

UNVEILING THE SHIFTING LANDSCAPE: EXPLORING URBAN EXPANSION AND LAND USE DYNAMICS IN ROHTAK

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Abstract

This study examines the urban transformation and expansion of Rohtak over the period of 1991 to 2018, focusing on the dynamics of expansion and changes in land use. Utilization of remote sensing tools along with Geographic Information Systems (GIS) data analysis, significant shifts in land use categories are identified, with particular emphasis on the expansion of the built-up area due to rapid urbanization. The research also explores the impacts of urban expansion on rural areas, revealing a decrease in agricultural land and an increase in open areas due to land acquisitions. Notably, the expansion of urban infrastructure into rural settings is facilitated by transportation networks. The findings highlight the complex interplay of biophysical, socio-economic, and institutional factors shaping land use dynamics in Rohtak. Understanding these dynamics is crucial for effective land use planning, environmental sustainability, and rural livelihoods amidst rapid urban growth. This study provides valuable insights into Rohtak's evolving urban landscape, emphasizing the need for integrated approaches to manage land use amidst urban expansion.

Keywords: Rohtak, Urban Transformation, Land Use Dynamics, Remote Sensing, Geographic Information Systems (GIS), Urban Expansion, Rural-Urban Interface, Sustainable Development.

INTRODUCTION

The research paper delves into an exhaustive examination of urban spread and the concurrent alterations in use of land as well as land cover within the research domain, leveraging data sourced from remote sensing and GIS. It commences by addressing significant concerns surrounding the velocity and scale of human-induced alterations to Earth's ecosystems, propelled by population escalation, infrastructural expansion, and agricultural pursuits (Hooke et al., 2012; Seto et al., 2011). It is noted that over half of Earth's continents have undergone transformations owing to human activity, with particular emphasis on unsustainable land change practices, notably the conversion of arable land into urban zones (Foley et al., 2005).

By 1950, urban dwellers comprised 27 percent of the global population, a proportion that burgeoned to around 50 percent by 2000. A pivotal juncture was reached in 2007 when urban populace surpassed rural populace, with over 54 percent residing in urban districts at the time (United Nations, 2016; UN-Habitat, 2014). Future population expansion is projected to predominantly transpire within metropolitan areas of developing nations, significantly reshaping the geopolitical landscape (Cohen, 2006).

The paper accentuates the cruciality of monitoring changes in land use as well as land cover, especially in metropolitan contexts with extensive human-environment interactions. Urban expansion is elucidated through two prisms: dynamic alterations within urban regions and encroachment upon adjacent non-urban territories, triggering shifts in land use patterns (Ravinder and Kaushik, 2014). Monitoring is imperative due to the propensity for urban land utilization to extend into rural settings, facilitated by transportation networks.

India emerges as a notable case of rapid expansion, underscored by swift urbanization and industrialization. As of the 2011 Census, India boasted an urbanization rate of 31.16 percent and housed 7,995 urban centers, emblematic of an aerial expansion trajectory propelled by advancements in secondary and tertiary sectors (Singh, 2013:105).

The paper culminates by underscoring the paramount importance of effective monitoring and planning of land usage and land coverage changes, especially amidst burgeoning urbanization and industrialization. Remote sensing techniques are deemed indispensable for furnishing timely and reliable and trustable information essential for judicious land use planning. The implementation of New Economic Policies in the early 1990s in India triggered transformative shifts in land use along with land cover patterns, illustrating the intricate interplay of biophysical as well as socio-economic factors in land transformation (Roy and Giriraj, 2008). Given the finite nature of land resources, effective monitoring and planning are imperative for managing changes of land use sustainably.

Pattern of Land usage and cover

For the purpose of avoiding any ambiguity, it is imperative to establish a sharp contrast among the idea of land use and the term land cover prior delving further into discussions or studies. Esteemed scholars like William and Turner-II (1996) have elucidated this distinction by defining land use as the human utilization of land to meet resource needs, encompassing activities such as settlement establishment, agriculture, and industrial development. Conversely, land cover pertains to the biophysical state of the land, encompassing flora, water bodies, soil, and artificial constructions covering the land's surface (Foody, 2002; Lambin et al., 2001).

Put simply, land use refers to how humans exploit and utilize land for various purposes, influenced by interactions of human beings with the environment. In contrast, land cover describes the physiological characteristics of the Earth's surface, including flora, water bodies, and urban infrastructure, without specifying the specific use of the land. While the usage is influenced by natural and socio-economic factors, land cover primarily focuses on the different types of land cover available.

The difference between land cover categorisation and land use classification lies in the former specifying surface cover types without detailing their specific usage, while the latter provides insight into how people use land based on socio-cultural and economic contexts. It's important to note that lands with the same cover type may have distinct uses, highlighting the nuanced nature of land use classification.

Land use pattern is influenced by a myriad of factors, including biophysical components such as climatic conditions, topographic factors, edaphic factors, and water availability (Foley et al., 2005), as well as cultural (Turner et al., 2007), institutional (Verburg et al., 2011), and economic dynamics (Rindfuss et al., 2004). These factors collectively drive demand for specific services and commodities, thereby influencing changes in land use patterns (Mather, 2001).

There exists substantial evidence of human-induced modifications to Earth's surface, underscored by the difference between land usage and land coverage (Foody, 2002). The utilization of land is a multifaceted subject intersecting various fields of study, serving as a means to generate income and

meet human needs. It is governed by factors such as land ownership, government regulations, and economic incentives, which can either constrain or incentivize land use activities.

The forthcoming paper endeavors to elucidate the dynamics of land usage as well as land coverage in Rohtak city over the years, shedding light on the evolving relationship between human activities and the surrounding environment.

In analyzing land use as well as land cover using remote sensing data, numerous educational institutions and government organizations have employed various classification techniques. Scholars namely Anderson et al. (1983), NRSA (2008), Chopra (2011), Ramchandra et al. (2014), and Roy et al. (2015) have utilized satellite imagery for classification, often employing supervised and unsupervised categorisation methods.

The incorporation of nearby villages such as Bohar, Asthal Bohar, Garhi Bohar, Kherisadh, Majra, Sunari Khurd, Sunari Kalan, Baliana, and Kanehli into Rohtak's municipal limits in 2010 expanded the city's boundaries. For analysis, the municipal limits of Rohtak in 2010 were utilized, considering the city's expansion over time.

By delineating these land usage pattern as well as land coverage categories and utilizing remote sensing techniques, this study aims to provide a comprehensive understanding and analysis of the evolving landscape dynamics of Rohtak city over the years.

Development of Urban Infrastructure and Expansion of Rohtak City

Rohtak is one of the oldest known cities in the state. It situated in the National Capital Region, has experienced significant urbanization and population growth since the mid-twentieth century. Following the division of the country, a surge in refugees caused dramatic population increase in the period of 1941 and 1951, prompting the settlement of new residential colonies like Gandhi Camp and Model Town. By 1971, Rohtak's population exceeded one lakh, earning it the status of Class-I municipality. Subsequent decades saw continued population growth, surpassing 2 lakhs in 1991 and nearly three lakhs in 2001. The 2011 census revealed a population exceeding three lakhs, reflecting ongoing urban expansion.

In the early 1970s, the Haryana Urban Development Authority also known as HUDA initiated plans for the development of residential sectors, resulting in the creation of five sectors primarily in the city's eastern areas. The foundation of MDU- Maharishi Dayanand University in 1976 further solidified Rohtak's reputation as an educational hub.

The 1990s marked a pivotal period with the introduction of new economic policies aimed at fostering nationwide economic growth, including Liberalization, Privatization, and Globalization (LPG) models. This resulted in the emergence of new industries and associated infrastructure across the country, contributing to Rohtak's development.

Government programs targeting the National Capital Region (NCR) also played a remarkable role in Rohtak's growth. These initiatives, coupled with the LPG policies, spurred rapid urban expansion and population growth.

As a consequence of these developments, land resources and land use patterns within Rohtak and its environs have undergone substantial modifications, reflecting the city's evolving landscape amidst rapid urbanization and demographic changes.

Land Usage and Land Cover of Rohtak City

The city of Rohtak has undergone significant transformations at three key junctures: post-partition influx of refugees, early 1990s economic policy reforms, and its designation as the Chief Minister's

residence in 2004, driving rapid development. This study investigates Rohtak's land use changes from 1991 to 2018, analyzing eight major categories including built-up areas, water bodies, open areas, agricultural land, and industrial areas. Visual representations of land use patterns within Rohtak's Municipal Corporation jurisdiction for the years 1991, 2001, 2011, and 2018 are presented in Figures 3.1 to 3.4.

Table 3.1: Pattern of Land Use and Land Cover of the city Rohtak (Area in Hectares)

Categories	Years							
	1991		2001		2011		2018	
	Absolute Area	% to total	Absolute area	% to total	Absolute area	Total	Absolute area	% Total
Total Built-up area	1085.850	7.820	1888.83 0	13.610	2475.90	17.840	2973.240	21.420
Urban Built-up area	991.350	7.1410	1658.520	11.950	2184.660	15.7380	2619.180	18.868
Rural Built-up area	94.50	0.680	230.310	1.660	291.240	2.098	354.060	2.550
Water Body	263.340	1.90	222.570	1.600	221.850	1.657	276.030	1.988
Open area	1792.80	12.920	1952.730	14.060	3598.290	25.922	4682.880	33.740
Wooded area	214.380	1.540	214.380	1.540	125.640	0.910	125.640	0.910
Agricultural area	10524.80	75.820	9451.620	68.100	7279.560	52.441	5598.450	40.331
Industrial area	Nil	0	127.170	0.920	156.060	1.124	190.980	1.380
Park/ Garden	Nil	0	23.850	0.170	23.850	0.171	33.930	0.240
Total	13881.170	100	13881.150	100	13881.150	100	13881.150	100

Source: Data based on Satellite Information

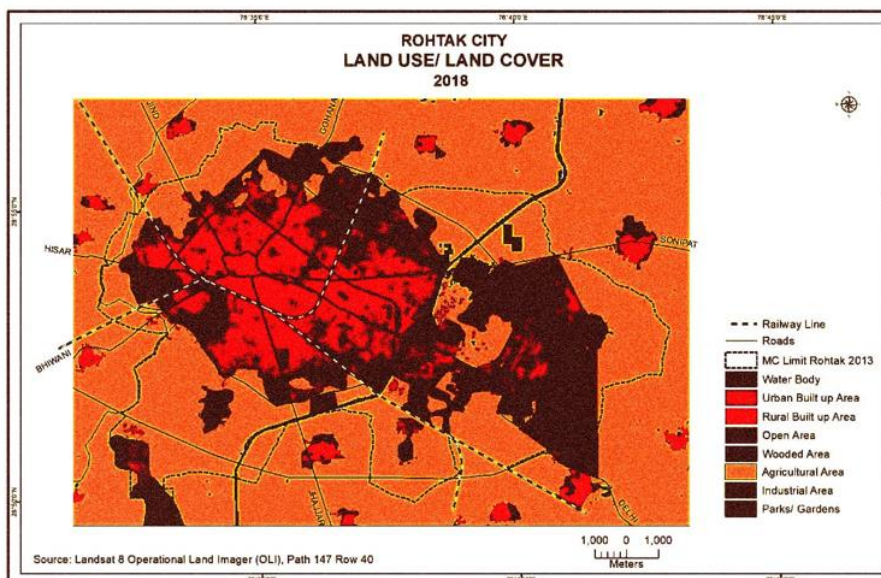
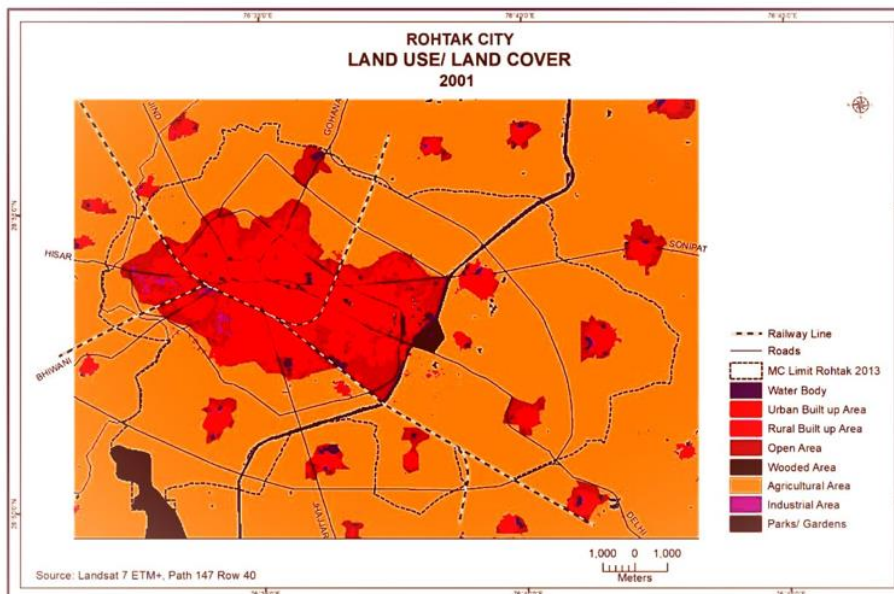
The table 3.1 presents significant shifts in land usage and coverage from 1991 to 2018. Urban and rural constructed/built-up areas expanded steadily, from 7.82% to 21.42% of the total land area. Conversely, water bodies remained relatively stable, ranging from 1.9% to 1.988%. Open areas saw notable growth, increasing from 12.92% to 33.74%, possibly indicating changes in land use or conservation efforts. Wooded areas remained consistent at around 1.54% to 0.91%. Agricultural land decreased markedly, from 75.82% to 40.331%, suggesting a shift away from agricultural practices. Industrial areas showed gradual growth, from nil to 1.38%. Park and garden spaces remained minimal, ranging from nil to 0.24%. These findings reflect dynamic changes in land use patterns, with urbanization, conservation, and economic development playing significant roles over the studied period.

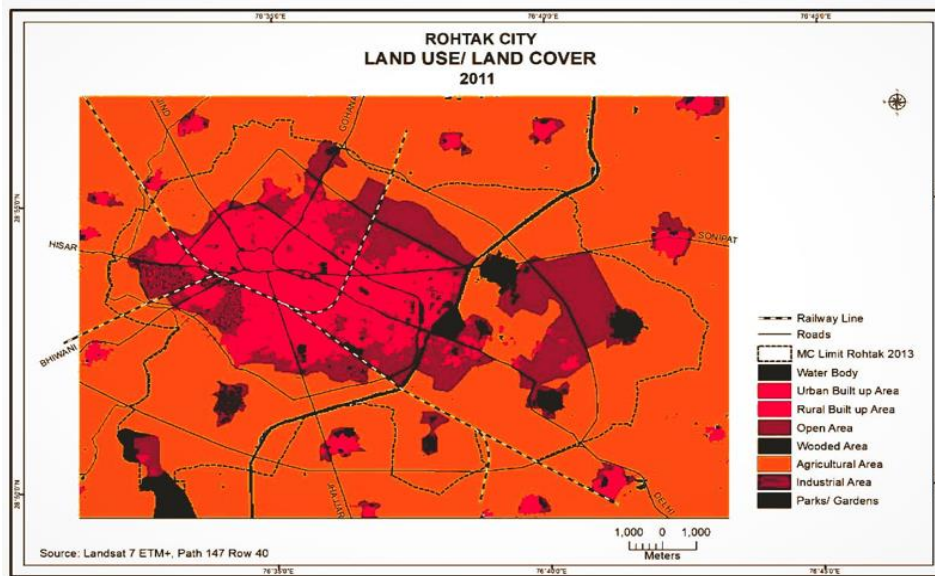
Table 3.2: Rohtak city: Average of Annual Growth Rate in Different pattern of Land use/Land cover

Land use/land cover categorisation	Average Annual Rate of Growth		
	1991-01	2001-11	2011-18
Total constructed	7.40	3.11	2.01
Urban constructed	6.729	3.172	2.84
Rural constructed area	14.371	2.645	3.081
Water Body	-1.548	-0.0323	3.488
Open	0.892	8.426	4.305
Wooded	0	-4.139	0
Agricultural	-1.019	-2.298	-3.298
Industrial	10	2.271	3.196
Park and Garden	10	0	6.037

Source: Data based on Satellite Images

The data provided in table 3.2 highlights trends in average annual rates of growth for various land use as well as land cover categories over three distinct time periods. Total built-up areas, encompassing urban and rural regions, exhibit declining growth rates from 7.40% to 3.11% to 2.01% across the respective intervals. Urban built-up areas follow a similar trend, declining from 6.729% to 3.172% to 2.84%. Conversely, rural built-up areas show fluctuating growth rates, peaking at 14.371% in 1991-2001 and gradually declining thereafter. Water bodies demonstrate negative growth from 1991-2001 (-1.548%), stabilize in the next period (-0.0323%), and notably increase from 2011-2018 (3.488%). Open areas consistently grow, with rates increasing from 0.892% to 8.426% to 4.305% over the periods, indicating ongoing land use changes or conservation efforts. Agricultural areas consistently decline in growth rate, from -1.019% to -2.298% to -3.298%, suggesting a shift away from agricultural land use. Industrial areas and park/garden spaces exhibit varying growth rates, indicating evolving patterns of economic development and urban green space expansion, respectively. These trends underscore dynamic changes in land use dynamics over the analyzed time periods.





Transformation in Municipal Boundaries

There has been a notably huge increase in the aerial extension of Rohtak city between the years 1991 and 2018, which has been followed by changes in the city's municipal limits. As it has been depicted in Table 3.3, the total land area of the city has raised by a factor of greater than four during this time period. In the year 1991, Rohtak encompassed a total area of around 29.97 square kilometers, which is equivalent to 2996.54 hec. In the years that followed, in 1998, there was a modification made to the municipal limits, which resulted in an increase of approximately 1.16 square kilometers, which is equivalent to nearly 116 hectares. By the year 2001, this city had grown to encompass a combined total area of approximately 3112.11 hectares, which is equivalent to around 31.12 square kilometers. This is an average growth rate of approximately 3.84 percent.

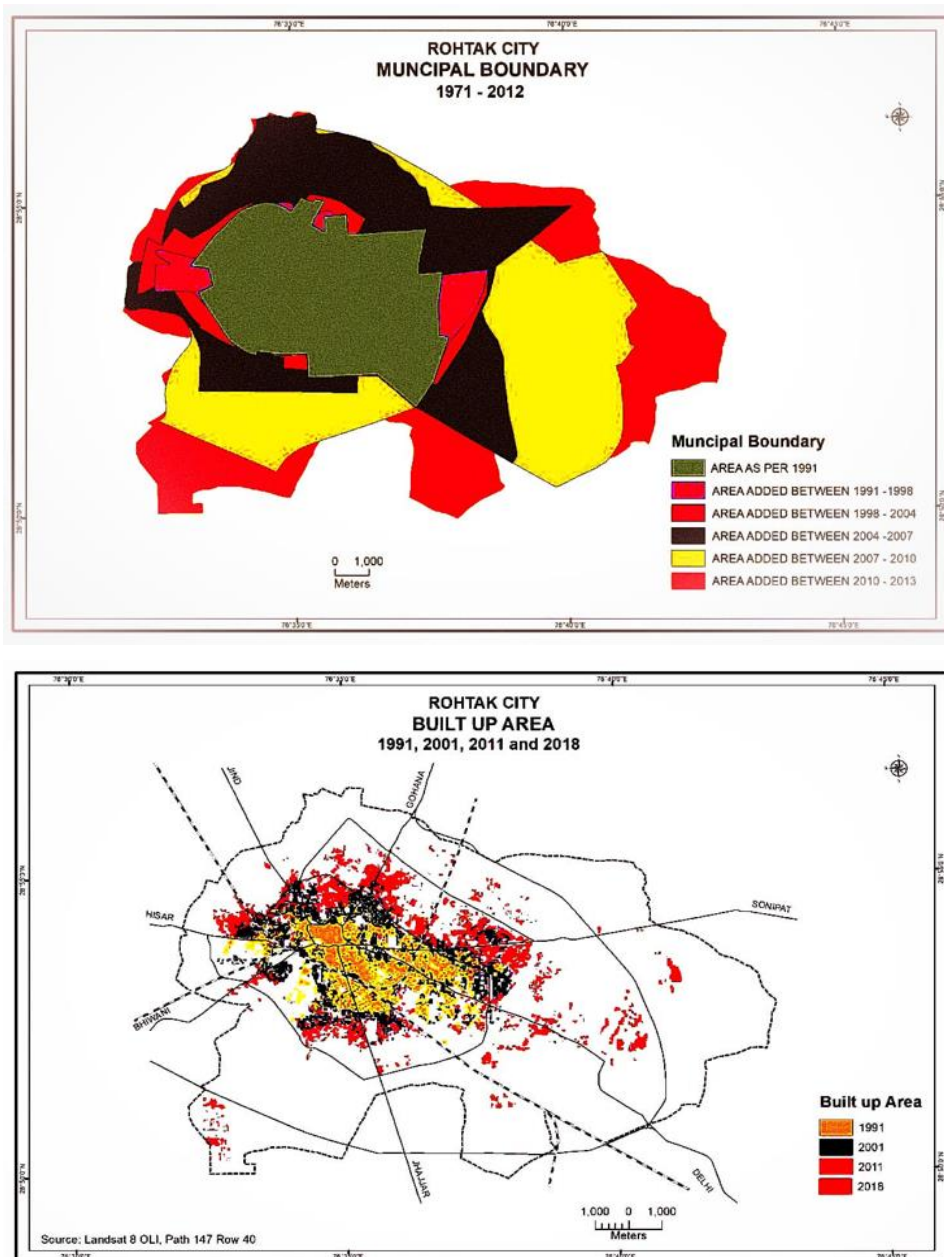
In the period between 2001 and 2011, the municipal limits were amended three times, which resulted in the most dramatic expansion for the municipality. During this time period, the overall area of the city witnessed a significant expansion, going from 3112.11 hectares to 11083.4 hectares (about 110.83 square kilometers). This represents a three-and-a-half-fold increase in just one decade. This substantial aerial extension is a reflection of the dynamic growth and development that Rohtak city has undergone over the course of the last few decades. This growth and development has been driven by a variety of causes, including demographic growth, the development of infrastructure, and tendencies in urbanization.

Table 3.3

Years	Population		Geographical Area		Population Density (persons per km ²)	Built-up area (Km ²)		Population Density within Built-up area
	Absolute	Decadal Change	(Km ²)	Decadal Change		Absolute	Decadal Change	
1991	216096	-	29.97	-	7210	9.91	-	21806
2001	294576	36.33	31.12	3.84	9466	16.59	67.41	17756
2011	413969	40.52	110.83	256.14	3735	24.76	49.25	16719
2018	497717*	20.50	133.81	20.730	3728	29.730	20.070	16741

Sources: Based on (i) Town Dictionary of Haryana, Census of India, 1991, 2001 and 2011,

Between 1991 to 2018, Rohtak city experienced significant growth in both land area and population, with the metropolitan city area expanding more than fourfold primarily due to incorporating surrounding rural lands and eight villages into the municipal limits. This has led to an additional 39,676 citizens. However, the estimated population growth rate from 2011 to 2018 only considered urban growth, not accounting for the new village populations. Despite Rapid City area expansion, population growth didn't match the pace, causing a higher expansion rate than population growth. Population density per sq-km fluctuated over time: from 7,210 in 1991 to 9,466 in 2001 due to fast urbanization, then decreasing to 3,735 in 2011 after municipal limit expansions. Despite further territorial growth in 2013, the population density remained largely unchanged at 3,728 people per sq-km by 2018. Population density of Urban built-up area consistently declined since 1991, mainly due to low-density residential area construction in the city outskirts. This trend is visually represented in Figure 3.6, illustrating the city's built-up area growth over the years.



Detection of Land Use /Land Cover

A change detection study conducted for Rohtak city between 1991 and 2018 reveals significant shifts in land use as well as land cover categories over three time periods: 1991-2001, 2001-2011, and 2011-2018. The analysis focuses on identifying origins and destinations of gains and losses in various land use categories during these periods. The tables provided (3.4a to 3.4c) display land use as well as land cover categories with total area in the base year and terminal year. Retained area by each category during the period is shown diagonally across the table. The most pronounced transitions occurred in the built-up area, encompassing urban and rural areas, reflecting rapid urbanization and development activities. Other categories like agricultural land, open area, aquatic bodies, industrial area, and parks and gardens also underwent notable changes, albeit to a lesser extent compared to the built-up area. Overall, the study offers valuable insights into the dynamics of land use as well as land cover changed in Rohtak city over nearly three decades, highlighting areas undergoing significant transformations and the driving forces behind these transitions.

Table 3.4 a Land use/Land cover Transformation During 1991-2001 (Area in Hectares)

Land Use/ Land Cover	Water Bodies	Urban Built-up area	Rural Built-up area	Open area	Wooded area	Agricultural area	Industrial area	Park/ Garden	Total area in 1991
1	2	3	4	5	6	7	8	9	10
Water Bodies	222.56	0	0	0	0	40.77	0	0	263.33
Urbanised Built-up area	0	991.35	0	0	0	0	0	0	991.35
Rural constructed/ Built-up area	0	0	94.5	0	0	0	0	0	94.5
Open area	0	481.55	117.72	1792.8	0	0	127.17	23.85	1792.8
Wooded/ forest area	0	0	0	0	214.38	0	0	0	214.38
Agricultural area	0	185.62	18.09	910.22	9451.62	0	0	10524.78	Agricultural area
Industrial area	0	0	0	0	0	0	0	0	Nil
Park	0	0	0	0	0	0	0	0	Nil
Total area in 2001	222.57	1658.52	230.31	1952.73	214.38	9451.62	127.17	23.85	13881.15

Source: Based on Satellite Images

Table 3.4 b Land use/Land cover Transformation in Rohtak During 2001-11 (Area in Hectares)

Land Use/ Land Cover	Water Body	Urban Built-up area	Rural Built-up area	Open area	Wooded area	Agricultural area	Industrial area	Park/ Garden	Total area in 2001
1	2	3	4	5	6	7	8	9	10
Water Bodies	221.85	0	0	0.72	0	0	0	0	222.57
City/Urban Built-up area	0	1658.52	0	0	0	0	0	0	1658.52
Village/ Rural Built-up area	0	0	230.31	0	0	0	0	0	230.31
Open/ Unused area	0	422.64	49.14	1952.73	0	0	0	0	1952.73
Wooded/ Forest area	0	3.42	0	85.32	125.64	0	0	0	214.38
Agricultural area	0	100.08	11.79	2031.3	0	7279.56	28.89	0	9451.62
Industrial area	0	0	0	0	0	127.17	0	127.17	Industrial area
Park/ Garden	0	0	0	0	0	0	0	23.85	23.85
Total area in 2011	221.85	2184.66	291.24	3598.29	125.64	7279.56	156.06	23.85	13881.15

Source: Based on Satellite Images

Table 3.4c Land use/ Land cover Transformation in Rohtak during 2011-18 (Area in Hectares)

Land Use/ Land Cover	Water Body	Urban Built-up area	Rural Built-up area	Open area	Wooded area	Agricultural area	Industrial area	Park/ Garden	Total area in 2011
1	2	3	4	5	6	7	8	9	10
Water Bodies	221.85	0	0	0	0	0	0	0	221.85
Urban/ City Built-up area	0	2184.66	0	0	0	0	0	0	2184.66
Rural/ Village Built-up area	0	0	291.24	0	0	0	0	0	291.24
Open area	10.71	350.37	0	3598.29	0	0	34.92	10.08	3598.29
Wooded area	0	0	0	0	125.64	0	0	0	125.64
Agricultural area	43.47	84.15	62.82	1490.67	0	5598.45	0	0	7279.56
Industrial area	0	0	0	0	0	0	156.06	0	156.06
Park/ Garden	0	0	0	0	0	0	0	23.85	23.85
Total area in 2018	276.03	2619.18	354.06	4682.88	125.64	5598.45	190.98	33.93	13881.15

Source: Based on Satellite Images.

Most of the gain has been derived from open land and land that is used for agricultural purposes. For this reason, the built-up area, agricultural land, and open area have been given the most attention in the process of analyzing the alteration of land over the course of various time periods. However, this does not imply that other categories of land use and land cover have not undergone any changes recently. There have been a lot of changes, yet the changes that have occurred have had considerably less of an impact.

During 1991-2001

The study of the changes in land use and land cover in Rohtak city from 1991 to 2018 indicates a number of noteworthy trends and transformations, particularly in the built-up area, which includes both urban and rural areas. The years 1991 to 2001 were marked by fast urbanization and development activities in the city of Rohtak, which resulted in substantial shifts in the patterns of land use. The dynamic nature of urban growth and infrastructural development throughout this time period is reflected in the increase of built-up areas in both urban and rural areas, as well as in the transformations that have taken place in water bodies and open areas.

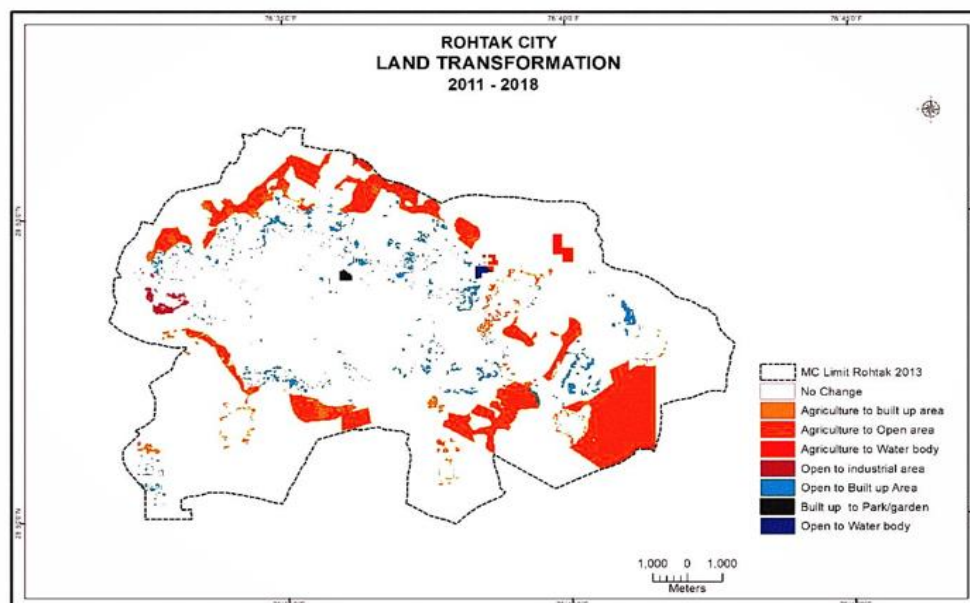
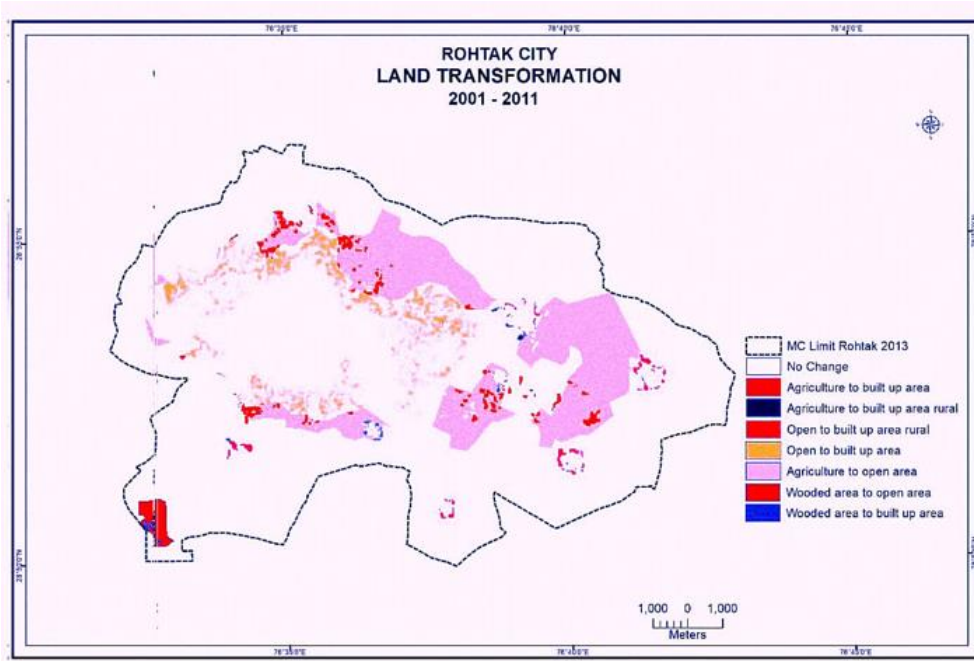
During 2001-2011

Between 2001 and 2011, Rohtak experienced significant development, largely attributed to being the residence of the state Chief Minister at that time. This period witnessed rapid urban growth and infrastructure development, reshaping the city's geography and demographic composition. In 2010, eight villages near Rohtak were merged into the municipal corporation, contributing to urban growth. Despite becoming part of Rohtak city, these villages experienced significant rural area growth, albeit at a slower rate compared to the built-up area expansion. Most of this expansion originated from open regions and agricultural fields, resulting in a decrease in agricultural land. Various land acquisitions were conducted during this period to facilitate development projects, including the development of an Industrial Model Township and real estate projects. Agricultural properties in villages like Garhi Bohar, Bohar, Kherisadh, and Khrawar were purchased, resulting in a significant reduction in agricultural land while increasing open area. Alterations were also observed in wooded and industrial zones, with a decrease in woodland area due to transformation into open and constructed environments, while industrial area expanded mainly in the western part of the city, particularly around the HSIIDC industrial sector.

During 2011-2018

Between 1991 and 2011, Rohtak's built-up area saw significant growth, which continued in the following years up to 2018. The total built-up area expanded by over twenty percent between 2011

and 2018. Notably, rural built-up area growth outpaced urban built-up area growth between 2001 and 2011, with a decadal growth rate of 3.08 percent for rural areas compared to 2.84 percent for urban areas.. Other noticeable alterations include expansions in areas surrounded by bodies of water, industry, and parks and gardens. The area submerged in water expanded by more than 55 hectares, particularly in the northeastern section where wastewater treatment plants were established. The industrial sector expanded by about 35 hectares, with developments like Asian Paints Limited and Maruti Suzuki India Limited in the eastern region and Sun Gold Foods and MG Motors in the western region. Parks and gardens increased across 10.08 hectares, primarily at the expense of urban built-up areas, exemplified by the creation of a public park at the former District Jail location in the southern peripheral area and another park constructed at the former University of Technology Institute campus.



Concluding Remarks

The city of Rohtak is currently experiencing significant horizontal expansion, primarily encroaching upon surrounding cultivable land. Its strategic location within the National Capital Region (NCR), close proximity to Delhi, and well-established transit networks have further fueled its growth as a focal point for developmental activities, attracting investors and real estate developers.

Recent years have witnessed dramatic changes in agricultural land use, with a gradual decrease in cultivable land due to government acquisition for various development projects. Between 1991 and 2018, agricultural area reduced by 46.20 percent, largely due to government acquisitions and private real estate development. However, much of the acquired land remains underdeveloped, leading to a significant growth in open areas.

Investors tend to purchase land near government-designated development zones for speculation, resulting in unoccupied land as they await future price increases. This trend is reflected in Rohtak's development, with built-up areas expanding more than three times and open areas growing at a comparable rate over the same period.

It is anticipated that as acquired lands undergo development, open spaces will shrink while residential built-up areas continue to rise. Despite some unoccupied land designated for the Haryana State Industrial and Infrastructure Development Corporation (HSIIDC), there has been a minor increase in industrial zones. The ongoing construction of the Kundli-Manesar-Palwal expressway (KMP) has further stimulated industrial sector growth, contributing to the city's expansion, particularly in the east along the Rohtak-Delhi Highway.

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