Analysis of Urban Growth and Its Impact on Agriculture Land around the Chalisgaon City in Jalgaon District of Maharashtra, India: A Remote Sensing and GIS Based Approach

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(Received: Feb 3, 2022; in final form: Sep 20, 2022)

Abstract: In India, the agricultural land has tremendously disintegrated which changed the land-use patterns. The agricultural land has declined continuously due to rapid urbanization in the country. In India, nearly 45% of the land cover comes under agriculture area, and 22% is under forest land, whereas this land was drastically decreasing day by day. The main aim of the study is to identify the urban growth along with the land use pattern of Chalisgaon city, situated in the Jalgaon district, of Maharashtra state. This is a comparative study from early 1990 to late 2020. The Landsat images have been used for the years 1990, 2000, 2010, and 2020 to identify the change in land use and land cover pattern. These images are processed and analyzed under GIS and maximum likelihood classification method. The Chalisgaon city covers a total of 1850 hectares area. In the last three decades, the total built-up area has increased from 556 hectares to 920 hectares. It is observed that, the urban expansion of the city is a major factor behind the declination the cultivational land area under study. In 1990 the agriculture area was about 1095 hectares that have been reduced to730 hectares in 2020. This study reveals the agricultural land gradually decreased due to encroachment of urban areas i.e., infrastructural, connectivity, population, and other related facilities.

Keywords: Urban Expansion; Agriculture; Land use pattern; Landsat Images**;** GIS.

1. Introduction

Development has played a major role within city limits in the constant evolution of land use, accommodating new infrastructure and projects while displacing conventional land-use patterns (Gumma et al., 2017). Assessment of land use and land cover pattern can be done through remote sensing technology (Hasan et al., 2021). Many academicians and scholars have successfully contributed to urban growth studies based on spatial and temporal patterns (Liu et al., 2019, Zhong et al., 2020, Meng et al., 2020), growth approaches (Liu et al., 2010, Kantakumar et al., 2016), driving processes (Zhong et al., 2020), and development forecast (Zhang et al., 2018). Several researchers have previously analysed metropolitan built-up land development and explained its operating methods for various cities and localities at the national (Sharma et al., 2022, Vani et al., 2020, Saini et al., 2020, Tripathy et al., 2019, Duijne et al., 2019, Salem et al., 2021,) and global (Dadashpoor and Ahani, 2019, Gong et al., 2018, Meng et al., 2020, Ma et al., 2016, Jia et al., 2020),) scales. Expansion of urban land the process of creating an environment conducive to urban populations and their activities is an integral part of urbanization. The inner-city land expansion changes the balance of habitats, geography, hydrology, land cover pattern, and surface energy (Grimm et al.,2008). Towns have occupied a negligible amount of the earth's surface still most urban problems have a profound effect on the environment and global change (Vellinga & Herb, 1999). The entire world is experiencing rapid expansion due to technological enhancement and changes in the lifestyle of human beings living in different localities around the world. (Tewolde & Cabral, 2011). Human geography is an integral part of the change in land utilization. The land is needed for non-agricultural use such as building roads, marketplaces, shopping centres, industries, etc. due to the rising urban population. As a result, neighbouring agricultural land diminishes. (Songsore,1977; Mishra, 2002). Numerous factors have impacted food production as urban landscapes have grown. Traditional farming practices used by farmers and family farms have declined due to the replacement of old farming land and migration to urban regions. (Roca, 1993). According to the Indian census published in year 2011, there are 1210.2 million people overall, with 377.1 million living in metropolitan areas. Over the past ten years, metropolitan regions have added 91.0 million people to their population. In relation to the nation's overall population, urban residents make up 31.8% of the population. (Census of India, 2011). Lopez has clearly indicated that such rapid population changes significantly affect the environment, resulting in the loss of farmed land. (Lopez et al., 2001). People move in higher proportions from rural to urban and from small to large urban areas, such as India's urban centres, in rapidly developing nations like India. Following the Industrial Revolution in the 1970s, there was globalization in the 1990s. In the past, forests have been cut down, meadows have been ploughed under or destroyed, marshes have been drained, and fields have been taken over by growing towns, but never at such a rapid rate. (Rahman, 2007).

In specially, information from RS-based multi-dimensional land use data can be used to evaluate structural differences in the LULC pattern. Furthermore, precise and thorough land-use information is important for creating environmentally and urban-friendly planning approaches. Utilizing spatial data, the current study is visualized to evaluate the effects of urban growth on agricultural land. (Alphan, 2003). The present study is visualized to assess the impact of urban expansion on agricultural land using spatial data.

2. Materials and methods

2.1 Study area

Chalisgaon City lies in Maharashtra's Jalgaon district, in the southwest corner. The Chalisgaon tehsil's administrative center is situated in Chalisgaon city. It is positioned in 20^0 26’ 20” North to 20^0 29’ 03” North latitude and 74^0 58’ 40” East to 75^0 02’ 13” East longitude (Toposheet No. 46 P/3) and is 344 meters above mean sea level. The Tittur river flow through the center of Chalisgaon city (Figure 1). According to the census, the city has a population of 108181 and a total area of 18.50 km2. State highways and railroads provide excellent access between Chalisgaon city and other cities. Since it is the only urban center of Chalisgaon tehsil, so the population of the surrounding villages also depends on it for goods and administrative services. Therefore, the surrounding population migrates to Chalisgaon city for a better lifestyle, medical facilities, educational facilities, and happiness, etc. The immigrant population and natural development population have been responsible for the expansion of the city. Chalisgaon is very developed in terms of agriculture so many agro-based industries are established in Chalisgaon such as Textile Mills, Belganga Sugar Factory, and Oil and Vidya Factory.

The combined primary and secondary data are used to support the current investigation. For the investigation of land use patterns, Landsat data from four decades (1990, 2000, 2010, and 2020) is examined. The USGS Earth Explorer website has been used to download Landsat data for the last four decades. ERDAS envision version 2015 and ArcGIS version 10.2 were also used to analyze the primary data, which included radiometric and geometric adjustments as well as registered to Universal Transverse Mercator projection (UTM-Zone 43 North) in the World Geodetic System (WGS84) datum. The municipal corporation Chalisgaon, the district statistics office of Jalgaon, the census handbook, etc. all have exposure to secondary data. Table 1 displays the specifics of the satellite data that have been gathered.

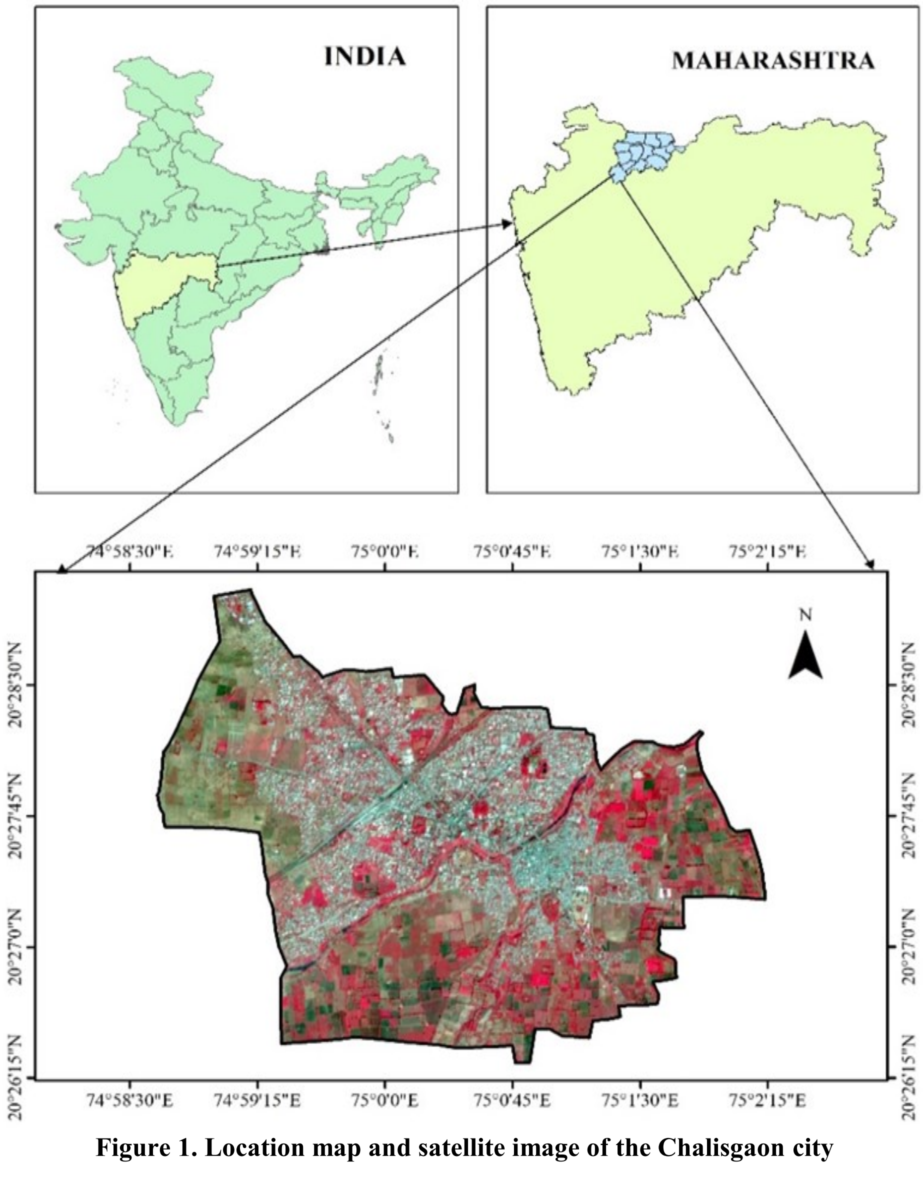

Figure 1. Location map and satellite image of the Chalisgaon city

Table 1. Specifications of Landsat data.

Data	Year of acquisition	Path/Row	Bands	Resolution
Landsat 5 TM imagery	01/02/1990	147/46	4,3,2	30m
Landsat 5 TM imagery	20/02/2000	147/46	4,3,2	30m
Landsat 7 ETM+ imagery	31/01/2010	147/46	4,3,2	30m
Landsat 7 ETM+ imagery	18/01/2020	147/46	4,3,2	30m

Source: USGS Earth Explorer website

2.2 Data processing and classification

False Colour Composite is also known as FCC generation: The multi-spectral (multi-band) composite image is generated with the ERDAS imagine software utilized to downloaded Landsat images and the layer stacking function to generate seven distinct bands images of Landsat. From this, a standardized FCC is created using the fourth, third, and second bands, from which the LULC scheme was extracted. From the reference data and Google Earth imagery, training sites are selected. The training sites are used by the ERDAS image classification software to determine the various land cover classes in the entire image of the study area. In general, a total of eighty training sites have been used to train the Landsat images. Maximum likelihood classification determines the likelihood that a given pixel belongs to a certain class by assuming that the statistics for each class in each band are normally distributed. All pixels are categorized unless a probability threshold is chosen.

Each pixel is categorized into the class with the highest likelihood (that is, the maximum likelihood). The pixel remains unclassified if the highest likelihood is below a threshold you specify. Size, shape, location, number of pixels, number of training sites for a particular class, placement, and uniformity were some of the features that were considered when assigning training sites. The maximum likelihood algorithm and minimum-distance classification are utilized in this study's supervised classification. Five major LULC classes are chosen for mapping the entire study region such as agricultural land; barren land; built-up land; vegetation land and water bodies.

ENVI implements maximum likelihood classification by calculating the following discriminant functions for each pixel in the image (Richards, 1999):

$$g_i(x) = \ln p(\omega_i) - \tfrac{1}{2} \ln |\Sigma_i| - \tfrac{1}{2}(x - m_i)^T \Sigma_i^{-1} (x - m_i)$$

where:

i = class

x = n-dimensional data (where n is the number of bands)

p(ωi) = probability that class ωi occurs in the image and is assumed the same for all classes

|Σi| = determinant of the covariance matrix of the data in class ωi

Σi-1 = its inverse matrix

mi = mean vector

2.3 Accuracy assessment

The error matrix is calculated for the assessment of the correctness of classified land use land cover images. It noted that, when linked with an identical site in the field, the matrix verified that the pixel had appropriately identified a certain feature type. The calculation of overall accuracy, user's accuracy (UA), producer's accuracy (PA), and Kappa coefficient provides an accurate result for classified images. In this entire process, we randomly selected 250 sample points (reference data) from the various sites of the study by ground authentication of GPS survey and Google Earth engine for appropriate calculation.

Overall accuracy (OA) = Total number of correct sample points - 100%total number of sample points (1)

Producer's accuracy (PA) = 100% - error of commission (%) (2)

User's accuracy (UA) = 100% - error of commission (%) (3)

Commission error = (off diagonal row elements) / (total number of row) (4)

Omission error = (off diagonal column elements) / (total number of column) (5)

$$\text{Kappa coefficient (K)} = \frac{N * \sum a - \sum ef}{N^2 - \sum ef} \quad (6)$$

where a diagonal frequency, N denotes total frequency, ef denotes expected frequency.

3. Materials and methods

3.1 Population growth and urban expansion

In the last three decades, Chalisgaon city's population along with population density have been constantly increased due to natural population growth and immigration from the surrounding villages which resulted into urban expansion of the city. Its observed that, the total population of Chalisgaon city was 77,420 in year 1991 that had increased to 1,08,181 in year 2011. The growth rate percentage is an important parameter to understand the change in land use and land cover pattern of the area under study. While comparing the growth rate for the years 1991-2001 with years 2001-2011, significant increase was observed from 17.68% to 18.73% respectively. The constant increase in population density is also noted from year 2011 to year 1991 (Table 2). The geographical factor, employment opportunity, infrastructural facilities, availability of good educational institutions, commercial activities, and industrial development in Chalisgaon city are favourable for the dwelling of the citizen. All the above mentioned factors are favourable for the migration of people from other areas toward Chalisgaon city. It's observed that natural population growth and immigration played a significant part in the amplification of urban area in the study region which ultimately resulted into declination of agricultural land.

Table 2. Chalisgaon city population growth, 1991-2011

Year	Population	Increased	Density	Growth rate in %
1991	77420	18078	4164	----
2001	91110	13690	4901	**17.68**
2011	108181	17071	5819	**18.73**

Source: Census report, Government of India

3.2 Land use land cover changes and loss of Agriculture land

A total of five land cover categories were identified and classified in the study. These were Built-up, Barren, Agriculture, Vegetation, and water bodies areas as shown in figure 2. There are significant Spatio-temporal changes in the pattern of land use land cover in the city of Chalisgaon as shown in table 3. The continuously positive changes were observed in the classes; built-up land and barren land, whereas barren land has negative change between 1990 to 2000. The negative changes were observed in Agriculture, vegetation, and waterbodies. However, but waterbodies have positive changes between 2010 to 2020. The built-up land has increased from 556 hectares to 920 hectares from 1990 to 2020 (table 3) with a percentage change of 19.64 (Table 3 and Figure2 & Figure 5). The study shows that there is a remarkable increase in the urban area between 1990 to 2020 (of 82 percent) while a total of 375 hectares of fertile agricultural land were lost due to the city's expansion. The main reason behind the increase in housing (i.e., settlements) and the development of infrastructures such as health, education, and other socio-economic factors.

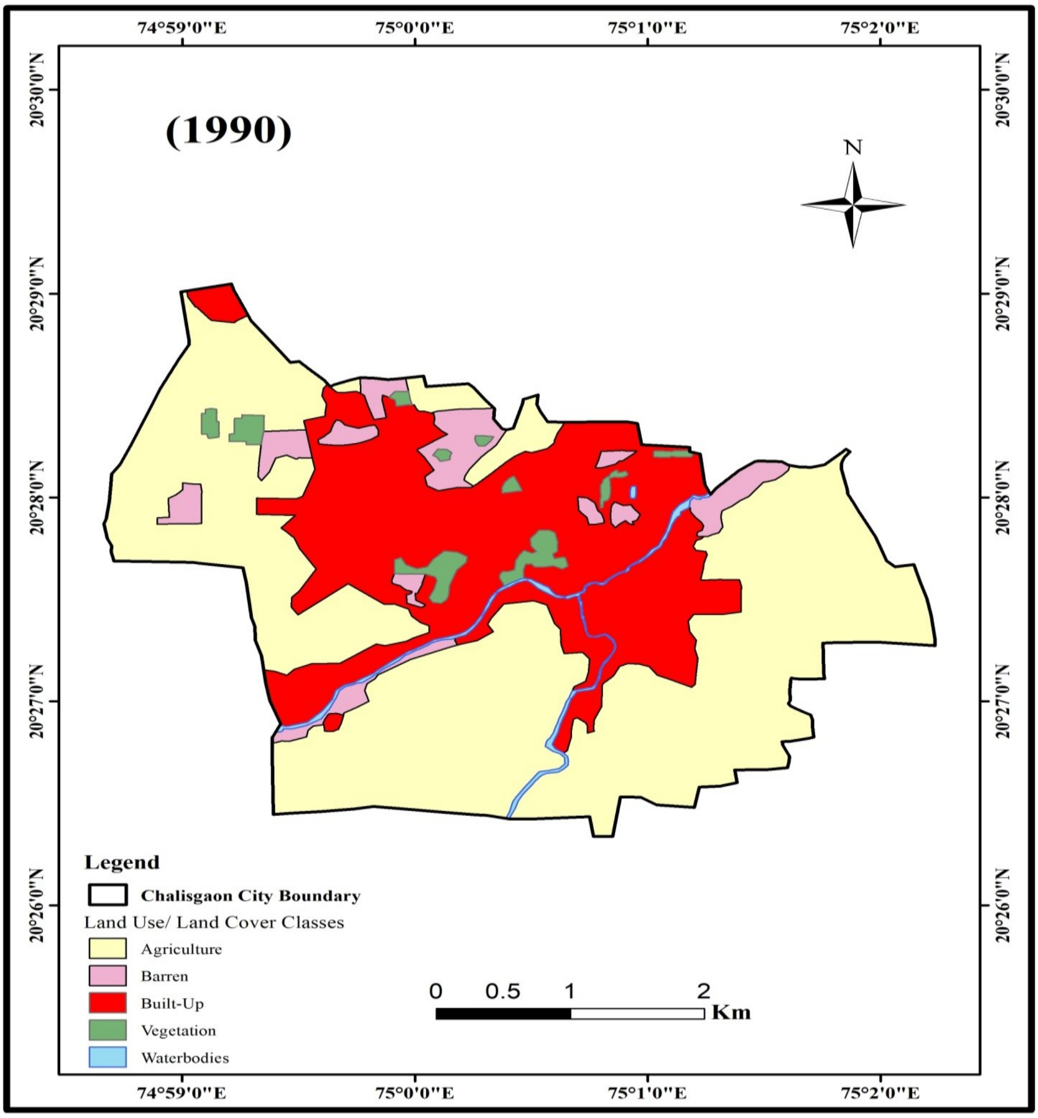

Figure 1. Land use/ land cover map of Chalisgaon city for the year 1990

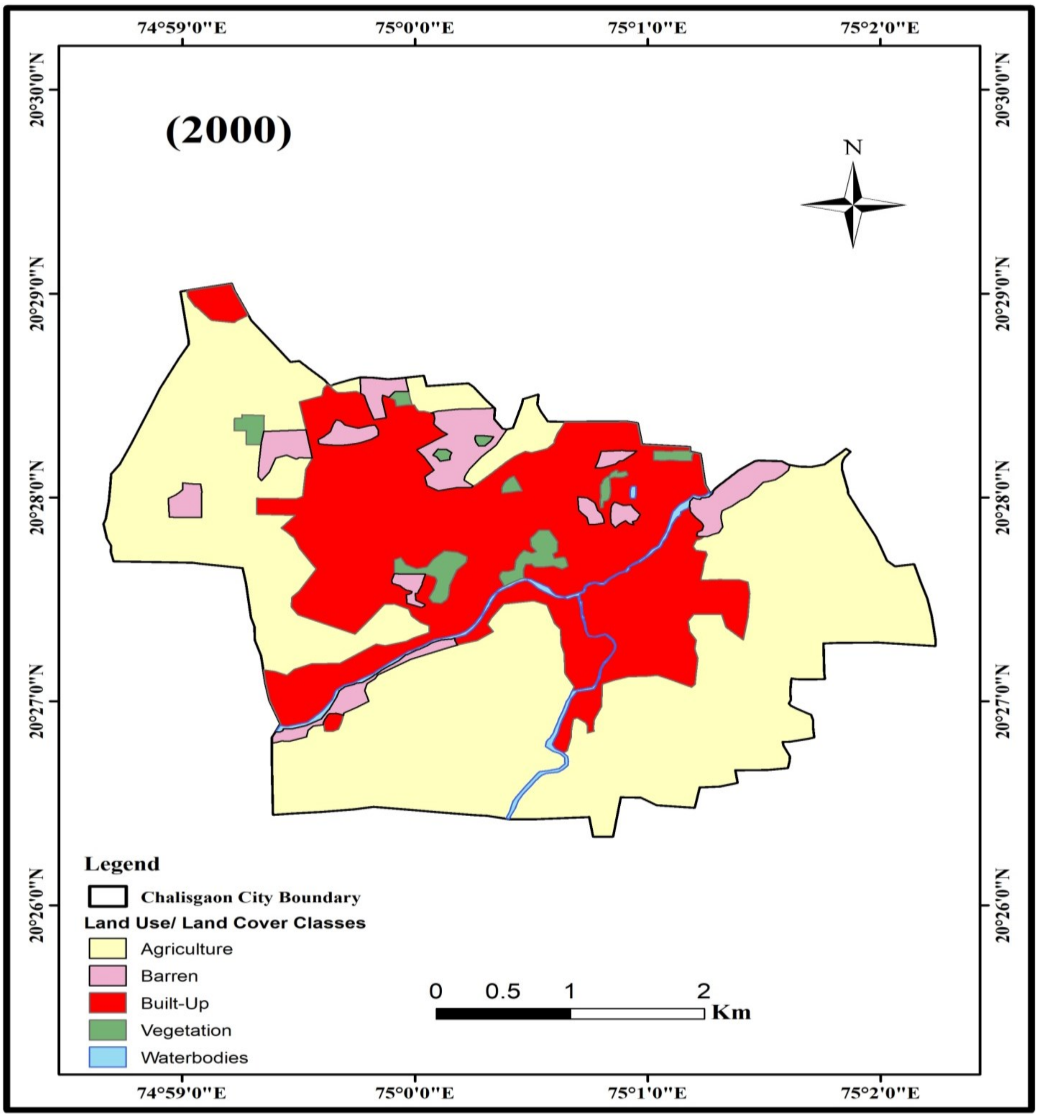

Figure 3. Land use/ land cover map of Chalisgaon city for the year 2000

Table 3: Land use land cover change from 1990 to 2020 (in Hectares)

Sr. No.	LULC		1990	2000	2010	2020	Changes (1990-2020)
1	Built up	Ha.	556	640	760	920	364
		%	30.05	34.59	41.09	49.69	19.64
2	Barren	Ha.	121	118	129	141	20
		%	6.54	6.38	6.97	7.61	1.07
3	Agriculture	Ha.	1095	1021	919	730	-365
		%	59.19	55.19	49.67	39.46	-19.73
4	Vegetation	Ha.	57	52	25	32	-25
		%	3.08	2.81	1.37	1.74	-1.34
5	Water bodies	Ha.	21	19	17	28	7
		%	1.14	1.03	0.91	1.50	0.36
	Total	**Ha.**	**1850**	**1850**	**1850**	**1850**	**00**
		%	**100**	**100**	**100**	**100**	**00**

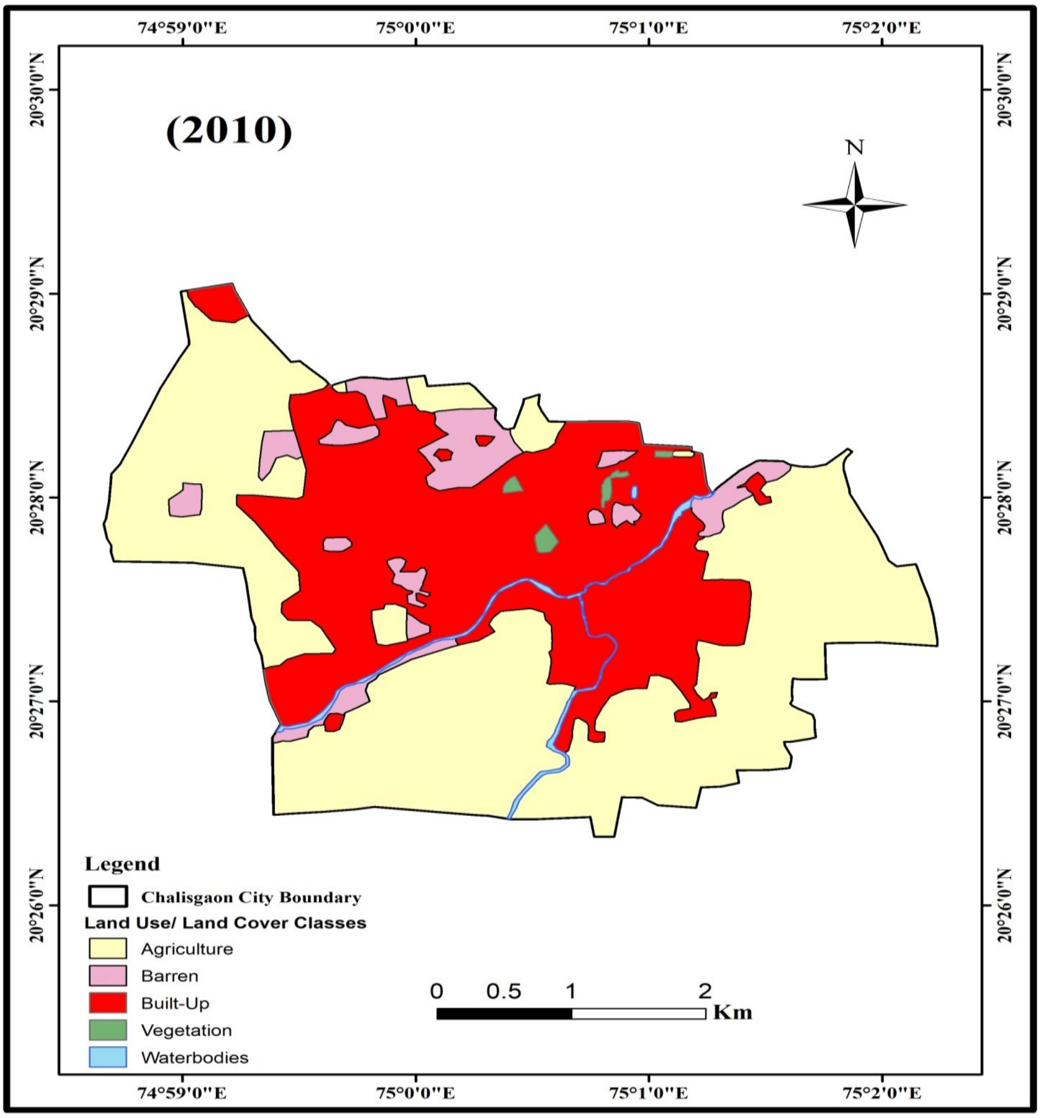

Figure 4. Land use/ land cover map of Chalisgaon city for the year 2010

Table 4. Accuracy Assessment of Land use /land cover classification

LULC Classes	1990		2000		2010		2020	
	PA (%)	UA (%)	PA (%)	UA (%)	PA (%)	UA (%)	PA (%)	UA (%)
Built up	90.00	81.82	90.92	83.33	88.87	80.12	91.60	84.61
Barren	77.78	87.50	77.91	77.78	88.98	88.83	80.12	88.86
Agriculture	100.00	91.67	81.88	90.01	86.67	92.85	86.64	92.13
Vegetation	80.12	100.00	67.42	66.67	100.00	85.71	100.00	100.00
Waterbody	100.00	100.00	84.75	83.76	83.33	100.00	100.00	100.00
Overall accuracy	90.00%		81.45%		88.82%		91.48	
Kappa coefficient	0.87		0.78		0.85		0.87	

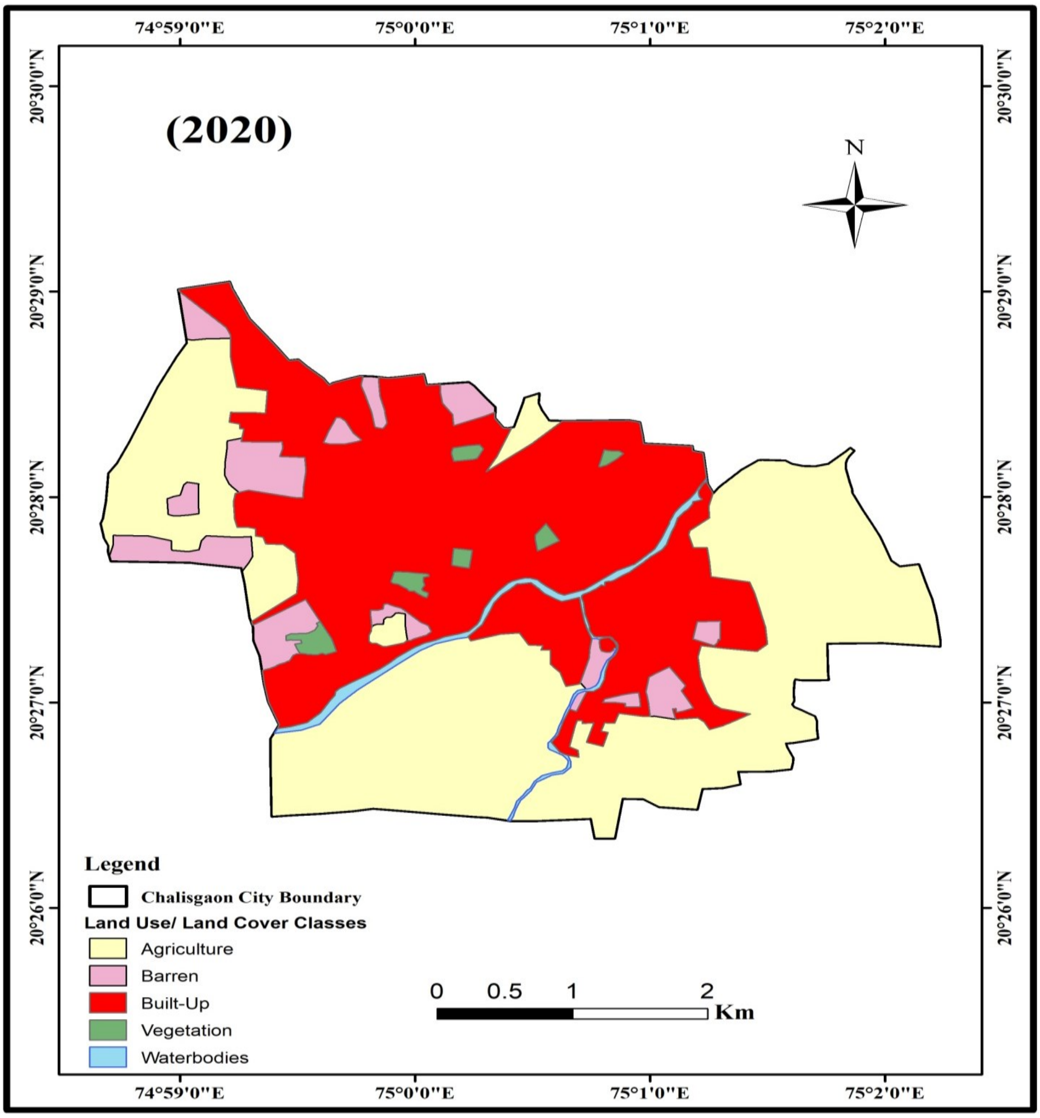

Figure 5. Land use/ land cover map of Chalisgaon city for the year 2020

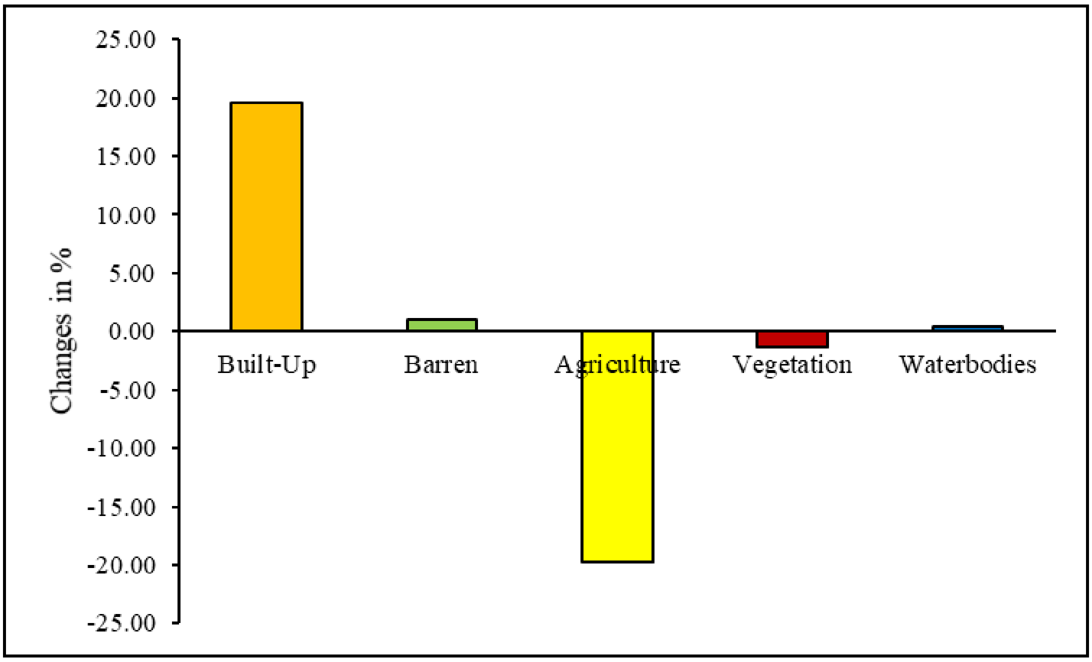

Figure 6. Changes of different land use land cover from 1990 and 2020 for Chalisgaon city

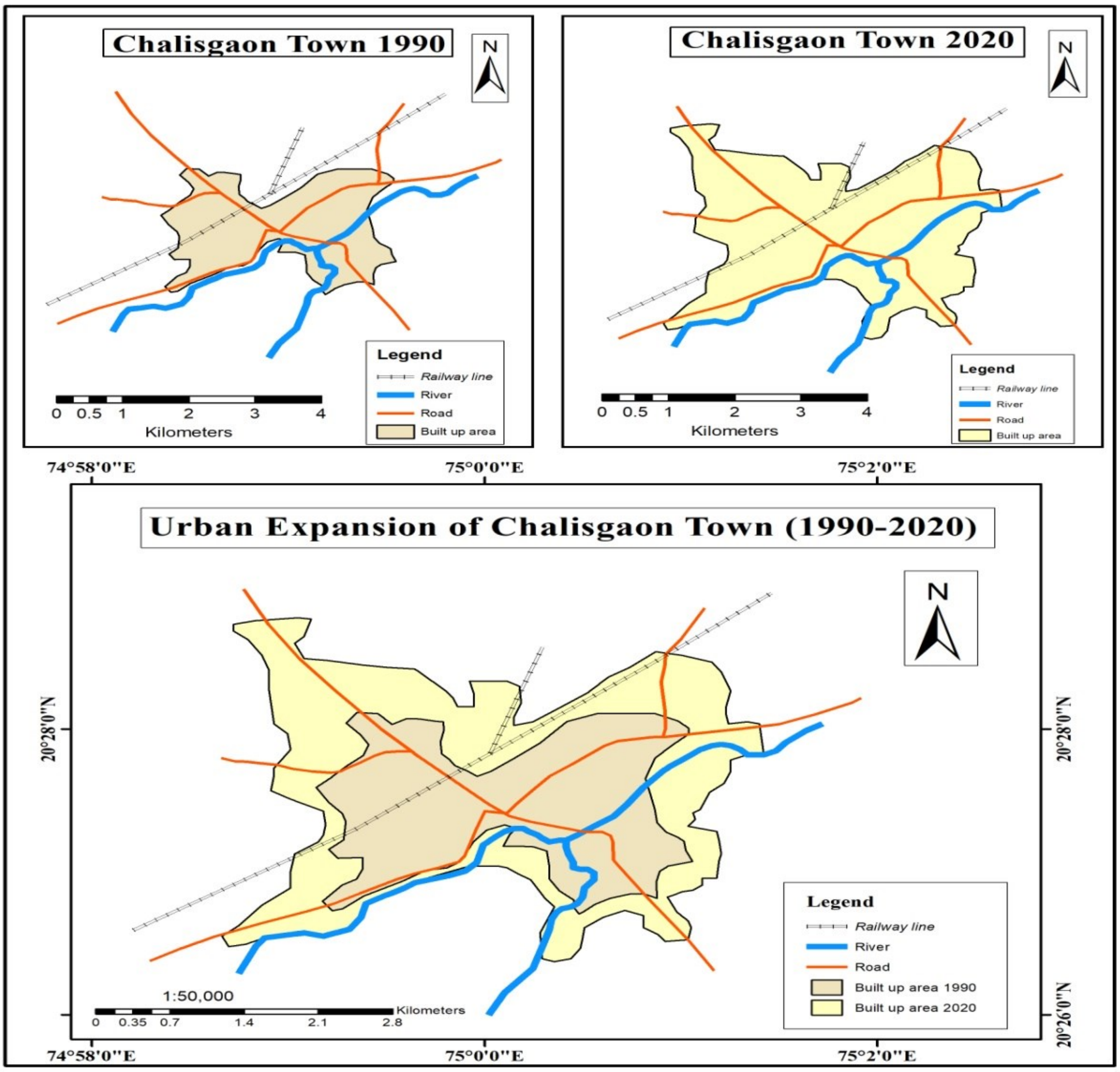

Figure 7. Map showing urban expansion since the year 1990 till 2020 in Chalisgaon city

3.3 Accuracy measurement of classification

Utilizing 150 control points from the LULC classified images for each year, the accuracy evaluation was utilized to validate the identification. The overall accuracy, producer's accuracy, and user's accuracy were computed separately. The condensed results of the assessment were plotted in Table 4. The matrix's diagonal elements are the only ones considered for overall accuracy. The overall accuracies were determined to be 90.00, 81.45, 88.82, and 91.48 for 1990, 2000, 2010, and 2020, respectively. The kappa coefficient values for the grouped images are 0.87, 0.78, 0.85, and 0.87 respectively. The accuracy result indicates that there is a strong association between digital classifications and ground reality (reference points) (Congalton, 1991). This sensible overall accuracy satisfied the change detection analysis criteria and was acceptable (Anderson et al., 1976; Lea and Curtis, 2010).

4. Conclusions

Agricultural The loss of agricultural land due to urban expansion and the urban lean in public funding for infrastructure, services, and subsidies are just illustrations of how modernization is frequently seen as having adverse effects on agriculture. The study shows that the impact of urban expansion of degradation of agricultural land in the study area was investigated the year 1990 to 2020. The land use/land cover study of the area under investigation was prepared using Landsat imageries. The maximum likelihood classification and minimum distance classification methods were used for thematic mapping of Landsat images. The results showed that land use land cover classes of Chalisgaon city have experienced rapid changes, particularly in built-up and agricultural land. Urbanization is the main cause for development in the region, and a huge area of cultivated land has been converted into a built-up land. Population explosion and changing land-use patterns are core responsible factors of urbanization. Built-up area of Chalisgaon city observed a general increment of 19.64% of the total area i.e., from 556 hectares to 920 hectares and the study area has lost about 365 hectares of fertile agriculture land during the study period 1990 to 2020. The accuracy assessment of the has been done by using Kappa coefficient, results shows that good accuracy for the study area. The overall accuracy is varies from 81.45% to 91.487%, while kappa coefficient is more 0.78 refers good accuracy. The result of this study can serve as basic information for policymakers and planners at the local level of administration to ensure that urban expansion information in the Chalisgaon city is smart and sustainable.

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