Peri-urban Delineation and Urban Expansion Quantification from 2001 to 2021 of Hisar City, India, using Geospatial Techniques

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Abstract
As the process of urbanization intensifies, a city expands from its center to its periphery. Due to the rise in human activities and population of a city, the physical limit gets stretched to provide housing along its periphery, resulting in extensive irreversible land cover alteration in the peri-urban areas. This chaotic and extensive urbanization in a peri-urban environment drives up the concerns about assessing and encouraging urban growth in a planned manner. The paper in a similar vein aims to determine peri-urban area and examine land cover change in and around the Hisar, an Indian city, between 2001 and 2021 by using geospatial techniques. The peri-urban zone of the hisar city has been delineated by applying the vector-based overlay analysis of different variables. The urban expansion was analysed with the help of the data acquired from image classification and by applying Shannon entropy model. The overall pattern of change in land uses shows that the area under built-up has increased by 99.17 percent by leaps and bounds. On the other hand, farmland, vegetation, water bodies and open spaces, are witnessing a sharp decline of 6.38 percent. The findings suggest that the built-up areas have substantially doubled from 4,965.12 ha to 9,889.2 ha throughout the study period. The scattered and random urbanization on the city outskirts is confirmed by the value of Shannon's entropy which increased from 1.93 in 2001 to 1.98 in 2021. The findings of the study would assist the administration and town planners in recognising the massive urban sprawl in the city and enable them to execute more effective approach to develop the peri-urban area.

Keywords: Hisar, Peri-Urban, Peri-Urban Delineation, Shannon Entropy, Urban Sprawl

1. Introduction

The world's population has significantly increased over a period of time. The human population has undergone an incredible transformation during the previous few centuries [1]. There were one billion people in 1800, but today, more than 8 billion people live on the planet Earth. In mid-November 2022, the global population hit the number of 8 billion. And it is estimated that the worldwide population should rise to a total of 9.7 billion till 2050, hitting a high of about 10.4 billion in the 2080s [2]. The expanding population leads to the high degree of urbanization and boost in the number of urban centers worldwide. As the global population rises, a large number of people relocate to urban environments from rural settings [3]. Urbanization is a population concentration phenomenon and it constituted one of the major processes of global transformation in recent time period [4].

Around the globe, urban areas are home to more people than rural ones. As per the urbanisation report of the United Nations, the urban areas are home to the 55 percent of the world's population. This was 25 percent higher than in 1950, when only 30 percent of the global population lived in urban environments. It is estimated that urban areas will be home to 68 percent of the world's population by 2050 [5]. The growth of population in urban area has led to the horizontal expansion of urban centers [6]. As a result of rapid urbanization, the cities expand beyond their boundaries and give birth to the new census towns (CTs) and outgrowths (OGs) [6] and [7]. This led to the formation of transitional zones; such zones are often known as urban, semi-urban, rural-urban fringe, urban fringe and more recently as peri-urban areas [7] and [8].

Peri-urban areas are the territories that encircle the core towns and cities, where urban and rural activities amalgamate with each other and the land cover is subject to abrupt changes triggered by intensive human endeavours [9]. As the transitional zone in between the rural and urban environment, peri-urban areas show a complex integration of land use that is neither purely rural nor urban in their true meaning [10]. These areas are recognized as the area that fuse the rural and urban land uses, along with the flow of human, labour, capital, commodity, and information [11]. By the virtue of their close proximity, urban and peri-urban areas rely heavily on one another for services and facilities [12]. These places frequently lose their rural traits as they successively grow more urbanized [13]. Peri-urban regions are progressively transformed into urban areas in just a handful of decades [14]. Furthermore, population expansion and uncontrolled and haphazard urban development contribute to the urban sprawl that soaks up the land on the periphery [15]. This is an irreversible and unfavourable pattern of development that is a primary cause of fear in peri-urban areas because of inefficient utilization of available land resources. Planning and analyzing for urban sustainability become more important in city outskirts with such widespread and unorganized development [16]. In response to the progressive proliferation of urban centers, there is constant alteration in the boundary of the peri-urban [17]. Underutilized policy instruments, combined with difficulties in precisely demarcating peri-urban areas, mislead planners and policymakers in anticipation of the magnitude and extent of the boundary of urban sprawl [18]. Thus, it is crucial to develop peri-urban zones effectively to assist in delineating the projected boundaries of urban expansion to accommodate prospective planning priorities [19].

The peri-urban areas are defined as an area of transition between rural and urban environments, as a transitional zone just lying on the city edges, it experiences dynamic and rapid growth in terms of demographic, economic and physical setup [20]. Due to proximity and connectivity with the urban center, the peri-urban area attracts and witnesses large-scale projects and developments such as residential buildings, educational institutions, recreational centers, industrial hubs, IT parks and airport, etc. The demand for land in the peri-urban regions is very high among real estate developers, industrialists and businessmen as the core of the city is congested and the value of land is also very high [21] and [22]. The process of urbanization is a blessing as well as a curse for the human sustainability. The advantage of the urban centers acting as a centripetal force led to the explosive proliferation of the urban population, along with the physical expansion as well as spread of urban settlements. The expansion of urban center occurs in the form of urban sprawl. Urban sprawl is characterised by its low density, transport dependence, new economic development [23]. Moreover, most of the development occurred in an unplanned and haphazard manner, which became a problem for the urban planners and the existing governing body. It also adversely affects the natural physical setting and the environment surrounding the urban center. Urban sprawl has brought about the loss of fertile cultivable land, open spaces, natural vegetation and water bodies in peri-urban areas [24]. The expansion of urban areas gradually alters the existing land use patterns in peri-urban areas [25].

Therefore, there is a dire need for the delineation of peri-urban area and quantify urban sprawl for better policies, governing systems and sustainable development. This will also be helpful in the better utilization of natural resources of peri-urban areas. The main objectives of this study to delineate the peri-urban area and analyse of urban sprawl of the city.

2. Study Area

Hisar city is located in western Haryana, with the 29.09°N latitude and 75.43°E longitude. The study area map is depicted with the Figure 1. The average elevation of the city is 215 meters above the mean sea level. Due to its continental type climate, Hisar experiences extremely hot summers and comparatively cool winters. The average annual temperature is 15.4 °C at the minimum and 32.3 °C at the maximum. The city is on the edge of the southwest monsoon region. There is about 429 mm of rainfall on average per year, with July and August seeing the most of it. Hisar city serves as the administrative headquarter of Hisar district. It is situated 250 km south-west from the state capital Chandigarh and 160 km to the west from the nation capital, New Delhi. Due to its strategic geographical location, the city of Hisar is recognized as a counter-magnet city of the National Capital Region, serving as a substitute hub for development. The city is conveniently served by all three means of transportation: airways, railways and roadways. The national highway 9 connects it with the national capital, New Delhi and the nation highway 52 connects it with the state capital, Chandigarh. The airport is on the city outskirts and is undergoing redevelopment and upgrading to an international cargo airport.

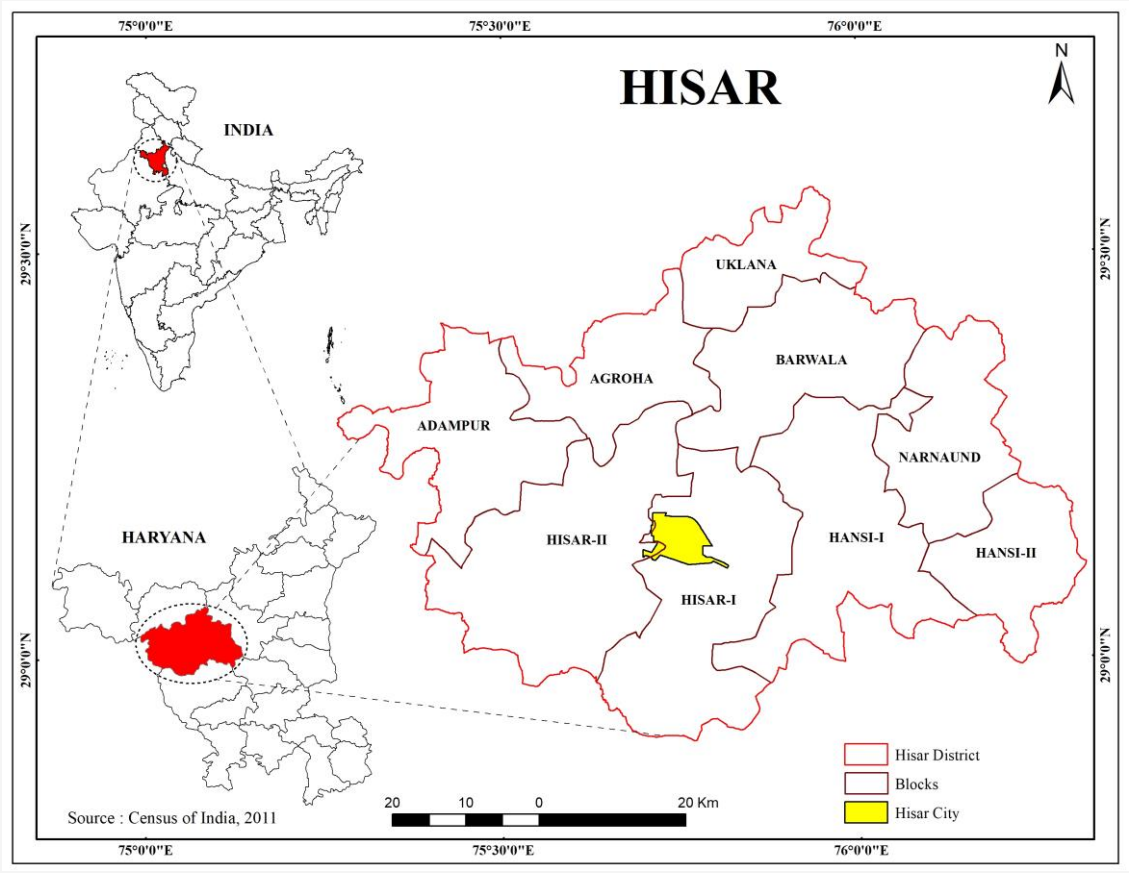

Figure 1: Location of Hisar City, India

Hisar is among the most rapidly growing cities in Haryana and the 141st most populous city in India. Being a counter-magnet city of Delhi-NCR (National Capital Region), the basic facilities and amenities of the city have undergone improvement and attracts a large number of migrants from nearby areas as well as from the neighbouring states of Rajasthan and Punjab. The steadily increasing population of the city led to urban sprawl. Consequently, the city is expanding outward from its core over the peri-urban region. The periphery of the Hisar has a considerable number of residential complexes, industries, research and educational institutions, which transforms the land use patterns. This entire process results in the substantial land alteration in the city periphery.

3. Database

While delineating peri-urban areas and quantifying urban sprawl, both primary as well as secondary sources of information have been utilised. In the delineation of the peri-urban region of the Hisar city, total seven variables/criteria from three different dimension, namely administration, demographics and economics have been used. As the only source that offers thorough data on each settlement in the nation is the Census of India, the data for administrative and demographic dimensions at the level of village were gathered from the Primary Census Abstract (PCA), Census of India 2011. On the other hand, data on the economic dimension was collected through a primary survey. In addition, for the quantification of urban sprawl, the satellite imageries of Landsat-5 TM for 2001 and Landsat-8 OLI_TRIS for 2021 have been collected from USGS Earth Explorer (https://earthexplorer.usgs.gov). The details of acquired satellite images is shown through Table 1 and analysed with the help of GIS software.

4. Methodology

The techniques and methodology executed for delineation of peri-urban areas and analysis of urban expansion in the present study are illustrated through the flow chat depicted in Figure 2. The study is broadly divided into three phases: the delineation of peri-urban areas, detecting changes in built-up land cover, and the quantification of urban sprawl. The peri-urban area is delineated with the help of seven variables that were selected after a thorough literature review.

Table 1: Specifications of satellite imageries

Satellite	Date	Path and Row	Sensor	Spatial Resolution	Source
Landsat 5	16/03/2001	147/40	TM	30 Meters	USGS
Landsat 8	07/03/2021	147/40	OLI	30 Meters	USGS

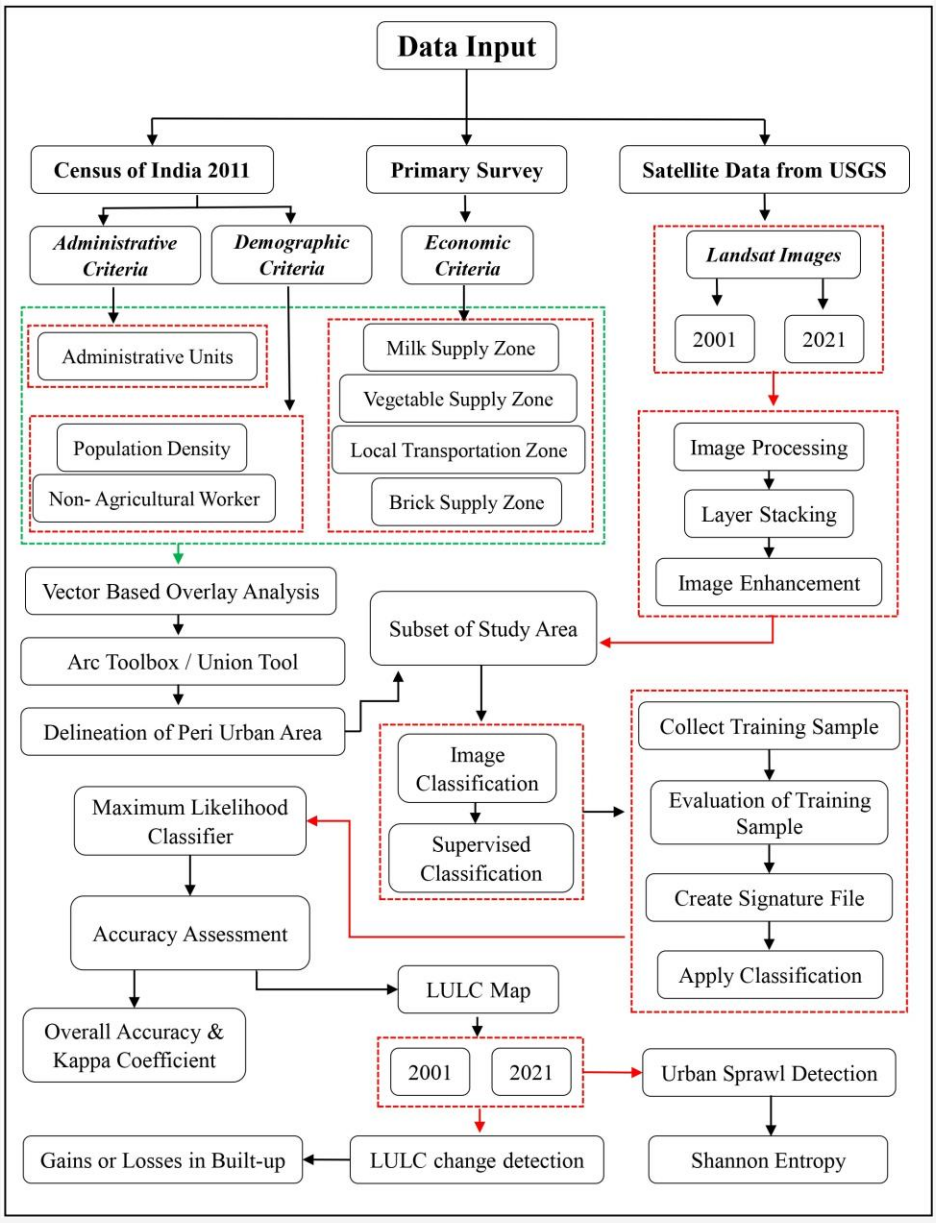

Figure 2: Flowchart of methodology utilized in the study

Further, the examination of built-up land cover change helps in computing the shifting of land use between built-up and non-built-up areas. Shannon entropy has been used for the assessing of urban sprawl. The following sections go over the minute details of each stage.

4.1 Peri-urban Area Delineation

The variables for different dimensions selected for the delineation of the peri-urban area were drawn from literature [6][11][12][16][26] and [27]. A total of seven variables have been selected from three dimensions.

These seven variables are: administrative unit or boundary, population density, non-agricultural workers, milk supply zone, vegetable supply zone, local transport and brick supply zone. The population density and percentage of non-agricultural workers of different administrative units that have been considered in the delineation of peri-urban area were within the range of twenty-five kilometres from the city center. The threshold values of population density and percentage of non-agricultural workers were taken 400 people per sq. km and 40 percent, respectively. Besides, all the census towns that are situated on the edge of the city have been considered as peri-urban area. For the delineation of peri-urban area of Hisar city, a vector-based overlay analysis has been performed on all the criteria that were selected for the delineation of the peri-urban region of the Hisar city. The vector overlay was performed by applying union tool in the analysis tools of the Arc Toolbox. Administrative units are categorized as peri-urban areas if they meet at least 50 percent of all the criteria.

4.2 Land Use and Land Cover Change

The acquired Landsat imageries were processed and analyzed by making use of the geospatial software. Initially, different spectrum bands of a satellite image were composited to obtain a multispectral image. Then an area of interest (AOI), that is the delineated peri-urban area of Hisar, has been masked from the multispectral imagery. After getting the AOI, the images were processed in order to enhance the image quality and visual retention. The images have been classified through the supervised image classification method, by applying the maximum likelihood classifier. The training sets are collected using Google Earth Pro and pre-existing familiarity of study area. The imagery has been categorized in six categories: water bodies, vegetation, agriculture, built-up areas, open land, and mining. The image classification has been followed by the accuracy assessment; accuracy was assessed across the board using 250 ground truthing points. The images of 2001 and 2021 have been classified, with overall accuracy of 91.20 and 94 percent accuracy, respectively, and kappa coefficients of 0.8911 and 0.9269, respectively. Ultimately, the LULC maps were created and the map statistics were used for supplementary analysis. After that, land use and land cover change detection has been performed between the classified images of 2001 and 2021. It is a post-image classification approach used to figure out the manner in which land use and land cover have changed and developed over time. The image overlay approach for change detection was used in the present study. This method is employed in this study, for identifying the gains and losses to the built-up area from various other classes.

4.3 Urban Sprawl Detection

The Shannon entropy index has been implemented to determine urban sprawl. It is extensively adopted to calculate the spatial concentration and dispersion of a particular phenomenon [12] and [28]. In the present study, Shannon entropy has been incorporated for determining the extent to which built-up area is dispersed or concentrated. The values of Shannon entropy range between 0 and log(n). Entropy values toward 0 suggest a highly compact concentrated built-up area, whereas values near log(n) imply an excessively dispersed distribution of built-up area [29]. The midway point value of log(n) is taken into account as threshold value; consequently, if the value of entropy is above the value of threshold, then the city is considered to be sprawling [30] and [31]. The Shannon entropy is calculated with the Equation 1:

$$H_n = -\sum_{i=1}^{n} P_i \log_e P_i$$

Equation 1

Where: H_n = Shannon entropy
P_i =Proportion of built-up area in i^{th} zone
n = Number of Zones

5. Results

5.1 Delineation of Peri-Urban Area

The peri-urban area of Hisar has been delineated by applying a vector-based overlay analysis of different criteria. In this analysis, a total of seven variables have been used to delineate the peri-urban area. These variables include administrative map, population density, non-agricultural workers, milk supply zone, vegetable supply zone, local transportation and brick kiln zone.

The administrative unit serves as a basis for defining the peri-urban region since it includes neighbouring areas where urban sprawl is expected to develop, resulting in land modifications on the city's outskirts [12] and [32]. As the population grows and the city expands, several new census towns develop on the periphery of the city; these towns are categorized as peri-urban area [8] and [33]. Hisar, an emerging prominent city, is surrounded by five census towns: Gangwa, Satrod Khurd, Satrod Khas, Satrod Kalan, and Mayyer. These towns have urban characteristics but rural governance. The location of these towns is shown in Figure 3. These towns are classified as peri-urban area of Hisar city in response to their strong links and proximity to the city.

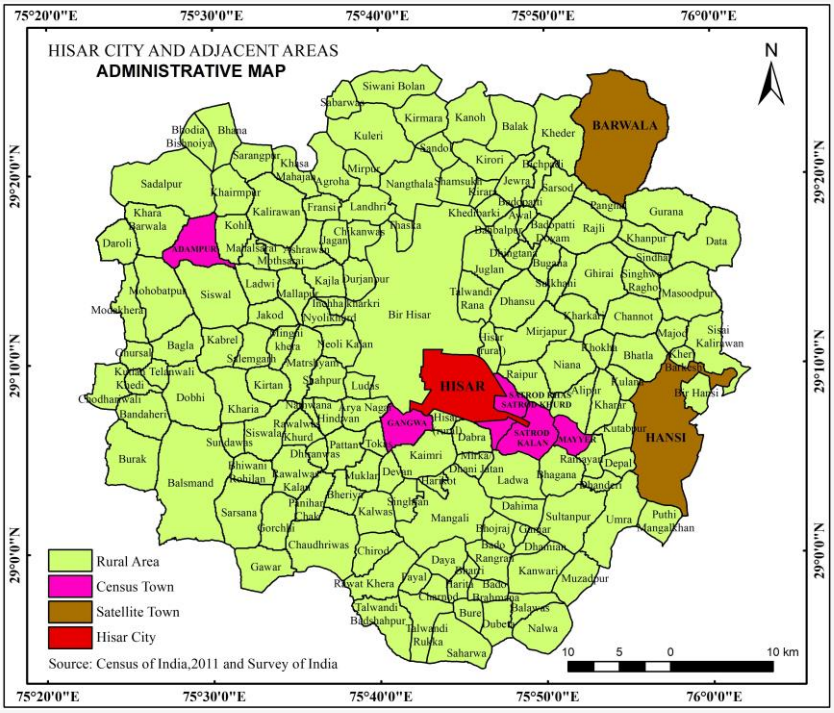

Figure 3: Administrative variable: Hisar city and adjacent areas

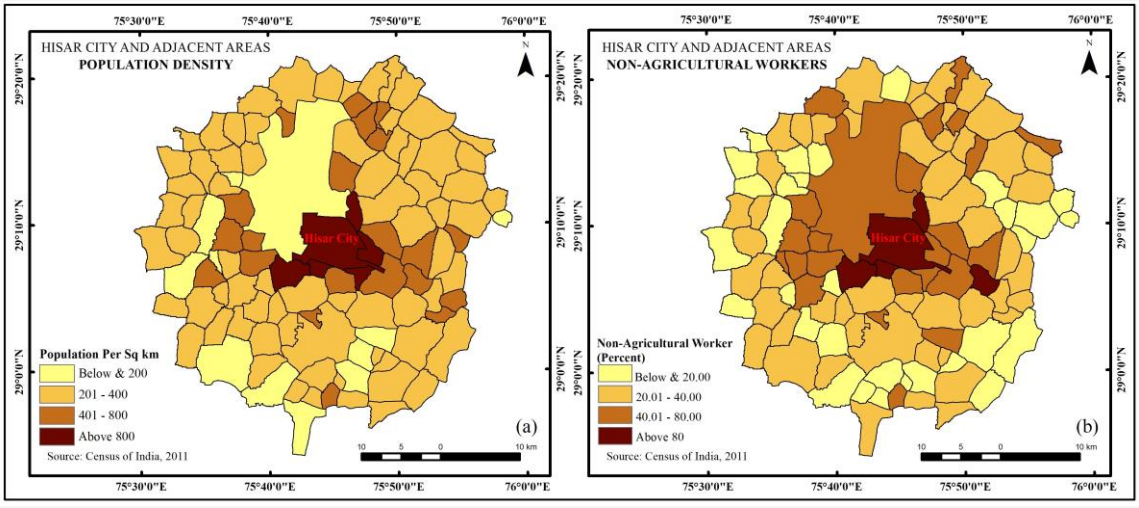

Figure 4: Demographic variables: (a) Population density; (b) Percentage of non-agricultural workers

Demographic variables have considerable importance in defining the peri-urban region. Population density is a reliable indicator to gauge the importance of a city [34] and [35]. The population in and around the city increases over time due to the pull factor of the city [36]. It is clearly visible on the map in Figure 4(a) that the area around the city has a higher density than the other area. As we move away from the city, generally, the population density decreases. The population density of 400 person/km^2 is considered the outer limit of the peri-urban region.

Non-agricultural workers are an essential component and an integral part of the peri-urban occupational structure. Indeed, a significant number of non-agricultural workers in the overall working population of a peri-urban area seems like a direct indication of urban influence. The administrative units with a higher percentage of non-agricultural workers, more than 40 percent, indicate peri-urban areas as they exhibit a stronger urban influence. The distribution of the non-agricultural population is extended more in the north, west, and east directions shown in Figure 4(b).

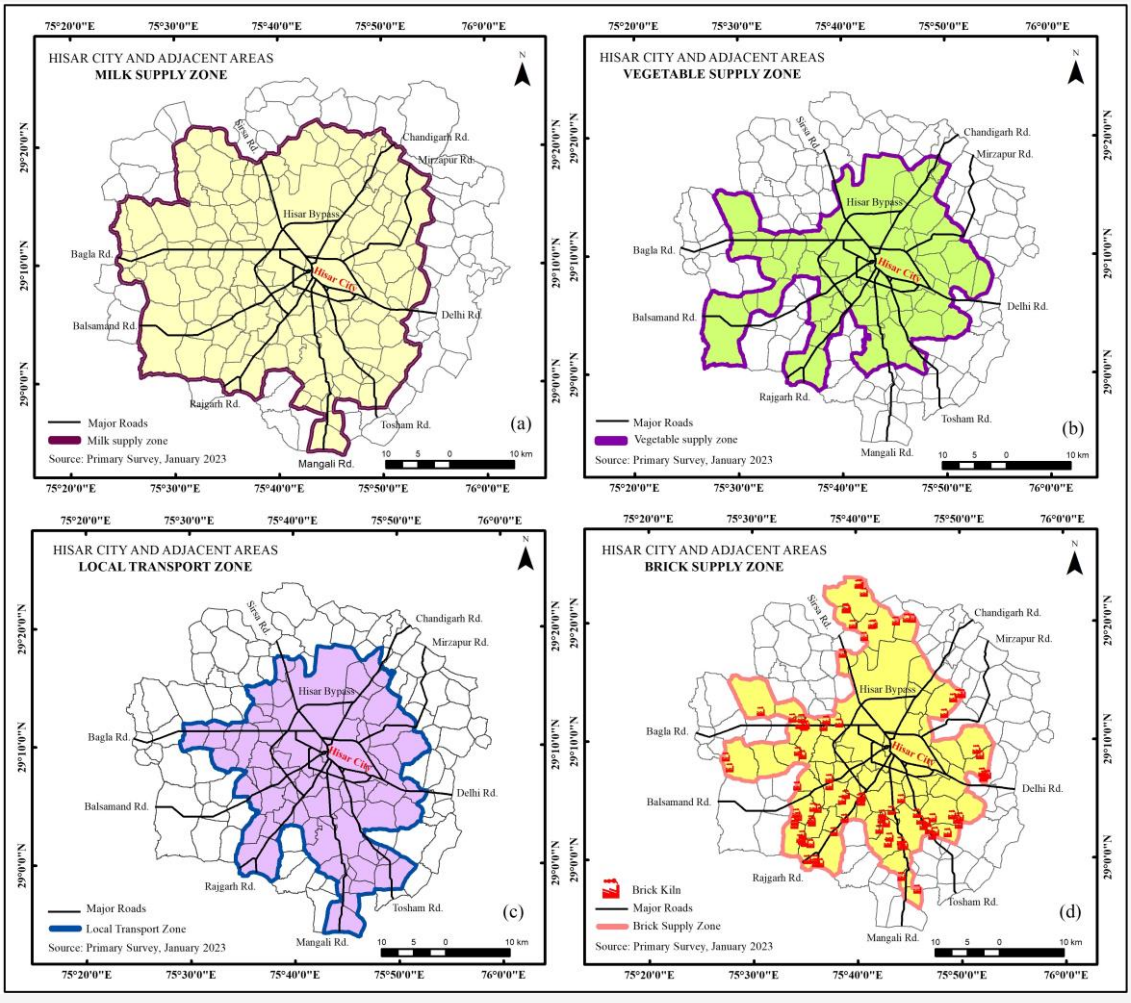

Figure 5: Zone boundary of economic variables: (a) Milk supply zone; (b) Vegetable supply zone; (c) Local transport zone: (d) Brick supply zone

The city enjoys a two-way economic relationship with the nearby areas. The peri-urban area thus, enjoys a close connection with the main city by means of the inflow and outflow of goods and services. The city periphery and adjacent rural areas are inextricably intertwined with the city economy and undergo continuous change in their economic activity. Four economic variables are included for the delineation of peri-urban area. The boundary of all economic variables has been demarcated on the basis of the primary survey. The boundary of economic variables shows the outer limit of the local phenomena. The milk supply is one of the most important functional links between the city and its surroundings. Milk is one of the most perishable products produced in the countryside for the urban market. The milk supply zone to Hisar city reveals that milk is supplied from the villages that are located 15 to 35 kilometres away from the city center.

The milk supply zone is more stretched in north, west, and south directions due to the absence of significant towns near the city. The sheer presence of Hansi town causes the supply zone to be less expanded in the east. This milk supply zone includes 109 villages and 5 census towns in the proximity of Hisar city depicted in Figure 5(a).

Vegetables, in particular, have drawn considerable attention, owing to the fact that they are incredibly perishable and are typically farmed near where they are going to be consumed. The vegetable production is primarily concentrated in peri-urban zones with significant urban populations and high-income elasticity of demand [37]. Vegetable farming is widespread in the surrounding area of Hisar city. The residents of the city get their supply indirectly through vegetable markets. The vegetable supply zone encompasses Hisar city, five census towns and 38 adjacent villages as shown in Figure 5(b). This zone generally extends along the key roads.

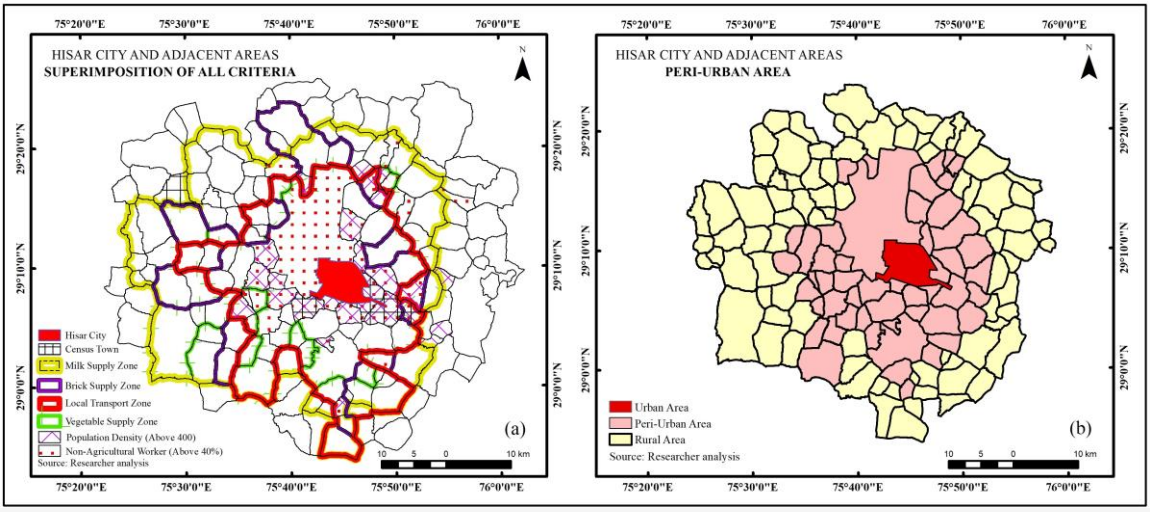

Figure 6: Peri urban extraction: (a) Superimposed variables (b) Peri-urban area of Hisar

The local transportation service zone plays an indispensable role in indicating the flow of people and goods between the city core and its outskirts. Due to the intense connection between the city and traffic flow, local transport is included in the delineation of peri-urban area. The local transport mode includes autorickshaw and e-rickshaw. As roads radiate in all directions from the city as shown on map in Figure 5 (c), the zone is extended in all direction from 15 to 30 km. As we move away from the city center, the frequency of local transport decreases. Brick kilns predominantly concentrate on peripheral locations inside the influence zone of the city. The demand for bricks in the city met by the brick kiln spread in the adjoining area of the city up to 30 km. Brick kilns are located along key routes which is easily depicted through map in Figure 5(d). Brick kilns are more useful and generate more economic returns than farming in this region. This zone plays an essential role in the delimitation of the periphery.

In order to accomplish the goal of delineating the peri-urban area of Hisar city, seven indicators were chosen in total. In the delineation of the peri-urban area of a Hisar city, a vector-based overlay analysis was performed for all of the criteria that represent the peri-urban region of Hisar as shown in Figure 6. Administrative units are categorized as peri-urban areas if they meet at least 50 percent of the criteria. On the basis of administrative, demographic, and economic variables, the peri-urban region Hisar city consists of 49 administrative entities (villages and census towns), covering 776.62 square kilometres (77662 hectares) as viewed in Figure 6. The peri-urban area stretches from 13 to 23 kilometres from the city center, its extension is more in the south and west direction as compared to the east and north direction of the city.

5.2 Land Use and Land Cover (LULC) Change Detection and Urban Sprawl

The land use and land cover maps for the year 2001 and 2021 have been prepared to perform LULC change detection and quantifying the urban sprawl in the Hisar city including its peri-urban area as shown in Figure 7(a) and (b). The satellite images were classified in the six categories to study the changes in the built-up class. Then the LULC map is converted under two major categories i.e., built-up and non-built-up, by merging all non-built-up classes under one category.

As the maps in Figure 7 show, the overall study area is 82,210.95 hectares (Hisar city and peri-urban area), with a total built-up area of 4,965.12 hectares in 2001, consisting 6 percent of the total area. On the other side, non-built-up area in 2001 was 77,245.83 hectares, which represents 94 percent of the total area. If we take a look at the spatial distribution of built-up area, it can be seen that out of the total 4,965.12 hectares of built-up area, 2,114.82 hectares are located within the Municipal Corporation (MC) boundary of Hisar city, which constitutes 42 percent of the total built-up area, and the remaining 58 percent is located in the peri-urban region of the city. In 2021, the scenario was changed, the total area under the built-up was raised to 9,889.2 hectares, which accounts for 12 percent of total area. On the other hand, the non-built-up area was decreased from 77,245.83 hectares in 2001 to 72,321.75 hectares in 2021, which represents 88 percent of the total area. The spatial distribution of built-up area among the study area shows that 30 percent of built-up area was lying in the municipal boundary of the city; which accounts for 2,996.19 hectares of built-up area, the remaining 70 percent was spread in peri-urban area of city.

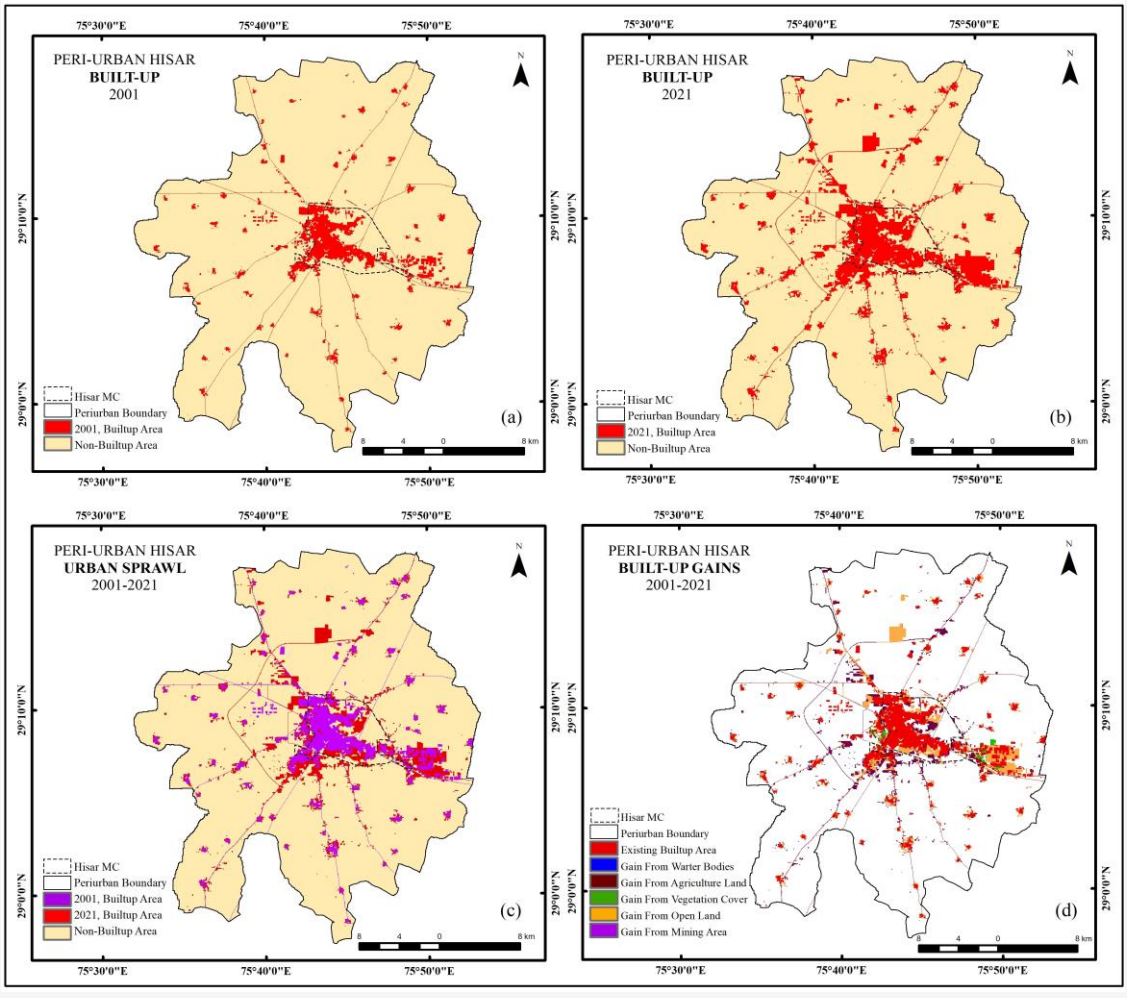

Figure 7: Built up area, urban sprawl and built-up gain: (a) Built up area in 2001; (b) Built up area in 2021; (c) Urban sprawl from 2001 to 2021; (d) Built-up area gain from 2001 to 2021

The comparison of built-up areas in 2001 and 2021 as shown in Table 2 and Figure 8(c) illustrated that the built-up area expanded from 4,965.12 hectares in 2001 to 9,889.2 hectares in 2021. Over a two-decade period, the built-up area increased by 4,924.08 hectares, nearly double the built-up area in 2001.

During the period of 2001-2021, most of the built-up expansion occurred in the peri-urban region of Hisar. It is observed that in 2001, over 40 percent of built-up area was consolidated within the municipal boundary of Hisar; however, by 2021, only 30 percent of the built-up area remained within the MC limits of Hisar. The expansion of census towns on the outskirts of cities, establishment of residential buildings, educational institutes, and a large number of industries were the primary reasons for the growing share of built-up area in the peri-urban region. It is also noted that most of the built-up expansion occurred along the major highways, i.e., national highways 9 and 52.

In the period of two decades between 2001 and 2021, if we were studying the gains and losses in the built-up region, we would find that there were no losses in the built-up area as shown in Figure 7(d). It denotes that the existing built-up area was not transformed into a non-built-up.

The total built-up gains during the two decades were 4,965.12 hectares, out of which the maximum gains were from open land that was 2,691.99 hectares, which accounts for 54.67 percent of total built-up gains, followed by gains from agriculture land, which accounts for 2,049.57 hectares or 41.62 percent. The remaining small proportion of 3.7 percent of built-up gain came from the vegetation cover, water bodies and mining area, which were 149.22, 18.81 and 14.49 hectares or 3.03, 0.38 and 0.29 percent, respectively as shown in Table 3. This gain indicates the magnitude of non-built-up land which has been transformed into built-up area.

Table 2: Analysis of land cover transformation

Categories	2001 Area (ha)	2021 Area (ha)	Change Area (ha)	Change (percent)
Total Built-up area	4,965.12	9,889.20	4,924.08	99.17
Total Non-built-up area	77,245.83	72,321.75	-4,924.08	-6.38
Built-up area in MC	2,114.82	2,996.19	881.37	41.67
Non-built-up area in MC	2,434.05	1,552.68	-881.37	-36.21

Table 3: Gains to the built-up Area

Categories	Area	Percent to total built-up Gains
Water Bodies	18.81	0.38
Agricultural Land	2,049.57	41.62
Vegetation Cover	149.22	3.03
Open Land	2,691.99	54.67
Mining Area	14.49	0.29
Total Gain	4,924.08	100.00

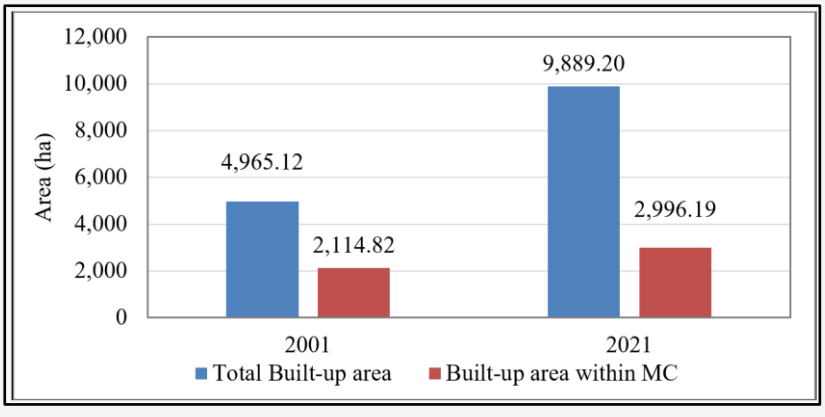

Figure 8: Built-up areas in 2001 and 2021

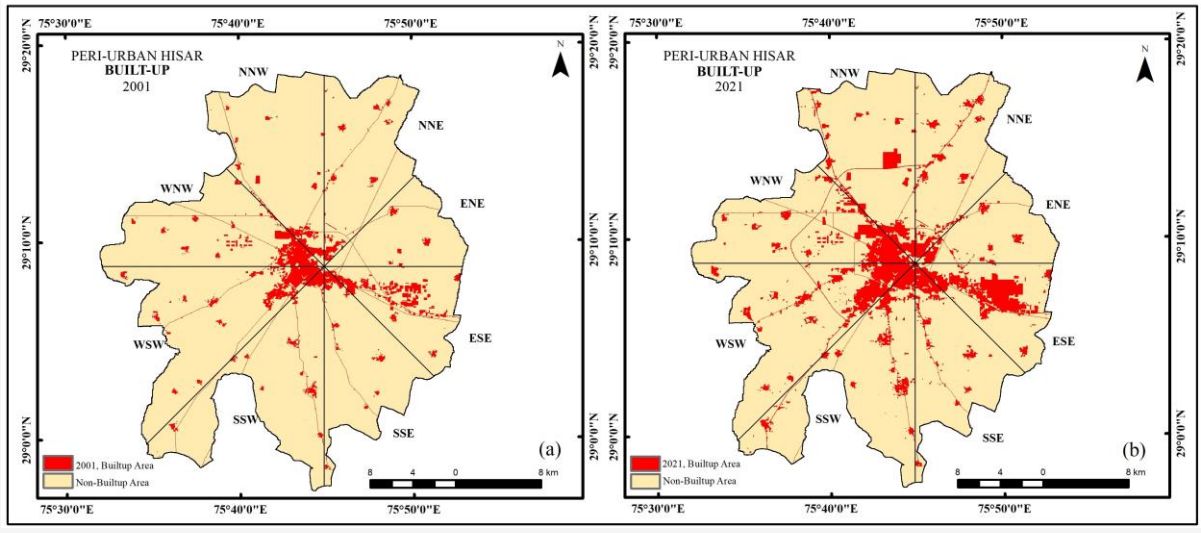

Figure 9: Built-up area divided into eight directional zones (a) 2001 (b) 2021

5.3 Urban Sprawl Detection

The urban sprawl in the demarcated peri-urban area was analysed by applying Shannon's entropy index. It is a common metric for assessing the magnitude of urban sprawl [38]. This index is used to measure the dispersion and concentration level of built-up areas [29] [30] and [31]. In the present study, as Figure 9 (a) and (b) illustrates that the study area was divided into 8 zones after taking central point of municipal boundary as the central node, to calculate the shannon entropy. So, the value of log(*n)* is 2.08 (*n* = 8). The years 2001 and 2021 were taken into account to figure out the entropy values. In the year 2001 the value of shannon entropy was 1.93, which increased to 1.98 in 2021. Urban sprawl is prevalent in the peri-urban areas of Hisar, as shown by the entropy value, which is farther away from 0 and closer to log(n). Additionally, the sprawling nature has been demonstrated by the values of entropy that were higher than the threshold values. Urban sprawl appears to have increased during the research period, based on the overall trend of entropy index outcomes from 2001 to 2021.

6. Discussion

In Hisar and its peri-urban area, the alteration in land cover occurred quite significantly between 2001 and 2021. Built-up area expanded considerably, from 4,965.12 hectares in 2001 to 9,889.2 hectares in 2021. The diminution of non-built-up areas (mainly agricultural land and open area) was the main factor contributing to the increase in built-up areas. Such a rapid drop in non-built-up land cover poses a major threat to the urban livelihood. Similar patterns of urban expansion can be observed in other Indian mid-sized cities [12] and [39]. Hisar city serves as a counter magnet to the National Capital Region, developing as a substitute hub for Delhi. The growth and development of the city provide new opportunities for the people, that cause a further rise in the magnitude of physical expansion and population growth of the city. The rapid growth in population, either naturally or by migration, put extra pressure on the limited land or services of the city resulting in high land value and consumption. This all-causes pressure on the peri-urban area of the city. In the case of Hisar, the basic facilities and amenities attract not only neighbouring people but also those from the neighbouring states of Punjab and Rajasthan. The expectations of better employment, healthcare and education have put a strain on the city's non-elastic resources. Owing to the congestion, the city boundaries grew outwards and new residential colonies and sectors developed in the east, south-west and north-west directions. During the study period five census towns were developed on the city outskirts, with four in the eastern direction and one in the southern direction. The outskirts of the Hisar city provided the means for the establishment of several manufacturing industries, educational and research institutions and also an international airport. The major transport routes that connect the city with the national capital, New Delhi, state capital, Chandigarh and to other major cities provide opportunities for development and hence major land alteration occurs along these transport routes.

The values of Shannon entropy proved the prevalence of urban sprawl in the peri-urban area of Hisar. On the other hand, scattered development was the most common type of urban sprawl in the periphery, depicting that erratic and low-density urban expansion is predominant. The primary factor contributing to such kind of growth is the dispersed pattern of the settlement and industrial expansion in the peri-urban areas. Such a kind of urban expansion phenomenon degrades the surrounding environment and modifies the natural landscape of the urban agglomeration in an irreversible manner. The process of development is taking place at the cost of adjacent open and prime agricultural land.

7. Conclusion

The study demonstrated the application of geospatial tools to analyse the dynamics of urban sprawl in peri-urban areas by using primary data, census data, and Landsat imageries. This paper primarily looked at the delineation of peri-urban region, evaluation of land cover change, and identification of urban sprawl in Hisar. The peri-urban zone of Hisar was identified by utilizing seven variables from three different dimensions by employing an overlay analysis technique. This zone is more extensive in the north, west and south directions as the absence of significant towns nearer to the city in this direction. The mere existence of Hansi town limits the extension of the zone to the east. The land cover change analysis showed that open and agricultural areas were largely lost to rapid built-up expansion. As a result, throughout the research period, the percentage of built-up land cover increased by 99.17 percent, whereas the percentage of non-built-up cover fell by 6.38 percent. The environment and development are at odds because of quickly and irreversibly changing land cover in the study area. Urban sprawl was evident in the values of the Shannon entropy index for peri-urban areas. This also reveals that the built-up area is spreading in a dispersed manner mainly, along the major transport routes.

This study can serve as a future guide for the urban planners and relevant agencies in the planned development of peri-urban Hisar. Further, a potential

future research agenda could involve predicting of urban expansion through machine learning tools.

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