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RESEARCH ARTICLE

Monitoring Land Use/Land Cover Response to Urban Growth of the city of Jalandhar using Remote Sensing Data

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Abstract

Monitoring land use/land cover changes and its response to urban growth is very important to understand the urban dynamics for sustainable urban planning. Therefore, this paper is an attempt to examine the land use/land cover response to the processes of urban growth in the Jalandhar city. The aim of the study was to characterize the temporal and spatial pattern of urban growth and land use/land cover using the census and remote sensing information. Data on total population, population growth, population density of Jalandhar city from 1901 to 2011 and Landsat images of period 1975, 1989 and 2010 were used for the study. Dynamics of land use/land cover were quantified using a supervised classification algorithm in the Geographical Information System. The results revealed that the total population in the city has increased many folds. It contributes to the enlargement of the city that resulted in conversion of farming land use dominant landscape into urban land use dominant landscape during the last three decades. The analysis would be helpful to sustainable urban land use planning decisions for the metropolis.

1. Introduction

Urbanization is a universal and the imperative socio-economic phenomenon, taking place all around the world, given that more than half of the world's population lives in the cities. This proportion will increase to over 72% by 2050 (United Nations, 2012). Most of this urban growth will occur in the developing countries and will be more rapid than expected in India (Bhagat, 2011). On a regional scale, it is clear that urban growth dynamics are strongly linked to population dynamics. Therefore, the increase in urbanization is proportional to the generation of new infrastructure aimed at supporting population increases, which in turn causes additional fragmentation (Moghadam and Helbich, 2013). Hence, urbanization has been by far the most important change process in terms of the extent and impact on landscape composition and pattern (Denga, et al. 2009; Frondoni, et al., 2011). It is one of the most pervasive anthropogenic causes of the loss of arable land (Lopez, et al., 2001; Fazal and Amin, 2011) and declining natural vegetation cover. An unprecedented rate in the urbanization resulted in conversion of rural landscape into the urban landscape (Turner, 1994; Dewan and Yamaguchi 2009; Taubenböck, et al., 2009). Urbanization led to land use/land cover change (LULC) which is now considered to be the significant part of the urban dynamics study. Land use/land cover change detection is now generating interest among the researchers and planners as it has serious implications for urban planning (Taubenböck, et al. 2009; Suzanchia and Kaur, 2011) in order to provide basic amenities and to develop proper infrastructure to fulfil the demand of the growing population. It has both spatial and temporal dimensions that need to be studied. Since the last decade, remote sensing has become an important data gathering tool for analysing these changes (Taubenböck, et al., 2009; Punia, et al., 2011; Schneider, 2012).

Moreover, urban planners require detailed spatio-temporal mapping and long term change detection analysis of the regional resources. Besides this, it was also found out that there are very few researches those linked the population growth dynamics with land use/land cover dynamics in the urban region. These two are really indispensable for sustainable urban planning. Hence, the study had two aims. One was to study the urban growth dynamics of the city of Jalandhar and the second was to quantify the spatio-temporal pattern of the land use/land cover of the city.

2. Study Area

Jalandhar city is situated in northern Punjab in India between the latitude of 31^0 19'32'' North and longitude of 75^0 34'45'' East (Fig: 1). It has an area of 102 sq. km. Jalandhar is coming under class 1 cities with a total population of 8, 73,725 (Census, 2011). It is the 4th metropolitan city of the state of Punjab after Ludhiana, Amritsar and Gurdaspur. It stands at 56th position among Indian metropolitan cities. The city forms part of the Trans Indo Gangetic plain, topography is almost plain and the soil is very fertile in the area. It is surrounded by cultivating land from all positions. Maximum temperature varies from 19.4^0C in January up to 40^0C in May and June (Fig: 2). The minimum temperature varies from 6.2^0C in January to 25^0C in May and June. Winters are cold and summers are warm. The area received an average annual rainfall of about 569 mm (Fig: 2). Maximum rainfall is received from the southwest monsoon. It is today going forth as a major hub for all economic activities in the country.

3. Materials and Methods

The study has two sections. First section deals with urban growth dynamics. For this, census data on total population, population growth, population density from 1901 to 2011 have been analysed (Table 1). Second section deals with land use/land cover changes in the area. For this purpose, remote sensing data have been used and details of the data are given in Table 2.

The maximum likelihood classification (MLC) method was used for land use/land cover mapping of the area. The maximum likelihood classification (MLC) tool considers both the variances and covariance's of the class signatures when assigning each cell to one of the classes represented in the signature file (Srivastava, et al., 2012). This algorithm is based on Bayes' theorem of decision making where the cells in each class sample in the multidimensional space are normally distributed. It assumed that the distribution of the cloud of points forming the category training data is Gaussian (normally distributed) (Kumar, et al., 2011). Given these two characteristics for each cell value, the statistical probability is computed for each class to determine the membership of the cells to the class (Srivastava, et al., 2012). MLC has one drawback that is; large amount of computation is needed to separate each pixel (Kumar, et al., 2011). ERDAS version 10 and Arc Map version 10 were used for the classification and mapping. Method of preparing the land use/land cover classified maps is shown in Fig: 3. The accuracy of the classified maps was made on the basis of toposheet and field works.

4. Results and Discussion

4.1. Urban growth: trend and pattern

Urbanization processes in India have two phases. These are pre-independence and post-independence phase. These two phases were taken into consideration while studying the urban growth dynamics in the study area. It takes in both temporal and spatial dimensions. Fig: 4, 5 and 6 shows the temporal dimension of the city. Fig: 4 indicates that the total population in the city has changed drastically. It has increased to around 2 lakhs (1961) from 67 thousand (1901). Sudden growth in population was due to the influx of population from Pakistan after independence. As per the 2011 census, the city has around 8.5 lakhs population. Hence, the absolute increase in the total population is about 8 lakhs.

Population growth was 2% in 1911, it increased to 52% in 1941 (Fig: 5). Then, it declined to 24.8% in 1951. After 10 years, it again rises till 1981, then it declined to 24.8% in 1991. In 2000, it again almost doubled. Then it again declined to 22% in 2011. It revealed that total population is increasing at a decreasing rate. It is probably because urban planners are taking initiatives to control the natural growth and growth due to migration. As far as the population density is concerned, it is increasing at an alarming rate (Fig: 6). Population density was 664 persons/sq.km (1901) and now, according to the 2011 census, it is 8566 persons/sq.km.

There are physical and socio-economic reasons behind fluctuations in total population, population growth and population density. As per the 1991 census, Jalandhar ranked second in India in the rate of urban growth and had the highest density of population at 598 persons per square km. The cause for this was the growing industrialization. Industrial production of sports goods began on a small scale during the late forties. Over the years, the sports goods

industry has developed at an impressive rate and of late Indian sports goods is also exported to different states. Hence, it is well recognized as the city of sports. It holds the highest number of hospitals in India. It is also emerging as a hub of educational institutions such as Institute of Banking Services (IBS), Lovely Professional University with a 600 acre campus and Dr. B.R. Ambedkar National Institute of Technology. All these factors are responsible for increasing population in the city.

4.2. Land use/land cover changes

Land use/land cover changes in an area are the consequence of the anthropogenic activities. These activities depend on the requirements of the population growth. It contributes to urban expansion of the urban center and development of infrastructure, including transportation, institutional development, and public offices. Consequently, changes in the land use/land cover occurred within and at the outskirts of the city. These alterations are counted as the response of land use/land cover to the urban growth. Table 3 and Fig: 7, 8, 9 displays the results of land use/land cover mapping in the city. Table 3 indicates that in 1975, agricultural land (cultivated and fallow land) covered maximum area of 304 sq.km followed by forest (130 sq.km.), barren land (108 sq.km.) and built up area (45 sq.km.). In 2010, built up area increased to 215 sq.km. Other LULC classes had shown a decline except barren land. Agricultural land (cultivated and fallow land) declined to 191sq.km. Similarly, forest area decreased to 87 sq.km during the period of analysis.

Fig: 7 shows the proportionate change among the classified land use/land cover classes. It indicates that, in 1975 agricultural land was dominant and built up area covered very minor area. Over the years, built up area increased from 8% (1975) to 37% (2010) and agricultural land decreased from 52% (1975) to 31% (2010). Forest cover decreased to 18% (2010) from 22% (1975). Overall change revealed that built up area increased many folds in comparison to other classes. Fig: 8, 9 and 10 shows the spatial pattern of the urban expansion of the city. These figures indicate that the city is expanding in south west direction. It contributes to conversion of rural landscape into the urban landscape. It is mostly occurring along the railway lines. The urban real estate is emerging in the city. New educational institutions like Lovely Professional University. Conversion of agricultural and forest land into built up area would affect the processes of the urban ecosystem.

Table 1 Data and sources

Data	Sources
Toposheet No-H43D11 (1:50000)	Survey of India
Total urban population	Census of India
Population growth rate	Census of India
Population density	Census of India
Landsat image	USGS global visualization viewer (http//glovis.usgs.gov)

Table 2 Description of remote sensing data

Satellite	Sensor	Path/Row	Date
Landsat-2	MSS	159/038	10/11/1975
Landsat-5	TM	148 /038	16/10/1989
Landsat-5	TM	148 /038	1/9/2010

Table 3 Absolute changes in land use/land cover classes of the study area

Land use/land cover classes	1975	1989	2010	Area changed (sq.km.) 1975-2010
	Area (sq.km)			
Built-up area	45	87	215	170
Cultivated land	116	144	104	-12
Fallow land	187	127	87	-100
Forest	130	159	87	-43
Barren land	108	69	93	-15

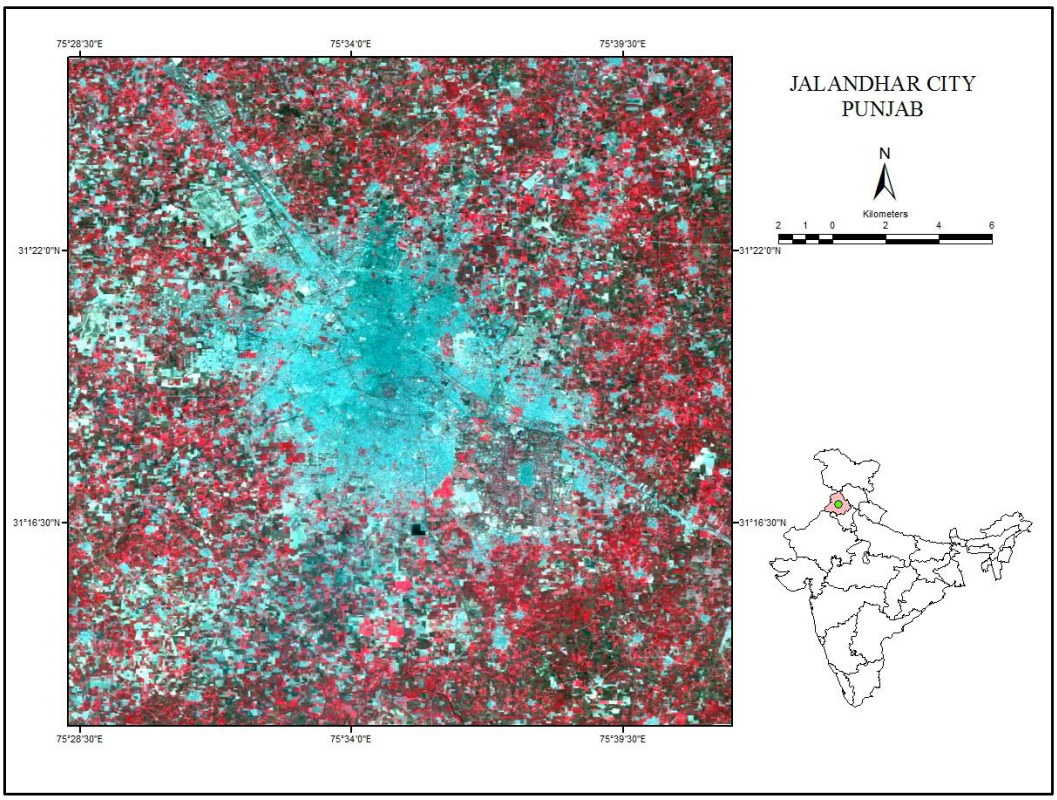

Fig: 1 Location of the study area

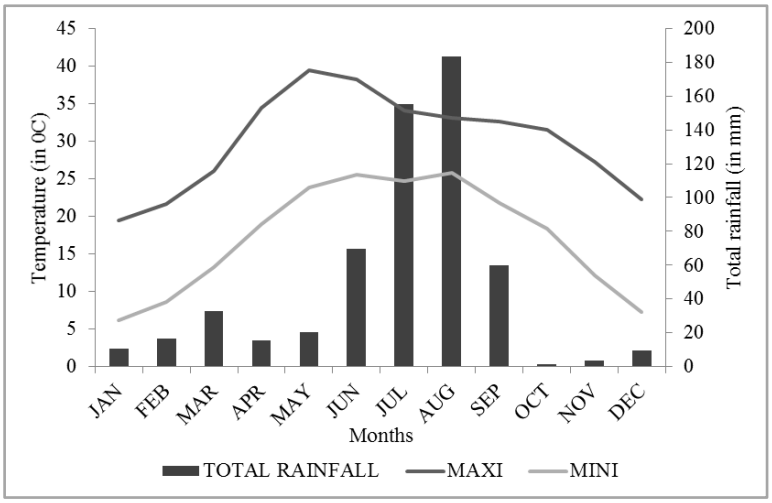

Fig: 2 Normal temperature and total rainfall in the study area

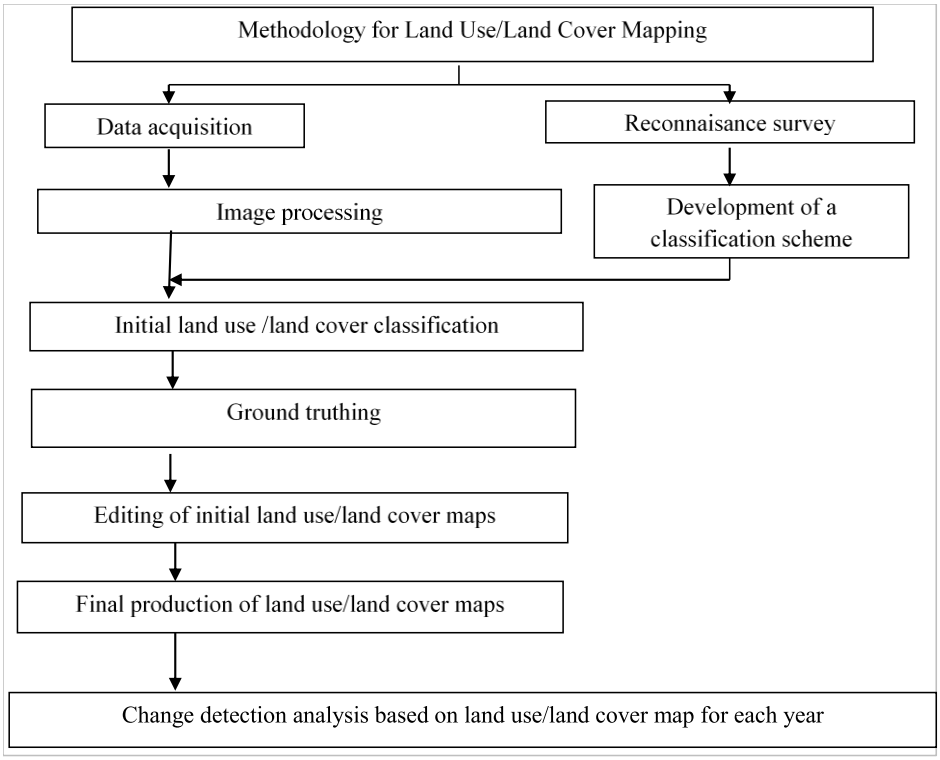

Fig: 3 Flow chart of methodology of land use/land cover mapping of the study area

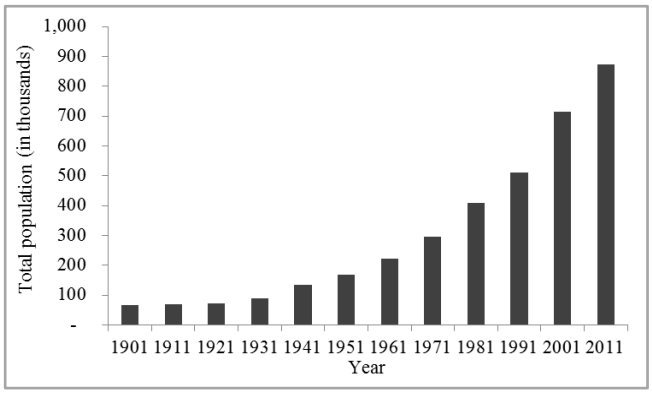

Fig: 4 Trend in total population of the study area

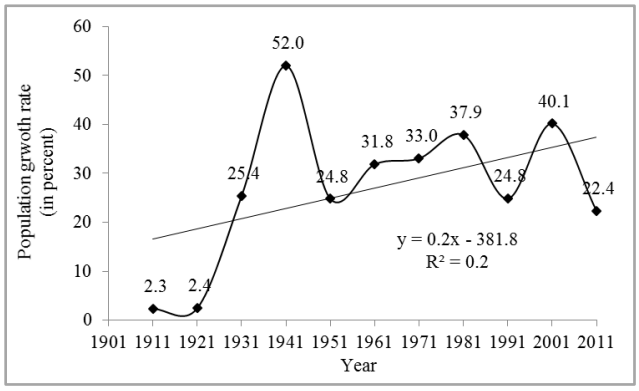

Fig: 5 Trend in population growth of the study area

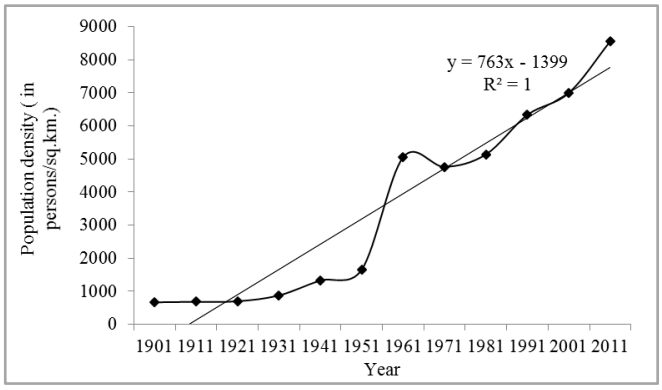

Fig: 6 Trend in population density of the study area

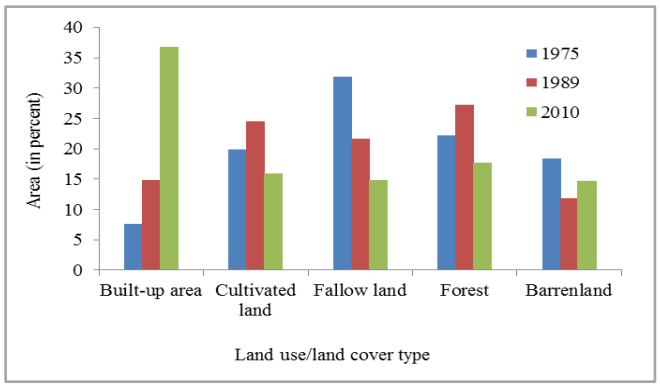

Fig: 7 Relative changes in land use/land cover classes of the study area

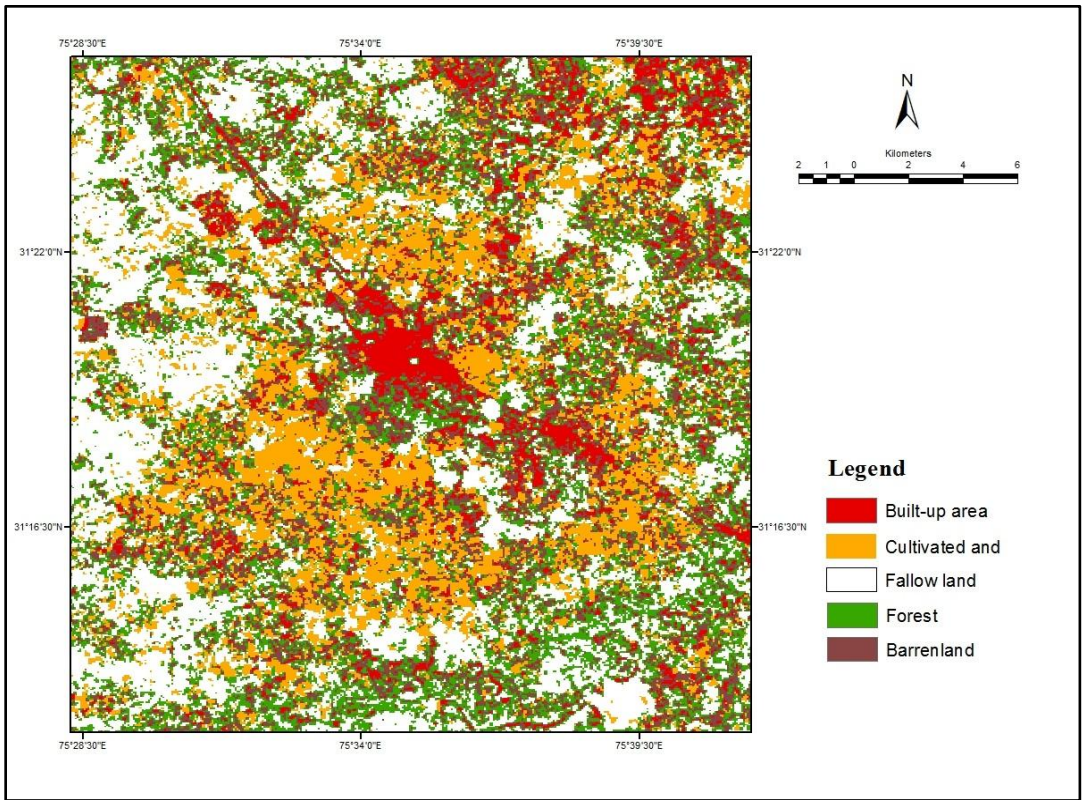

Fig: 8 Classified land use/cover maps of the study area of 1975

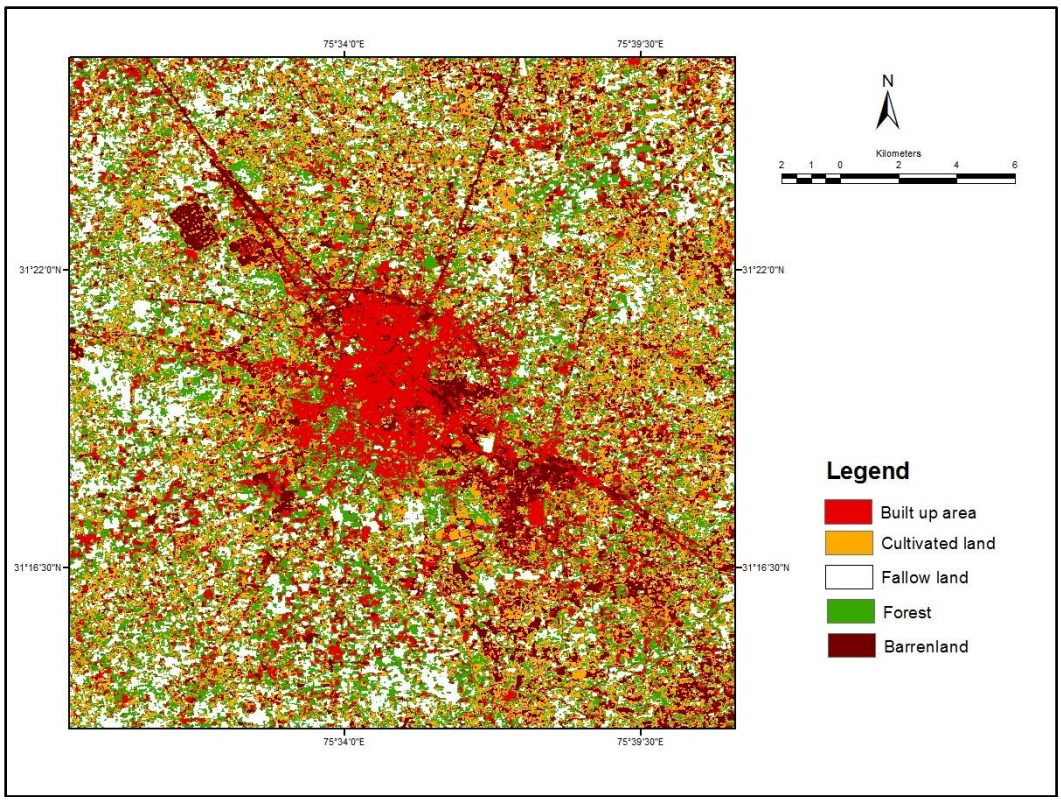

Fig: 9 Classified land use/cover maps of the study area of 1989

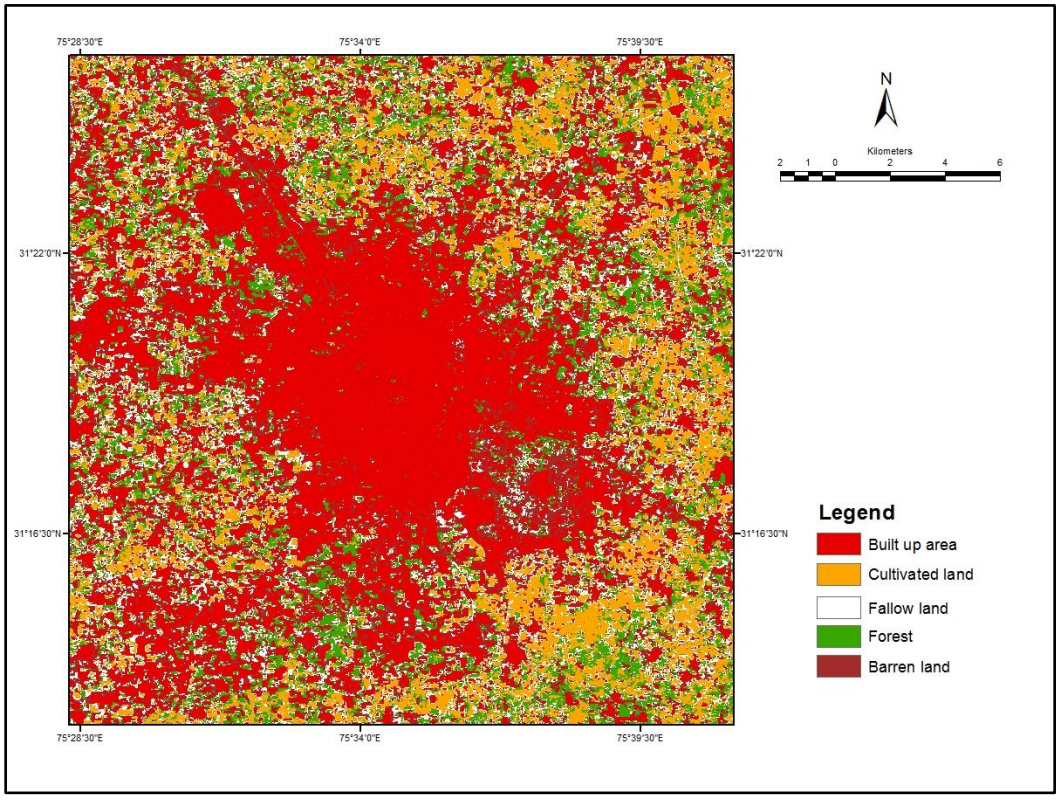

Fig: 10 Classified land use/cover maps of the study area of 2010

5. Conclusion

The study was an attempt to understand the land use/land cover response to urban growth in the city. The findings revealed that the total population in the city increased to almost 8.5 lakhs (2011) from 67 thousand (1975). Similarly, population density has also increased many folds. There are physical as well as socio-economic reasons behind these changes. It resulted in urban expansion. As a result, land use/land cover has changed drastically at the periphery of the city. It thus leads to the transformation of the rural landscape into the urban landscape. Consequently, most of the agricultural land converted into urban areas. Built up area has increased to 37% (2010) from 8% (1975). On the other hand agricultural land decreased to 31% (2010) from 52% (1975). Urban expansion is the root cause behind this. The study would help the planners in sustainable urban planning in the city.

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