

Analysis of Land Use/Land Cover Changes using Remote Sensing Data and GIS in Ahmedabad Municipal Corporation Area, Gujarat, India

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ABSTRACT

The present study encompasses the Land use/land cover (LU/LC) change detection in Ahmedabad Municipal Corporation area by using Geographical Information Systems (GIS) and Remote Sensing (RS) technology, over a period of a decade at an interval of 5 years, i.e., for the year 2005, 2011 and 2016. Based on geographical conditions, remote sensing data and field survey, the study area was classified into six categories. The comparison of LU/LC in 2005, 2011 and 2016 derived from Ahmedabad Municipal Corporation map and satellite imagery interpretation indicates that there is a consistent increase in built-up area and open tree cover area. On the other hand, dense tree cover, open land area and water spread area of waterbody declined correspondingly. Moreover, the overall tree cover of Ahmedabad Municipal Corporation area has declined from 2523.01 ha to 2477.45 ha from the year 2005 to 2016 which may be due to rapid urbanization of the Ahmedabad Municipal Corporation area. This study of detailed LU/LC change analysis with regular monitoring will be fruitful to draw the attention of urban planners and decision makers for sustainable development, detailed area planning as well as to overcome the problem of decline in green spaces and urban sprawl. Additionally, the findings of the present study will be useful in monitoring the dynamics of land use resulting from the changing demands of the growing population.

Keywords: Change detection, Land Use Land Cover, Geographical Information Systems, Remote Sensing

Mathematics Subject Classification: 92-XX, 35Q92, 46N60, 62P12

Journal of Economic Literature (JEL) Classification: Q25

1. INTRODUCTION

The most important natural wealth of any region is land resource and its proper utilization is a matter of utmost concern to its people (Codjoe, 2007). Over millennia, human beings have gradually become expert in utilizing and exploiting land resources for their own purposes. In today's scenario, the demand for land resources for agriculture, urban and industrial uses is rising with the rapid increase of the human population and their activities. The complex interactions between humans and the physical environment cause the conversion or modification of the Earth's terrestrial surface which is commonly known as Land use/land cover (LULC) changes (Pielke et al., 2011; Hassan et al. 2016). The

changing pattern of land use and land cover is a dynamic process taking place over time and space; also it becomes a core component of existing strategies for managing natural resources and monitoring of environmental changes. Remote Sensing (RS) and Geographic Information System (GIS) are powerful techniques to derive accurate and timely information on the analysis of change detection of LULC pattern (Carlson and Azofeifa, 1999; Guerschman et al. 2003; Muttitanon & Tripathi, 2005; Masria et al. 2015). Remote Sensing (RS) is an essential tool applicable for detecting and monitoring the physical characteristics of an area by measuring its reflected and emitted radiation at a distance mainly from satellite or aircraft (Hudak and Wessman, 1998). Whereas, GIS techniques are commonly defined as the integrated processes of hardware and software framework that are carried out for capturing, storing, retrieving, checking, integrating, analyzing and displaying geographically referenced (spatial) data related to positions on the Earth's surface in order to facilitate development-oriented management and decision-making processes (Aboyade, 2001; Mallupattu et al., 2013). Due to the detailed geo-referencing procedures, these methods are the most common tools for quantification, mapping, visualization and analysis of LULC patterns as well as the digital format of these techniques suitable for computer processing, repetitive data acquisition, cost-effective, less time consuming with more accuracy (Lu et al, 2004; Muttitanon & Tripathi, 2005; Prakasam, 2010; Phukan et al., 2013; Samal and Gedam, 2015). In combination with drainage, lithology and land use land cover collateral data, satellite data analysis provides an accurate estimation of geo-morphological trends, water resources, land degradation, forestry, agriculture, other environmental and climate change issues (Fung and Ledrew, 1987; Li and Yeh, 1998; Long et al. 2008; Sharma, 2009; Prakasam, 2010; Samal and Gedam, 2015, Kumar and Jharia, 2015, Achmad et al. 2018).

Gujarat is emerging as most progressive and well administrated state of India as well as the state is concerned about its environment and different issues of natural resources. Gujarat has a population of 60.38 million in 2011 (Census, 2011) exhibiting a decadal growth rate of 19.17 percent as compared to the all India growth rate of 17.64 percent. In the same way, the state shows, the population growth rate of rural and urban areas was 9.23 percent and 35.83 percent, respectively, as per Census, 2011 (townplanning.gujarat.gov.in). Since, the formation of the independent state, Gujarat's urban population has been rising steadily (Pandya and Patel, 2013). The trend of decadal growth rate of urban population in Gujarat reveals that, the pace of urbanization was higher than the national average during the decade 1991-2001 and 2001 - 2011, and may be expected to remain high in the next one decade as well. Hence, the tree cover in urban areas around the state is declining and impervious concrete cover is increasing due to the demand of the land for development. As a consequence the major environmental problems faced by urban areas include increase in the temperature, deterioration in air quality, noise and the problems of waste disposal etc. As a consequence, the urban areas are experiencing environmental degradation and resource depletion, despite several initiatives taken up to stop such degradation.

In 1411 AD, the Ahmedabad city was established as a walled city on the eastern bank of the Sabarmati River, presently the seventh largest metropolis in India and the largest in Gujarat State. As per the 2011 Census of India, the population of the Ahmedabad city has increased from 3.31 million in 1991 to 5.8 million in 2011. Ahmedabad Municipal Corporation area is progressing rapidly as well as

the city is witnessing a major construction boom and alterations everywhere due to the rise in population, industrialization and large-scale migration to urban areas. Therefore, the impacts of all these factors are required to be analyzed to understand the changes in LULC that have led to rapid growth of Ahmedabad Municipal Corporation areas. Change detection of land use-land cover with respect to population dynamics of Ahmedabad for a time period of 1991- 2010 using GIS and statistical techniques (Sikarwar and Chattopadhyay, 2016), tree cover assessment in Ahmedabad Municipal area for the year 2011 (Singh, 2012) and land use - land cover mapping of entire Ahmedabad District for the year 2017 (Rawal et al. 2020) has been done previously. However, little information is available regarding change detection analysis of LULC of Ahmedabad Municipal Corporation area for the year 2005, 2011 and 2016. Hence, the present investigation attempted to record comparative land use and change detection analysis of LULC of Ahmedabad Municipal Corporation area from 2005 to 2016 using RS and GIS geospatial techniques.

2. STUDY AREA

Ahmedabad was established in 1411 by its namesake, Sultan Ahmed Shah, to serve as the capital of the Gujarat Sultanate. The city was the Capital of Gujarat from 1960-1970 thereafter, the capital was shifted to Gandhinagar. Moreover, the city is also known as "Manchester of the East" because of its thriving textile industry. Ahmedabad Municipal Corporation (AMC) area is the largest municipal corporation area in the western Indian state of Gujarat and is located in between $22^{\circ}54'N$ to $23^{\circ}08'N$ latitudes and between $72^{\circ}26'E$ to $72^{\circ}42'E$ longitudes. The area of Ahmedabad Municipal Corporation (Fig.1) is 46,985 ha and

consisting of 62 wards, along with the city accommodates total population of 56,33,927 as per year 2011 Census (District Census Handbook Ahmedabad, 2011). The AMC area has boundaries of Koteshwar, Bhat, Ranasan, Chiloda(Naroda) (CT), Amiyapur, Zundal, Lilapur, Khoraj and Khodiyar villages in the

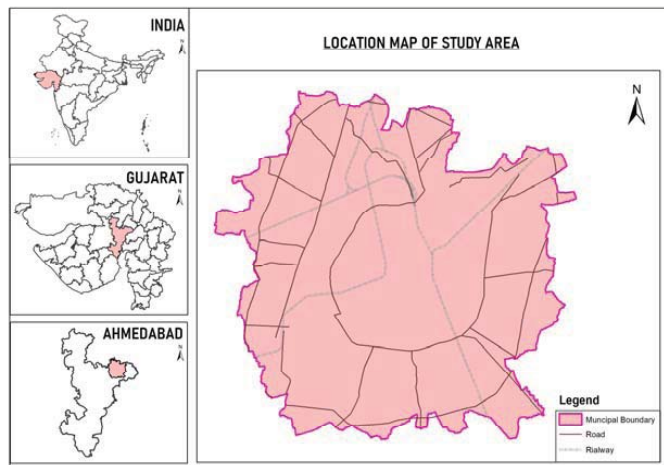


Figure. 1 Study Area – Ahmedabad Municipal Corporation area

north, Devdi, Geratpur, Badodara, Hathijan, Geratnagar, Bibipur, Memadpur, Gatrad, Singarva (CT), Kathwada, Bilasiya and Enasan village boundaries in the east, Ode, PaldiKankaj, Ropda, Aslali, Gamdi and Visalpur village boundaries in the south, Sanathal, Shela, Ghuma, Manipur, Bopal (CT), Palodiya, Nandoli, Rancharada, Rakanpur, Santej and Lapkaman village boundaries in the west.

3. MATERIALS AND METHODOLOGY

The present work was based on the analysis of Satellite data of October to January months for the years 2005, 2011 and 2016 (Table-1) and other ancillary data *i.e.* Municipal corporation boundary and ward maps as obtained from Ahmedabad Municipal Corporation office as well as ground information by field visits had also been used. The imagery was classified into six distinct LULC categories described in Table-2.

Table 1. Satellite data used

Satellite : ResourceSat-2 ;		Product : LISS-IV			
Path / Row	Month Year	Path / Row	Month Year	Path / Row	Month Year
202-078	Jan-2005	203-053	Nov-2005	93/57A	Nov-2011
202-073	Jan-2005	202-065	Nov-2005	91/57D	Nov-2011
202-075	Jan-2005	203-054	Nov-2005	90/56D	Dec-2011
202-076	Jan-2005	202-087	Nov-2005	91/56C	Dec-2011
202-081	Oct-2005	202-088	Nov-2005	90/56B	Jan-2016
202-082	Oct-2005	202-074	Nov-2005	90/56D	Jan-2016
202-082	Oct-2005	202-075	Nov-2005	91/56C	Jan-2016
202-084	Oct-2005	93/57D	Oct-2011	91/57B	Nov-2016
202-085	Oct-2005	91/56D	Nov-2011	91/56D	Nov-2016
202-068	Nov-2005	91/57B	Nov-2011	93/57D	Nov-2016

Table 2. LULC Classes considered in the study

S.N.	LULC Categories	Features
1.	Dense Tree cover	Tree Density >40%
2.	Open Tree cover	Tree Density >10%-<40%
3.	Built up area	Construction (Residential, industrial, commercial infrastructures etc)
4.	Open land	Vacant Land
5.	Water body	Water spread area of Pond/ lakes/River/ Canal/reservoirs etc.
6.	Sand	Sand deposition

Imagery is represented with tone, texture, shape, location and associated features as inherent elements that can provide clue towards detection and identification during image interpretation. These components and ground truthing data were considered as the key to image interpretation in the present work. The Satellite imageries were obtained from National Remote Sensing Centre (NRSC) and ERDAS software was used for digital image processing.

The map of Ahmedabad municipal area was superimposed on satellite imageries and the area without vegetation was masked out so as to attempt classification of green cover area. The classification was done by using ERDAS Image processing System. Normalized Differential

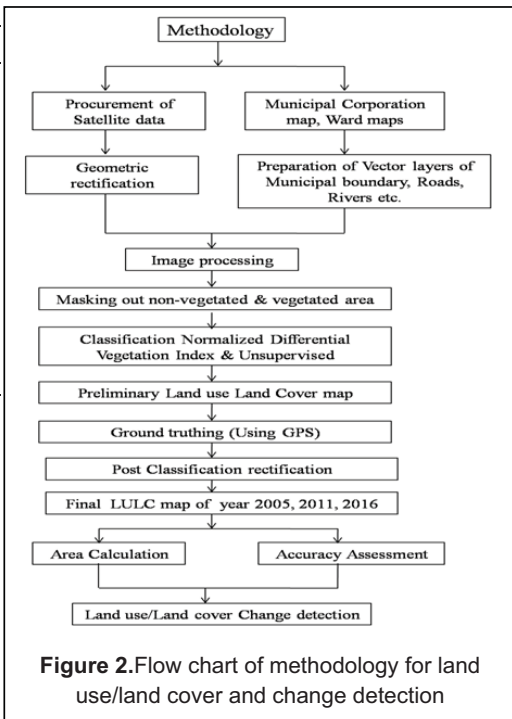


Figure 2. Flow chart of methodology for land use/land cover and change detection

Vegetation Index module was used for tree cover classification and unsupervised classification was used for other classes i.e. Built-up area, Open land, Water spread area in water body etc. Before satellite imagery processing and classification, a detailed field survey was carried out in the study area using Global Positioning System (GPS) equipment. This survey was undertaken to obtain precise location point data for each land use and land cover class included in the present classification categories.

The digital interpretation method was adopted for interpreting the remote sensing data. Ahmedabad municipal corporation boundary of 2016 was superimposed on Satellite imageries of year 2005, 2011 and 2016 for masking out other areas and classification. The detailed methodology adopted is given in Figure 2.

4. RESULT AND DISCUSSION

The detailed changes of land use and land cover of the Ahmedabad Municipal Corporation area during 2005 to 2016 are depicted in Table 3. and the resulting land use/ land cover maps of the year 2005, 2011 and 2016 have been represented in Figure 3, 4 and 5. In the year 2005, dense tree cover of Ahmedabad Municipal Corporation was recorded as 768.31 hectares which got declined by 74.71 hectares to 693.6 hectares during the period 2005-2011. Over the period from 2011 to 2016, dense tree cover further declined by 73.08 hectares to 620.52 hectares in 2016 (Table 3). However, major area of this category got converted to open tree cover and the overall decline from 2005 to 2016 was 147.79 ha. which constitute about 19.24%. Major changes of dense tree cover were found on southern-west and southern-east side of the Ahmedabad Municipal Corporation area (Figure 3, 4 and 5). Tree species recorded during ground truthing were mainly Gandobaval (*Prosopis*) on outskirts of the city and others were Neem (*Azadirachta indica*), Gulmohar (*Delonix regia*), Pipal (*Ficus religiosa*), Garmodo (*Casia fistula*), Vad (*Ficus benghalensis*) etc. inside the city area.

Furthermore, the analysis of tree cover data reveals that, open tree cover increased from 1754.70 hectares in 2005 to 1761.76 hectares in 2011 and further increased by 95.17 hectares during the period from 2011-2016 and it was recorded as 1856.93 hectares in year 2016 (Table-3). Overall the area under this category over a decade (2005-2016) increased from 1754.70 ha. to 1856.93ha. which constitute 5.83%. The main reason of change in this category may be due to conversion of dense tree cover area to open tree cover area. Open tree cover increased in scattered manner and several changes were mainly recorded on north, north-east and west side area of AMC (Figure 3, 4 and 5). The ground verification revealed that, major area was covered with tree species such as, Gandobaval (*Prosopis juliflora*), Deshibaval (*Acacia nilotica*), Asopalav (*Polyalthia longifolia*), Nilgiri (*Eucalyptus* sp) etc. inside the city area.

Built up area comprises of residential, commercial and industrial areas. During 2005, this area was recorded as 8168.31 hectares. Further, the area increased by 1890.12 hectares to 10058.43 hectares during the period 2005-2011. Moreover, the area increased by 4085.79 hectares during the period 2011-2016 and it was recorded as 14144.2 hectares in 2016 (Table 3). Overall the area under this category over a decade (2005-2016) increased from 8168.31ha to 14144.2 ha. which constitute 73.16%. Due to rapid urbanization, growing demand of houses, shops and technological

advancements in machinery of construction work, the built-up area increased by more than double rate during the period of 2011 to 2016 as compared to 2005 to 2011.

Table 3 Area statistics and percentage of the land use/cover units for the year 2005, 2011 and 2016

Land use and land cover categories	2005		2011		2016		Change area (ha)			2005-2016	Annual change (%)
	Area (ha)	Area (%)	Area (ha)	Area (%)	Area (ha)	Area (%)	2005-2011	2011-2016	2005-2016	Changed area (%)	
Dense Tree Cover	768.31	1.64	693.6	1.48	620.52	1.32	-74.71	-73.08	-147.79	-19.24	-1.75
Open Tree Cover	1754.70	3.73	1761.76	3.75	1856.93	3.95	7.06	95.17	102.23	5.83	0.53
Built-up Area	8168.31	17.38	10058.43	21.41	14144.2	30.10	1890.12	4085.79	5975.89	73.16	6.65
Open Land/Area	35255.88	75.04	33804.34	71.95	29438.97	62.66	-1451.5	-4365.4	-5816.9	-16.50	-1.50
River/Water body	1037.8	2.21	666.87	1.42	870.86	1.85	-370.93	203.99	-166.94	-16.09	-1.46
Sand	0.00	0.00	0.00	0.00	53.5	0.11	0.00	53.5	53.5	-	-
TOTAL	46985	100.0	46985	100.0	46985	100.0	-	-	-	-	-

Open land mainly includes vacant land without non-agricultural development work. Under this category, in Ahmedabad Municipal Corporation area, some agricultural activities were recorded in the year 2016. The area was recorded as 35255.88 hectares in year 2005, which declined by 1451.5 hectares during the period from 2005 to 2011 and was recorded as 33804.34 hectares in 2011. Furthermore, in 2016, the area again declined by 4365.4 hectares and it was recorded as 29438.97 hectares. Overall the area under this category over a decade (2005-2016) declined from 35255.88 ha. to 29438.97 ha. which constitute 16.50% (Table 3). Due to growing demand of residential, commercial, institutional buildings etc, the open land area declined more than three times during the period of 2011 to 2016 as compared to 2005 to 2011.

Previous study on Ahmedabad city for the duration 1991 to 2010 reported that, it has experienced rapid change, particularly in the agricultural land, vegetation cover, and built-up area as well as during the same period built-up area of Ahmedabad City sub-district has witnessed an overall increment of 173 percent and such huge change has contributed mainly from agricultural and forest land (Sikarwar and Chattopadhyay, 2016). It was reported that, the tree cover in the city Ahmedabad was estimated about 4.66 % of the geographical area in 2010, which is below the average tree cover in the urban areas in the state (Singh, 2012). Moreover, the present study reveals that the overall tree cover of Ahmedabad Municipal Corporation area was 2523.01 ha in 2005 which declined to 2455.36 ha in 2011 whereas, it shows marginal increase to 2477.45 ha in 2016. The improvement of tree cover in 2016 was may be due to the initiatives taken towards different plantation activities for sustainable tomorrow, by the AMC, State Forest Department, Ahmedabad Urban Development Authority (AUDA) and other organizations. On the other hand, in this municipal corporation, the build-up area increased

by 5975.91ha. i.e., from 8168.31ha. in 2005 to 14144.2ha. in 2016, whereas, open land area over a decade (2005–2016) declined by 5816.9ha., i.e., from 35255.88 ha. in 2005 to 29438.97ha. in 2016 (Table 3.).

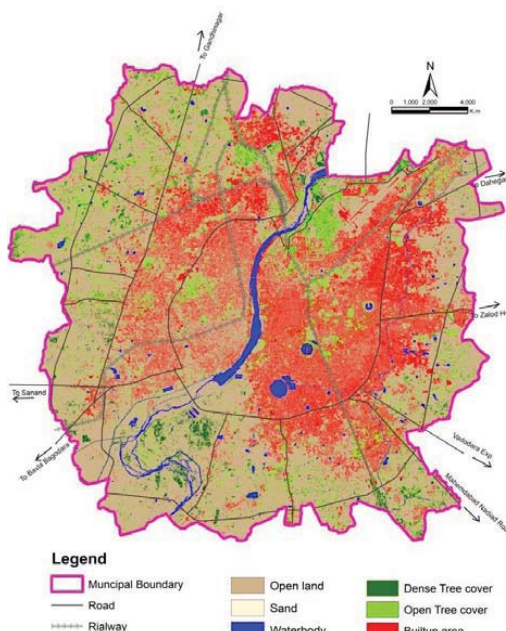


Figure 3. LULC map of Ahmedabad Municipal Corporation for year 2005

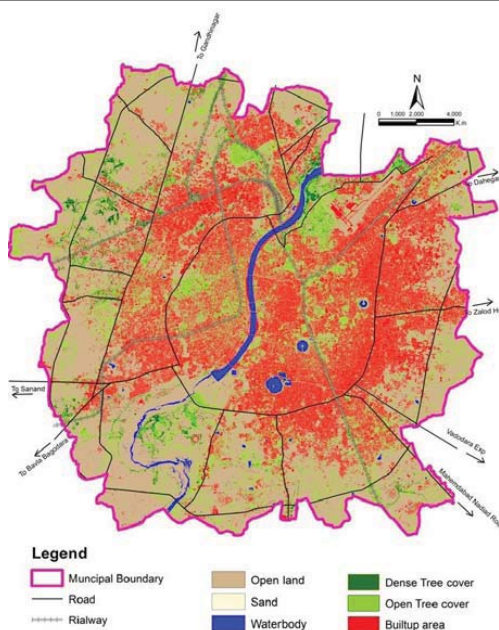


Figure 4. LULC map of Ahmedabad Municipal Corporation for year 2011

Water body includes river, stream, lakes, ponds etc. Sabarmati river, Kankaria lake, Chandolatalav, Vastrapur lake, Malek saban lake, Makarba lake, Vasna barrage are main water bodies recorded in Ahmedabad municipal corporation area. Water spread area of water bodies declined from 1037.8ha. to 666.87ha during the period from 2005 to 2011 and increased from 666.87 ha to 870.86 ha during the period from 2011 to 2016 (Table 3). Overall the area under this category over a decade (2005-2016) declined from 1037.8 ha to 870.86 ha. which constitute 16.09%. The changes of water spread area of water bodies may be due to variation in drainage pattern or diversion of water bodies for other purposes.

The analysis of progressive change (%) in LULC during 2011 and 2016 with respect to 2005 is depicted in Figure 6. It was found that from 2005 to 2016 the area of dense tree cover declined consistently by 9.52% whereas open tree cover increased by 5.43% this may be due to conversion of dense tree cover to open tree cover in municipal area. During the same period the built-up area consistently increased by 50.02% and open land declined by 12.38% which may be due to urban expansion and population increase in the study area during

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and urban areas of the district are -0.2 % and 30%, respectively. The growth rate of rural population is very slow in the district due to urbanization, whereas the growth rate of urban population is very high in the district (District Census

HandbookAhmedabad,

2011). It was reported that, the density of

population in Ahmadabad district is 890 persons per sq.km against the State average of 308 persons (District Census Handbook Ahmedabad, 2011). The key reasons behind the LU / LC changes are rapid population growth, reclassification of rural areas as urban areas, rural-to-urban migration, lack of valuation of ecological resources, ignorance of biophysical limitations and the use of ecologically incompatible technologies etc(Mallupattu and Reddy, 2013). Hence, information of present study on land use / land cover changes is useful for the selection, planning and implementation of land use of the Ahmedabad Municipal Corporation area and can be used to meet the increasing demands for basic human needs and welfare.

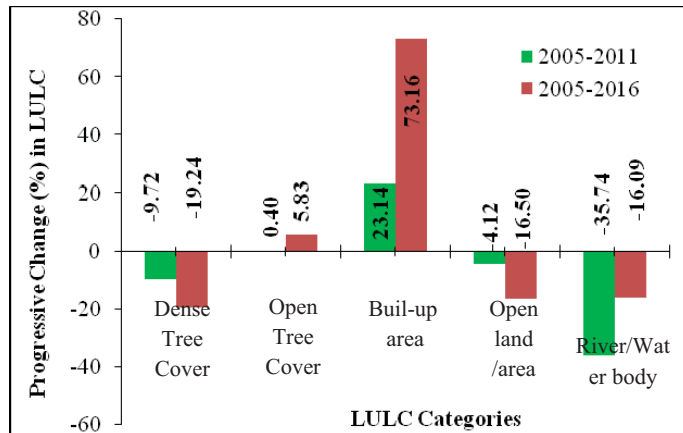


Figure 6. Progressive change in LULC with respect to 2005

5. CONCLUSION

The present study provides the data on Land use/Land cover changes in municipal corporation areas of Ahmedabad, Gujarat using remote sensing data and GIS technology over a period of a decade at an interval of 5 years, i.e., for the year 2005, 2011 and 2016. The study revealed that open tree cover and built-up areas increased during the year 2005 to 2016 resulting in substantial reduction of dense tree cover, open land area and water spread areas of water bodies in the Ahmedabad Municipal Corporation area. Many environmental challenges and social impacts can be triggered by the increase in built-up areas and decrease in green spaces of any urban city. Ahmedabad district has witnessed decadal (2001 to 2011) urban population growth rate of 30% which clearly indicates the significant impact of population and its development activities on LU/LC changes. The findings of the study of Land use/Land cover classes over a period of a decade can be useful by urban development authorities, city planners, managers, forest departments, all organizations involved in the decision-making process regarding land use and other different stakeholders in monitoring, evaluation and trend analysis of the changes in urban forest cover as well as land use/land cover in the municipal corporation areas. Additionally the data can be used for the designing of prospective land use policies

for environmental sustainability, protection of natural resources and preparation of potential future master plan for the Municipal Corporation area of state largest megacity Ahmedabad.

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