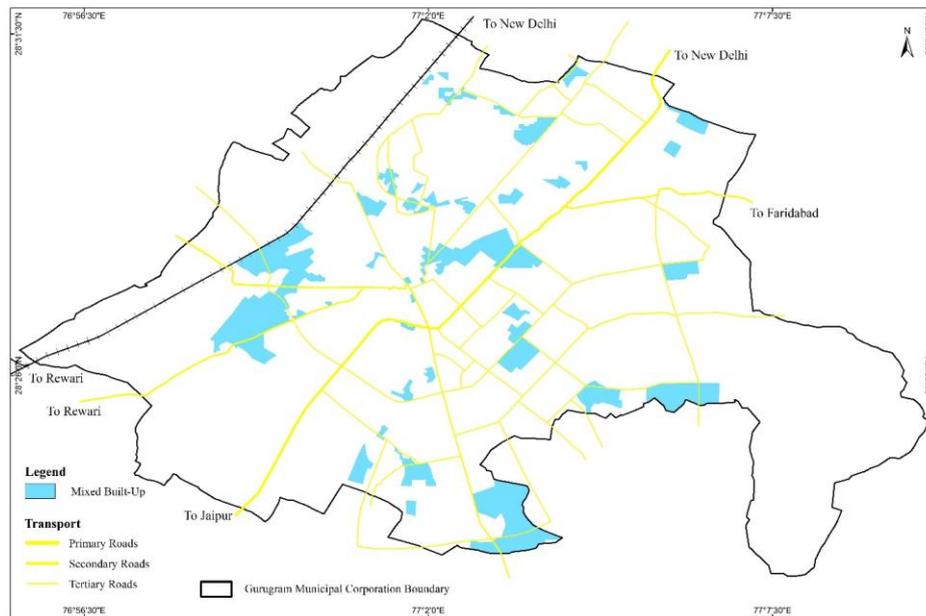


Source: Prepared by Researcher Based on the Google Earth Images, 2021

Mixed Built-up Area of Gurugram City, 2021: -

The mixed built-up areas showcased a unique blend of residential and commercial developments, reflecting the city’s dynamic growth and urban planning approach. Vibrant neighborhoods emerged, such as Sector 15, where residential apartments coexisted with commercial establishments, enhancing convenience for residents. In DLF Phase I, the integration of residential complexes, office spaces, retail outlets, and eateries created a lively urban environment that facilitated seamless living and working experiences. The HUDA City Centre also exemplified this mix, combining housing with shops, restaurants, and entertainment facilities to serve a diverse population. Covering 21.13 sq. km, these areas, which account for 9.16% of the urban areas include sectors like Sector 29 and Sikanderpur. The presence of institutional areas, vital for public services, further underscores the city’s commitment to creating self-sufficient neighborhoods that cater to various needs and lifestyles, making Gurugram an attractive location for both living and business activities.

Map 5: Mixed Built-up Area of Gurugram City, 2021

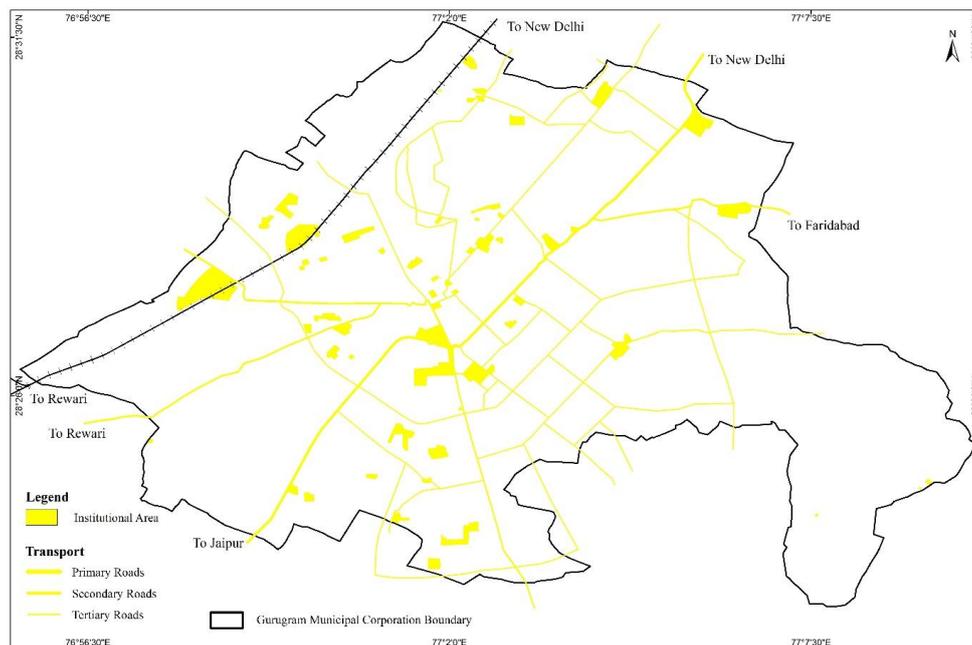


Source: Prepared by Researcher Based on the Google Earth Images, 2021

Institutional Area of Gurugram City, 2021

The institutional areas also played a crucial role in shaping the city's educational and administrative infrastructure. These regions were primarily defined by the presence of schools, colleges, and government offices, significantly contributing to the city's overall development. Sector 44 emerged as a notable hub for educational institutions, housing several prestigious schools and colleges that enhanced Gurugram's reputation as an educational center. Additionally, the vicinity of Gurgaon University in Sector 56 became another important institutional zone, featuring not only academic institutions but also research facilities and administrative offices. This area attracted both students and professionals, creating an environment that supported learning and academic advancement. The Sector 14 area, with its numerous government offices, highlighted its importance as a key administrative center, delivering essential services and governance for Gurugram. These institutional areas were vital to the city's infrastructure, addressing both educational and administrative needs. They played a significant role in fostering a knowledgeable and skilled workforce, thereby contributing to the city's growth and enhancing the overall quality of life for residents. Comprising 2.96% of the urban area, these institutional areas included educational and healthcare facilities located in sectors like 44 and 32.

Map 6: Institutional Area of Gurugram City, 2021

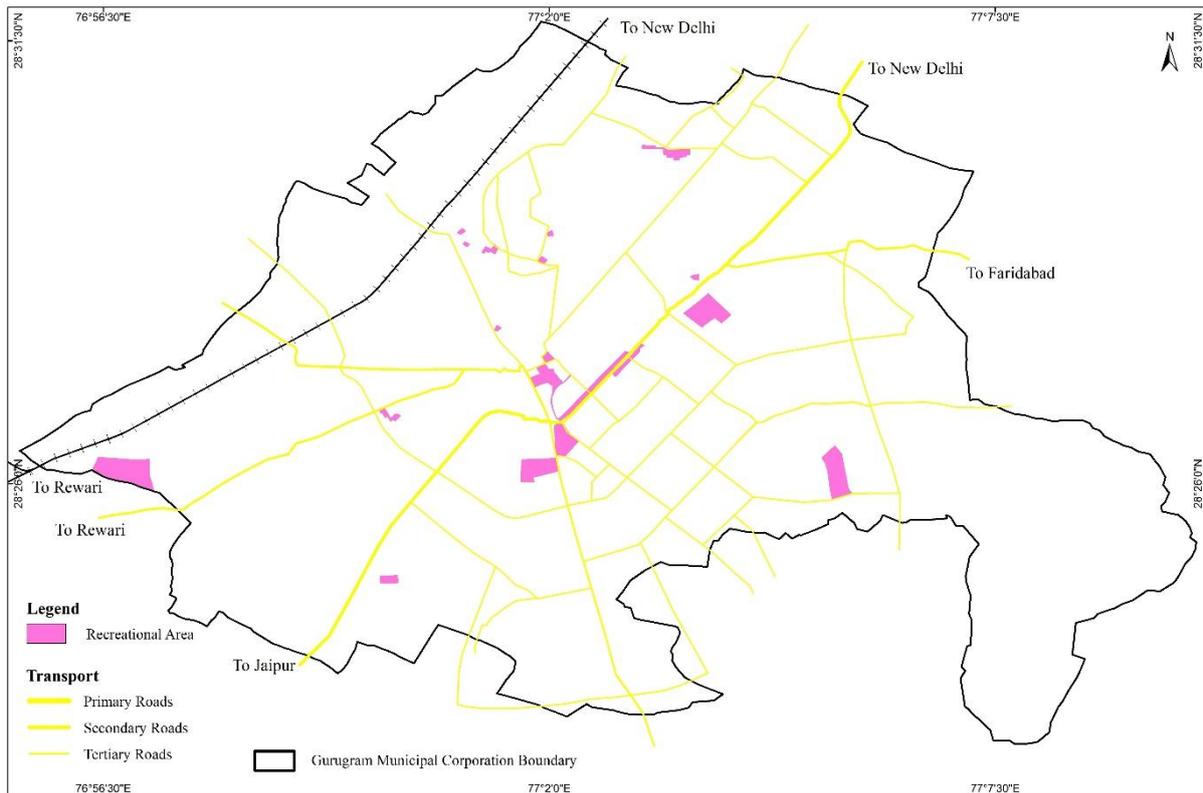


Source: Prepared by Researcher Based on the Google Earth Images, 2021

Recreational Area of Gurugram City, 2021

The recreational areas provided a diverse array of leisure and entertainment options, showcasing the city's commitment to enhancing residents' quality of life. A standout attraction was the Kingdom of Dreams in Sector 29, known for its grand theatrical productions and lively dining experiences, making it a favorite destination for locals and visitors alike. Leisure Valley Park, also in Sector 29, offered a serene escape with landscaped gardens, walking trails, and recreational facilities, serving as a popular spot for family outings and community events. Additionally, shopping malls like MGF Metropolitan Mall and Ambience Mall functioned as multifaceted recreational hubs, combining retail with entertainment zones that included movie theaters and dining options. Overall, Gurugram's recreational areas, though limited to 1.56% of the city's land, reflected a blend of modern entertainment and natural spaces, catering to a wide range of interests and contributing to the city's vibrant lifestyle.

Map 7: Recreational Area of Gurugram City, 2021



Source: Prepared by Researcher Based on the Google Earth Images, 2021

Vacant Land of Gurugram City, 2021

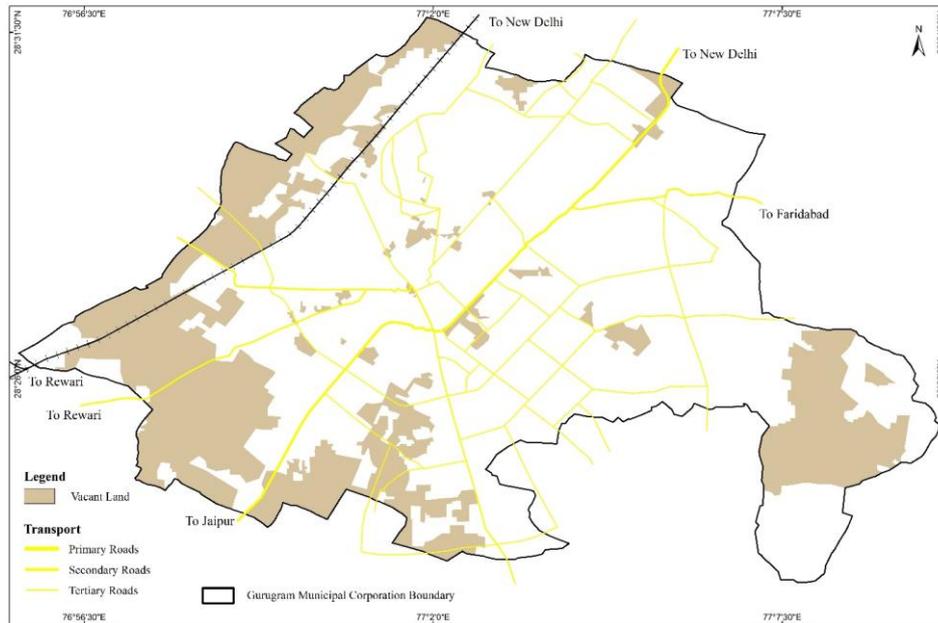
The vacant land areas reflected the city's ongoing development and growth potential. Despite significant progress in various sectors, several plots remained undeveloped, particularly in areas like Sohna Road, which, although close to emerging residential and commercial developments, contained large stretches of vacant land poised for future real estate projects.

Similarly, the land surrounding the Southern Peripheral Road (SPR) featured numerous undeveloped plots, indicating opportunities for transformation into commercial and residential spaces as the city continued to expand. Vacant land was also prevalent in the outskirts, such as in Sector 88 and Sector 89, where areas were earmarked for future urbanization in response to rising demand.

Overall, the vacant land in Gurugram in 2021 illustrated both the current state of the city and its prospects for future expansion and development. The outskirts of the city feature 60.71 sq. km of vacant land designated for future development, while agricultural land has dwindled to just 0.53 sq. km, signaling the decline of large-scale farming in the region.

In 2021, vacant land comprised 26.33% of Gurugram's total area, with significant concentrations in outskirts areas such as Sector 99A and Sector 108, which are earmarked for upcoming residential and commercial projects.

Map 8: Vacant Land of Gurugram City, 2021

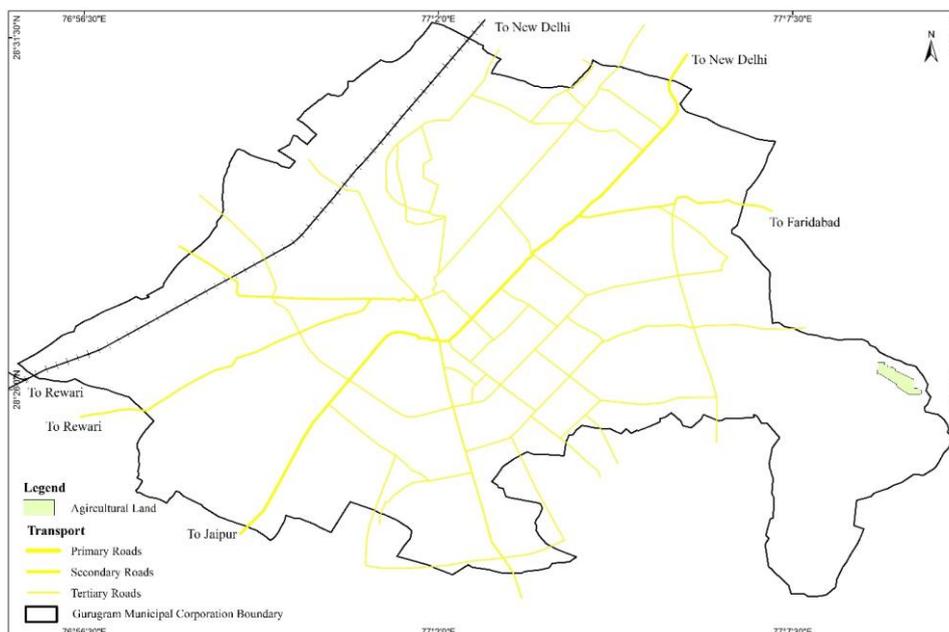


Source: Prepared by Researcher Based on the Google Earth Images, 2021

Agricultural Land of Gurugram City, 2021

Historically, areas such as Sector 102 and Sector 104 were vital agricultural zones known for their vast fields and traditional farming practices. However, rapid urbanization led to the gradual conversion of much of this land into residential and commercial developments, reflecting the city's transformation. In contrast, the northeastern parts of Gurugram, particularly around the village of Manesar, retained more agricultural land, characterized by expansive fields and active farming communities. The agricultural lands within Gurugram's municipal limits were increasingly fragmented due to ongoing real estate projects and infrastructure development, signalling a clear transition from agriculture to urban use. New residential complexes and commercial centers began to replace formerly fertile lands, illustrating the challenges of balancing urban growth with the preservation of agricultural heritage in a rapidly expanding city. Agricultural land, once a dominant feature of Gurugram, had dwindled to just 0.23%, with small pockets remaining on the outskirts while most areas had been converted into urban developments. Water bodies were also scarce, covering only 0.02% of the land, as many natural lakes and ponds were filled in or diminished, leaving Sultanpur Lake as one of the few remaining water bodies on the city's periphery.

Map 9: Agricultural Land of Gurugram City, 2021

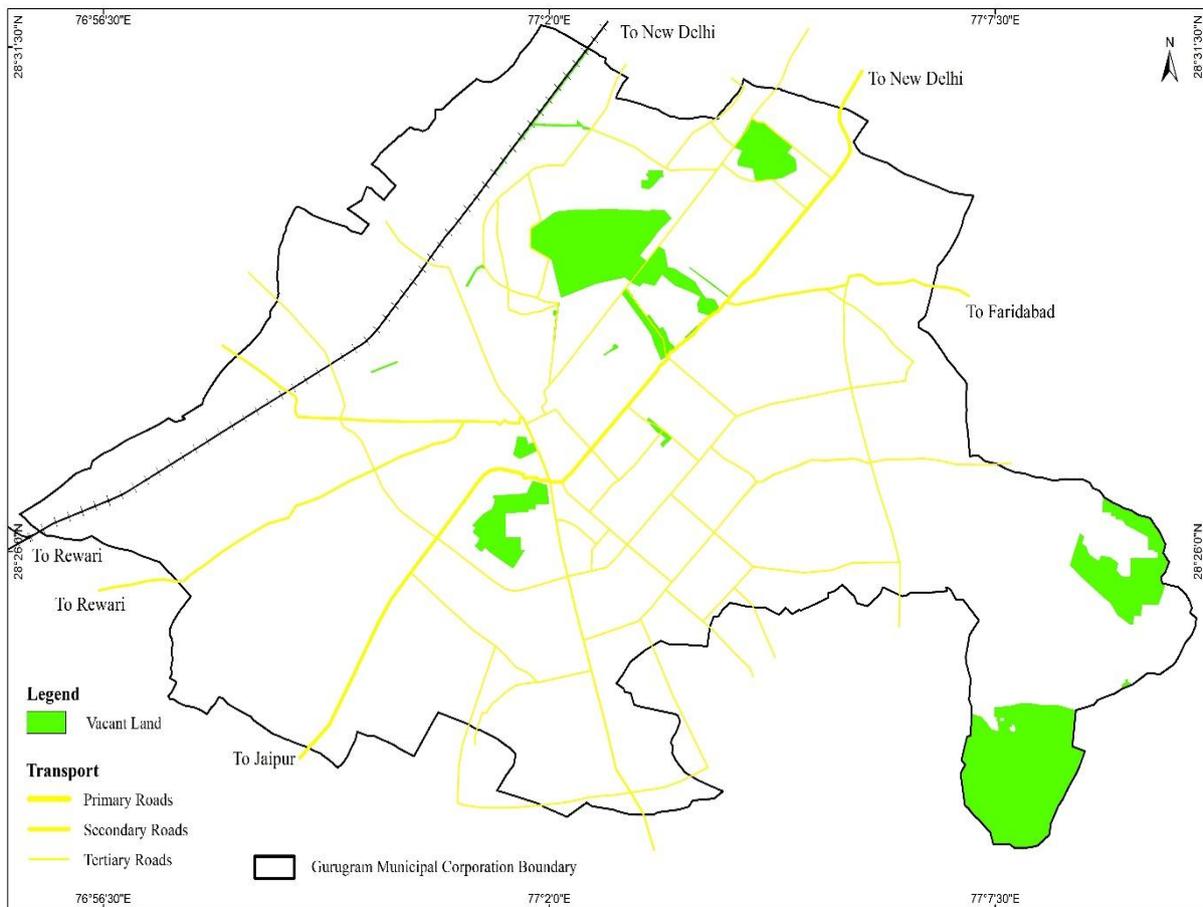


Source: Prepared by Researcher Based on the Google Earth Images, 2021

Vegetative Land of Gurugram City, 2021

The city featured several notable vegetative lands within its municipal boundaries, despite the city's rapid urbanization. Key green spaces, such as Sultanpur National Park, which spans over 1,400 hectares and is renowned for its diverse bird species, played a vital role in maintaining ecological balance and providing recreational areas for residents. The Aravalli Golf Course also contributed to the city's greenery with its well-maintained lawns and trees. Additionally, the Tau Devi Lal Bio-Diversity Park promoted biodiversity and environmental awareness, featuring native plants and walking trails. However, the rapid expansion of Gurugram posed challenges to preserving these vegetative lands, which had diminished to 7.82% of the city's area. Despite the presence of important parks like Aravalli Biodiversity Park and Leisure Valley Park, these green spaces faced threats from encroaching urbanization. Institutional areas, comprising 2.96% of the land, included educational institutions and hospitals that were essential for the city's infrastructure. Overall, the remaining vegetative land, covering 18.04 sq. km, represented some of the few surviving natural spaces in Gurugram.

Map 10: Vegetative Land of Gurugram City, 2021



Source: Prepared by Researcher Based on the Google Earth Images, 2021

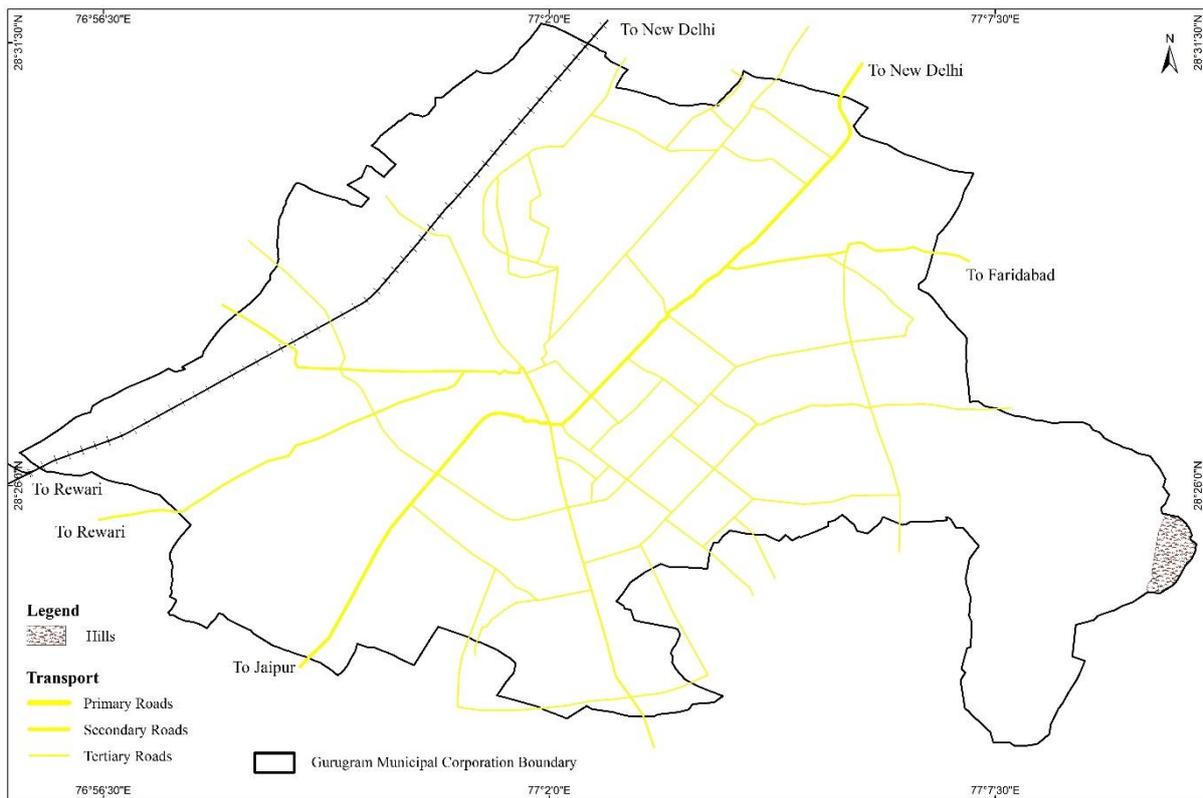
Hills Area of Gurugram City, 2021

The city area and the surrounding have presence on hills that enhance the region's topographical diversity. While the city is predominantly recognized for its modern urban development, it also featured notable hillocks. A prominent example is the Aravalli Hills, which extend into the Gurugram area.

These ancient hills, characterized by rugged terrain and lush vegetation, provide a striking contrast to the surrounding urban sprawl. Beyond their natural allure, the Aravalli Hills play a crucial role in maintaining the region's ecological balance.

Covering 1.20 sq. km, these hills, which account for 0.52% of Gurugram's area, are primarily located in the eastern parts of the city, near Faridabad Road. However, they face threats from illegal mining and urban encroachment, jeopardizing their persistence as a natural feature.

Map 11: Hills Area of Gurugram City, 2021



Source: Prepared by Researcher Based on the Google Earth Images, 2021

CONCLUSION

The morphological assessment of land use and land cover (LULC) in Gurugram City as of 2021 reveals profound transformations driven by rapid urbanization, economic growth, and infrastructural development. The city has transitioned from a predominantly agricultural landscape to a bustling urban center. The findings illustrate a significant decline in agricultural land, which has dropped to a mere 0.23% of the total land area, highlighting the pressing challenge of maintaining food security amidst expanding urban sprawl. The conversion of agricultural fields into residential, commercial, and industrial zones underscores the economic pressures and demographic shifts that have characterized the region. Residential areas now dominate, comprising 40.73% of Gurugram's land, driven by an influx of professionals attracted to the city's burgeoning corporate and IT sectors. However, the industrial areas that are critical to the local economy also face increasing pressure from residential and commercial developments. The study identified key industrial hubs like Udyog Vihar and Manesar, which play a vital role in Gurugram's economic framework but require careful planning to ensure sustainable growth. Commercial zones, accounting for 3.79% of the area, particularly around Cyber City and MG Road, underscore the city's status as a significant business hub in the National Capital Region. Vacant land, comprising 26.33% of the total area, presents both a challenge and an opportunity for future urban planning. This unused land signifies potential for further development but also raises concerns regarding unplanned expansion and the loss of green spaces. The assessment indicates that while some green spaces and natural features like the Aravalli hills persist, they are increasingly threatened by urban encroachment and infrastructure projects. In conclusion, the morphological assessment of Gurugram reveals a complex interplay of growth and transformation, necessitating a balanced approach to urban development that considers economic, social, and environmental dimensions.

REFERENCES

- [1]. Alawathugoda, C., Hinge, G., Elkollaly, M., & Hamouda, M. A. (2024). Impact of Utilizing High-Resolution PlanetScope Imagery on the Accuracy of LULC Mapping and Hydrological Modeling in an Arid Region. *Water*, 16(16), 2356.
- [2]. Crisp, J., Morris, T., & Refstie, H. (2012). Displacement in urban areas: new challenges, new partnerships. *Disasters*, 36, 23-42.
- [3]. Dadashpoor, H., Azizi, P., & Moghadasi, M. (2019). Land use change, urbanization, and change in landscape pattern in a metropolitan area. *Science of the Total Environment*, 655, 707-719.

- [4]. Gandhi, G. (2024). Dynamics of Urban Sprawl: Mapping the Changing Faces of Gurugram. In *International Conference on Trends in Architecture and Construction*. Singapore: Springer Nature Singapore.167-177.
- [5]. Gaur, S., & Singh, R. (2023). A comprehensive review on land use/land cover (LULC) change modeling for urban development: current status and future prospects. *Sustainability*, 15(2), 903.
- [6]. Gupta, R. K. (2021). Dynamics of Urbanization and Land Use/Land Cover Changes of Gurgaon, Ranchi and Jaipur, India. *Applied Ecology and Environmental Sciences*, 9, 296-311.
- [7]. Harishkumar, H. V., & Reddy, B. V. (2017). Impact of urbanization on land use pattern of rural-urban gradient of Bengaluru North: an economic analysis. *Economic Affairs*, 62(2), 303-312.
- [8]. Herdini, H. R., & Gamal, A. (2024). Validating modelling and prediction of land use landcover change dynamics based: A literature review. In *AIP Conference Proceedings* (Vol. 3215, No. 1). AIP Publishing.
- [9]. Mohan, M., Pathan, S. K., Narendrareddy, K., Kandya, A., & Pandey, S. (2011). Dynamics of urbanization and its impact on land-use/land-cover: a case study of megacity Delhi. *Journal of Environmental Protection*, 2(09), 1274.
- [10]. Muluneh, M. G. (2021). Impact of climate change on biodiversity and food security: a global perspective, a review article. *Agriculture & Food Security*, 10(1), 1-25.
- [11]. Obeidat, M., Awawdeh, M., & Lababneh, A. (2019). Assessment of land use/land cover change and its environmental impacts using remote sensing and GIS techniques, Yarmouk River Basin, north Jordan. *Arabian Journal of Geosciences*, 12, 1-15.
- [12]. Oliver, T. H., & Morecroft, M. D. (2014). Interactions between climate change and land use change on biodiversity: attribution problems, risks, and opportunities. *Wiley Interdisciplinary Reviews: Climate Change*, 5(3), 317-335.
- [13]. Roy, P. S., Ramachandran, R. M., Paul, O., Thakur, P. K., Ravan, S., Behera, M. D. & Kanawade, V. P. (2022). Anthropogenic land use and land cover changes. A review on its environmental consequences and climate change. *Journal of the Indian Society of Remote Sensing*, 50(8), 1615-1640.
- [14]. Sadashivam, T., & Tabassu, S. (2016). Trends of urbanization in India: issues and challenges in the 21st century. *International Journal of Information Research and Review*, 3(5), 2375-2384.
- [15]. Sikarwar, A., & Chattopadhyay, A. (2020). Analyzing population and land use change: selected case studies of Indian metropolitan cities. Springer Nature.
- [16]. Suriya, S., & Mudgal, B. V. (2012). Impact of urbanization on flooding: The Thirusoolam sub watershed–A case study. *Journal of hydrology*, 412, 210-219.