

Investigation and Analysis of Land Use/Land Cover (LULC) change using remote sensing image interpretation for urban area of Rajkot Municipal Corporation, Gujarat

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Abstract

In the current study, to understand LULC changes during the period from 2005-2016 in Rajkot Municipal Corporation, the digitalised satellite imageries (LISS-IV) were assessed and interpreted. During investigation and analysis, various LULC categories such as open land/area and water bodies had shown a gradual decline by 66.19 ha (0.79%) and 156.73 ha (41.60%) respectively during the period.

Moreover, the analysis showed a gradual increase in built-up area by 198.13 ha (16.50%) during the same period. Some fluctuation in dense tree cover and open tree cover have been observed in these years i.e. 2005, 2011 and 2016. The dense tree cover was found fluctuating in each assessment year from 2005 to 2016 but its overall analysis showed declining status of the dense tree cover by 33.18 ha (20.87%). On the other hand, the open tree cover was found to have increased by 57.97 ha (22.47%) during the period from 2005-2016. Findings of the current study can be utilised in town designing and planning for future development in sustainable management of the city.

Keywords: LULC, Remote sensing, Rajkot Municipal Corporation, Gujarat.

Introduction

The cities around the world are experiencing change of the Land Use/Land Cover (LULC) due to the growth of population and very fast urbanisation⁴ which accelerate the change in land use patterns of urban areas. These urban areas need advanced technology to get up-to-date information about geomorphological features³ which can be used in the sustainable development of urban areas. The remote sensing technology has been used for monitoring change detection of urban areas which is a very important technology for planning and management of urban areas⁷ and its monitoring at regular interval through it can give status of land use occupied with different developmental activities.

The prediction showed that more than 60 % of the human population will live in the city by 2030 that will lead to an acceleration in growth of the urban area and rapid LULC change^{2,6}. Changing land and other attributes in urban areas are some of the offshoots of overpopulation in city areas

which would result in rapid changes in the urban landscape by converting natural vegetation into open surface land or built-up area².

The expression of the earth is always changing due to various anthropogenic activities and natural miracles which showed the urgency of regular monitoring of earth to improve the management, to get knowledge of increasing or decreasing trends and estimation of LULC changes⁸. In the current study, an attempt has been made to know the LULC changes over period of time (2005-2016) in Rajkot Municipal Corporation which can provide baseline information about LULC changes.

Material and Methods

Study Area: The Rajkot Municipal Corporation is located in Rajkot city of western part of India (Fig.1). It is considered in fastest developing city in Gujarat state⁵. Rajkot city, the headquarter of Rajkot district is situated in the western part of the Gujarat state (Fig.1). It lies between the parallels of 22° 20' to 22° 12' N latitudes and 70° 43' to 70° 51' E longitudes. The area of Rajkot Municipal Corporation is 10400 ha and accommodates total population of 12, 87,000 ¹.

Data used: During the study of LULC, the satellite data of the months from October to January for the years 2005, 2011 and 2016 other ancillary data i.e. Municipal Corporation boundary and ward maps as obtained from Rajkot Municipal Corporation office had been used. To initiate the study, the satellite imageries (LISS-IV) have been procured from the National Remote Sensing Centre (NRSC) and furthermore ERADAS software has been used to digitalised imageries (Fig.8). The assessment of LULC change was carried out using remotely sensed data and imageries collected from NRSC from October to January for the years 2005, 2011 and 2016 (Fig.8). The details of satellite data used are given in table 1.

To assess change in LULC, more than a decade (2005-2016) duration was targeted in which three years i.e. 2005, 2011 and 2016 satellite imageries at 5 years interval were taken to consider for interpretation. In the satellite imageries, tone, texture, shape, location and associated features are key elements that can provide clue towards detection and identification during image interpretation (Table 2). All three years imageries have been geo-referenced using vector layer and all 5 important categories (Table 2) such as dense

tree cover, open tree cover, built-up area, open land area and water spread area of river/water body/canal were extracted from geo-referenced imageries (Table 2).

During the analysis of satellite imageries, latest boundary maps were superimposed on all three years imageries which were collected from the office of Rajkot Municipal Corporation. Before satellite imagery processing and classification, a detailed field survey was undertaken in the

study area using Global Positioning System (GPS) instrument. The ground truthing was done to know the real status of land use in the areas of Rajkot Municipal Corporation which has been categorised in 5 classes included dense tree cover, open tree cover, built-up area, open land area and river/water body/canal as shown in table 2. The methodology is also described in the chart given in fig. 2.

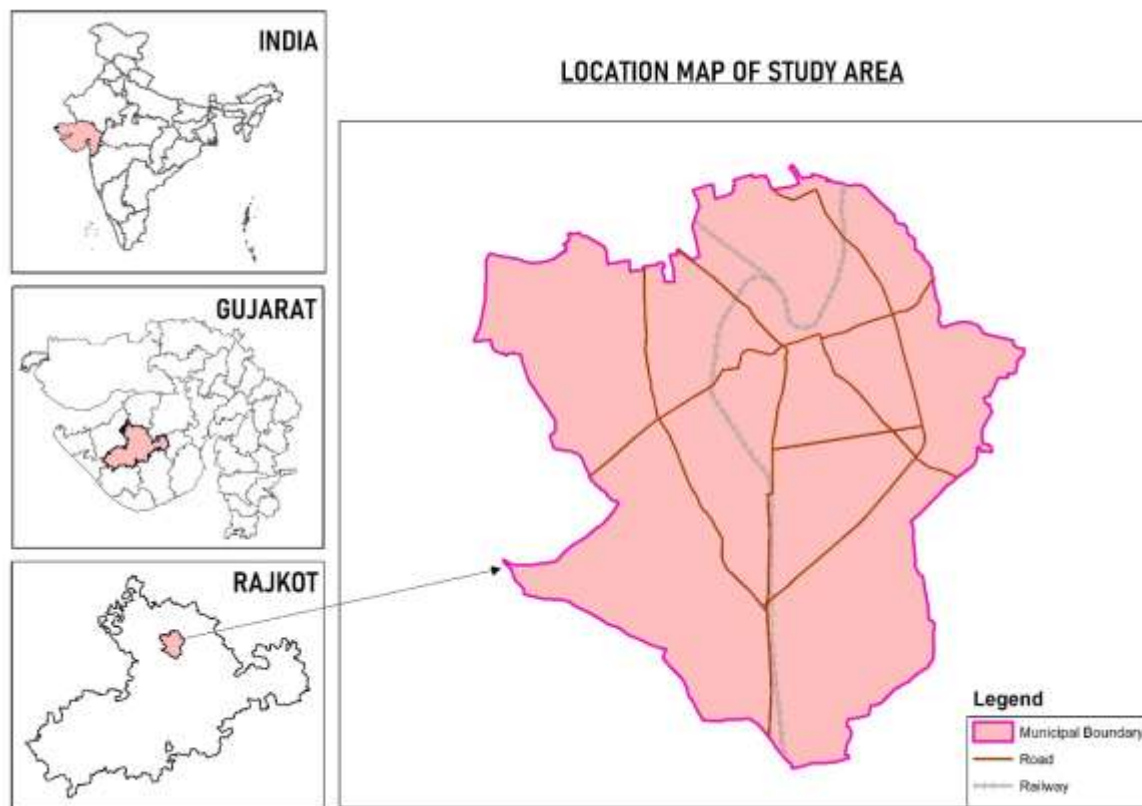


Fig. 1: Location of Rajkot Municipal Corporation

Table 1
Data used during the study

Satellite	Product	Path/Raw	Month, Year
IRS-P6	LISS-IV	202-82	19-October-2005
IRS-P6		202-83	19-October-2005
Resourcesat2		91-56C	06-December-2011
Resourcesat2		91-56D	12-November-2011
Resourcesat2		91-56C	02-January-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	Constructions (Residential, industrial, commercial infrastructures etc.)
4	Open land	Vacant land
5	Water body	Water spread area of Pond/lake/River/Canal/reservoirs etc.

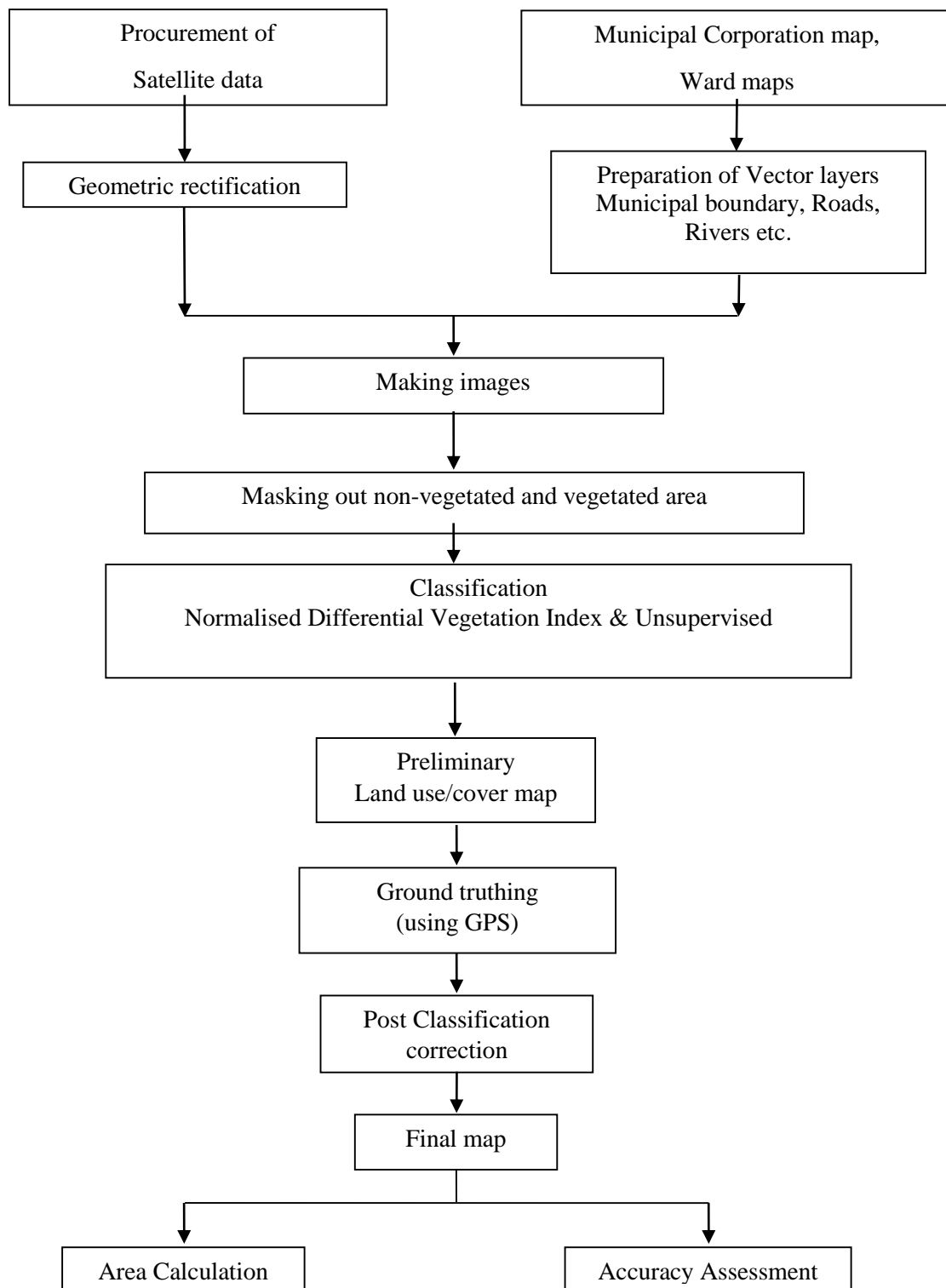


Fig. 2: Flow chart of methodology

Results and Discussion

An investigation and analysis of imageries for the decade from 2005-2016 showed gradual increase of built-up area in Rajkot Municipal Corporation whereas other categories of LULC such as open land/area and water spread area of River/water body/canal showed gradual decline of area during this period. However, dense tree cover and open tree cover showed fluctuation in their respective cover in each years as presented in table 3. In addition, the detail of

changes in LULC categories of Rajkot Municipal Corporation are described in the table 3.

Dense Tree Cover: Year wise analysis of dense tree cover revealed that the dense tree cover in the years of 2005, 2011 and 2016 were found to be 158.98 ha, 117.14 ha and 125.8 ha respectively which got declined by 41.85 ha between the years 2005-2011 and increased by 8.66 ha between the years from 2011 to 2016. Moreover, the analysis showed an

overall decline in dense tree cover by 33.18 ha which constitutes about 20.87%. Fig. 3 reflects that R^2 value is more than 50% ($R^2 = 0.56$) meaning thereby that there is average difference of observed data in dense tree cover from 2005 to 2016 in Rajkot Municipal Corporation. The decline of dense tree cover was noted in the western part of Rajkot city while the marginal increase of dense tree cover in the year of 2016 in a scattered manner was observed throughout the city. Tree species recorded during ground truthing were mainly *Azadiracta indica*, *Delonix regia*, *Polyalthia longifolia*, *Prosopis juliflora* and *Cassia siamea*.

Open Tree Cover: Rajkot Municipal Corporation had 257.94 ha of open tree cover in the year of 2005 which got increased by 69.25 ha to 327.19 ha during the period 2005-

2011. Later, the open tree cover of the city got declined by 11.27 ha and was recorded as 315.92 ha during the assessment year 2011 to 2016. Overall the area under this category over a decade (2005–2016) increased from 257.94 ha to 315.92 ha which constitutes 22.47%. In the observed data in fig. 4, R^2 value is 60% ($R^2 = 0.60$) which means that there are medium differences in open tree cover from 2005 to 2016 in Rajkot Municipal Corporation (Fig. 4).

Moreover, overall analysis showed the fluctuations in open tree cover from 2005 to 2016 which might be due to conversion of dense tree cover area to open tree cover area or various plantation activities carried out by Rajkot Municipal Corporation/Forest Department.

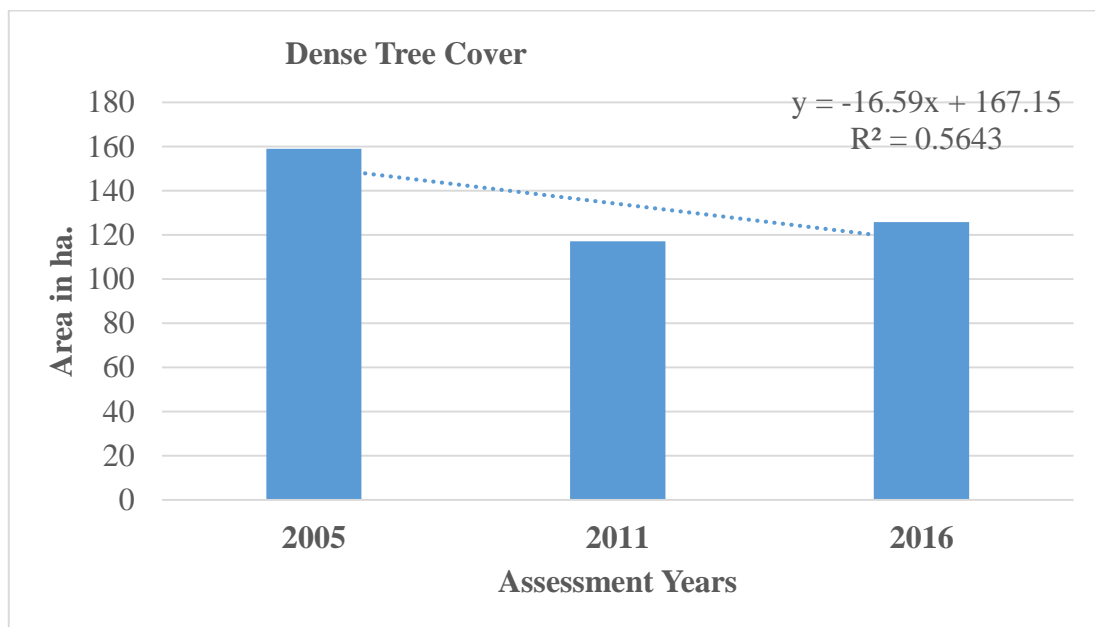


Fig. 3: Year wise graphical representation of dense tree cover Rajkot Municipal Corporation Area

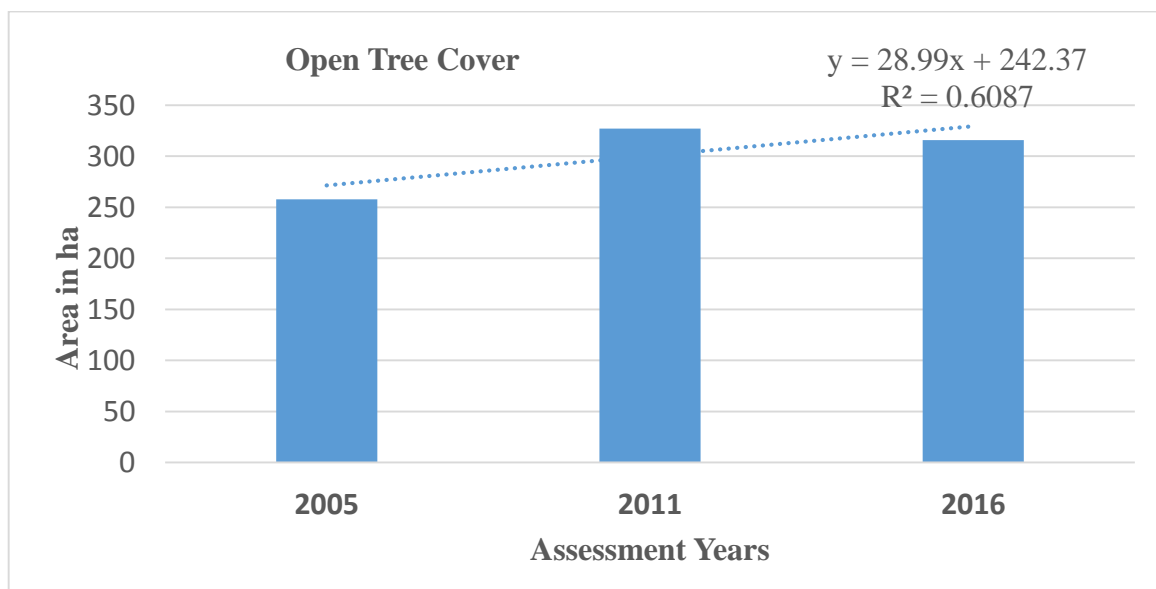


Fig. 4: Year wise graphical representation of open tree cover in Rajkot Municipal Corporation Area

Built-up Area: Built-up area is very dynamic and dependent on the population which means if population increases, then built-up area such as residential, commercial and industrial etc. also automatically increases. In the current assessment from the year 2005 to 2016, there has been regular increase of built-up area in each assessment year. During the year of 2005 -2011, the built-up area got increased by 72.8 ha and took total net built-up area to 1273.54 ha from 1200.74 ha. The increase of built-up area by 125.33 ha was noted in next assessment year also taking total built –up area to 1398.87 ha during the year of 2016 from 1273.54 ha during the year of 2011. An overall analysis of built-up area showed an increase of 198.13 ha (16.50%) from 1200.74 ha in 2005 to 1398.87 ha in 2016. Year wise analysis (Fig. 5) of built-up area showed $R^2 = 0.97$ (97%) indicating smaller differences in observed information of built up area from 2005 to 2016 in Rajkot Municipal Corporation (Fig. 5).

Image interpretation of Rajkot Municipal Corporation showed that notably, built-up expansion has taken place mostly on northern and southern sides of the Rajkot city which might be due to rapidly growing demand of houses, shops and technological advancements.

Open land: The open land area includes vacant land without non-agricultural development. In Rajkot Municipal Corporation, a total of 8405.57 ha area was recorded under the open land category in the year 2005. An analysis of imageries showed a decline of 60.60 ha area under open land category during the period from 2005 to 2011 which means the open land area got declined to 8345.52 ha in 2011 from 8405.57 ha of 2005. Furthermore, overall analysis showed 66.16 ha declined status over the decades (2005-2016) which constitute about 0.79%.

Table 3
Status of LULC in Rajkot Municipal Corporation

S.N.	LULC Categories	Years (Area in ha)			Chang over period of time (Area in ha)		
		2005	2011	2016	2005-2011	2011-2016	2005-2016
1	Dense Tree Cover	158.98	117.14	125.80	-41.85	8.66	-33.18
2	Open Tree Cover	257.94	327.19	315.92	69.25	-11.27	57.97
3	Built-up Area	1200.74	1273.54	1398.87	72.80	125.33	198.13
4	Open Land/Area	8405.57	8345.52	8339.38	-60.06	-6.13	-66.19
5	River/Water Body/Canal	376.76	336.62	220.03	-40.15	-116.58	-156.73
Total		10400	10400	10400	-	-	-

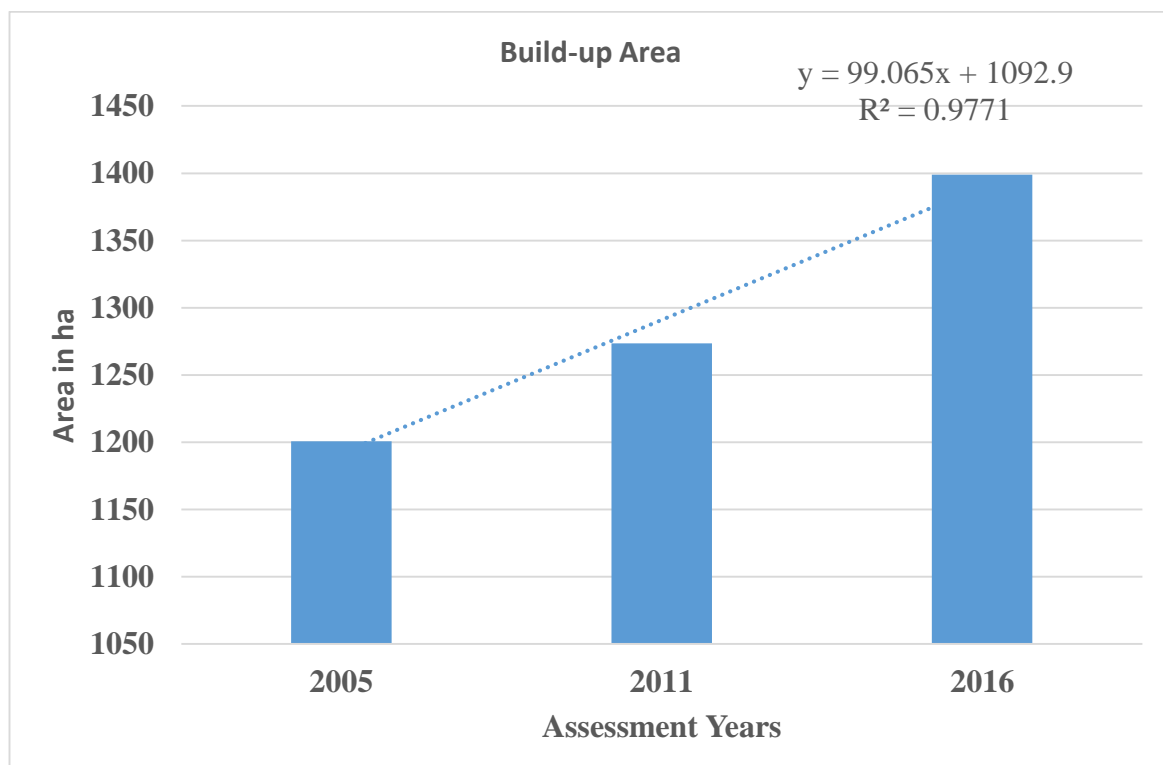


Fig. 5: Year wise graphical representation of built-up area in Rajkot Municipal Corporation Area

Year wise analysis reflected R^2 value = 0.81 (81%) which means there are smaller differences in information (Fig. 6) of open land cover from 2005-2016. The declines of open area continuously from 2005 to 2016 might be due to growing demand of land for residential, commercials, institutional buildings etc.

Water bodies –water spread area: Water bodies are also very important and dynamic components in LULC categories which include river, stream, lakes, ponds etc. In Rajkot Municipal Corporation area, Aji River and Aji dam are considered the main water bodies. Year wise analysis showed that water spread area of all these water bodies

declined from 376.76 ha to 336.62 ha during the period from 2005 to 2011 and it further declined from 336.62 ha to 220.03 ha during the period from 2011 to 2016 (Table 2).

Overall the area under this category over a decade (2005 – 2016) declined by 156.73 ha i.e. from 376.76 ha to 220.03 ha which constitutes about 41.60% (Table 2). Fig. 7 reflects R^2 value 0.92 (92%) which means that there are smaller differences in year wise information (Fig. 7) of water bodies cover of Rajkot Municipal Corporation. The changes in the water spread area of water bodies may be due to variation in drainage patterns or diversion of water bodies for other purposes.

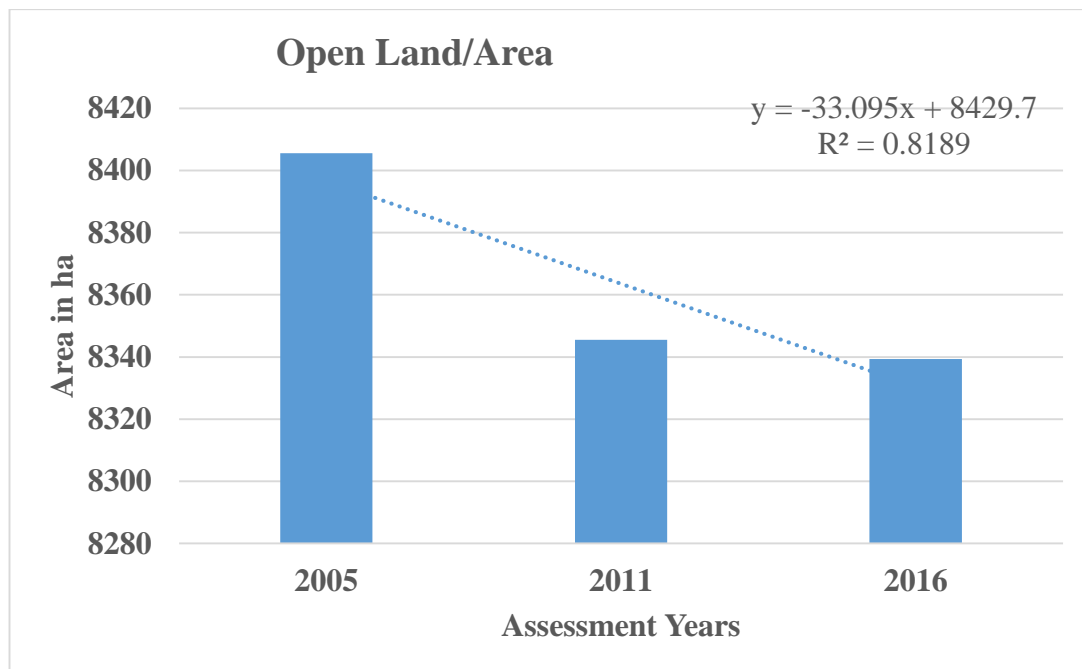


Fig. 6: Year wise graphical representation of Open land area in Rajkot Municipal Corporation Area

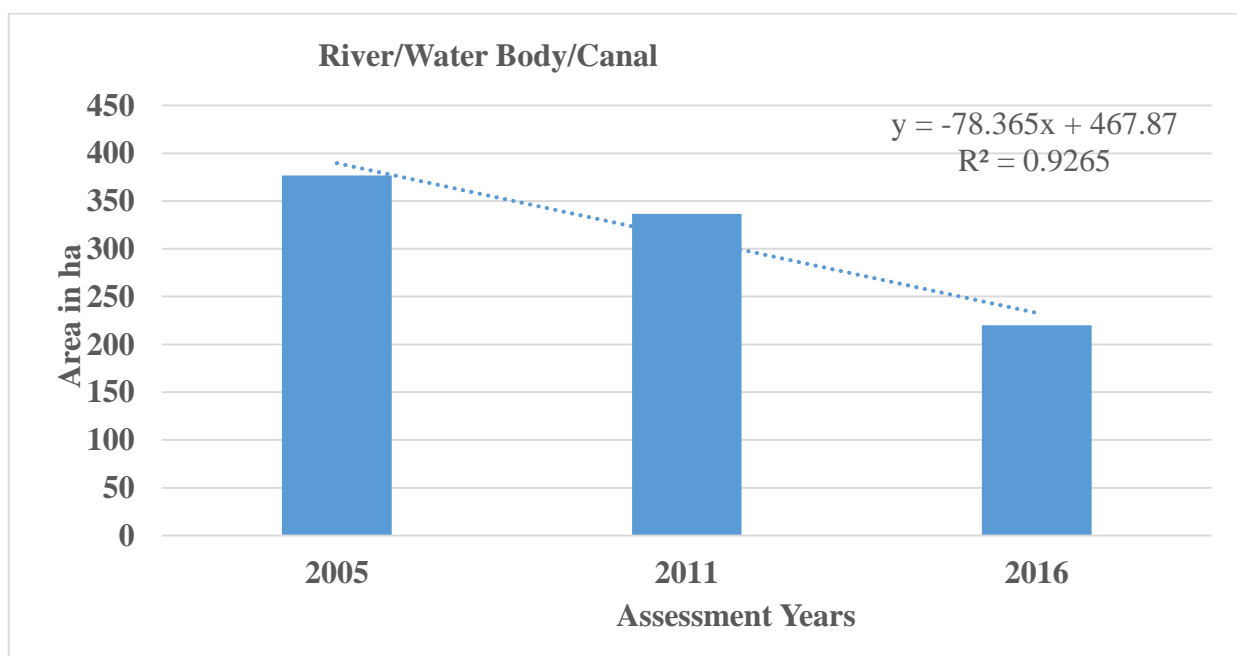


Fig. 7: Year wise graphical representation of Open land area in Rajkot Municipal Corporation Area

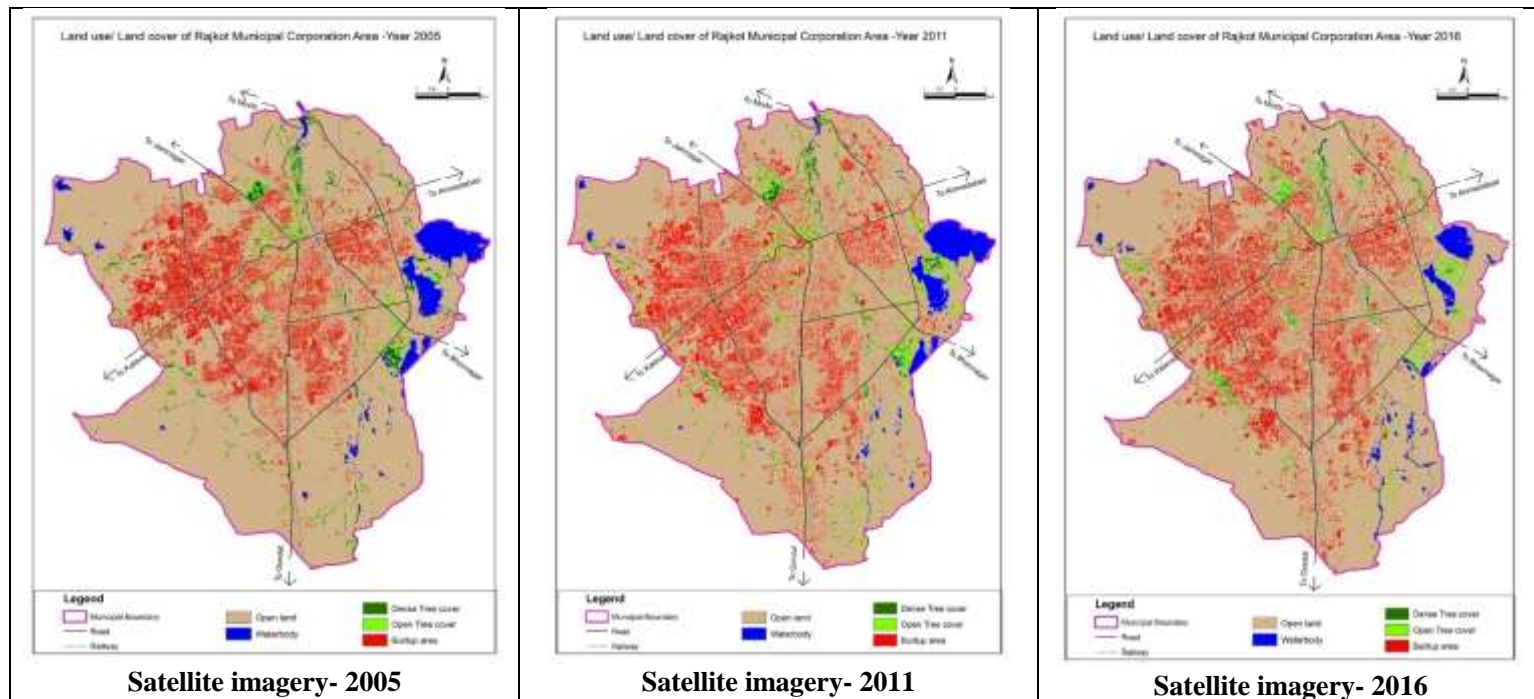


Fig. 8: Satellite Imageries of the years of 2005, 2011 and 2016 of Rajkot Municipal Corporation

Conclusion

The study revealed that LULC categories such as dense tree cover, open tree cover, built-up area, open land area and river/water body/canal area of Rajkot Municipal Corporation are dynamic in terms of its expansion or decline during the period of about a decade (2005-2016). Overall investigation and analysis showed that Rajkot Municipal Corporation has experienced fast growth of built-up area and steep decline of water bodies and open land area.

However, vegetation covers especially dense tree cover and open tree cover showed years-wise fluctuation which might be due to various plantation activities carried out by Rajkot Municipal Corporation authority, State Forest Department and other organisations. This study provides baseline information of LULC which may further be used in the improvement of urbanisation in a sustainable manner by town planners of Rajkot city. More notably, there is a need for control on random built-up increases especially in water bodies and other open land areas.

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