Chapter V

Spatio-temporal Analysis of Land Use/Land Cover

5.1 Introduction:

The changing pattern of land use and land cover of the earth's surface reflects the interrelationships of physical processes and the pattern of productivity of land, ecological status and the biochemical and hydrological cycles. Land cover is constantly moulded and changed by land use, for example, vegetation is converted into pasture or cropland. Land use refers to the use of land in different manners. On the other hand, Land cover is "the biophysical state of the earth's surface and immediate subsurface" (Turner et al., 1994). It also depicts the physical condition of the ground surface such as vegetation, soil, rivers, ponds, lakes etc.

Land use is associated with human activity and it also involves land management and modification of natural resources and the environment. Therefore, land use is defined as the utilization of land by human beings. The natural landscapes are converted into other land uses for various purposes for example agriculture, industrial activities, recreational and residential. Land use and land management practices have a major impact on natural resources including water, soil, nutrients, animals and plants. The most recent significant effects of land use include water pollution, urban sprawl, soil erosion, soil degradation, salinization and desertification. Land is utilized for spatial and economic development in different levels-local, regional and global. Land cover in any region is associated with local climate, landforms and these are altered but by the human actions.

Land use/land cover changes play a major role in deriving information of the conversion of vegetative areas into other uses. Climate has been recognized as a contributing factor to this phenomenon and also 33% rise in the rise in atmospheric $C0^2$ since 1850 (Stuiver, 1978) has been noted, the use of CO^2 is considered a prominent factor in the loss of biological diversity (Rudd, 2011). Further in developing countries overgrazing and other agricultural practices are considered to be a cause of land degradation and desertification (Abdi et al., 2013; Leena, 2014). Thus, land use and land cover reflect physical as well as human aspects over the surface.

The changing information is important for modelling, policy making, monitoring and sustainable development. Land use changes with increase of population, industrialization and urbanization. The three directly exerts pressure on the land and as a result pernicious effects on the environment is observed such as soil erosion, air, land, water quantity, climate change and loss of biodiversity (Giri et al., 2003). Foody, (2002) stated that land cover changes is an important component in the environment which is a serious threat to the ecosystem.

Industrialization determines the level of development and at times have detrimental effects on the environment, such as generation of industrial waste water and effluent causes widespread organic and toxic pollution and eutrophication (Q. Wang & Yang, 2016). Therefore, land cover monitoring is very important as it provides information and knowledge of natural resources in temporal basis. Land use changes induced by the natural and human factor disturb global cycles like carbon, nitrogen, hydrological, oxygen and flora, fauna, various plant species and climate change.

Coastal zone is a transitional zone where land and water interact, in which processes land use directly affect the oceanic ecosystem and uses and vice versa. In general, coastal areas are extremely dynamic and experience rapid change (Ministry of Earth Science, 2009; S et al., 2011). Coastal zones have concentration of population, development of industrialization and tourism, abundance of coastal ecosystems like mangrove forest etc. In contrast, discharge of industrial waste, and municipal sewage increase the temperature of water (Abbaspour et al., 2005) and affects the aquatic ecosystem.

5.2 Review of Literature:

Adepoju et al., (2006), has made an attempt on, “Land Use/Land Cover Change Detection In Metropolitan Lagos (Nigeria)”. This study focused on rapid urbanization in few cities. Remote Sensing and GIS were used to monitor the change from 1998 to 2002. The data products used for the study were Landsat TM, Landsat ETM, SPOT-PAN and post-classification approach was used to analysis. The results of the study stated that forest, low density residential and agricultural land uses were most threatened in this period.

Anil et al., 2011, has focused on the “Studies on Land use/Land cover and Change Detection from parts of South West Godavari District, A. P. – using Remote Sensing and GIS Techniques”. In this study, land use/land cover analysis has undertaken between 2000 to

2010. The study was accomplished through Remote Sensing Techniques and Satellite Data (Landsat, IRS-1D-LISS-III and SOI toposheets). Satellite data was processed in ArcGIS 9.2 and ERDAS IMAGINE 9.1. The main land use classes were agricultural land, aquaculture tanks, settlements, rivers, drains, mangroves, mud flats etc. Later Change Detection Techniques was done for the images to find out the changes in the study area and feature classes were identified through visual interpretation. Huge transformation was noticed in the category of aquaculture tanks (33.02%) and agricultural land (25.66%) but no significant changes were observed in classes of natural streams/rivulets, mangroves etc. Agricultural lands and aquaculture tanks indicated a decreasing trend whereas fallow land and areas under mixed plantations and settlements indicated an increasing trend. The reasons attributed for this were changes in the pattern of agriculture and increased urbanization.

Brahmabhatt et al., (2000), has proposed, "Land Use/Land Cover Change Mapping in Mahi Canal Command Area, Gujarat, Using Multi-Temporal Satellite Data". This analysis mainly focused on temporal changes (1988-89 to 1997) in Mahi Right Bank Canal using Remote Sensing and GIS methods and outcome stated that the study area was saturated with salinity and agricultural land was converted into the urban zone.

Chauhan & Nayak, (2005), studied, "Land Use/Land Cover Changes near Hazira Region, Gujarat Using Remote Sensing Satellite Data". This study was based on geospatial data, processed in ArcGIS 9.2 software. It stated that the coastal ecosystem was affected because of enhanced industrialization.

Da Silva et al., 2020, has made an attempt on "Land Use/ Land Cover (LULC) Mapping in Brazilian Cerrado Using Neural Network With Sentinel-2 Data". This study analysed multispectral Images (Sentinel-2A & Sentinel-2B) and applied artificial neural network methods for extracting land use land cover mapping. This technique was successfully applied in thematic classification with high accuracy level (Kappa coefficient 0.77). Finally, little confusion was seen in pasture and crop land classes because the signature characteristics of both the categories are quite similar.

Fallati et al., (2017), "Land Use and Land Cover (LULC) of the Republic of the Maldives: First National Map and LULC Change Analysis Using Remote-Sensing Data." This study stated that environmental impact is observed on fragile coral reef habitat because of human intervention. Digital Globe's Worldview 1 and 2 satellites were used and nine land-use classes and 18 subclasses were generated. Accuracy assessment and post-classification comparison depicted the growth of built-up and agricultural areas.

Fan et al., 2007, has proposed a study on, "Land use and Land cover change in Guangzhou, China, from 1998 to 2003, based on Landsat TM/ETM+ Imagery". This study examined the global environment in developing countries through land use/land cover analysis. Landsat TM/ETM+ Images of the dry season were taken to detect LULC patterns in 1998 and 2003. LULC changes during this period was detected. Post classification methods was used to extract the changes in land uses. The results have showed that urban expansion increased in five countries.

Fonji & Taff, (2014), have analyzed a study on, "Using Satellite Data to Monitor Land-Use Land-Cover Change In North-Eastern Latvia". In the present study, the study area was classified into six categories. The main objectives of the research was to classify, examine and detect changes for Land use. Both physical data as well as socio-economic demographic data was used in the work.

Jayakumar & Arockiasamy, (2003), carried out a study on, "Land use/land cover mapping and Change Detection in part of Eastern Ghats of Tamil Nadu using Remote Sensing and GIS". This paper analysed land use/land cover, using IRS 1C LISS III Digital data and Landsat TM, during 1990 to 1999 and toposheet of the same year was also considered. 467 ha increase was observed in single crop category and about 434 ha decrease was noted in land with or without scrub category. The results stated that cropland was converted into the scrubland. This analysis successfully identified the agricultural land for better economic development.

Kumar et al., (2019), has examined the, "Effect of Land Use Changes on Water Quality in an Ephemeral Coastal Plain: Khambhat City, Gujarat, India". This paper stated that anthropogenic activities have exerted irreversible changes on natural resources. The outcomes will help policy making and decision to understand the trend of groundwater development and take timely mitigation measures for its sustainable management.

Mallupattu & Sreenivasula Reddy, (2013), proposed a study on, "Analysis of Land Use/Land Cover Changes Using Remote Sensing Data and GIS at an Urban Area, Tirupati, India". The present study was intended to determine the changes in urban area from 1976 to 2003. Remote sensing and GIS techniques were used in these studies. The study area was classed in eight categories and it was analysed that built-up area, open forest and plantation increased whereas agricultural land and dense forest decreased due to the urbanization.

Miheretu & Yimer, (2018), analysed a study on, "Land Use/Land Cover Changes and their Environmental Implications in the Gelana Sub-Watershed of Northern Highlands of Ethiopia". This study examined the spatial and temporal land use/land cover (LU/LC) changes and their environmental consequences between 1964 and 2014 in the Gelana sub watershed. The results stated that over the period of analysis few catergories expanded due to the population growth, demands of agricultural products and rural settlements for fuel extration and constructional purposes. LULC information helps in land management, policy making and preservation of natural resoureces.

Mishra et al., (2020), examined the study on, "Land Use and Land Cover Change Detection Using Geospatial Techniques in the Sikkim Himalaya, India". In this study, three (1988–1996, 1996–2008 and 2008–2017) time periods were considered. Landsat TM and Sentinel data was used for land use classification. The outcome of this investigation revealed that the major land use in the watershed was forestry. Further, it stated that there is a need of policy implications for the sustainable land-use/cover practices in the Sikkim Himalaya.

Misra & Balaji, (2015), made a study on, "A Study on the Shoreline Changes and Land-Use/Land-Cover along the South Gujarat Coastline". This study evaluated the decadal changes in historical shoreline changes, using satellite images of Landsat TM, ETM and OLI. The LU/LC was carried out in order to identify the various classes in this region which were vulnerable to the environmental degradation.

Mukherjee & Singh (2020), had carried out a study on, "Assessing Land Use–Land Cover Change and its Impact on Land Surface Temperature Using LANDSAT Data: A Comparison of Two Urban Areas in India". This study investigated the spatial and temporal changes in land use and patterns of vegetation and its impacts on Land Surface Temperature (LST) in two Indian cities (Surat and Bharuch, South Gujarat). Three-year satellite data (1998, 2008 and 2016) had been procured for the estimations and correlation. The overall accuracy land use/land cover change analysis of the classified images for Surat city was 89.49%, 91.96% and 94.20% for 1998, 2008 and 2016 years respectively. In Bharuch district, the overall accuracy of the classified images was 95%, 96% and 98% for the years 1998, 2008 and 2016 respectively. It was concluded, that in this period there was an increase in built up area and its impact was noted on climate and consequently in vegetation pattern. Simultaneous increase in land surface temperature and urbanization was also observed. Land management implications, systematic planning and environmental degradation were also discussed.

Rawal et al., 2020, had been made a study on, “Land Use and Land Cover Mapping- A Case Study of Ahmedabad District”, In this study, a fusion of pixel-by-pixel image classification and object based image classification were used different in platforms like ArcGIS and e-cognition respectively. Satellite imagery (LISS-IV, 2017) was used for the land use/land cover pattern analysis. In the present study, for the better accuracy, different algorithms viz., Nearest neighbourhood for object based classification in e-cognition, Developer s/w, maximum-likelihood supervised classification technique for pixel based classification, NDVI and TGI for vegetation was done extraction. The over-all accuracy of the classified map was 84.48% with Producer’s and User’s accuracy as 89.26% and 84.47% respectively. Kappa statistics for the classified map was 0.84. 100% accuracy was obtained in water class and also in Urban-Airport and Urban Plantation classes.

Shah et al., (2015), had done an analysis on, “Land Use Changes in Vagra Taluka , Bharuch District – Gujarat : An Analysis with the Application of Remote Sensing Data. March.” The paper suggested that remote sensing data and methods can be used as a reliable and scientific input for developing the coastal area in sustainable and integrated manner. It concluded that, proper land management practices would be required to maintain the ratio between coastal ecology and economic development.

Shamsudheen et al., (2005), focused on the “Land Use / Land Cover Mapping In the Coastal Area of North Karnataka Using Remote Sensing Data” IRS LISS III data was used to investigate land use/land cover and image classification and accuracy assessment was done. The study highlighted that a considerable forest area was degraded.

Wang et al., 2015, analysed a study on, “Impact of Land Use/Land Cover Changes on Ecosystem Services in the Nenjiang River Basin, Northeast China”. The primary data sets utilised in this investigation were 1:250,000 land use/land cover maps of China from 1980 to 2005. Land use/land cover types were classified into 6 level I categories and 25 level II categories. Six level I categories were reclassified in order to determine ecosystem service value for each land cover type defined in the ecosystem service valuation model: forest, grassland, agriculture, wetland, lakes/rivers, and barren land. According to the findings, the most valued land use type was forest (40.00 billion USD, or about 40.03% of total value in 1980; 38.71 billion USD, or approximately 39.70% of total value in 2005). From 1980 to 2005, the economic value of ecosystem services in the Nenjiang River Basin declined from 2.43 billion USD to around 97.2 million USD per year owing to massive land use/land cover changes under the encouraging strategy.

Xia et al., (2007) worked on the "Dynamics of Coastal Land Use Patterns of Inner Lingdingyang Bay in the Zhujiang River Estuary". In this study, coastal land use pattern was analysed using geospatial technology. This investigation showed that tidal flat and water channels were becoming narrower because of construction and growing industries.

5.3 Remote Sensing & GIS Techniques:

Remote Sensing has the ability of capturing changes of landscapes, extracting the modification of information from satellite data applying effective and automated change detection technique (Roy et al., 2002). Over the past two decades, data from earth sensing satellites have become significant in mapping the earth's surface features, managing natural resources, infrastructure managing and studying environmental change. Remote sensing and GIS is providing new techniques for advanced ecosystem and sustainable resource management (Turner Jr., 1997). The gathering of remotely sensed data (satellite imagery) facilitates the synoptic view of earth-system functions, size and patterns of landscapes and change at local, regional and global scales over time. This data also provides ecological status and the regional, national and global conservation and management of biological diversity (Parthasarathy & Natesan, 2015).

GIS is the association of computer hardware and software with capability of capturing, storing, retiring, manipulating, analyzing and displaying spatial and non-spatial information for the policy making and decision making system (Elhaja et al., 2017). GIS helps in accomplishment of various analysis on the data thus obtained from remote sensing after mapping provide the ability to measure extent and distribution of resources, analyze resource interactions and identify suitable locations for specific action and plan future events (X. Wang & Yin, 1997). Global Positioning System (GPS) helps in the ground truth verification of the land use presented by these advance technologies. One of the significant applications of GIS is of generating on the basis of spatial and non-spatial data. The integration of data from various sources (primary and secondary) provides large information/statistics on any particular object of the earth surface such as location, altitude, nature, pattern, trend etc. Every piece of data has specific geographic coordinates (e.g., latitudes and longitude) which is useful for the identification of industrials, hospitals, schools, forest area, rivers, roads, railways etc.)

5.4 Database and Methodology:

Remote sensing is the science of detection of the earth surface features and determination of their biophysical characteristics. It has been broadly employed to evaluate natural resources and environmental problems. This advance technology has ability to capture large-scale areas at once using space-borne sensor in repetitive manner. High resolution imagery and GIS techniques are effective tool for land use/land cover analysis. The study concentrates on the analysis of land use and land cover through processing of LISS III and LISS IV satellite imagery of Surat-Bharuch Industrial region.

5.4.1 Database:

In the present analysis, toposheets 46B/8, 46B/12, 46B/16, 46C/9, 46C/10, 46C/11, 46C/13, 46C/14 and 46C/15 were used and IRS-LISS-III (1997) and Resource-Sat-2 LISS-IV (2017) were used to take for thematic layers.

5.4.2 Remote Sensing Data:

For the study, data from clear and cloud free imageries was taken into consideration. The entire study area was covered in three scenes. The technical specification of IRS-LISS-III and Resource-Sat-2 LISS-IV sensor and band specifications area given below (Table 5.1,5.2,5.3)-

Table 5.1 Technical Specification of LISS III and IV Sensor

Sensor	Date of Passing	Row/Path	Spatial Resolutions	Spectral Range	No of Bands	Temporal Resolutions	Swath
LISS III	25th Feb, 1997	94/57, 93/56, 93/57	23.5 m	0.52 m to 1.70 m	4	24 Days	140 km.
LISS IV	19th Mar, 2017	93/57D, 93/56D, 93/57B	5.8 m	0.52 m to 0.86 m	3	5 Days	70 km.

Source- www.isro.gov.in

Table 5.2 Band Details- LISS III

Band Number	Spectral Range	Resolutions (m)
Band 2	0.52 – 0.59 (green)	23.5
Band 3	0.62 – 0.68 (red)	23.5
Band 4	0.77 – 0.86 (NIR)	23.5
Band 5	1.55 – 1.70 (SWIR)	23.5

Source-www.isro.gov.in

Table 5.3 Band Details- LISS IV

Band Number	Spectral Range	Resolutions (m)
Band 2	0.52-0.59 (green)	5.8
Band 3	0.62-0.68 (red)	5.8
Band 4	0.77-0.86 (NIR)	5.8

Source-www.isro.gov.in

5.4.3 Methodology:

For land use and land cover (LULC) analysis, the study area was specifically visited cultivated areas, industrial areas, river and other sites. Thereafter, present land use and land cover classes were generated and topographical maps were taken from survey of India (SOI), all collected toposheets were georeferenced. Digital image processing techniques were used for the subsequent analysis. Further, (IRS-LISS-III-1997) and (Resource-Sat-2 LISS-IV-2017) satellite images were corrected geometrically. Both satellite imagery were classified in ArcGIS 10.2 software, using on-screen digitization technique. In addition, Ground Control Points (GCP) were collected for post-field verification (Fig. 5.1).

5.5 Land Use / Land Cover:

The land use under different classes of land during 1997 to 2017 are presented in Table 5.4. Based on the field experiences a total six broad level-I classes of LU/LC including:

1. Agricultural land	2. Built-up land	3. Water bodies
4. Barren lands	5. Saltpan area	6. Others land

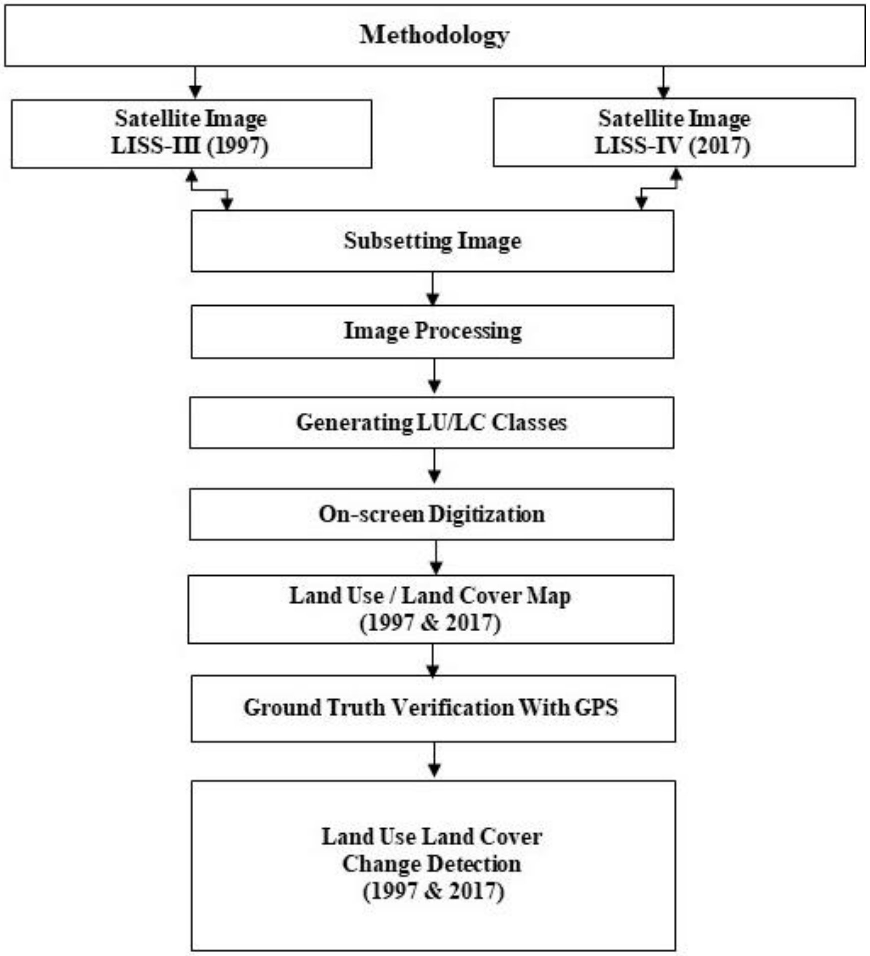

Fig. 5.1 Flow Chart of Methodology for Preparation of Land Use/Land Cover Maps (1997 & 2017)

Olpad Taluka, Surat District

5.5.1 Land Use/Land Cover Classification-1997:

In the year 1997, agricultural land (crop land and non-crop land) together occupied 78.14% of the total geographic area. The crop land was more on the north of the river Narmada largely because of the availability of fertile soil and irrigation facilities whereas the southern part was more industrialised and urbanised like Surat, Kim, Ankleshwar and Bharuch. Nearer towards the coast more cropland was noted on the western side. Built-up land accounted for 6.05% of the total area which was found to be intense in the southern part of the study area such as Sachin, Sayan, Olpad, Hazira and Surat city. Other areas which are more intense were Kavi, Jantran, Sarod, Tankari, Sarban and Jambusar City in the northern side. Vagra, Mangrol, Muler, Keshwan, Kadodara and large industrial hubs like Bharuch, Ankleshwar, Panoli, Dahej are found in the central part. Apart from these, small pockets of built-up land covered the villages of Vilayat, Karela, Ikhar, Palej, Amleshwar, Akhod, Ambhel, Kosamba, Sadhiyer, Barbodhan, Hansot etc. Water bodies occupied about 4.19% of Surat-Bharuch industrial region. Dense network of water bodies was found in the northern-western (near Mahisagar river), central (Narmada River) and southern (Tapi river) segments. However, number of ponds and lakes were found near the villages such as Kavi, Degam, Jantra, Sigam, Uber, Rampore, Tankari, Islampore, Pipalia, Kesrol, Tham, Amleshwar in Jambusar and Hansot talukas and also in the southern part of Barbodhan, Kareli, Sisodara, Piludara, Rayma, Balota and Parvat, near Surat city. Salt pans covered about 0.64% percent of the total area and it was largely observed in western part of the Jambusar and Vagra talukas in Bharuch district. Small portion was found in western portion of Hansot taluka. Saltpan is the only sea-based industry

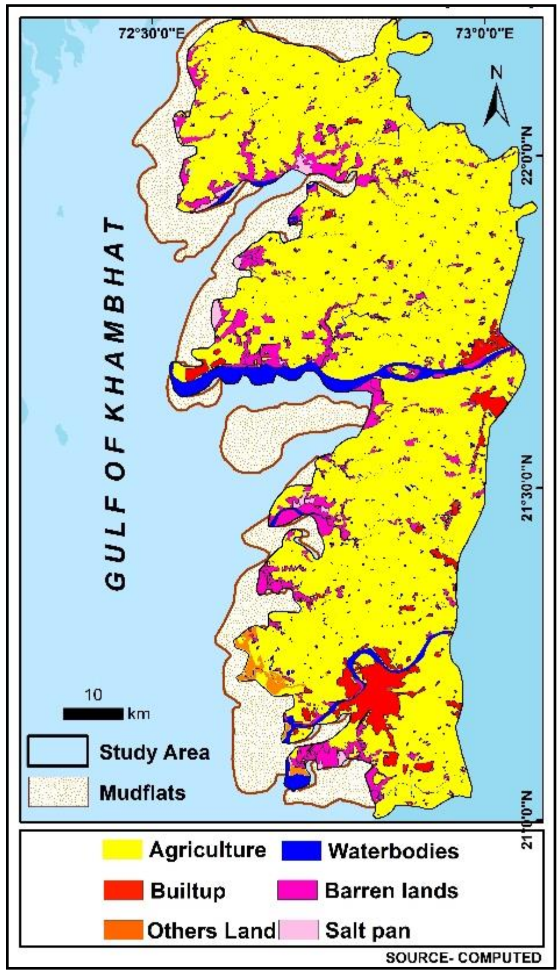

Fig. 5.2 Land Use/Land Cover of LISS-III (1997)

in the Jambusar taluka. Barren lands accounted for about 9.11% of the study area. It was largely observed in the north-western segment and as small patches along the coast. Other lands were combination of scattered vegetation and link roads joining the village settlement. They were also found in mixture with the scrub land over the entire study area in the form of small pockets and covered an area of 1.87% (Fig. 5.2).

5.5.2 Land Use/Land Cover Classification-2017:

Agricultural land occupied about 76.07% of the total geographical area and spread over the entire study area. The crop land was vastly observed in the north-central part of the study area, nearer to the river and also in the coastal zones. Built-up land accounted for 10.15% of the total LU/LC classes which was found in the southern part because of sprawling Surat city. It is surrounded by many densely populated areas such as Bhatpore, Magadalla, Surat GIDC, Paligam, Lajpur, Haripura, Kamrej, Punagam, Sayan, Gothan, Valenja, Hazira, Olpad, Kim, Kosamba, Panoli, Ankleshwar and Hansot towards south. Kavi, Jantran, Sarod, Tankari, Sarban and Jambusar City are dense areas towards the northern side. Other small pockets of built-up land were observed in the entire region such as villages of Vagra, Mangrol, Muler, Keshwan, Kadodara, Sahol, Asnad, Dumas and large industrial hub of Dahej and Jambusar. Water bodies occupied about 4.03% with two major rivers - Narmada and Tapi. The former flows in the central part and whereas, latter flows towards south. Bharuch and Ankleshwar are the two major cities along the banks of the river Narmada and on the bank of Tapi lies the Surat city. On the north, a small river Vishvamitri also flows. Between Narmada and Tapi rivers is the river Purna. Beside these major rivers, a large number of creeks are also found along the coast.

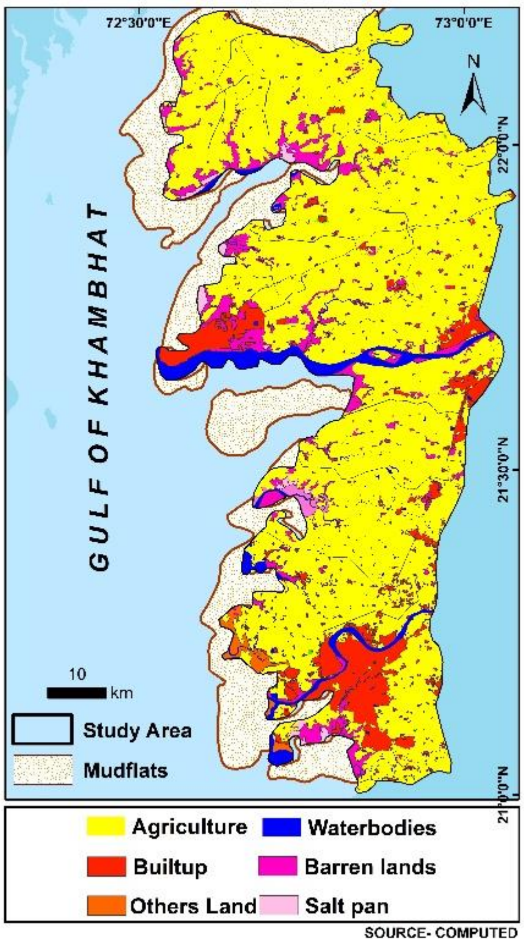

Fig. 5.3 Land Use/Land Cover of LISS-IV (2017)

Large number of surface water bodies (ponds, lakes, water tanks etc.) are observed between the two rivers and also on the south of river Tapi. The area under water body was almost stagnant throughout the two time periods. Salt pan covered about 0.64% percent of the total area and it was largely observed in western part of the Jambusar and Vagra talukas in Bharuch district. Small portion was found in western portion of Hansot taluka. Barren lands accounted for about 8.25%. It was observed in the north-western segment and small patches also were observed all over the region. 0.82% of the study area was occupied by ‘others’ which consisted of mostly of link roads, joining the village settlement and scattered vegetation cover. They mostly occupied the western part and also small pieces of land were observed in the central part (Fig. 5.3).

5.5.3 Change Detection Analysis:

In geospatial technology, change detection is one of the significant applications. It provides with the changes in specific features over a certain time period. In this present study, after procurement detailed land use/land cover information, change detection analysis was done by using two data sets between the year 1997 to 2017 (Table 5.4).

The results of LU/LC showed that the area under agriculture land reduced from 78.14% in the year 1997 to 76.07% in 2017. The study area noted 2.07% reduction in agricultural land which had indicated encroachment of the people on the land for habitations. The threat to agricultural land eventually brings a danger on the supply of food materials and on inflation (Mengistu & Salami, 2007). Built-up land is an area of urban environment or human footprints, human uses non-agricultural land for buildings, transport and communication, water storage etc. An increasing trend was observed in between 1997 to 2017. In 1997 built-up area was 6.05% but in 2017 it became 10.15%. Increase in built-up land was by 4.10% is mainly because of rapid population growth and associated activities. In 2017, sprawl was noted in both industrial as well as urban areas. Water bodies stretched over only 4.19% of the total study area in 1997 but decreased to 4.03% in 2017. During this period minor change (0.16%) was observed. The changes in water bodies might be reason of fluctuation in rainfall or anthropogenic activities. Barren lands include gullied/ravenous lands, barren/rocky/stony/sheet rock area and land with scrubs. It showed downward trend from 9.11% in 1997 to 8.25% in 2017. This was a net decrease of 0.86%. Barren lands were lost because of conversion into agricultural lands. This change can be explained by a recent increase in agricultural activities to supply the food requirement of newly created human settlements. It was found in the western and north-western part of the study area where the unevenness of the terrain is observed. In this area, mostly barren mudflat and small vegetation cover area were converted into saltpans. However, in 1997, 0.64% of area was under salt pan but in 2017, it increased to 0.73%. This change was observed mainly in Jambusar taluka (Bharuch district) where major saltpan industries are located. The 'other land class' decreased between 1997 (1.87%) to 2017 (0.82%). This was due to the development in many sectors such as agriculture, transport, industries and settlements. (Fig. 5.4).

Table 5.4 Attribute Data of On-Screen Digitization Classification of Change Detection Images (%)

Feature Class	1997	2017	Change
Agriculture	78.14	76.07	(-) 2.07
Built-up land	6.05	10.15	(+) 4.1
Water bodies	4.19	4.03	(+) 0.16
Saltpan	0.64	0.73	(+) 0.09
Barren lands	9.11	8.25	(+) 0.86
Others land	1.87	0.82	(+) 1.05
Total	100	100	
Source- Computed			

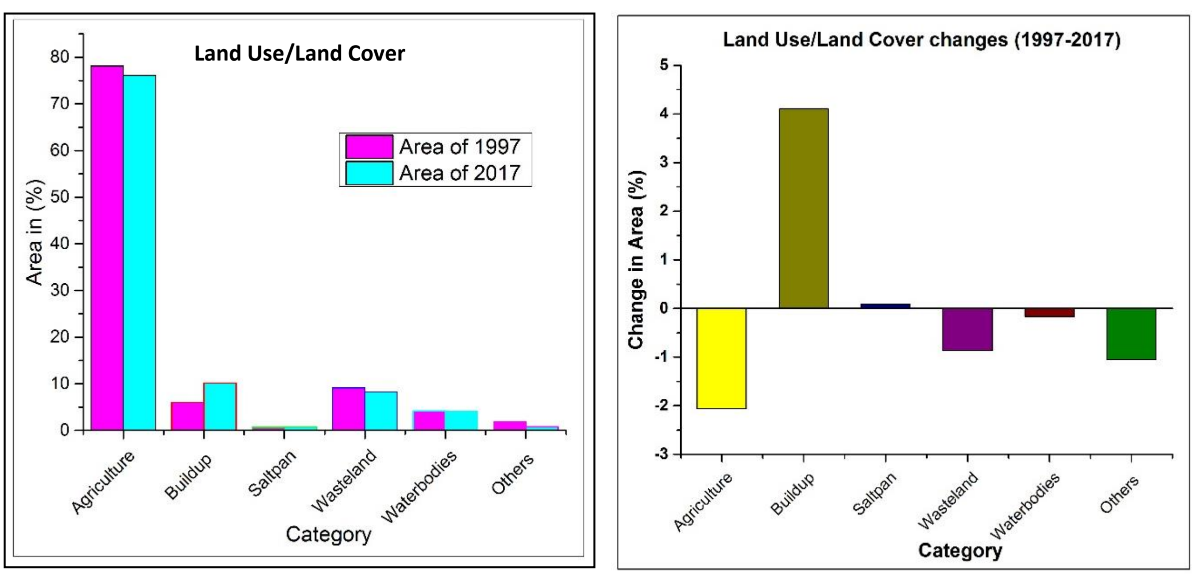

Fig. 5.4 LU/LC classe (1997-2017)

5.6 Identification of Industrial Sprawl:

Vagra Taluka, Bharuch District

Another important aspect of this chapter is the identification of industrial sprawl. Industrialization is a widespread phenomenon that is associated with fast population growth, resulting in changes in land use and land cover. In recent decades, huge industrial expansion has been transforming the agricultural land, waterbody, forest area and others lands. Such changes were associated with certain socio-economic contexts. However, the transformation has put immense pressure on the natural environment. The present study, focuses on industrial land use changes between two years (2007 to 2017). For the analysis, 11 Gujarat Industrial Development Corporation's (GIDC's) were taken into consideration. The boundary of the GIDC was collected from (gujarat.ncog.gov.in). Further, two types of land categories viz., (1) industrial land use and (2) open space were extracted from satellite imagery (LISS-III and LISS-IV). Thereafter, the industrial intensity was calculated using the following formula-

Industrial Intensity = Gross Area / Net Area x 100

5.6.1 Sachin GIDC:

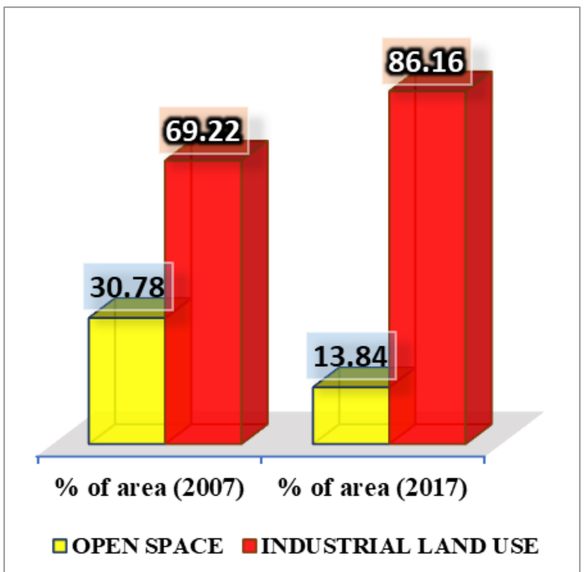

Fig. 5.5 Landuse/Landcover - Sachin GIDC

Sachin GIDC is located in the southern part of Surat, between 21°04'26.22'' to 21°06'24.54'' north latitudes and between 72°05'00.36'' to 72°05'03.09'' east longitudes. It has a large number of big and small industries which is spread over 6.79 sq. km area (Fig. 5.5 and 5.6). The industrial area is managed by Gujarat Industrial Development Corporation (GIDC), Surat Special Economic Zone (SEZ) and Diamond SEZ. It is the largest industrial area in the study area.

In the year 2007, 69.22% area was under industrial land use and 30.78% was open space and in 2017, the industrial land use increased to 86.16% whereas open space decreased

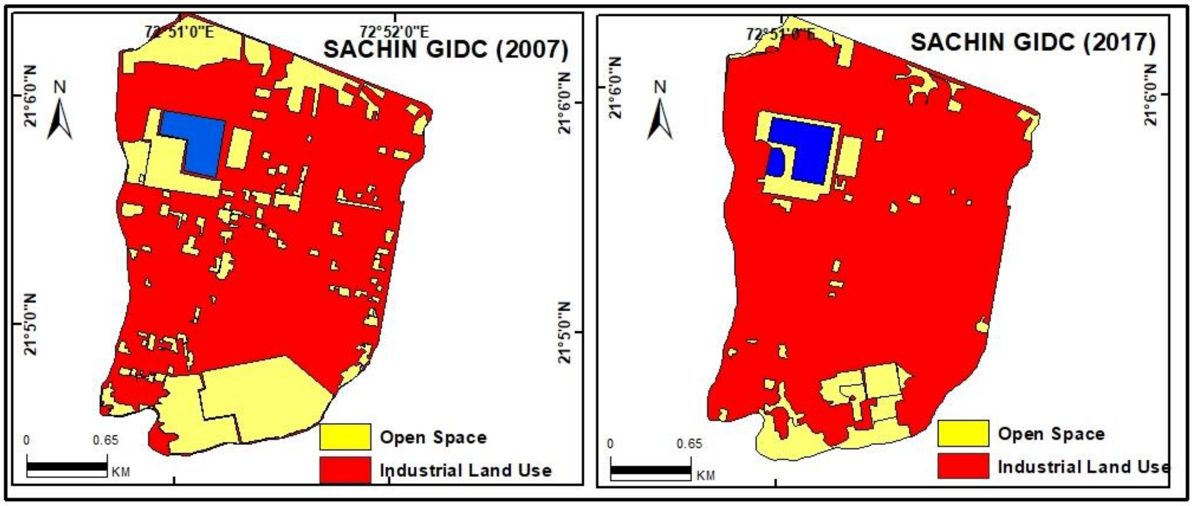

Fig. 5.6 Land Use Distribution of Sachin GIDC

to 13.84%. Over a period of 10 years 16.94% of the area under industries increased in 2007 to 2017 (Table 5.5).

5.6.2 Pandessara GIDC:

It is also located in the south of Surat City, between 21°7'50.593"N to 21°8'47.334"N latitudes and between 72°49'44.877"E to 72°50'49.798"E longitudes. It currently has approximately 230 large and small-scale industries managed by Gujarat Industrial Development Corporation (GIDC) and Surat Special Economic Zone (surSEZ).

This industrial area is approximately spread over 2.8 sq. km. In 2007, industrial land use covered 82.86% area and 17.14% was open space whereas in 2017, 95.36% area was industrial land use and just 4.64% was open space (Table 5.5). Thus, by the year 2017, 12.50% area increased in the decade (Fig. 5.7 and 5.8).

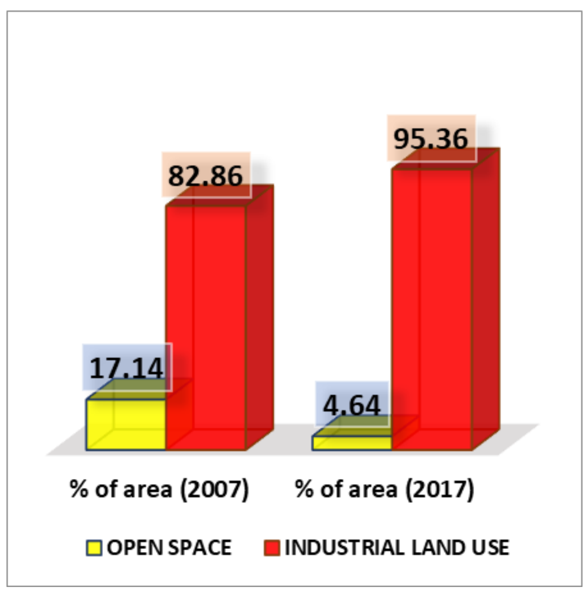

Fig. 5.7 Landuse/Landcover- Pandessara GIDC

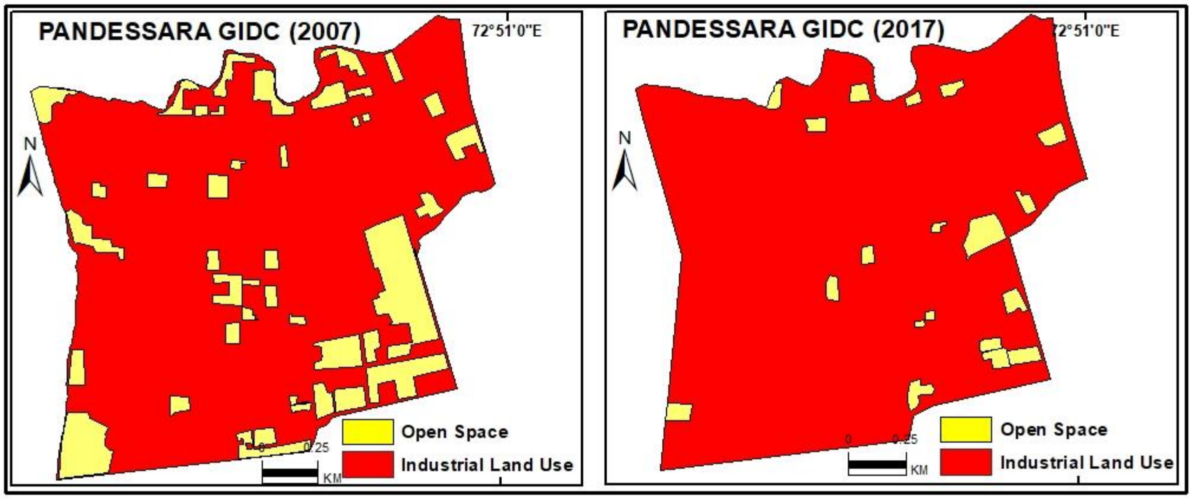

Fig. 5.8 Land Use Distribution of Pandessara GIDC

5.6.3 Khatodara GIDC:

It is another GIDC, which lies on the south of Surat City, between 21°10'33.246"N to 21°10'52.737"N latitudes and between 72°49'25.103"E to 72°49'43.732"E longitudes. This is a small industrial area occupying approximately 0.28 sq. km (Table 5.5).

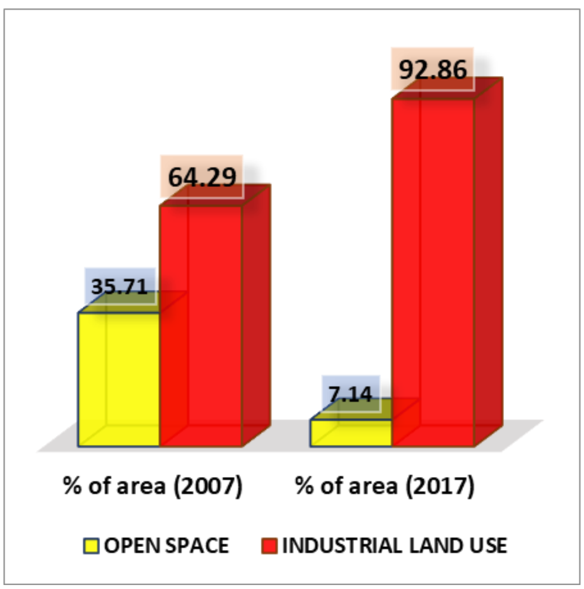

Fig. 5.9 Landuse/Landcover- Khatodara GIDC

In 2007, industrial land use covered 64.29% and 35.71% was open space whereas, in 2017, 92.86% area was industrialised and just 7.14% were open space. An increase of 28.57% was noted in the GIDC and almost the entire region is now industrialized (Fig. 5.9 and 5.10).

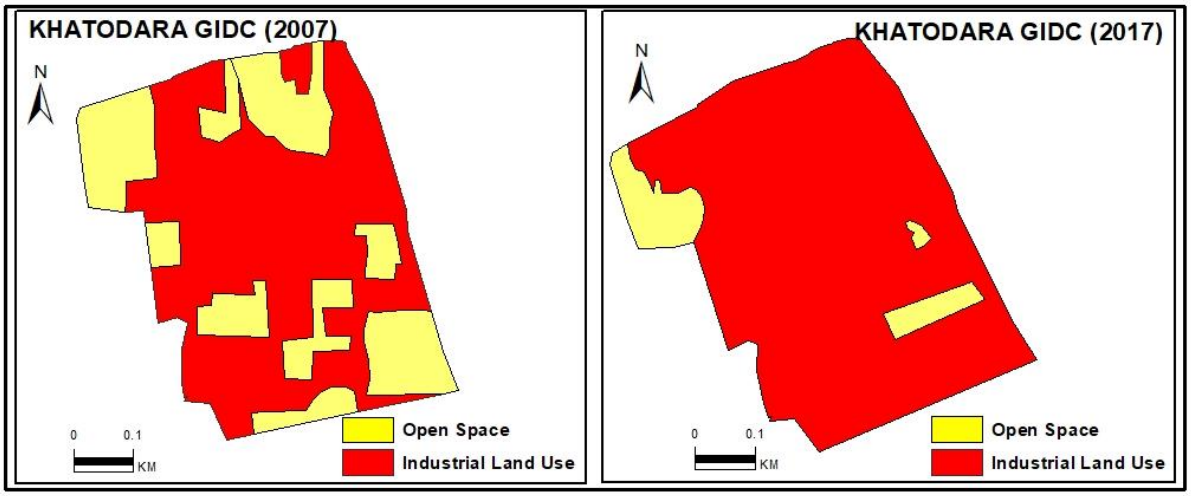

Fig. 5.10 Land Use Distribution of Khatodara GIDC

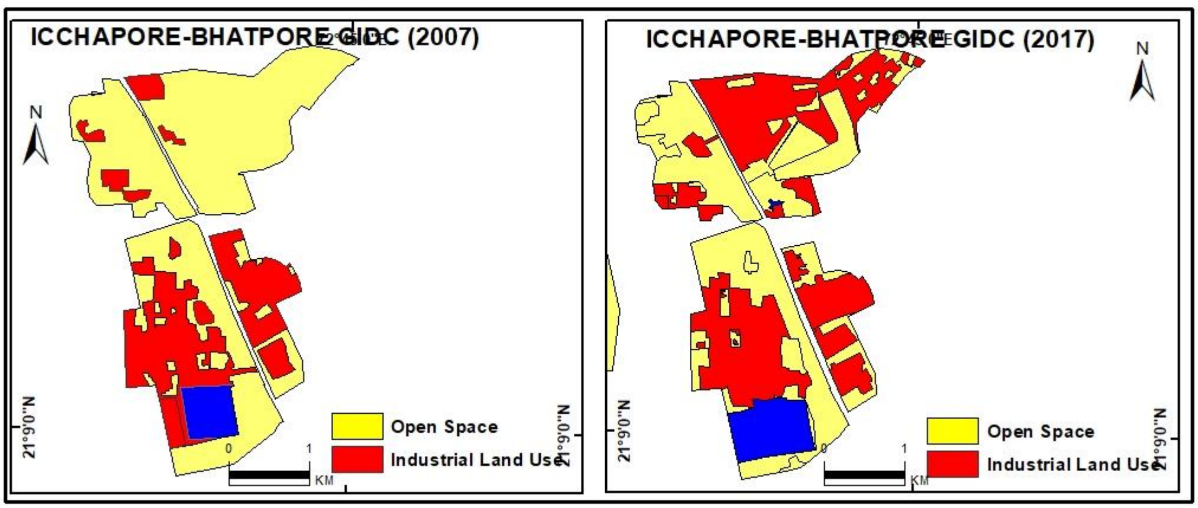

Fig. 5.12 Land Use Distribution of Icchapore-Bhatpore GIDC

5.6.4 Icchapore-Bhatpore GIDC:

It is touched in the western part of Surat City, between 21°8'45.95"N to 21°11'26.431"N latitudes and between 72°42'58.448"E to 72°44'18.701"E longitudes and is spread over 9.43 sq. km area (Table 5.5).

In the year 2007, industrial land use category occupied 28.42% area and 71.58% was open space. The industrial land use category increased to 51.11% while open land decreased to 48.89%. Thus, an increase of 22.69% was noted and 50% of the area is still remaining where industries can be developed (Fig. 5.11 and 5.12).

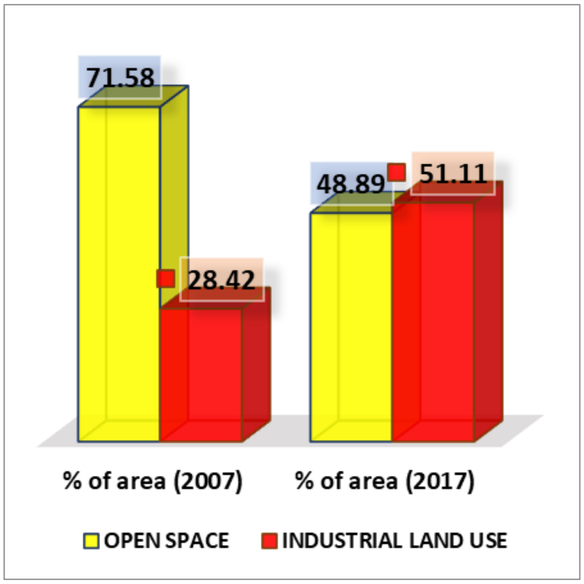

Fig. 5.11 Landuse/Landcover- Icchapore-Bhatpore GIDC

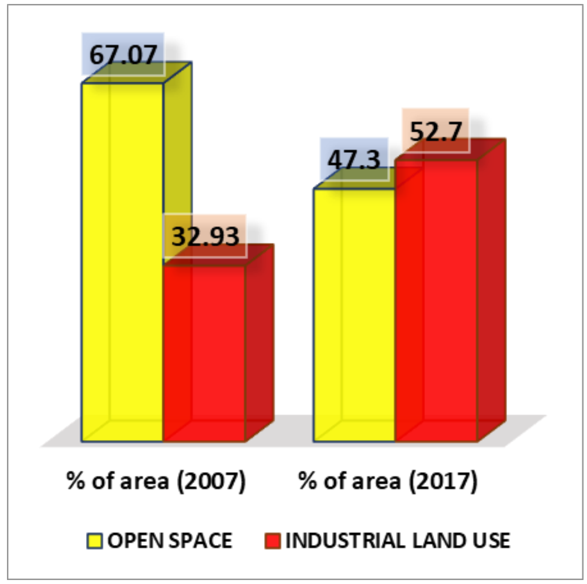

Fig. 5.13 Landuse/Landcover - Panoli GIDC

5.6.5 Panoli GIDC:

Panoli GIDC is situated in the Bharuch district and extends between 21°31'29.595"N to 21°35'10.598"N latitudes and between 72°58'43.587"E to 73°0'27.955"E longitudes and it spread over 9.81 sq. km. of area (Table 5.5). In this GIDC, many large, medium and small-scale industries are in-service.

In the year 2007, the industrial land use category was just restricted to 32.93% and two-thirds (67.07%) area was open space. In a decade, 52.70% area is industrial land use and

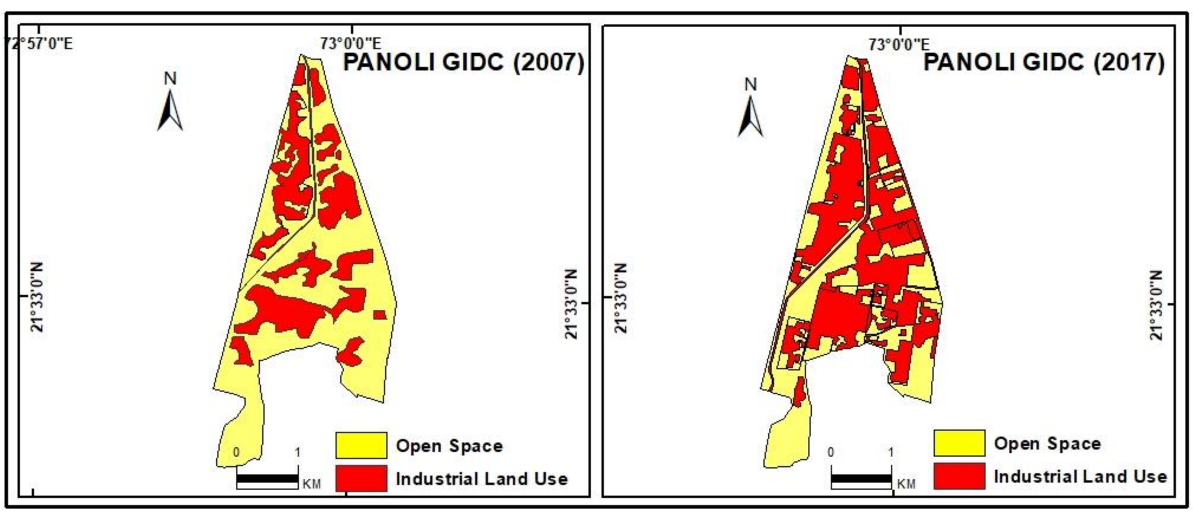

Fig. 5.14 Land Use Distribution of Panoli GIDC

47.30% was open space. During this time period (2007-2017) industries expanded in 19.78% of the area (Fig. 5.13 and 5.14).

5.6.6 Katargram GIDC:

The Katargram GIDC (Surat district), extends between 21°13'21.279"N to 21°14'1.738"N latitudes and between 72°50'20.771"E to 72°50'38.78"E longitudes with approximately 0.69 sq. km of area. In 2007, industrial land use was 32.93% and 67.07% was open space (Table 5.5). In 2017, 52.70% area was under industrial land use and 47.30% was open space. 19.78% increase in industrial are area was noted (Fig. 5.15 and 5.16).

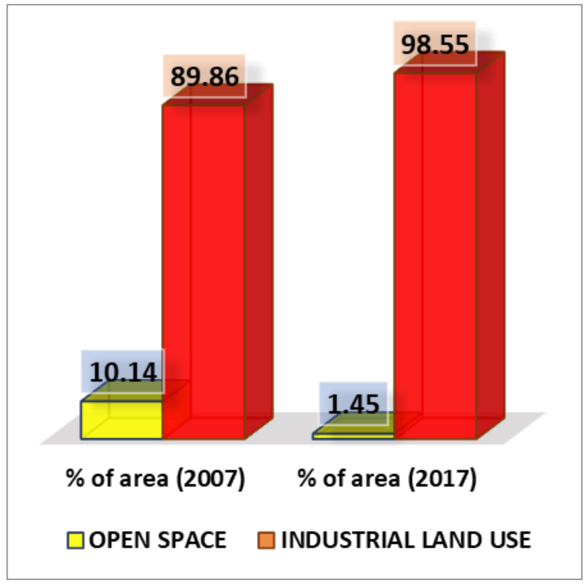

Fig. 5.15 Landuse/Landcover - Katargram GIDC

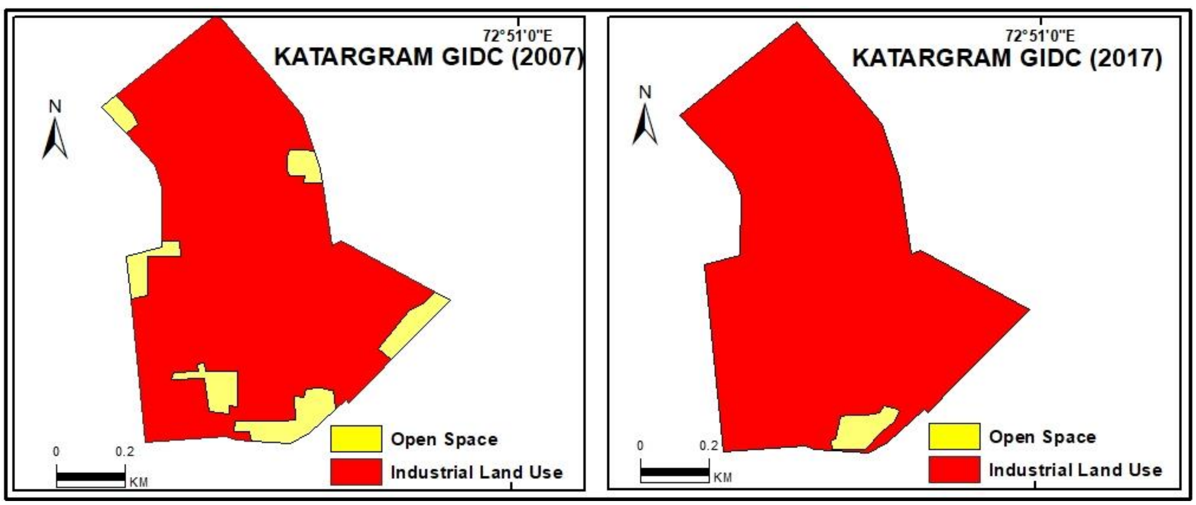

Fig. 5.16 Land Use Distribution of Katargram GIDC

5.6.7 Olpad GIDC:

This GIDC lies on the north-western part of Surat City and extends between 21°19'3.132"N to 21°19'29.327"N latitudes and between 72°44'54.276"E to 72°45'18.154"E longitudes. This industrial area is spread over around 0.39 sq. km. In 2007, the category industrial land use occupied 23.08% area and the remaining three-fourth was in open space (Table 5.5). In comparison to 2007, in 2017 (51.28%) area of the area was industrial land use and the remaining 48.72% was in the open space. Fig. 5.17 and 5.18 showed that 28.21% of the area was increased in 'industrial land use' during (2007 to 2017).

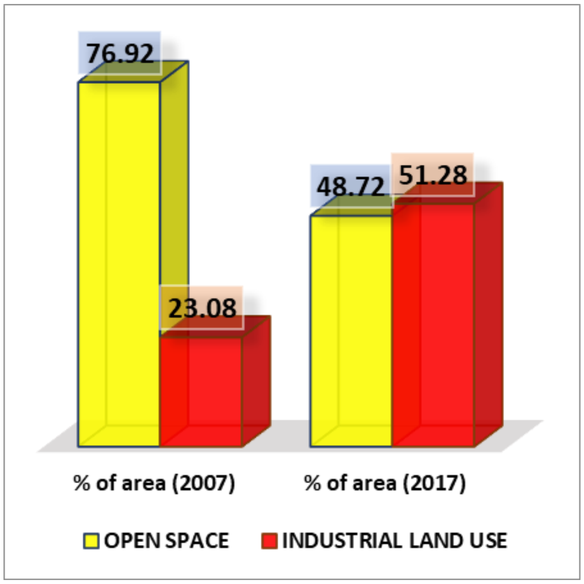

Fig. 5.17 Landuse/Landcover - Olpad GIDC

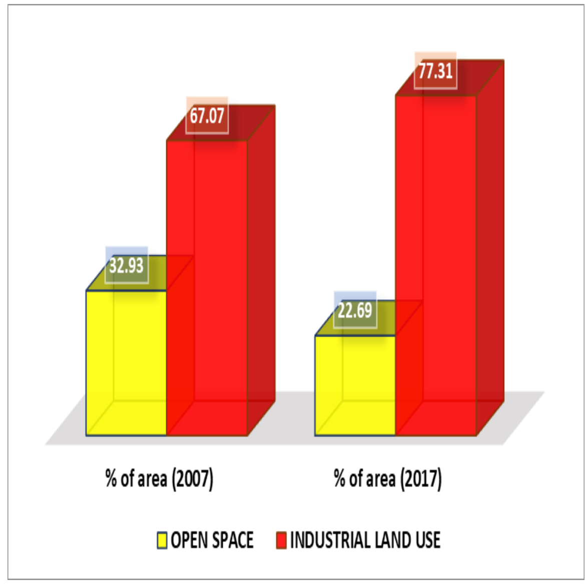

Fig. 5.19 Landuse/Landcover - Ankleshwar GIDC

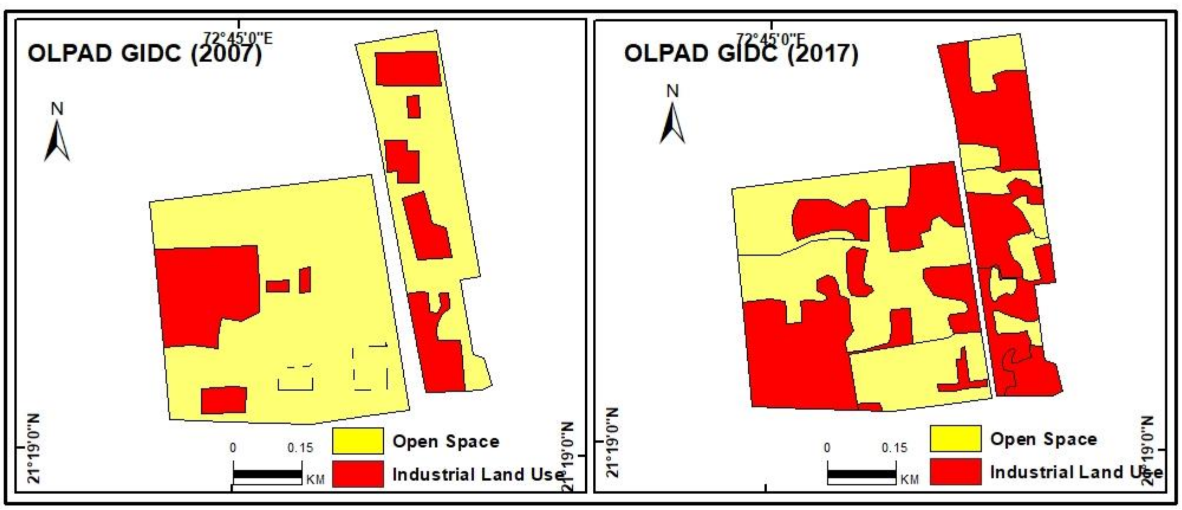

Fig. 5.18 Land Use Distribution of Olpad GIDC

5.6.8 Ankleshwar GIDC:

Ankleshwar GIDC is located in the Bharuch district and extends between 21°35'41.409"N to 21°37'57.96"N latitudes and between 73°0'2.452"E to 73°2'41.801"E longitudes. It occupies approximately 14.15 sq. km of area (Table 5.5).

In 2007, industrial land use was 67.07% and one-third (32.93%) was open space. A moderate growth (10.25%) was noted and, 77.31% area was industrial land use and 22.69% open space (Fig. 519 and 5.20).

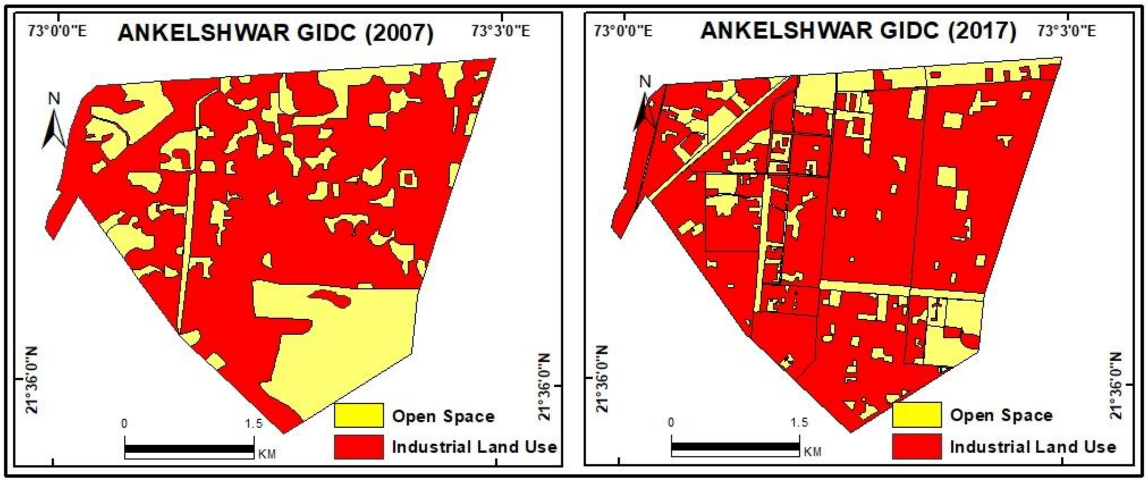

Fig. 5.20 Land Use Distribution of Ankeleshwar GIDC

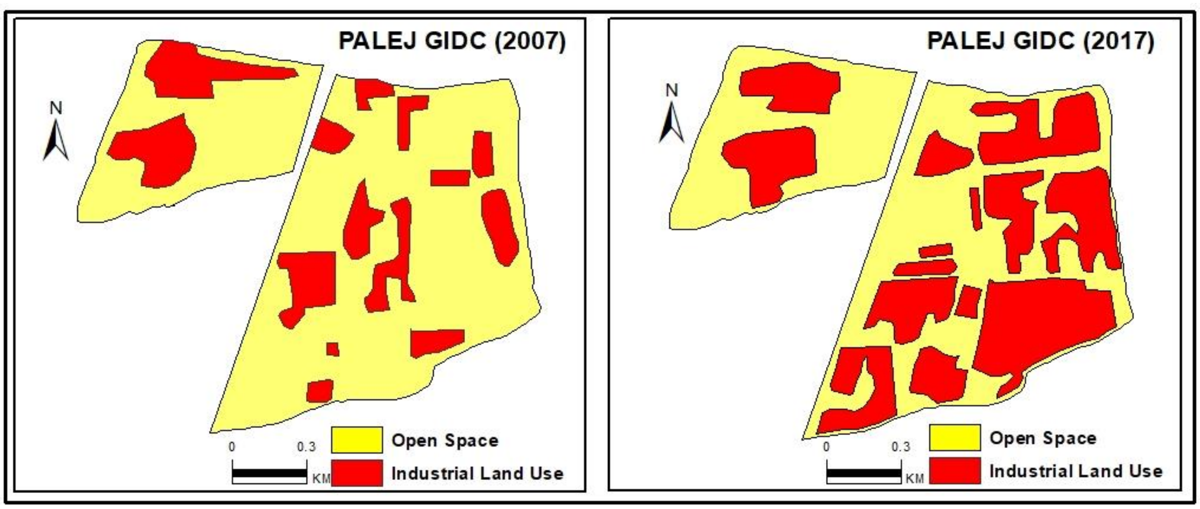

Fig. 5.22 Land Use Distribution of Palej GIDC

5.6.9 Palej GIDC:

Palej GIDC (Bharuch district) extends between 21°54'58.856"N latitudes to 21°55'44.762"N and between 73°4'26.63"E to 73°5'27.555"E longitudes covering 1.70 sq. km area (Table 5.5). In 2007, industrial land use was 21.76% and 78.24% was open space. Ten years later, industrial land use increased to 44.97% and open space decreased to 55.03%. 23.21% of the industrial area expanded in a decade (2007 to 2017) (Fig. 5.21 and 5.22).

5.6.10 Dahej GIDC:

The industrial area of Dahej GIDC is located in the western part, in the Bharuch district. It extends between 21°39'31.66''N to 21°43'52.177''N latitudes and between 72°32'12.374''E to 72°38'37116''E longitudes.

It is approximately of 55.33 sq. km area (Table 5.5). In 2007, the industrial land use cover was 18.69% and 81.31% were in open space. In its comparison in 2017, 48.71% area became industrialized and 51.29% remained open space. 30.02% of the industrial area increased (Fig. 5.23 and 5.24).

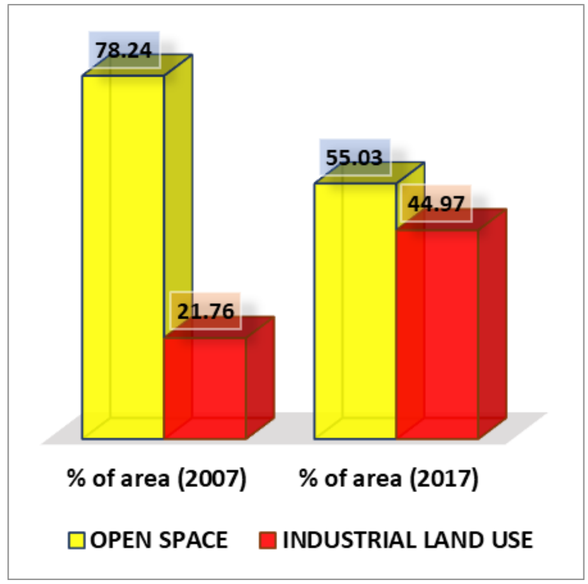

Fig. 5.21 Landuse/Landcover- Palej GIDC

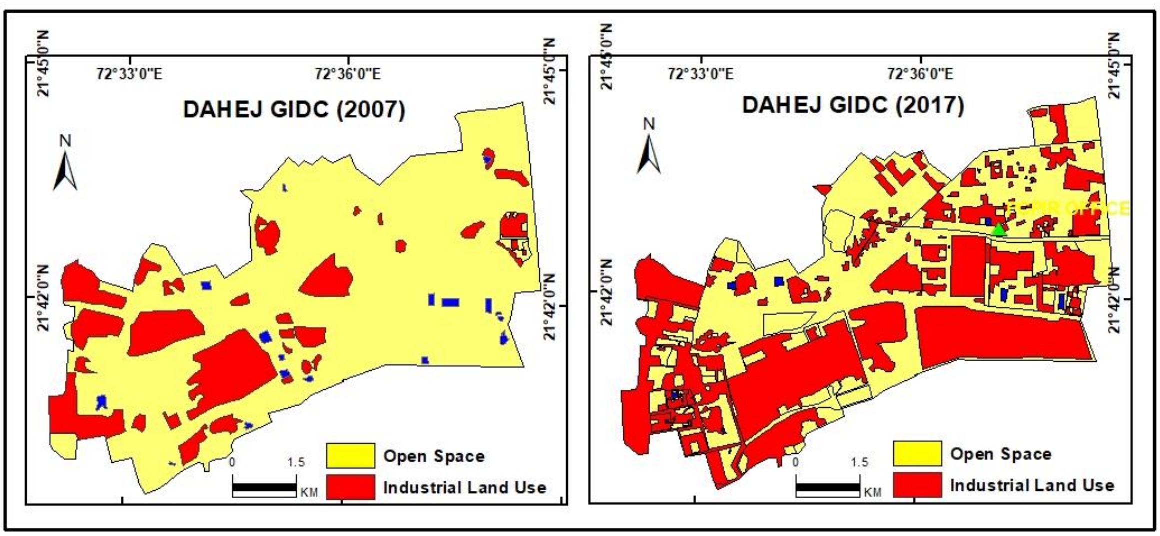

Fig. 5.24 Land Use Distribution of Dahej GIDC

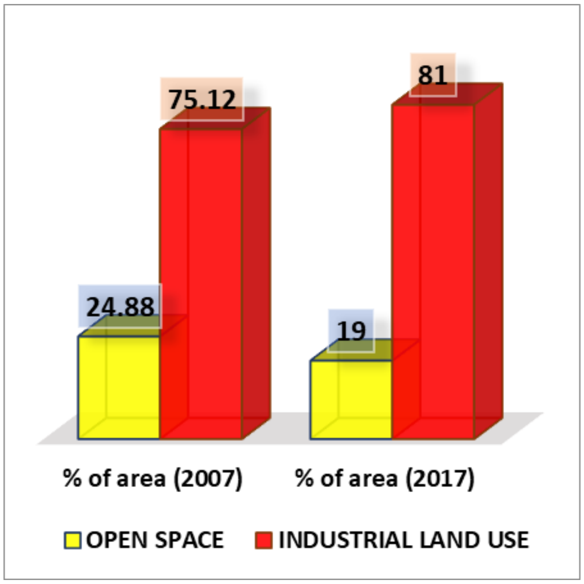

Fig. 5.23 Landuse/Landcover - Dahej GIDC

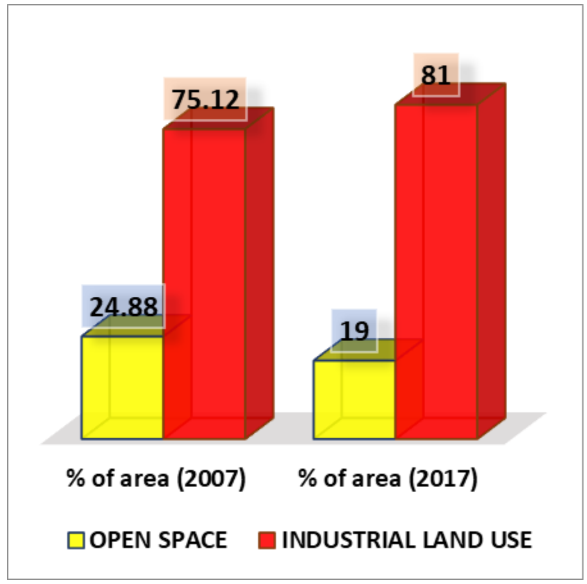

Fig. 5.25 Landuse/Landcover - Bharuch GIDC

5.6.11 Bharuch GIDC:

Bharuch GIDC is situated in the north-eastern part of the Bharuch city and it extends between 21°43'17.719"N to 21°44'54.296"N latitudes and between 73°0'19.113"E to 73°0'48.132"E longitudes. This industrial area approximately occupies a 2 sq. km area (Table 5.5). In 2007, the industrial land use category was covered 75.12% of area and 24.88% was open space. In 2017, 81.00% area came in category of industrial land use and 19.00% is open space. 5.88% of the area is expanded in industrial category between 2007 to 2017. (Fig. 5.25 and 5.26).

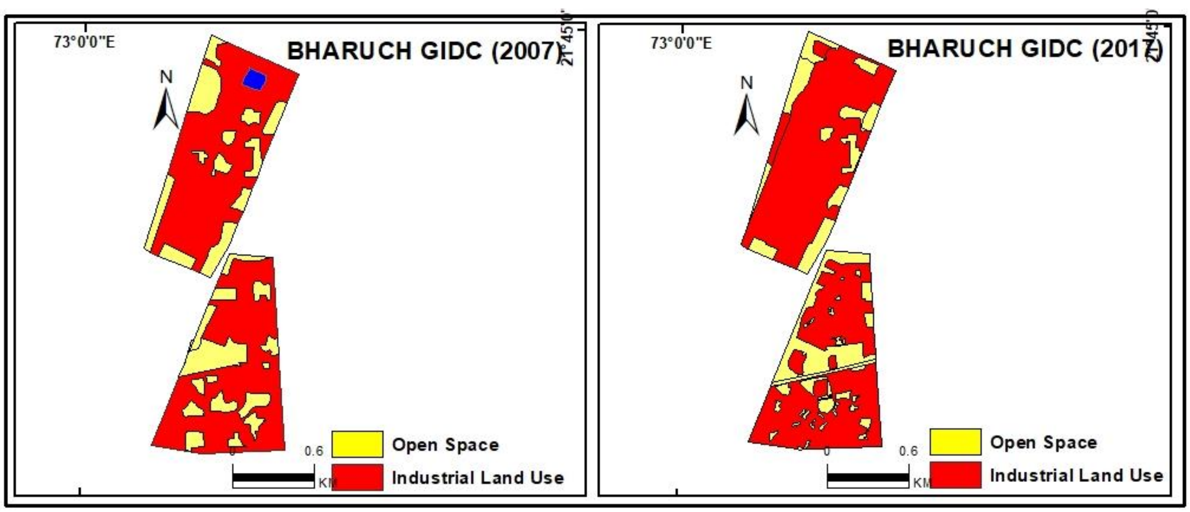

Fig. 5.26 Land Use Distribution of Bharuch GIDC

Table 5.5 Results of Change Detection of Industrial Land Use and Open Spaces between (2007 to 2017)

S. N	Name of GIDC	Total Area (sq. km)	2007 Industrial Land Use (%)	2007 Open Space (%)	2017 Industrial Land Use (%)	2017 Open Space (%)	Change in Industrial Land Use/Open Spaces
1	Sachin GIDC	6.79	69.22	30.78	86.16	13.84	16.94
2	Pandessara GIDC	2.8	82.86	17.14	95.36	4.64	12.5
3	Khatodara GIDC	0.28	64.29	35.71	92.86	7.14	28.57
4	Icchapore-Bhatpore GIDC	9.43	28.42	71.58	51.11	48.89	22.69
5	Panoli GIDC	9.81	32.93	67.07	52.7	47.3	19.77
6	Katargram GIDC	0.69	89.86	10.14	98.55	1.45	8.69
7	Olpad GIDC	0.39	23.08	76.92	51.28	48.72	28.2
8	Ankleshwar GIDC	14.15	67.07	32.93	77.31	22.69	10.24
9	Palej GIDC	1.7	21.76	78.24	44.97	55.03	23.21
10	Dahej GIDC	55.33	18.69	81.31	48.71	51.29	30.02
11	Bharuch GIDC	2	75.12	24.88	81	19	5.88

Source-Computed

Resume:

This chapter focused on Land Use/Land Cover changes in Surat-Bharuch industrial region by using remote sensing data. The findings of this study revealed significant changes in land use and land cover between 1997 and 2017. The main change observed that the area of agricultural land decreased and an increase in built-up land in 2017. Other classes of LU/LC included water bodies, saltpan area, barren land and they significantly changed.

Subsequently, area under industrial land use rapidly grew in this region specifically Dahej, Sachin, Palej, Olpad and Khatodara GIDC's. On the other hand, significantly less transformation was observed at Bharuch, Katargram and Pandessara GIDC's. The next chapter will focus upon the identification of waste disposal sites of the study area.

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