Land Use Change Detection Analysis of the River Front Project area Using Remote Sensing and GIS Techniques: A Case Study of Ahmedabad City

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Abstract:

Ahmedabad is the fastest growing city of India. Due to the rapid development, urban open space is under strong pressure in Ahmedabad city. In this paper Land-use and Land-cover changed detection is assessed for an area within the distance of 1 km. from the banks of Sabarmati River in Ahmedabad city. In this study Indian remote sensing satellite data of LISS III and LISS IV sensors covering Ahmedabad city for the years of 2008 and 2014 were analysed for identification of land use classes and monitoring the changes in land use. The NDVI images of 2008 and 2014 were generated to identify vegetation classes like dense vegetation, grass, shrubs, and cultivated fields. Using GIS techniques a buffer of 1 km on both sides of Sabarmati River was created for monitoring changes in land use along the Sabarmati River bed. This is important because of the recent development of river front project which is supposed to improve the urban quality of life is reducing the open space and gardens. Satellite data was classified using the unsupervised classification techniques. The various urban land use classes were identified on the unsupervised image based on field visits and also the NDVI Image. Based on this analysis, various urban land use classes like open spaces, built-up area, water bodies as well as green cover areas were mapped. These results of this study indicate that the area around 1 km buffer zone of Sabarmati River is under development face. Due to this the river bed is shrinking, water flow is becoming less and the natural green cover area has reduced on both the sides of the river bank within 1 km buffer. Moreover, in future many buildings may be developed on the bank of the river under the River front project.

Key words: Change detection; unsupervised classification; land-use and land-cover; NDVI, change monitoring

1. Introduction:

Land is the one of the most important natural resources. Human life and its developmental activities are based on it. Land-use and land-cover data are essential for planners and decision makers and that concern with land resource management. Land-use refers to the types of utilization to which man has put the land for some specific use. Spatio-temporal data base have become very important in recent years as many real world applications like location based services, Geographic Information System etc. need to store real world data which shows spatial as well as temporal characteristics of land use data base. Land-use reflects the importance of land as a key and finite resource for most human activities including agriculture, industry, forestry, energy production, settlement, recreation, water catchment and storage.

The Sabarmati Riverfront project of Ahmedabad city is an environmental improvement, social upliftment and urban rejuvenation project that will refurbish Ahmedabad. Due to the development of this project the surrounding land-use of the river belt is also in the changing phase. The area within 1km. of the river belt on both sides is selected for the study.

Sabarmati River is the beauty of Ahmedabad city. This River holds a long history of Ahmedabad and it is the only victim of the growth of this city. It is always being a main attraction for tourists and the residents of the city. Sabarmati River has many times changed its path and experienced floods in history. Due to this Ahmedabad city have many small hills which provide a beautiful

landscape to the city. Because of this geographical reason, the river bed of Sabarmati remained as a vacant land for a long time. There were many slums along the river bed. This area was covered with many trees and vegetation. Some areas were used for dumping solid waste and chemicals along the River and also into the River. River Front Project will change the scenario of this land. This change could be monitored with many measures. This study makes an attempt to understand this geographical change of this land.

2. Data used:

IRS P6 (mx) LISS III (2008) and LISS IV (2014) data are used in this study. LISS III image resolution is 23.5 meters with four bands and LISS IV image resolution is 5.8 meters with three bands. Ahmedabad Urban Development Authority (AUDA) map is used as the base map. LISS images are shown below with the buffer zone within 1 km. surrounding the river Sabarmati. Arc GIS 10.3.1 and Microsoft softwares are used in this research work.

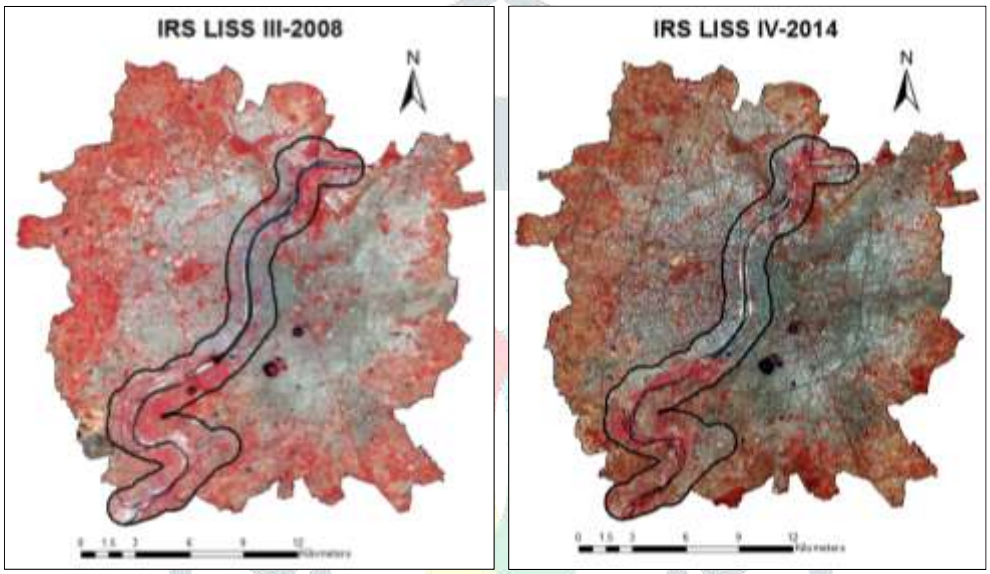

Figure:1 IRS-P6 LISS III 2008 and LISS IV 2014 Satellite images

S/N	Data Type	Year	Image Date	Band	Resolution
1	IRS-P6 –LISS III	2008	1-11-2008	B2:0.52-.59 B3:0.62-.68 B4:0.77-0.86 B5:1.55-1.70	23.5m
3	IRS-P6 –LISS IV	2014	16-3-2014	B2:0.52-.59 B3:0.62-.68 B4:0.77-0.86	5.8m

Table: 1 Image Information

3. Study area:

Ahmedabad city is located on the banks of river Sabarmati in Gujarat State, which is on the western side of India. Ahmedabad is situated at 23.0300° N latitude, 72.5800° E longitude covering an area of 466 sq. kms. It lies at an altitude of 48.77 metres above sea level. Ahmedabad is located in a very dry and sandy area. Most of the localities in Ahmedabad are covered with sand. Since, Ahmedabad lies on the western side in the state of Gujarat, which is basically a plane and sandy area; it experiences extreme type of climate.

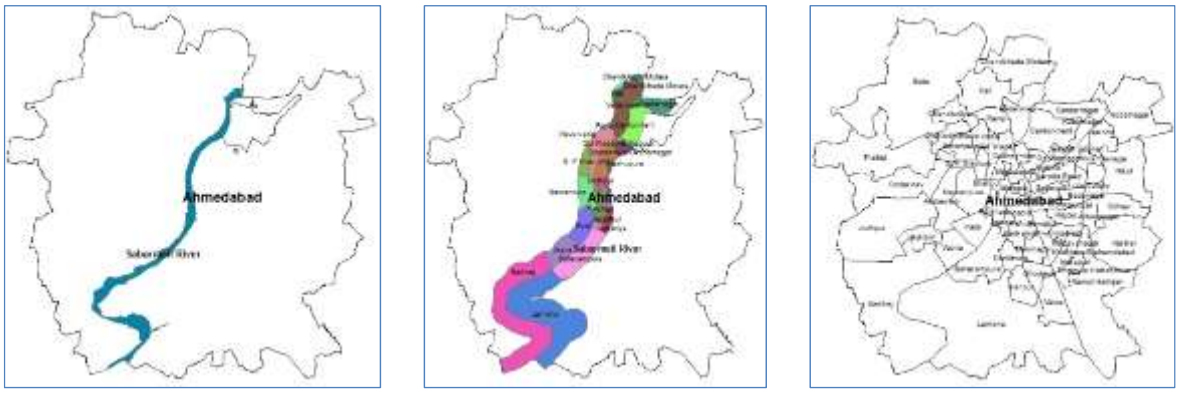

Figure-2: Ahmedabad City, Sabarmati River Corridor and wards of City

4. Methodology:

4.1 Methodology flow chart:

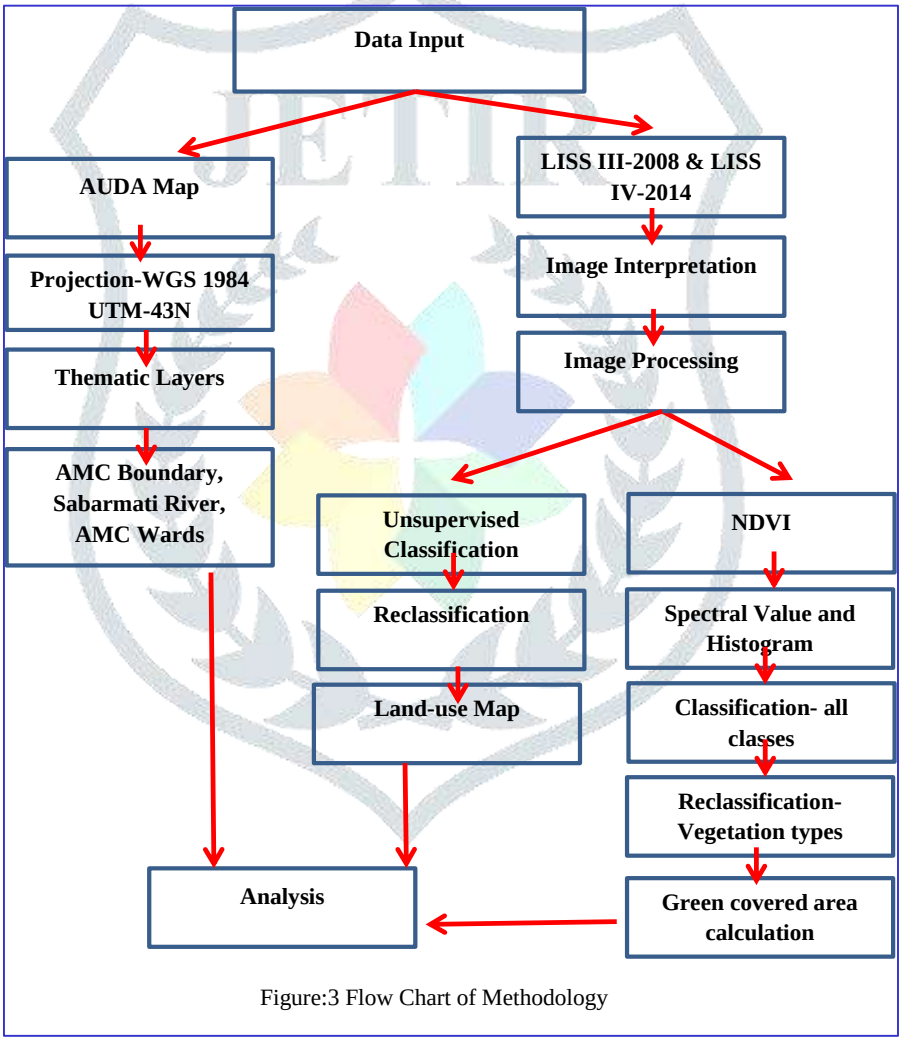

Figure:3 Flow Chart of Methodology

IRS P6 LISS III (mx) Image (2008) and LISS IV (mx) image (2014) were sourced for interpretation and analysed in order to obtain the require data for this work. Change detection techniques incorporate image enhancement, multi date data classification and comparison of two independent land-use classifications. Satellite data were clipped on a base map to generate shape files using Arc map object identification method. Then Land-use and Land-cover maps were developed from satellite images for defining spectral classes by clustering image data and assigning pixels into classes. Multi temporal land-use data processing was carried out using Arc GIS 10.3.1 software. Regions of interest were defined to extract statistics for classification. Unsupervised classification

was used with true colour band composition (3, 2, and 1) to clusters pixels into data set into classes corresponding to the selected area. The NDVI images of 2008 and 2014 were generated to identify vegetation classes like dense vegetation, grass and shrubs, cultivated fields etc. IRS LISS III and LISS IV images are used for data acquirement. Ahmedabad Urban Development Authority (AUDA) map is used as the base map of study area.

4.2 Mapping and Creating Database:

Visual interpretation is important to identify different features of the region. Thematic maps are digitized using object identification method with Arc GIS software using AUDA map as the base map. Than a buffer generated within 1 km. distance to the Sabarmati River included the area coming under different wards of Ahmedabad city. These maps were geo-referenced with true projection (UTM).

4.3 Land-use map generation:

The static land-use land-cover distribution for each study year derived as shown in figure 4. Land-use is the manner in which human being employ the land and its resources and land-cover implies the physical or natural state of the earth's surface. Indian remote sensing satellite data of LISS III and LISS IV sensors covering Ahmedabad city for the period of November 2008 and March 2014 were analysed for identification of land use classes and monitoring the changes in land use. Then Land-use Land-cover maps were developed from satellite images by defining spectral classes and by clustering image data and assigning pixels into classes. Based on this analysis, final maps showing various urban land use classes like open spaces, built-up area, water bodies as well as green cover areas were prepared.

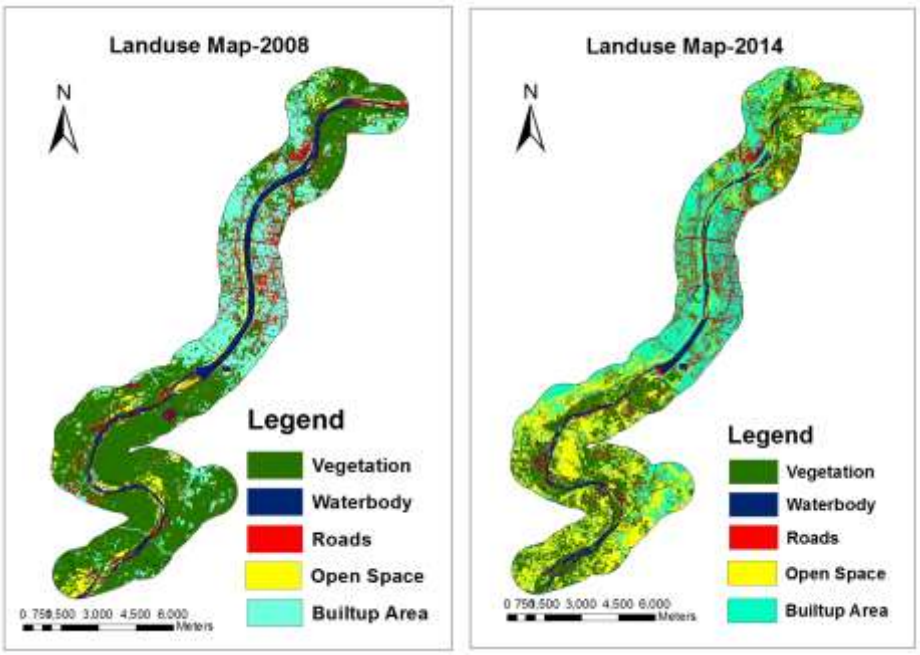

Figure:4 Land-use Map for IRS LISS III(2008) and LISS IV(2014) Images

4.4 Unsupervised classification:

Unsupervised classification finds spectral classes (or clusters) in a multiband image without the analyst's intervention. The Image Classification toolbar aids in unsupervised classification by providing access to the tools to create the clusters, capability to analyse the quality of the clusters, and access to classification tools. With this method 5 classes are classified. They are (i) Vegetation,(ii)Water body,(iii)Roads,(iv)Open Space, and (v)Built-up Area. The maps above represent these classes for two different years.

4.5 Comparison of Land-use classes for 2008 and 2014 maps:

Image classification refers to the task of extracting information classes from a multiband raster image. The resulting raster from image classification can be used to create thematic maps. The various maps representing different classes of land use for two years were prepared.

4.6 NDVI map generation:

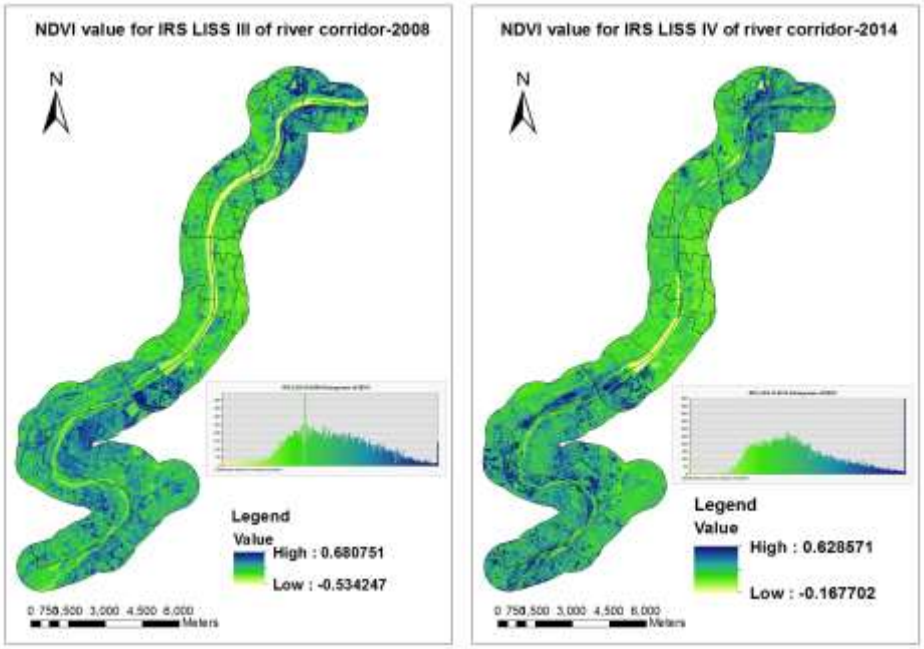

Figure:10 NDVI Value of IRS LISS III(2008) and LISS IV(2014) Images

The NDVI images of 2008 and 2014 were generated to identify vegetation classes like dense vegetation, grass and shrubs, cultivated fields etc. The various vegetation classes were identified on the unsupervised image based on field visits and also the NDVI Image. With this method, one can extract total area under green cover. By using Arc NDVI method; green cover area is extracted from IRS LISS III data (2008), and LISS IV data (2014). The Normalized Difference Vegetation Index (NDVI) is a standardized index allowing one to generate an image displaying greenness (relative biomass). This index takes advantage of the contrast of the characteristics of two bands from a multispectral raster dataset—the chlorophyll pigment absorptions in the red band and the high reflectivity of plant materials in the near-infrared (NIR) band. The documented and default NDVI equation is as follows:

NDVI = ((NIR - Red)/ (NIR + Red))

NIR = pixel values from the near infrared band

Red = pixel values from the red band

This index outputs values between -1.0 and 1.0. The differential reflection in the red and infrared (IR) bands enables to monitor density and intensity of green vegetation growth using the spectral reflectivity of solar radiation. Green leaves commonly show better reflection in the near-infrared wavelength range than in visible wavelength ranges. When leaves are water stressed, diseased, or dead, they become more yellow and reflect significantly less in the near-infrared range. Clouds, water, and snow show better reflection in the visible range than in the near-infrared range, while the difference is almost zero for rock and bare soil. The NDVI process creates a single-band dataset that mainly represents greenery. The negative values represent clouds, water, and snow, and values near zero represent rock and bare soil. The equation ArcGIS uses to generate the output is as follows: NDVI = ((IR - R)/ (IR + R)) * 100 + 100

With this method NDVI of the study area is generated using LISS images of 2008 and 2014.

4.7 Classification of NDVI:

The Colour map function is a type of raster data renderer. It transforms the pixel values to display the raster data as either a grey scale or a colour (RGB) image based on specific colours in a colour map file, or based on a colour ramp. One can use a colour map to represent analysed data, such as a classified image, or when displaying a topographic map (or index colour-scanned image). Following this method IRS P6 LISS III and LISS IV Images are used to generate NDVI classification.

4.8 Reclassification:

NDVI classes are reclassified with spatial analysis and generated different types of green covered area of the region. NDVI threshold method was adopted for grouping of the green vegetation classes into three classes like (i) dense vegetation (ii) medium vegetation, (iii) sparse vegetation. The below map represent these classes for two satellite images

5. Result and Discussion:

5.1 Vegetation:

The maps shown below represents the area covered with vegetation during the years of 2008 and 2014 in the study area. The area under the cover of vegetation is decreased during this period. 2008 map represents good amount of vegetation in the upper portion of river incorporating wards of Chandkheda, Motera, Kali, Sabarmati and Sardar Nagar. Also one can see good amount of high vegetation cover on the bank of river Sabarmati near Vasana and Behrampura. Other area has less amount of green cover. This can be possible due to the construction work of River Front project. 2014 map represents very less amount of high vegetation cover area. AMC construction work was in on-going process here. A big pathway is constructed on the both side of river Sabarmati. Because of this, the area under tree cover has declined here.

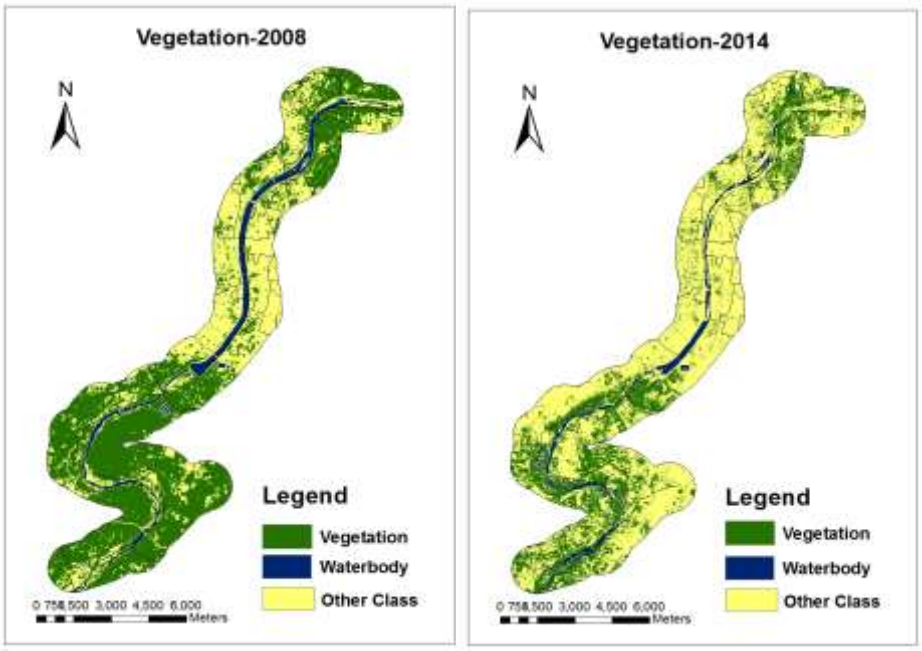

Figure:5 Vegetation area for IRS LISS III(2008) and LISS IV(2014) Images

5.2 Water body:

The below map shows the flow of River Sabarmati. In 2008 map one can see more amount of river flow than 2014 map. We can see water flow from Motera up to Vasna Barrage in 2008. The whole river bed is full of water in 2008. In 2014 map one can see less amount of water flowing in the river. This is due to the construction of River front Project on the bank of the river. The

upper part of the river has no water flow in 2014. The maximum amount of water can be seen near Navarangpura and Paldi in 2014. The lower portion of the river bed near Lambha and Sarkhej area is absolutely empty

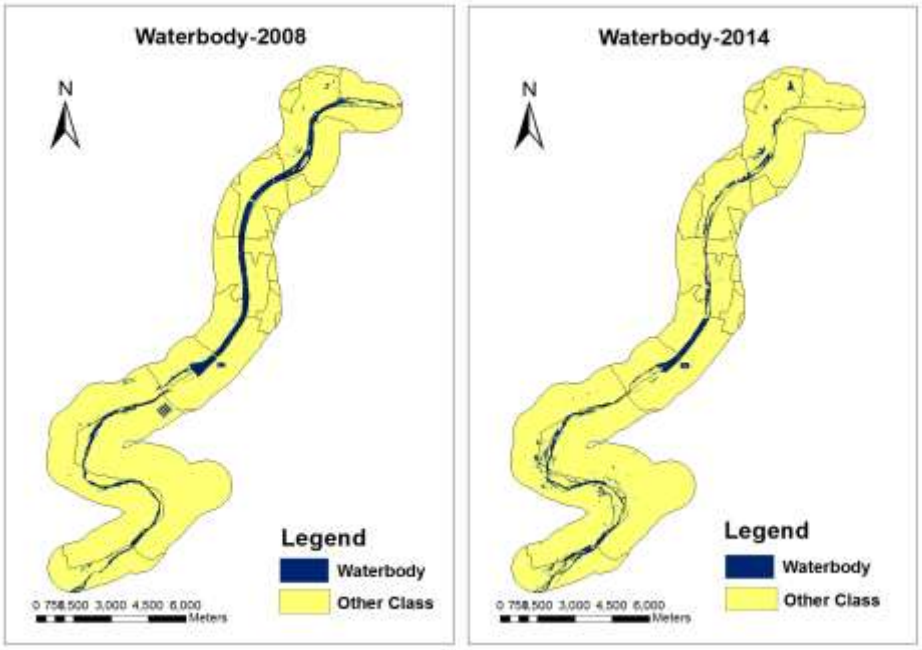

Figure:6 Water body for IRS LISS III(2008) and LISS IV(2014) Images

5.3 Roads:

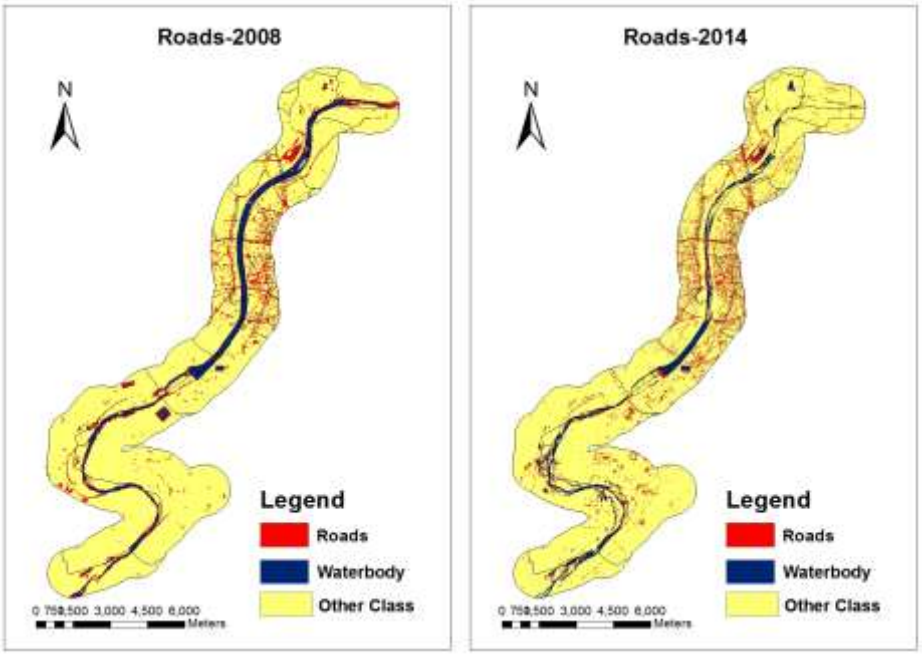

Figure:7 Roads for IRS LISS III(2008) and LISS IV(2014) Images

The above map represents the area covered with roads in the years of 2008 and 2014. Due to the development of River Front project, many roads are constructed in this area. In 2008 map one can see less number of roads constructed here, but in 2014 map one can see a large number of roads in this area.

5.4 Open space:

2008 map represents fewer amounts of open space in comparison to that of the year 2014. Many trees, plants and grass areas are cut by AMC to develop the River Front Project during last six years. Also the agricultural activity, which was initiated in the river bed, is vanished. There were many settlements of poor people on the bank of the river. Now they are rehabilitated on other place. Because of all these reasons; open space is increased in 2014.

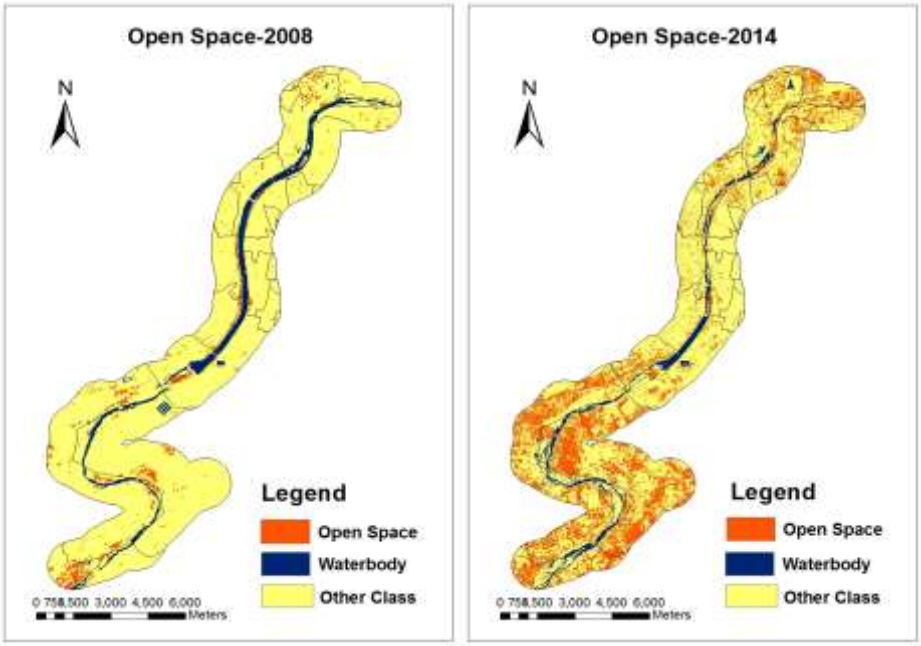

Figure:8 Open Space/Fallow land for IRS LISS III(2008) and LISS IV(2014) Images

5.5 Built-up area:

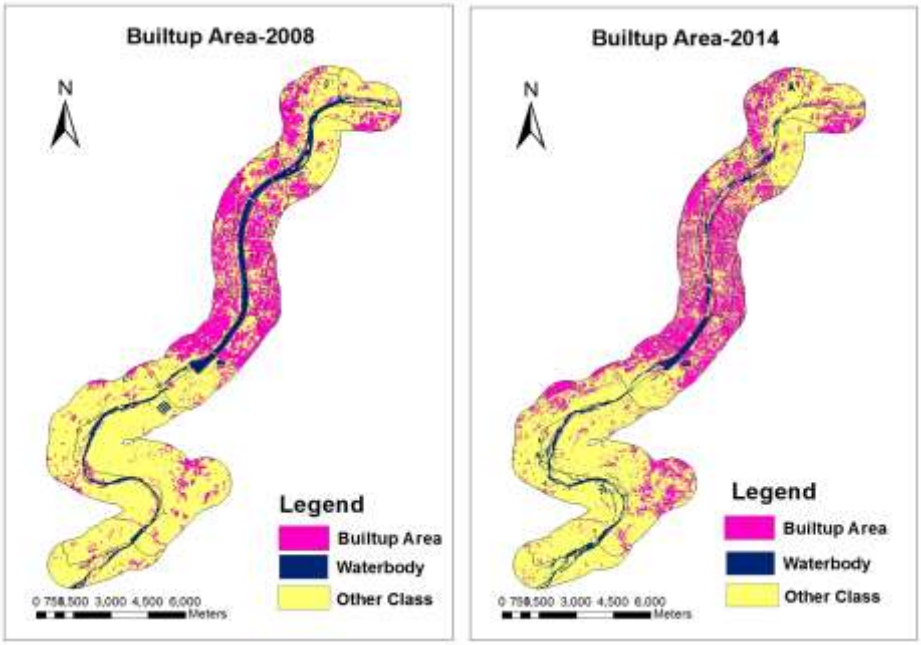

Figure:9 Built-up Area for IRS LISS III(2008) and LISS IV(2014) Images

One can see less difference in built-up area covered during last six years. The slums settlements which one can see in Lambha and Sarkhej area during the year of 2008, cannot be seen in 2014 map. The eastern part of the River Sabarmati is developed in these six years and due to this development the area falling under Kalupur, Khadia, Raikhad, Jamalpur and Kankaria have more

built up area in 2014 comparison to that was in the year 2008. Also the wards such as Ranip and Cantonment have shown more built-up area in 2014 than those in the year 2008.

5.6 Change Detection in Green Cover:

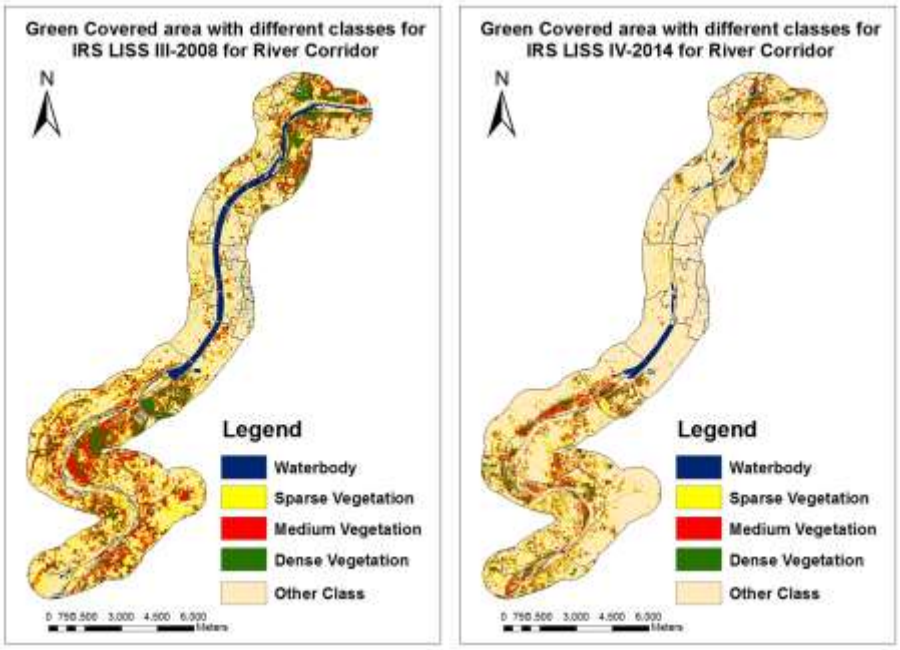

Figure:11 Green covered area with different classes for IRS LISS III(2008) and LISS IV(2014) Images

The above method gives us change detaction of vegetation covered area for 2008 and 2014 satallite images. It answers as below. Water-body area is reduced about 4.9% during last six years. Sparse vegetation area is reduced about 9.72% in last six years. Medium vegetation is reduced for about 6.7%, Dense vegetation is reduced about 4.97% in 2014 map, and other area covered is increased about 21.7% in 2014. The increased areas are open land, built-up land and roads. Total green covered area is reduced by 21.39% in last six years. The natural growth of most of the trees and vegetation is removed. The Minicipality has planned to develop green belt along this corridor. However, this will not replace the fluvial boidiversity of the fluvial ecosystem.

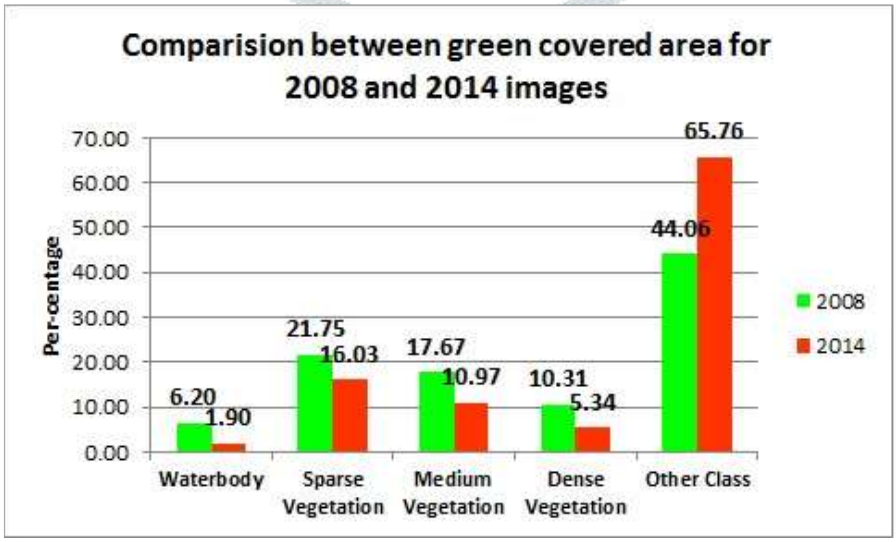

Figure:12 Comparison between green covered area for IRS LISS III(2008) and LISS IV(2014) Satellite Images

6. Conclusion:

This result indicates that the study area is under development phase and as a result, the river bed is shrinked , water flow became less , and green covered area is redused on both the sides of the river bank within 1 km of buffer zone. In future many buildings will be developed on the bank of the river by the River front project. Also this project will give us some new areas of green covered as flower beds, lawns,plants and tress. Sabarmati river is the heart of ahmmedabad city. On 27th august 2015 government declared to develop ahmedabad city as a smart city. This will develop a new urban landscape in the study area in future. However, the current situation shows that lot of green vegetation has declined along River Front area. However, we hope that the study area will be developed by developing more landscapes and beautiful green buildings.

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