

Remote Sensing, GIS and GPS based Modelling of Land Use/Land Cover Transformation: A Case Study of Rohtak City in Haryana

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Land use and land cover are undoubtedly the most significant aspects of the phenomenon of global environmental change occurring at both a spatial and temporal scale. The population accumulation for dwelling and other services like housing, healthcare, employment, and many others has led to a change in the land use in the outer areas of large cities as a result of various developmental activities. Currently, globalization is having an impact on the entire world. Any innovative housing, marketing, or industrial model township has an impact not only on the cities inside a country, but has also been adopted by cities across international borders. Inappropriate development on fertile agricultural land has frequently resulted in significant issues for the destruction of these priceless resources as well.

Over the past few decades, land use/ land cover of Rohtak City has seen a great deal of visible change. However, precise knowledge on this transformation is needed in order to comprehend, evaluate, and plan for the future. This information is made available through the use of remote sensing, GIS, and GPS in the present work. It has examined Rohtak's development from the 1970s until 2019. An attempt has been made to understand the city's expansion and offer the GIS outputs required for proper long-term planning.

In 1954, the Rohtak city had an area of 11.66 km^2 which had grown to 29.59 km^2 in 2001. It demonstrates how, over the course of 47 years, the Rohtak city's municipal limit has grown to encompass an area of 17.93 km^2 . According to the findings, Rohtak city has grown most in the east and north zones, where it now occupies 8.30 km^2 and 4.43 km^2 respectively, and least in the south (1.88 km^2) and west (3.32 km^2). In 2013, Rohtak city has grown to a 140.16 km^2 area, indicating that it has consumed 110.57 km^2 of surrounding rural region in just 12 years, from 2001 to 2013. So in a short period of time, Rohtak city has experienced remarkable growth. Again, the east zone of the city recorded most urban growth during this time, adding 57.03 km^2 to its extent, while the west zone saw the least (13.88 km^2).

In Rohtak's outskirts, the government carried out a variety of development initiatives. During the years 2006 to 2013, 4924.90 acres of agricultural land was purchased for this purpose in eight villages which have been entirely merged into Rohtak city's municipal boundary. The purchase was made with the intention of establishing residential areas, commercial districts, IMT, parks, the Institute of Driving & Traffic Research, sewerage water treatment plants, water treatment plants, water works, Rajeev Gandhi Sports Complex, Police Training College Sunaria, District Jail Sunaria, Pandit Lakhmi Chand State University of Performing & Visual Arts, Indian

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Institute of Management (IIM), industrial training schools, and other facilities. With its expansion in 2007, 2010, and 2013, however, little parcels of acquired land have been included under the city boundaries.

In 1960, Rohtak city had 9.92 km² of built up that was continuously developed, with the majority of the land (4.18 km²) distributed in the east zone and a very small portion (0.94 km²) in the south zone. In the years 1960 to 1983, it grew to 18.29 km². With a share of 8.16 km², the east zone has once again seen the highest of built up area, while the south zone has the lowest amount of area (1.86 km²). It demonstrates how the city grew by 8.37 km² over a period of 24 years. The east zone, where the founding of the M.D. University was the key built-up, has the highest 3.98 km² area. The southern zone, with 0.92 km², had experienced the least amount of urban sprawl.

Between 1983 and 2006, the continuous built-up area grew to 32.67 km². The east zone had the most continuous built-up area (14.50 km²), while the south zone had the lowest continuous built-up area (3.74 km²). It demonstrates how, between 1983 and 2006, a 14.38 km² area had been swallowed by urban sprawl. With a share of 6.34 km² and 3.42 km², respectively, the east and north zones saw the most urban sprawl, while the south and west zones had the least, with shares of 1.88 km² and 2.74 km², respectively. Particularly, the city has expanded along the northern side of National Highway 10.

The city's continuous built-up area increased to 81.29 km² between 2006 and 2019, indicating a 48.62 km² expansion, with the east zone experiencing the biggest sprawl of 34.41 km². North zone of the city recorded 5.62 km² sprawl. With a respective share of 3.90 km² and 4.69 km², the west and south zones have experienced the least urban sprawl. Due to state policy, sprawl has progressed quickly over the past thirteen years. For the construction of IMT, residential and commercial areas, recreational areas, public and semipublic areas, public utilities and infrastructure, the transportation network, etc., the government has bought a significant amount of agricultural land.

It has been found that the city has grown from a 9.92 km² area in 1960 to 81.29 km² area in 2019, meaning that 71.37 km² of land has been continuously built up over the course of 59 years. With a share of 44.73 km², the east zone has experienced the most sprawl. The north, west, and south zones, on the other hand, have seen a sprawl of 10.36 km², 8.79 km², and 7.49 km² area, respectively.

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By using GeoEye-1 satellite imagery and ArcGIS 9.3 software, land use and land cover have been examined for the years 2006 and 2019. The analysis of land use/ land cover has also been done in relation to urban sprawl and expansion. Built-up area was distributed over 37.33 km² in 2006 and it increased 81.29 km² in 2019. Thus, a 38.29 km² area has emerged between 2006 and 2019.

An area of 89.59 km² of agricultural land made up 63.92 percent of the entire study area. In 2019, it has shrunk to 53.54 km² (38.20%) in area. It demonstrates that agricultural land had a loss of 36.05 km², or 25.72 percent, of the overall study area. A total of 34.12 km² of agricultural land has been transformed into various built up usages.

Rohtak city working as a service centre (as Delhi growth pole). Suitable, sustainable and proper planning must be its focus point as a growing service centre. Establishment of planned physical infrastructure is a welcoming process in the sustainable development of the city but haphazard built up growth will create a serious threat along with demands like water supply,

The city has an area of 140.16 km² which was divided into 22 municipal wards in 2018 on the basis of population size ranging from 22000 to 26000. So, keeping in view of population size, the area of the ward has not been given any importance. These 22 wards have been taken into account to analyze and compare the results. The ward no 10, 9, 22 and 2 has large area of 41.7 km², 21.86 km², 21.45 km² and 11.1 km² respectively whereas other wards have less area in their boundary. There are total number of seven wards having the area less than 1 km² and total number of four wards having area ranging from 1 km² to 2 km².

In 2006, the study area had 37.34 km² area under built up category in which wards number 12, 10, 9, 20, 8, 1 and 11 had the high share of 4.99 km², 3.50 km², 2.93 km², 2.41 km², 2.30 km², 2.28 km² and 2.14 km² area respectively under built up. There were total number of seven wards had the built up area ranging from 1 km² to 1.80 km². On the other hand, remaining eight wards have the built up area ranging from 0.34 km² to 0.98 km².

In 2019, the city had built up area of 75.63 km². Thus, the city experienced a net growth of 38.29 km² in built up area during 2006 to 2019. The ward number 10, 9, 8 and 22 emerged as having highest built up area of 19.46 km², 11.09 km², 6.07 km² and 5.73 km² respectively which shows that these particular wards witnessed the highest built up growth of 15.96 km², 8.16 km², 3.77 km² and 4.11 km² area respectively during 2006- 2019. On the other hand, eight wards i.e. ward numbers 4, 11, 13, 14, 15, 16, 17 and 19 witnessed no change in their previous built up

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size. It is found that the ward numbers 4, 15, 16, 17 and 19 had the saturated built up density in horizontal perspective in 2006. No other kind of non built up class existed in these wards. Similarly, ward no 6, 12, 13 and 14 reached to near saturation of built up density (ranging between 0.91 to 0.99). The wards no 3, 7, 11, 18 and 20 had also high built up density (ranging between 0.75 to 0.88). On the other hand, ward no 22, 10, 9, 2, 8 and 1 had very low built up density (ranging from 0.08 to 0.33). The ward numbers 5 and 21 had the moderate built up density. During 2006 to 2019, a sum of five wards i.e. 8, 10, 9, 21 and 5 witnessed the highest net growth in their respective built up density whereas ward number 4, 11, 13, 14, 15, 16, 17 and 19 have no change of built up density during the same duration.

Shanon's entropy has been used to understand the compactness of sprawl of Rohtak city. In 2006, the wards 9, 10 and 22 have the entropy value ranging upto 0.02 which represents the fragmented built up area in these wards whereas large number of wards i.e. 3, 4, 6, 7 and 11 – 20 have high entropy values that denotes the compact built up area across these respective wards. On the other hand, wards 1, 2, 8, 5 and 21 have moderate entropy values. In 2019, the ward 3-7 and 11-20 have the high entropy values whereas ward 1, 2, 8-10, 21 and 22 have moderate entropy values. It shows that the built up area is shifting towards compactness in all wards of Rohtak city.

The relative entropy is observed very high in wards 3, 4, 6, 7 and 11-20 in 2006 and wards 5 and 21 witnessed the high relative entropy values. Wards 1, 2 and 8 have moderate relative entropy values whereas wards 9, 10 and 22 have the less entropy values in 2006. In 2019, the wards 3-7 and 11-20 witnessed very high relative entropy values. Wards 1, 8-10 and 21 have high relative entropy values. On the other hand, wards 2 and 22 witnessed the moderate relative entropy values and no ward exists in low entropy value.

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