

# Application of Remote sensing and Geo-Spatial Techniques for Land use Land Cover Mapping and Change Detection of Bhavnagar Municipal Corporation Area, Gujarat

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## ABSTRACT

### Article Info

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Remote sensing and Geographic Information System (GIS) are one of the detailed and useful ways to develop land use classification maps. It vastly improves the selection of areas designated as forest, tree cover, industrial and/or urban zones of a region. The present study has been carried out in Bhavnagar Municipal Corporation (BMC) to detect change in land use land cover from 2005 to 2016, as new developments (agriculture, commercial, industrial and urban) are emerging from time to time. Maps and land records obtained from Bhavnagar Municipal Corporation and the remote sensing data of Resource Sat-2, LISS-IV for the year 2005, 2011 and 2016 data were used for interpreting the quantitative data of spatial and temporal dynamics in the study area. Based on geographical conditions, remote sensing data and field survey, the study area was classified into seven categories. The increase was observed in salt pan (+152.73%), water bodies (80.84%), dense tree cover (21.08%), open tree cover (7.21%) and built up area (38.36%), whereas, the salt affected area (63.39%) and open land area (6.50%) decreased over the study period. The driving force behind this change was economic development, rapid urbanization and industrialization along with extensive population growth.

### Article History

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**Keywords:** Bhavnagar, Change detection, GIS, Gujarat, Land use/land cover, Remote sensing

## I. INTRODUCTION

In the developing countries, population growth, migration toward urban agglomeration and the reclassification of rural areas as urban centers are the main aspects for rapid growth of urbanization[1](Erasu, D., 2017). Dynamics of growth

in urban agglomeration and land use change are of utmost consideration for ecologically achievable developmental planning. Thus, constant monitoring of the phenomena of growth and mapping and scrutinizing LULC changes are needed [2] (Treit and Rogan, 2004). Ecologists pay considerable attention to the land use change impacts chiefly with respect to its effects on biodiversity and aquatic ecosystems [3] (Butt et al., 2015). The natural and socio-economic

factors used by human beings in different time and space influences the land use land cover pattern of the region. In current times, the tremendous agricultural and population pressure is gradually increasing the scarcity of land resource [4] (Dolui et al., 2014).

Remote Sensing (RS) has been used to classify and map LULC changes with different techniques and data sets. Landsat images are widely used in the classification of different landscape components at a larger scale [5] (Ozesmi and Bauer, 2002). Remote sensing and GIS are well-established information technologies, which are broadly recognized in managing land and natural resources. To understand landscape dynamics, remote sensing and GIS is a cost effective alternative tool. The combination of remote sensing and geographic information systems (GIS), has been extensively applied as an influential and useful tool in determining land use and land cover change [6](Ehlers et al., 1990). Various studies have been conducted all over the world regarding the change analysis of tree cover and changes in land use through different methods of RS-GIS [6] [5] [7] [4] [3] [8] [9] [10] [11] [12]. Land use and land cover is continuously changing the surface of the earth. In the past few decades the conversion of forest and wood land, grass and pasture land into agricultural and pasture land has been dramatically increasing in the tropics [13] [14].

Gujarat has the fastest growing economy in India. It is also, one of the most industrialized states within the nation making it the richest state with a GDP per capita income twice that of the country as a whole. Population of Gujarat as per Census 2011 is 60383628 (Approx 6 Crore) which is around 18% rise in last 10 year. The urban population has risen from 37 per cent in 2001 to 43 per cent in 2011, making it one of the fastest growing urbanised states, according to the Census [15]. Hence, the present study area is growing at fast pace in terms of urbanization, industrialization, and population. This in turn leads to large scale

changes in Land use pattern. Land use change is a dynamic phenomenon that modifies with respect to time and space due to anthropogenic pressure and development. Evaluating the current land use and its intermittent change is convenient for urban planners, policy makers and natural resource managers and remote sensing offers an important means of detecting and analyzing temporal changes [16]. Therefore, the main objective of this study was to use RS- GIS application to determine and quantify the extent of changes in LU/LC of Municipality Corporation, Bhavnagar from 2005 to 2016 using satellite imagery and topographic map.

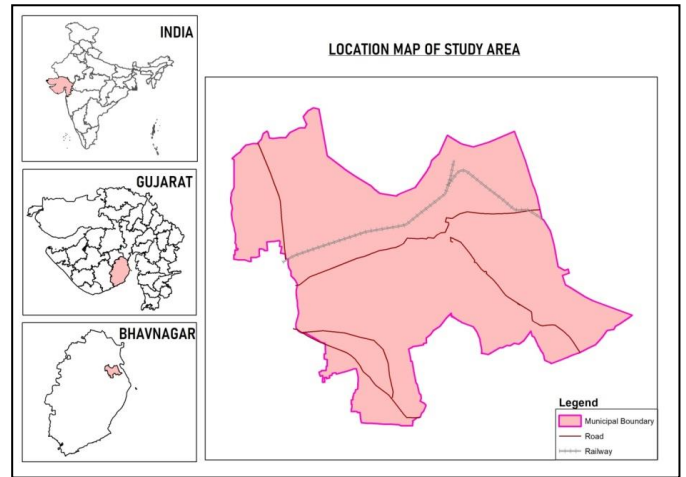
## II. STUDY AREA

Bhavnagar district is located in the south-east corner of the peninsular region of Gujarat well-known as 'Kathiawar or Saurashtra'. It lies between 21.18° and 22.18° latitude and 71.18° and 72.18° longitude situated at 25.300 mt above sea level. The length from north to south of this territory is about 151.7 kms and from east to west about 108.6 kms. It is bounded in the north by Surendranagar and Ahmadabad districts, in the west by Rajkot and Amreli districts, in the south by the Arabian Sea and part of Amreli district and in the east by the Gulf of Khambhat. The area covered by the district is 10,034.00 sq. km i.e. 5.11 percent of the total geographical area of Gujarat State. Area wise rank of the district is 6th among the districts of the state. For administrative convenience, the district has been divided into 11 talukas with total 793 villages and 21 towns. The total area of Municipal Corporation under Bhavnagar is 10800.00 ha.

Bhavnagar district forms a part of Kathiawar Peninsula and is sub-divided into four sub-micro regions, namely, Bhavnagar Coastal Plain, Palitana Savarkundla Upland, Songadh Forested Plain and Keri, Kalubhar and Ghelo Plain on the basis of topography, climate, geology, soils and natural vegetation. The

major part of the Bhavnagar region extends over the coastal areas. It remained a major port, for almost two centuries, trading commodities with Africa, Mozambique, Zanzibar, Singapore and the Persian Gulf [17].

This flourishing maritime trade resulted in the high rate of urbanization surplus wealth and cosmopolitan culture of the town. The forest area in the district is very limited and not concentrated, but scattered. Forests are found only in the hilly areas near Sihor, Palitana and Bhavnagar. According to the figures available from the Forest Department for the year 2010-2011, out of the total area of the district, an area of about 269.24 sq. km is covered by forest. It accounts for 1.41 percent of the total forest area of the state.



**Fig. 1** Study area: Bhavnagar Municipal Corporation

### III. 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 Bhavnagar 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

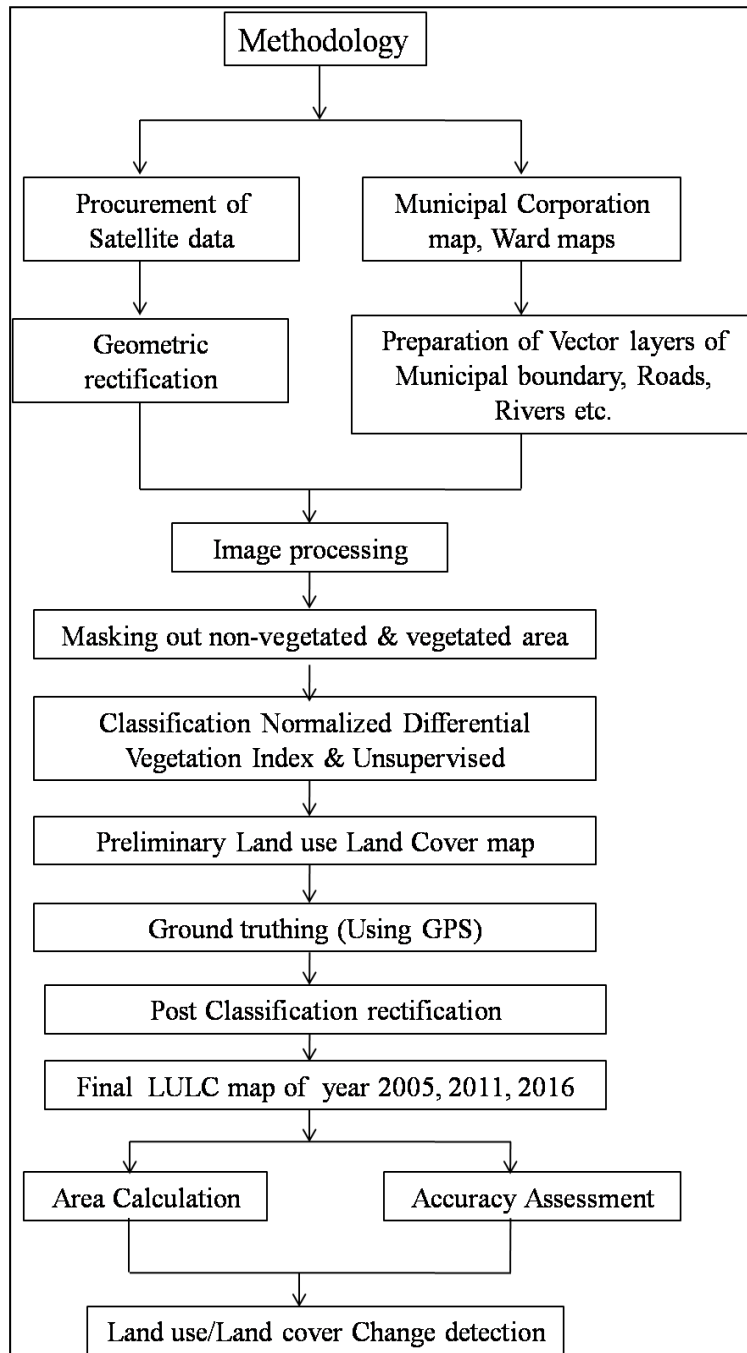
An imagery is represented with tone, texture, shape, location and associated features as inherent elements that can provide clue towards detection and identification during image interpretation. These components and ground truthing data were considered as the key to image interpretation in the present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

**Table 2.** LULC Classes considered in the study

SN	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	River/Water body	Water spread area of Pond/ lakes/River/ Canal/reservoirs etc.
6	Salt pan	Salt industries and salt works
7	Salt affected area	Saline soils

The digital interpretation method was adopted for interpreting the remote sensing data. Bhavnagar 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.



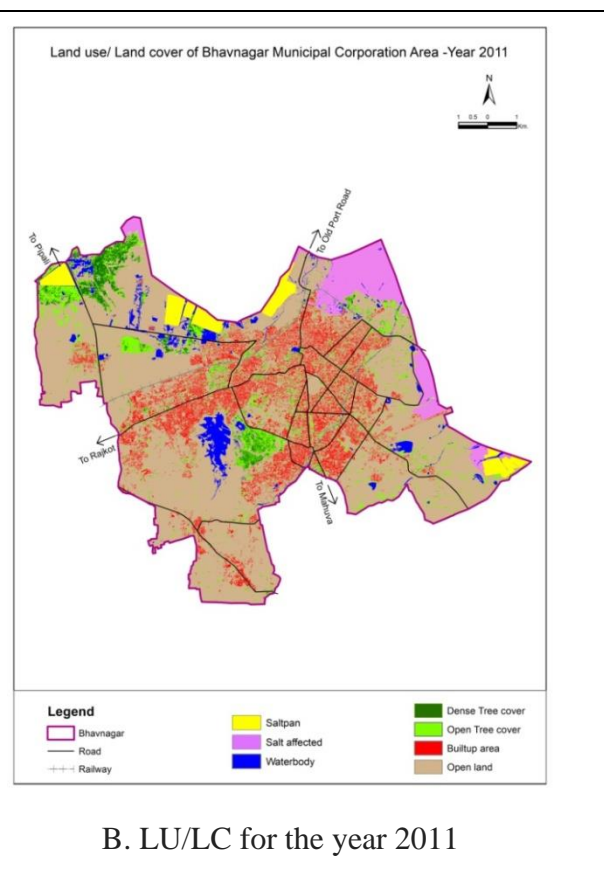
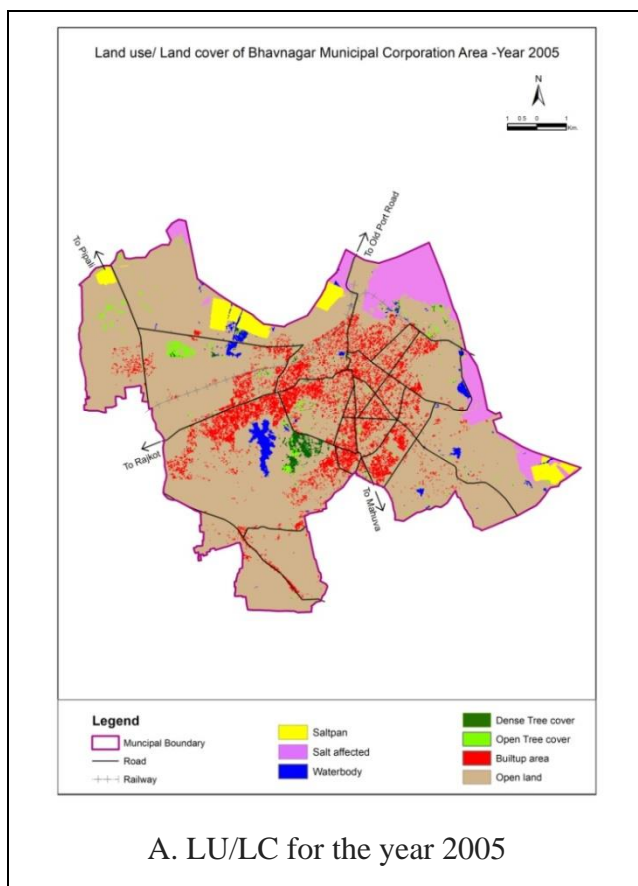
**Figure 2 :** Flow chart showing methodology for land use/land cover and change detection

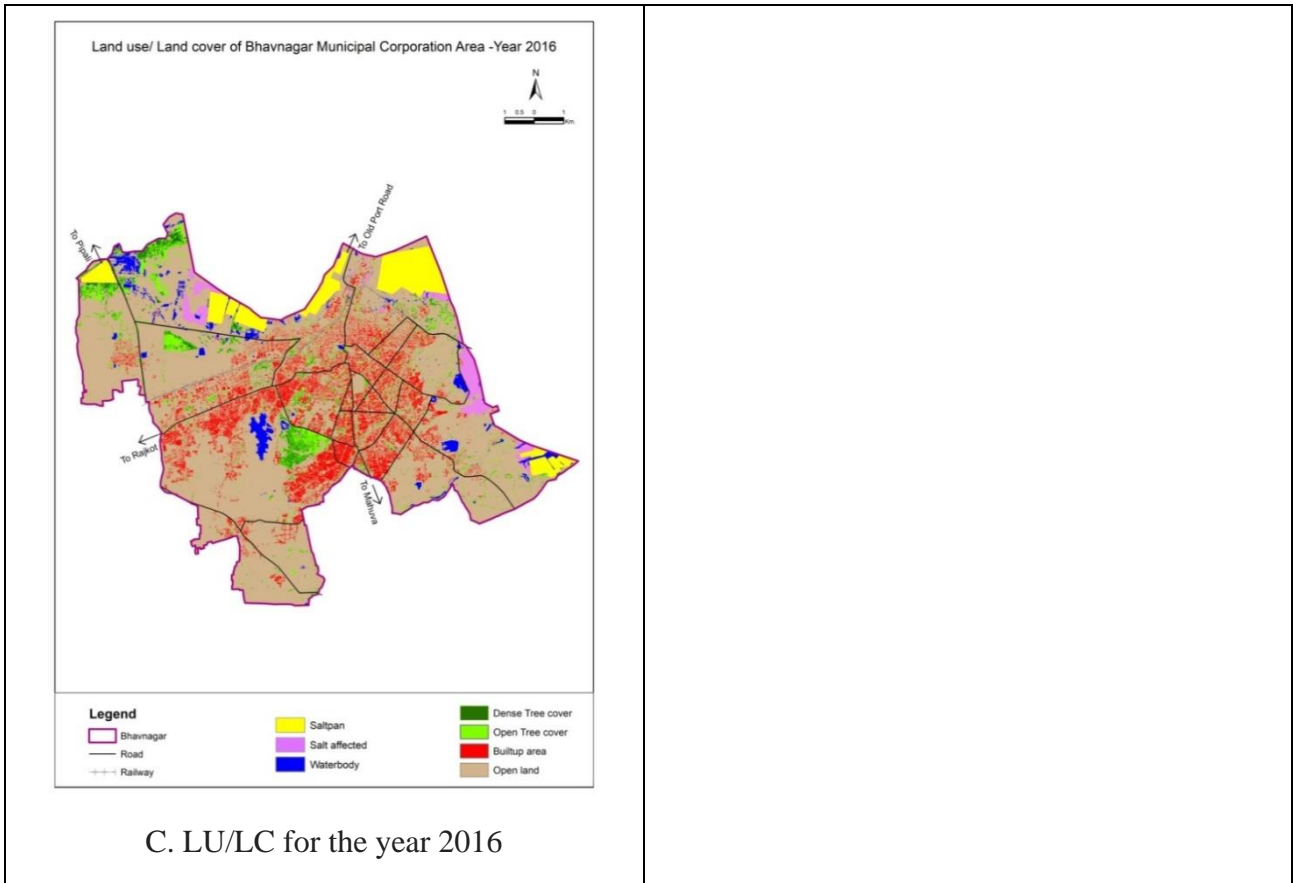
#### IV. RESULTS AND DISCUSSION

Table 3 reveals that total land cover of Bhavnagar Municipal Corporation is 10800.00 hectares. The details regarding changes occurred in land use land cover in Bhavnagar Municipal corporation over the year 2005, 2011 and 2016, have also been depicted in the table. Furthermore, the maps illustrating LULC pattern over the studied year have also been given in figure Fig. 3 (A, B,C for the year 2005, 2011 and 2016 respectively).

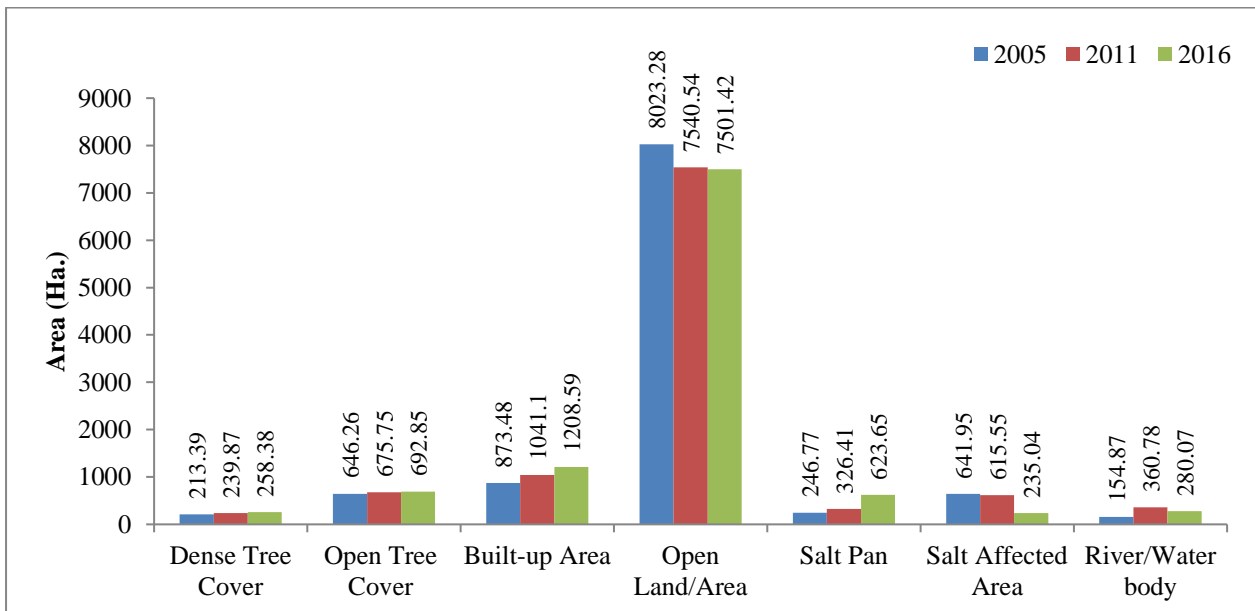
**TABLE 3. AREA STATISTICS AND PERCENTAGE OF THE LAND USE/COVER UNITS FOR THE YEAR 2005, 2011 AND 2016**

Land use and land cover categories	2005		2011		2016		Change area (ha)			% change in Area	Annual change
	Area (ha)	Area (%)	Area (ha)	Area (%)	Area (ha)	Area (%)	2005-2011	2011-2016	2005-2016	2005-2016	(%)
Dense Tree Cover	213.39	1.98	239.87	2.22	258.38	2.39	26.48	18.51	44.99	21.08	1.92
Open Tree Cover	646.26	5.98	675.75	6.26	692.85	6.42	29.49	17.1	46.59	7.21	0.66
Built-up Area	873.48	8.09	1041.1	9.64	1208.59	11.19	167.62	167.49	335.11	38.36	3.49
Open Land/Area	8023.28	74.29	7540.54	69.82	7501.42	69.46	-482.74	-39.12	-521.86	-6.50	-0.59
Salt Pan	246.77	2.28	326.41	3.02	623.65	5.77	79.64	297.24	376.88	152.73	13.88
Salt Affected Area	641.95	5.94	615.55	5.70	235.04	2.18	-26.4	-380.51	-406.91	-63.39	-5.76
River/Water body	154.87	1.43	360.78	3.34	280.07	2.59	205.91	-80.71	125.2	80.84	7.35
TOTAL	10800	100	10800	100	10800	100					

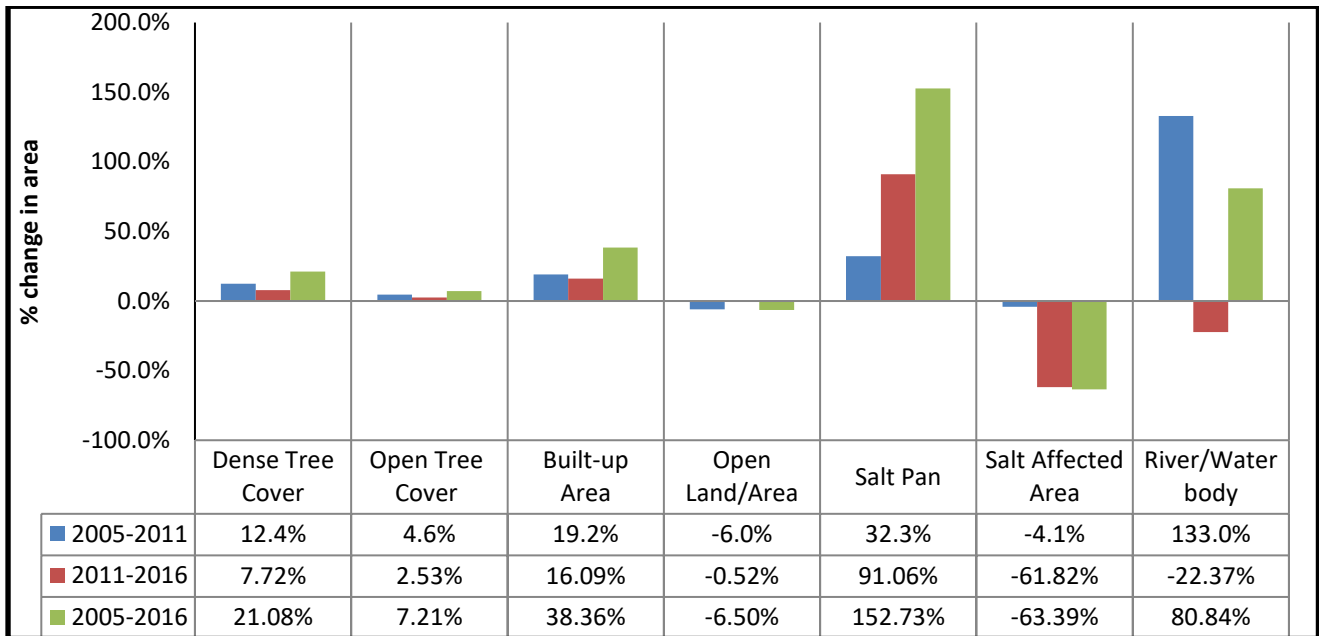




**Figure 3** A, B, C Maps showing Land use/Land Cover changes in Bhavnagr Municipal Corporation (2005-2016)



**Figure 4** Change of areal coverage (hectares) of different land use types at different intervals



**Figure 5** Change of areal coverage (%) of different land use types at different intervals

In the year 2005, dense tree cover of Bhavnagar Municipal Corporation was recorded as 213.39 hectares which increased by 26.48 hectares during the period 2005-2011 and it was recorded as 239.87 hectares in 2011. Over the period from 2011 to 2016, dense tree cover further increased by 18.51 hectares and it was recorded as 258.38 hectares in 2016 (Table 3). However, the overall increase from 2005 to 2016 was 44.99 ha. which constitute about 21.08% (Fig.5). Major changes of dense tree cover were found on north-west side of the Municipal Corporation area. Tree species mainly recorded during ground truthing were Gorad (*Acacia senegal*), Gando baval (*Prosopis juliflora*), Neem (*Azadirachta indica*), Asopalav (*Polyalthia longifolia*) etc.

The analysis of tree cover data reveals that, open tree cover increased from 646.26 hectares in year 2005 to 675.75 hectares in year 2011 and further increased by 17.1 hectares during the period from 2011-2016 and it was recorded as 692.85 hectares in year 2016 (Table 3; Fig.4). Overall the area under this category over a decade (2005-2016) increased by 46.59 ha. i.e., from 646.26 ha to 692.85 ha. which constitute 7.21% (Fig.5). Several changes in open tree cover were

mainly recorded on north-west and middle part of the municipal corporation area.

Built up area comprises of residential, commercial and industrial areas. During 2005, this area was recorded as 873.48 hectares. The area increased by 167.62 hectares during the period 2005-2011 and it was recorded as 1041.1 hectares in year 2011. Moreover, the area increased by 167.49 hectares during the period 2011-2016 and it was recorded as 1208.59 hectares in 2016 (Table 3; Fig.4). Overall the area under this category over a decade (2005-2016) increased from 873.48ha to 1208.59 ha. which constitute 38.36% (Fig 5). On the other hand, according to 2001 Census the total population of the district was 24,69,630. There has been net addition of 4,10,735 persons during 2001-2011. The decadal growth rate of the district comes to 16.6 percent. The growth rates for the rural and urban areas are 10.6 percent and 26.5 percent respectively. The growth rate of urban population is high in the district. The highest percentage of urban population to total population has been noticed in Bhavnagar taluka where population is increased to 81.7 percent during the decade (District census handbook, Bhavnagar, 2011). Hence, the swift in population growth resulted



in the rapid urbanization, growing demand of houses, shops, infrastructure, commercial spaces, and technological advancements in machinery of construction work, the built-up area increased over a time period i.e. from 2005 to 2016.

The Open land mainly includes vacant land without non-agricultural development work. The area under this category was recorded as 8023.28 hectares in year 2005, which declined by 482.74 hectares during the period from 2005 to 2011 and was recorded as 7540.54 hectares in 2011. Furthermore, in 2016, the area again declined by 39.12 hectares and it was recorded as 7501.42 hectares (Fig.4). Overall the area under this category over a decade (2005-2016) declined from 8023.28 ha. to 7501.42 ha. which constitute -6.50% (Fig. 5). As mentioned earlier, the population in this region has been increasing rapidly and more people migrate towards urban areas in search of better economic development and livelihood opportunities. The increasing demand of residential, commercial, institutional buildings etc. may have occupied the open land which resulting in remarkable decline in open area.

Gujarat owing to its long coastline is one of the highest salt producing states in the country and has produced 232.99 tonnes of salt in the year 2017-2018 (Raval, 2018). Bhavnagar is surrounded by salt water in its two directions i.e. by Gulf of Khambhat in east and by Arabian Sea in the south. The Salt pan area mainly includes land covered with salt and minerals and can be defined as natural or manmade depression in which salt water gathers and leaves a deposit of salt on evaporation. Important minerals available in the district are Lime Stone, Bentonite, White Clay, Dolomite, Atta Pulgite Diatomaceous earth. Trap Rock etc. Huge deposits of lignite are also available in Ghogha and Bhavnagar Talukas [18]. During 2005, this area was recorded as 246.77 hectares. The area increased by 79.64 hectares during the period 2005-2011 and it was recorded as 326.41 hectares in year

2011. Moreover, the area further increased by 297.24 hectares during the period 2011-2016 and it was recorded as 623.65 hectares in 2016 (Table 3; Fig.4). Overall the area under this category over a decade (2005-2016) increased from 246.77 ha. to 623.65 ha. which constitute 152.73% (Fig.5). It is recorded that, in Bhavnagar Municipal Corporation, the salt pan area increased by more than three times during the period of 2011 to 2016 as compared to 2005 to 2011. The increase of salt pan area was recorded mainly in north-west side of this municipal corporation area.

Salt affected areas are widespread over the arid and semi arid regions of India. The climate of this district is characterized by hot summer and general dryness except in the coastal region. Salt-affected areas are mainly characterized by presence of high concentrations of salts in the soil. The area under this category was recorded as 641.95 hectares in year 2005, which declined by 26.4 hectares during the period from 2005 to 2011 and was recorded as 615.55 hectares in 2011. Furthermore, in 2016, the area again declined by 380.51 hectares and it was recorded as 235.04 hectares. Overall the area under this category over a decade (2005-2016) declined from 641.95 ha. to 235.04 ha. which constitute 63.39% (Fig.5). The salt affected area in Bhavnagar Municipal Corporation, declined by more than at the rate of fourteen times during the period of 2011 to 2016 as compared to 2005 to 2011. In this category the decline of area may be due to conversion of salt affected area to salt pan area.

Water body includes river, stream, lakes, ponds etc. Water spread area of water bodies increased from 154.87 ha. to 360.78 ha. during the period from 2005 to 2011 and declined from 360.78 ha. to 280.07 ha during the period from 2011 to 2016 (Table 3; Fig.4). Overall the area under this category over a decade (2005-2016) increased from 154.87ha. to 280.07ha. which constitute about 80.84% (Table 3; Fig.4). 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 5. The Municipal Corporation of Bhavnagar had shown increase in the Dense tree cover and Open tree cover by 21.08% and 7.21% respectively, despite of increase in built up area by 38.36%. Urban growth may have positive or negative impacts on environment but unplanned growth of urban areas always has negative effects (Hassan et al., 2016). However, increase in tree cover area along with increase in built up area reveals that BMC (Bhavnagar municipal corporation) has put several planned policies in developmental activities. BMC is very well known for the managing the city by using private sector participation as well as introduction of innovative mechanism in management to serve people efficiently. City has prepared different plans for improving services and to nullify gap between services and demands (<https://www.bmcgujarat.com/AboutBMC.aspx>). Salt industry and related infrastructural developments are on the increase for last two decades in coastal belt of Gujarat [19], consequently the present study also revealed increase in the saltpan area by 152.73% which is highest among all the land use land cover classes. As the salt pan area gets peaked up, there was a decline in salt affected areas by 63.39%. It was also observed that, the open land area during 2005-2016, declined by 6.50%, due to emerging developmental projects in the BMC.

## V. CONCLUSION

The present study has taken efforts to identify the change detection of land use land cover by using digital image processing technique (Rs-GIS) for the year 2005– 2016 for Bhavnagar Municipal Corporation. LULC changes in present study area are

governed by a combination of environmental, geographical and socio-economic factors. The census data indicated the rapid population growth during the study period. The rapid population growth in urban areas was mainly due to migration of people from rural to urban areas. However, increase in dense tree cover and open tree cover along with increasing built up area, indicates the good planning strategy of the BMC. Besides this, the study showed substantial reduction in salt affected area and open land area as well as considerable increase in the saltpan area. The major driving force behind this may be the emerging opportunities and industrial development in the study area.

The data available in this study would provide critical input to decision-making of ecological management and environmental planning for future. It can also be useful to the Urban developers, city planners, forest department and other stake holders involved in the monitoring process.

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