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LAND USE AND LAND COVER MAPPING – A CASE STUDY OF AHMEDABAD CITY

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ABSTRACT:

Land cover mapping using remote-sensing imagery has attracted significant attention in recent years. The classification of land use and land cover is an advantage of remote sensing technology that provides all the information on the land surface. Numerous studies have investigated land cover classification using different broad array of sensors, resolution, feature selection, classifiers, Classification Techniques and other features of interest from over the past decade. Firstly, the pixel-based image classification technique is widely used worldwide and works on their spectral reflectance per pixel. Classification algorithms such as parallelepiped, minimal distance, maximum probability, Mahalanobis distance are some of the classification algorithms used in this technique. Other, the classification of images by object is one of the most adapted land cover classification techniques lately, which also takes into account other parameters such as shape, color, softness, compactness, etc. except for the spectral reflectance of a single pixel. It is currently possible to obtain more precise information on the classification of land use by using the latest technologies, recent algorithms and relevant according to our study. In this study, a combination of Maximum likelihood classification and support vector machine is performed using ArcGIS Pro Software. The aim of the study is to analyze LULC pattern using satellite imagery and GIS for the Ahmedabad City and its surrounding in the state of Gujarat, India using LISS-IV imagery for the year 2007, 2017 Kappa stats for the classified map for the both methods are calculated at 0.7 and 0.9 respectively. This classified map at 1:4,000 scale generated using recent available high-resolution space borne data is a valuable input for various research studies over the study area and also provide useful information to town planners and civic authorities. The technique developed can be replicated to produce such LULC maps for other study areas also.

KEY WORDS: Land Use Land Cover, LISS-IV, Image Classification, Ahmedabad

INTODUCTION:

Land use/land cover (LULC) plays an important role in global climate as well as in topographical change. Some natural devastations like deforestation, biodiversity loss, global warming, increased natural disasters-floods, etc. Changes of human or natural origin are often associated with changes in terrestrial cover. Therefore, available data on LULC changes can provide critical input to decision-making on environmental management and planning for the future. Changes in LULC are unforeseen and uncontrolled due to pressure resulting from population growth and rising socio-economic needs. Changes are usually caused by inadequate management of agriculture, urban areas, vegetation, forested land, etc. This leads to serious environmental concerns.

Remote sensing techniques and geographical information systems allow the spatial distribution of land use/land cover changes over a large area to be studied. Many organizations and institutions around the world have undertaken these studies in the past and in the present, focusing on the applications of LULC changes. GIS provides a flexible environment for collecting, storing, displaying and analyzing spatial data and Remote sensing imagery is one of the important data resources of GIS providing high resolution satellite imagery. The rich data collection and spectral resolution of satellite imaging is the main reason they are used in this type of study. The change detection process is executed to acknowledge the change in LULC over a certain period. Numerous techniques are developed such as post-classification comparison, conventional image differentiation, image ratio, image regression and manual on-screen scanning, etc. A variety of studies have used different methods of classification and came out with different accuracies but post classification comparison was found out to be most accurate procedure as from the literature. Multi-temporal mapping using remote sensing and the Geographic Information System (GIS) is especially useful for land management and environmental studies. Frequently updated information about land use is essential for many socio-economic and environmental applications, including urban and regional planning, conservation and management of natural resources, etc. (Homer et al.2007; Lu & Weng 2007; Jensen 2009). Historically, aerial photographs have been an important source of land use information (Bauer et al., 2003). In recent decades, maps have been created using ancient traditional methods such as digitization, digitization, investigation methods, etc. Such methods are still in use at some places (Kamagata et al., 2006). Land use and land cover mapping methods have become more advanced and informative as a result of a high-resolution data set in recent times. These methods are dependent on image interpretation and fieldwork. These and other related problems leave many potential users skeptical about the capabilities of remote sensing data (Rowlands & Lucas, 2004). Remote sensing data are more uniform than auxiliary data, which vary in data format, accuracy, spatial resolution, and coordinate systems (Lu and Weng, 2007). The aim is to improve the understanding of the methods, their processing and the technique of spatial distribution in Ahmedabad Ahmedabad city and its surrounding, which is located in western India.

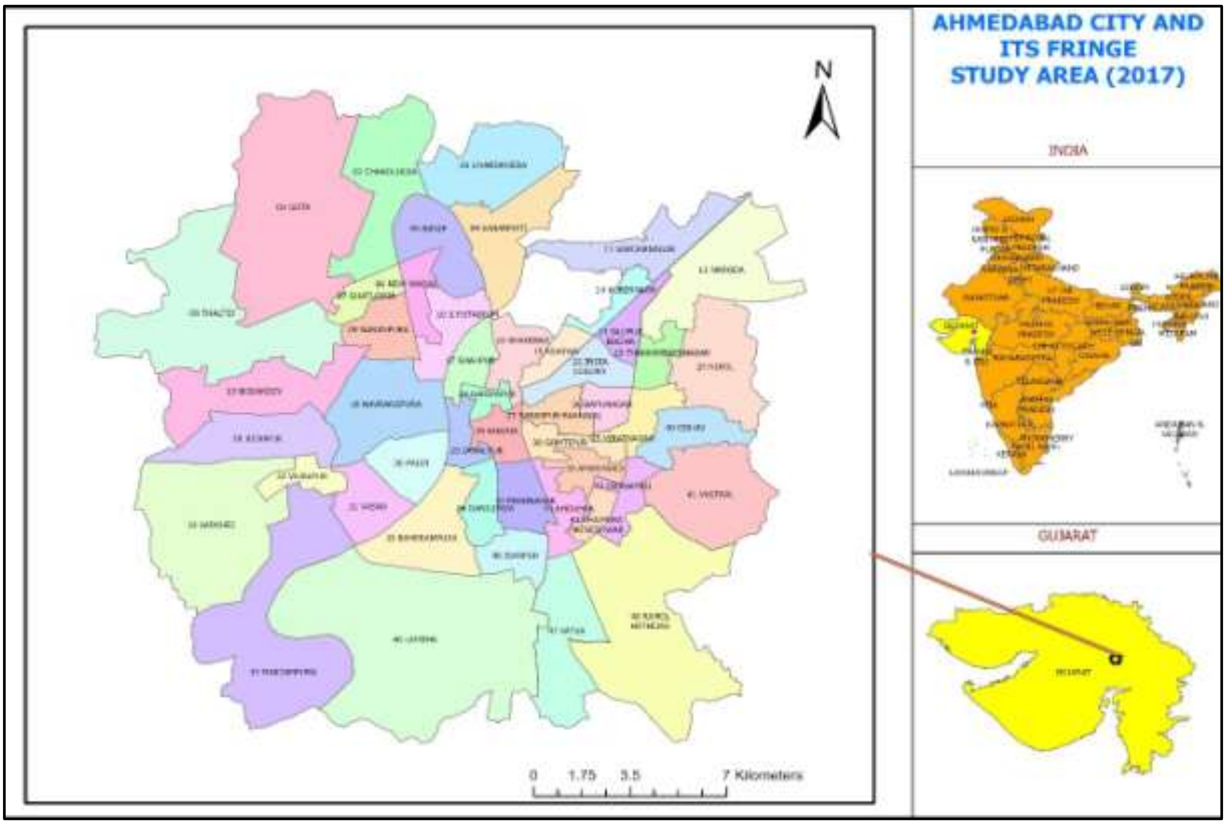
A variety of classification approaches have been developed and extensively used to produce land cover maps. They vary in logic from supervised to unsupervised classification; parametric to nonparametric to nonmetric, or rigid and flexible (fuzzy), or pixel, sub-pixel and profile classification (Keuchel et al.). 2003 and 2005). However, there are two Traditional types of classification procedure and each of these types finds application in the processing of remote sensing images: one is referred to as supervised classification and the other one is unsupervised classification. These can be used as alternative approaches, but are often combined into hybrid methodologies using more than one method (Richards and Jia, 2006) but Object-oriented image classification methods provide a promising tool for mapping detailed land cover (Mori et al.,2004).

OBJECTIVE:

The objective of the present study is to generate a high accuracy land use/cover classification map for Ahmedabad city and its surrounding which located in the state of Gujarat, India using recent period high resolution data. To our knowledge, such a recently classified map using high-resolution satellite data has not been attempted. The cards available are quite ancient. In the current context of rapid urbanization and changing land use patterns, this contribution is essential for several studies.

STUDY AREA:

More than 600-year-old Walled City of Ahmedabad founded by Ahmed Shah is India’s first World Heritage City. Ahmedabad City is situated along the banks of River Sabarmati in Gujarat (India). It is the largest city in the state and the seventh-largest Metropolis in India. The city of Ahmedabad is governed by Ahmedabad Municipal Corporation (AMC), the area of approximately 466.35 km² and Greater Ahmedabad is under the jurisdiction of the Ahmedabad Urban Development Authority (AUDA) with an area of approximately 4200 sq. km. The population of the city has increased from 3.31 million in 1991 to 5.8 million in 2011 (Census of India, 2011). Ahmedabad is showing remarkable activities in terms of urbanization and industrialization in recent decades. The interaction of demographic and economic forces has resulted in highly segmented spatial pattern of growth in terms of income-class and environment qualities. It is essential to study the trends and magnitude of changes in LULC as well as the population change in the towns and villages of the Ahmedabad City for better policy and development planning. A buffer of 2.4 km was taken around the AMC boundary and that whole area of about 922.43 sq. km is taken as the study area to understand future expansion of the city and its land use. (Buffer taken is as per the availability of data).



The urban and peri-urban regions of Ahmedabad are characterized with diverse microenvironments viz. rural areas in West, densely populated urban conglomerates in West and Central regions, industrial regions in the Central and East Ahmedabad. The study area of Ahmedabad is shown in Figure.1

DATA SETS AND MATERIAL:

LISS IV images have been acquired for the years, 2007, 2017 for land use mapping purposes. The pre-processing and post image processing and analysis were carried out to enhance the quality of the images and the readability of the features LISS IV data sets were geometrically corrected and the projection was set to Universal Transverse Mercator (UTM) projection system, Zone 43N. The spheroid and datum were referenced to WGS84. All the images were geometrically co-registered to each other using ground control points into UTM projection with geometric errors of less than one pixel, so that all the images have the same coordinate system.

Table 1 Data Used

SR. NO.	SATELLITE SENSOR	YEAR	RESOLUTION (M)
1	LISS - IV	2007	5.8
2		2017	

METHODOLOGY:

Supervised Classification Methods: Support Vector Machine (SVM) SVM is performed by making use of an efficient hyperplane searching technique that uses minimal training area and therefore consumes less processing time. It is a nonparametric method but capable of developing efficient decision boundaries and therefore can minimize misclassification. There will be an infinite number of hyperplanes and SVM will select the hyperplane with maximum margin. The margin indicates the distance between the classifier and the training points. Classification has done using National Remote Sensing Center's Standards.

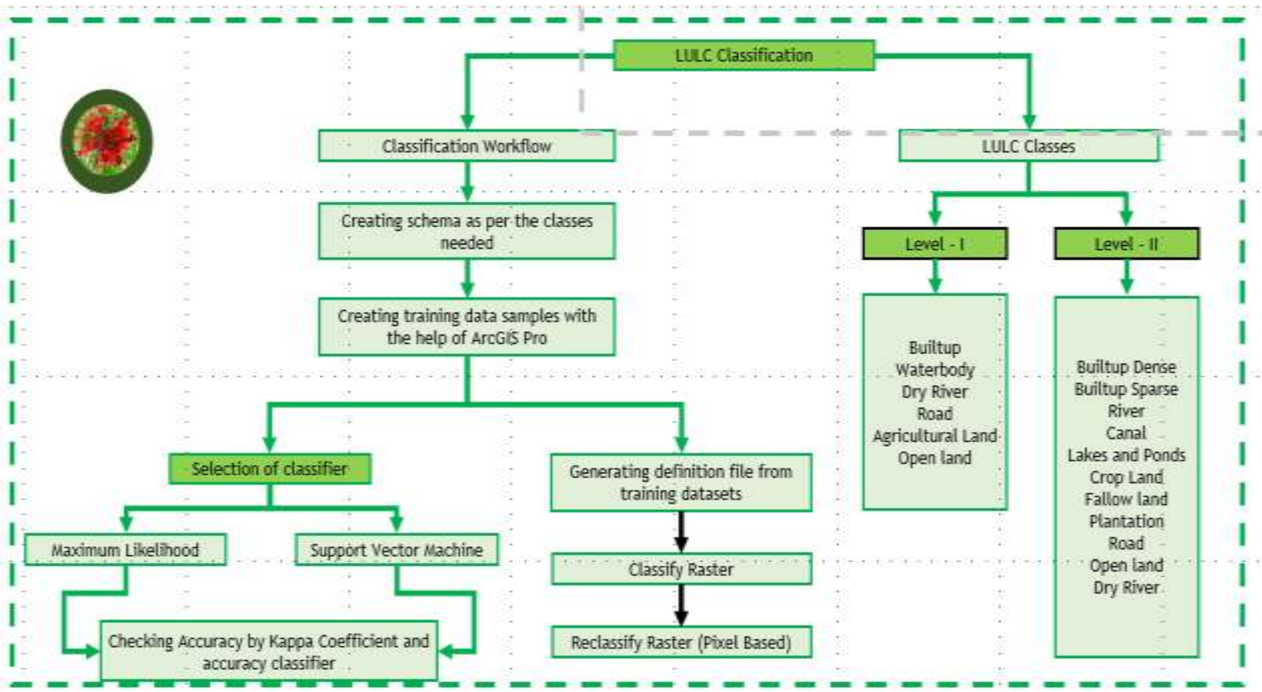


Diagram 1: Methodology

Table 2 Level – I Classification Description

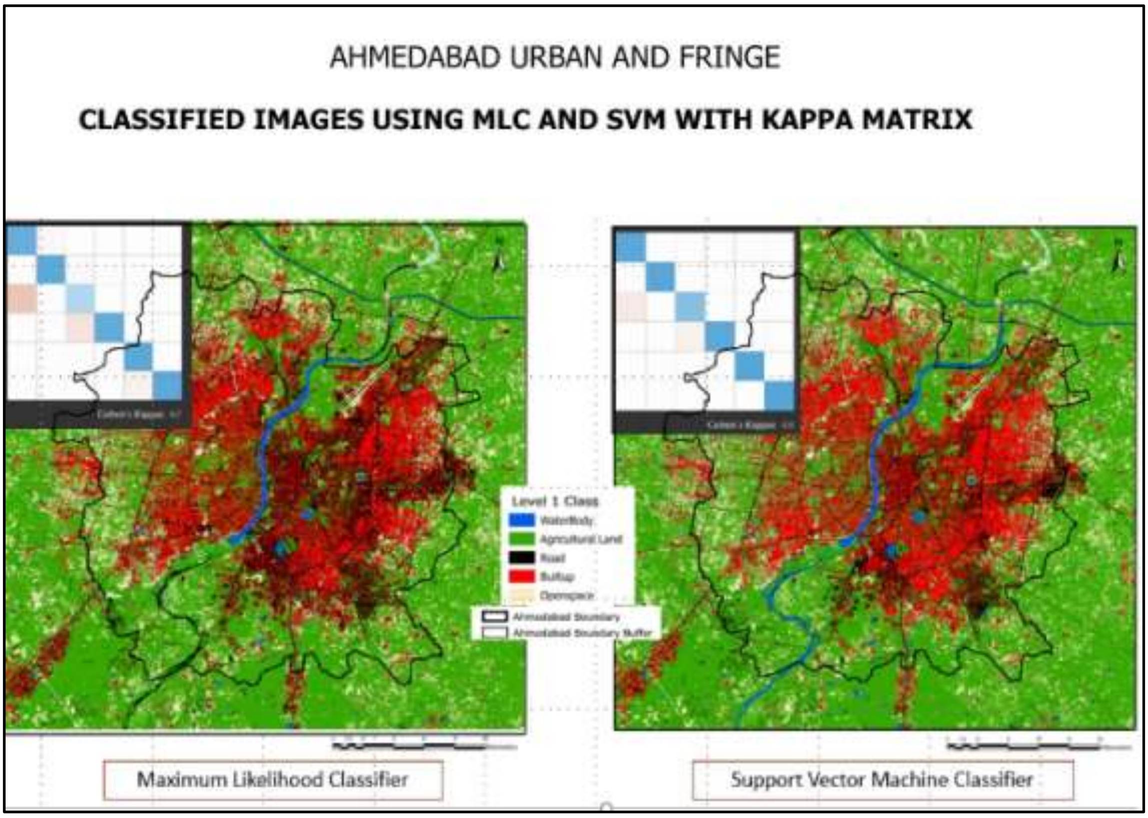
Built Up	It is an area of human habitation developed due to non- agricultural use and that has a cover of buildings in the rural and urban. It includes commercial, residential, utilities in association with water and vacant lands.
Agricultural land	These are the lands primarily used for farming and for production of food, fiber, and other commercial and horticultural crops. It consists of Croplands, Plantations, Fallow land & Current Shifting Cultivation areas.
Waste Land	Described as degraded lands which can be brought under vegetative cover with reasonable effort and which is currently underutilized and land which is deteriorating for lack of appropriate water and soil management or on account of natural causes.
Water Bodies/ Wetlands	All submerged or water- saturated lands, natural or man- made, inland or coastal, permanent or temporary, static or dynamic, vegetated or non- vegetated, which necessarily have a land- water interface, are defined as wetlands.
Roads	A road is a thoroughfare, route, or way on land between two places that has been paved or otherwise improved to allow travel by foot or by some form of conveyance.

Maximum Likelihood Classification (MLC) In MLC, the distribution for each class in each band is assumed to be normal and the probability a given pixel belongs to a specific class is calculated based on this assumption. Each pixel is then assigned to the class that has the highest probability. Classification is performed by calculating the discriminant functions for each pixel in the image.

Table 3: Level – II Classification Description

Built-up Dense	This class describes the land covered by closely compacted buildings.
Built-up Sparse	This class includes buildings which are dispersed or scattered that is which are not dense.
Crop Land	These are the areas with standing crop as on the date of Satellite overpass. Cropped areas appear in bright red to red in color with varying shape and size in a contiguous to non-contiguous pattern. It includes kharif, rabi crop lands.
Fallow Land	These are the lands, which are taken up for cultivation but are temporarily allowed to rest, un- cropped for one or more season, but not less than one year.
Plantation	It includes the planting of ornamental flowering trees and plants along the city road, in parks, public places, and compound and houses both in towns and villages. It also includes the development of 'nature parks' for preservation of different species of plants.
River	Rivers/streams are natural course of water flowing on the land surface along a definite channel/slope regularly or intermittently towards a sea in most cases or into a lake or an inland basin in desert areas or a marsh or another river.
Canals	Canals are artificial water course constructed for irrigation, navigation or to drain out excess water from agricultural lands.
Lakes/Ponds	This category comprises areas with surface water in the form of ponds, lakes, tanks.
Road	A road is a thoroughfare, route, or way on land between two places that has been paved or otherwise improved to allow travel by foot or by some form of conveyance.
Open Land	Open land refers to non-built-up land with no, or with insignificant, vegetation cover.

SATELLITE DATA ANALYSIS:



Comparison Result of Supervised Classification Methods: Classification was done on the satellite image of the year 2017 using both the classification techniques i.e. Support Vector Machine (SVM) and Maximum Likelihood Classifier (MLC). The kappa co- efficient, which is a statistic used to measure interpreter reliability, was 0.7 for MLC and 0.9 for SVM method. As a result, SVM classification method was used for classification purpose.

LEVEL 1 CLASSIFICATION:

For the classification purpose we have taken 2 level of classification classes which are based on NRSC- ISRO LULC Guidelines. Level 1 classification was done to understand the change and growth of the city and Level 2 classification images were used as an input for the model.

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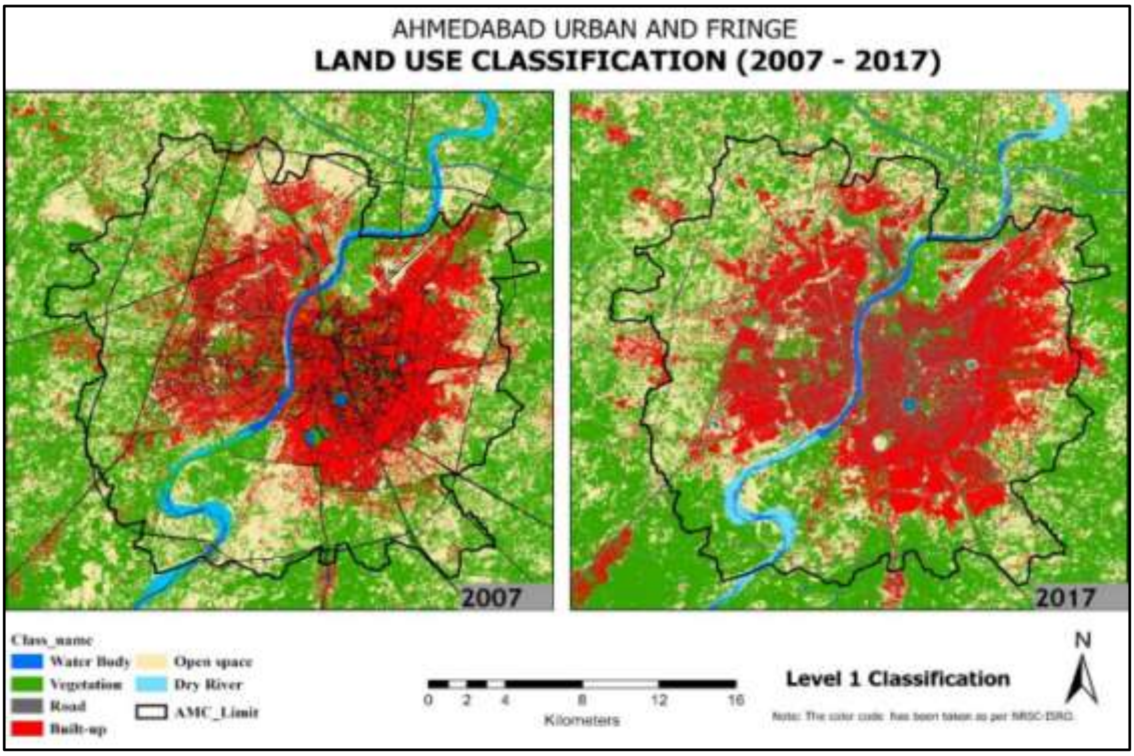
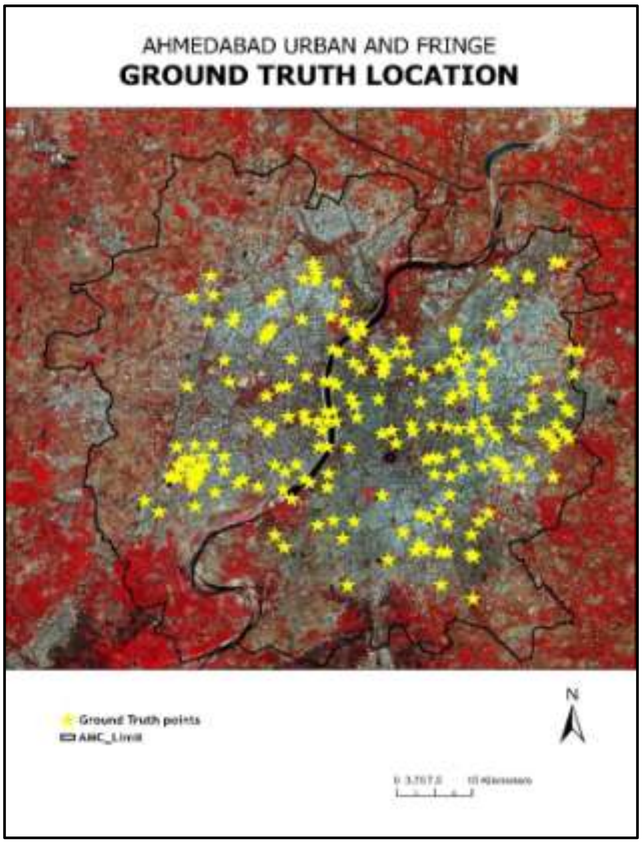


The most general or aggregated classification is Level 1 which includes broad land use categories. Level 1 classification was done using Support Vector Machine (SVM) classifier technique. The results are shown in the Map (3).

The classified image shows 6 broader land use classes. In the year 2007, built-up was mostly restricted within the city limits whereas by 2017, it has grown outside the city limits too. The process of change has been shifted from core to periphery region.



GROUND TRUTH: Field survey was performed throughout the study area using Global Positioning System (GPS). This survey was performed in order to obtain accurate location point data for each LULC class included in the classification scheme as well as for the creation of training sites and for signature generation. Ground truth points are collected generously using the GPS and also corroborated with the high-resolution data. The distribution of GT points in the study area.

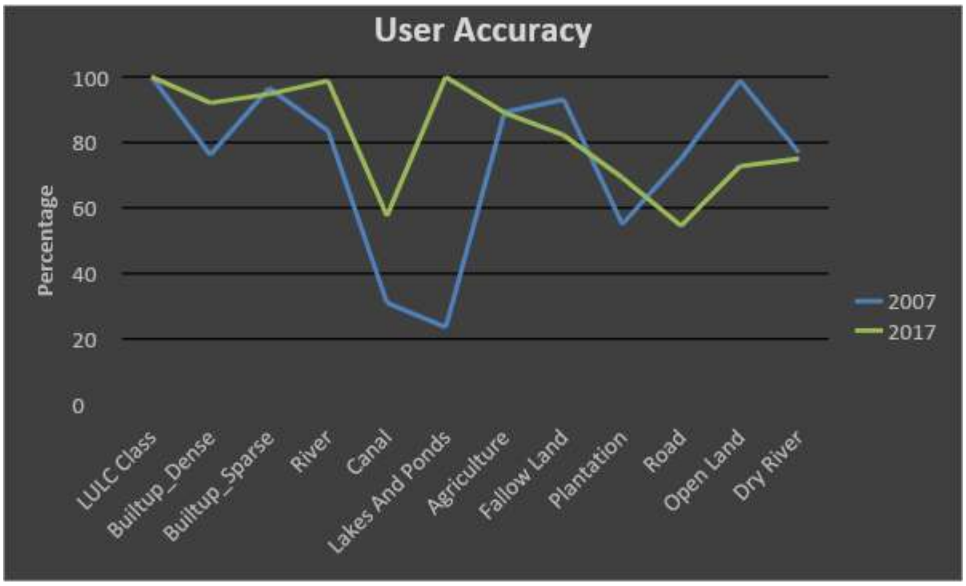
	
White roof Top with China mosaic	Low Rise Dense Buitup
	
High Rise Dense Buitup	Industiral Area
	
Fallow Land	Garden

Figure 1: Ground verification photos

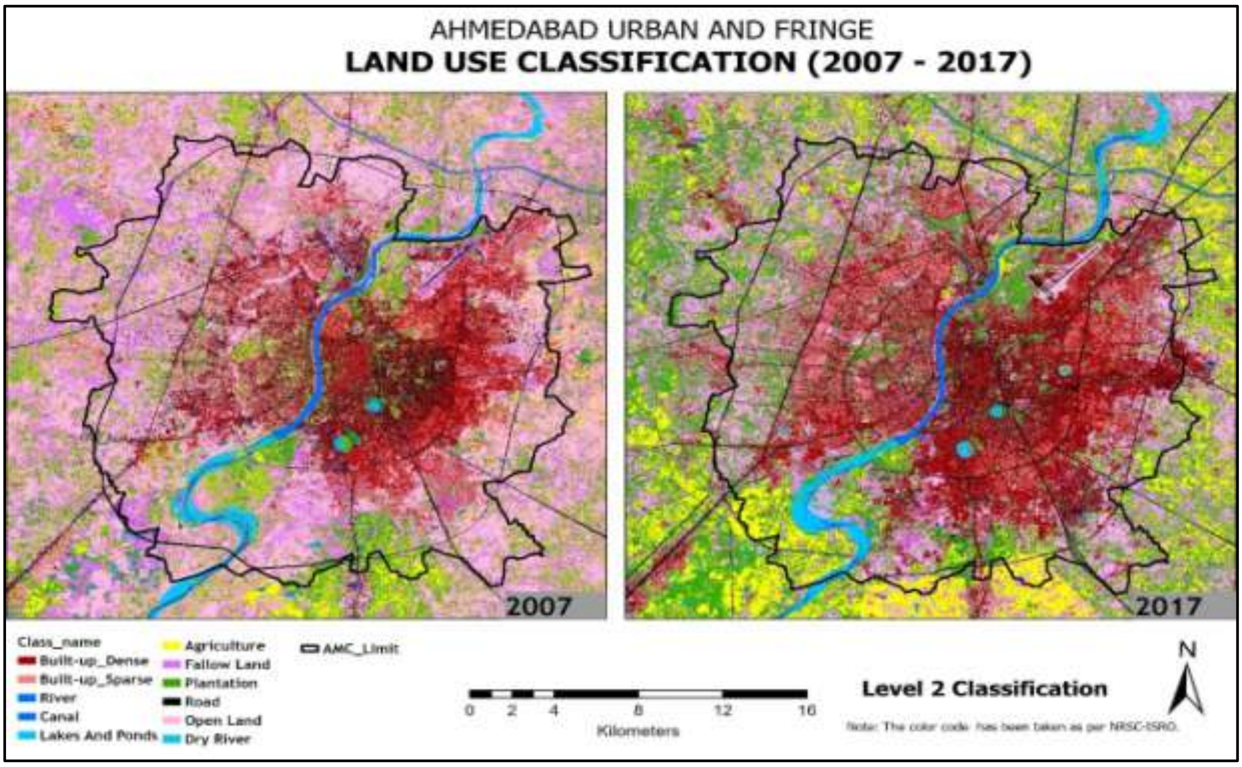
ASSESSMENT OF CLASSIFICATION RESULTS USING ERROR MATRIX:

The error matrix-based accuracy assessment method is the most common and valuable method for the evaluation of change detection results. Thus, an error matrix and a Kappa analysis were used to assess change accuracy, Kappa analysis is a discrete multivariate technique used in accuracy assessments (Congalton and Mead, 1983; Jensen, 1996). Classified Map of Ahmedabad district is shown in Figure 6 and 7 respectively. Table shows the accuracy of the assessment in terms of average User's Accuracy, average Producer's Accuracy and Overall Accuracy. Table 3 shows the class wise Kappa statistics of the study area. The final classification product provides an overview of the major LULC features of Ahmedabad district for the year 2017.

The over-all accuracy of the classified map is 84.48% with Producer's accuracy as 81.01% and 85.54% respectively. Kappa statistics for the classified map are calculated as 0.76.85 and 83.65.


User Accuracy
Percentage
100
80
60
40
20
0
LULC Class
Builtup_Dense
Builtup_Sparse
River
Canal
Lakes And Ponds
Agriculture
Fallow Land
Plantation
Road
Open Land
Dry River
2007
2017

Temporal analysis trend chart shows the change in all land use class with respect to time. On X-axis are the Level 1 classes and Y-axis denotes the area of respective land use classes. Waterbody



remains constant throughout the years; just slight variation is seen. Major difference is seen in the green cover (agricultural cover). The trend for the built-up and road in the increase of the area over the years is similar.**LEVEL 2 CLASSIFICATION:** Within each Level 1 class are a number of more detailed Level 2 LULC classes. The built-up class includes two sub classes: Built-up dense & Built-up sparse. Agricultural land includes three sub classes: Crop Land, Plantation & Fallow land. Likewise, Level 2 classification includes 11 classes. Level 2 classification was done using Support Vector Machine (SVM) classifier technique. The results are shown in the map (5). The dense built-up is seen clearly in the city center and over the years the built-up sparse has been increasing outside the city boundary. For better understanding and visualization, trend chart is been created as shown in the graph (7).

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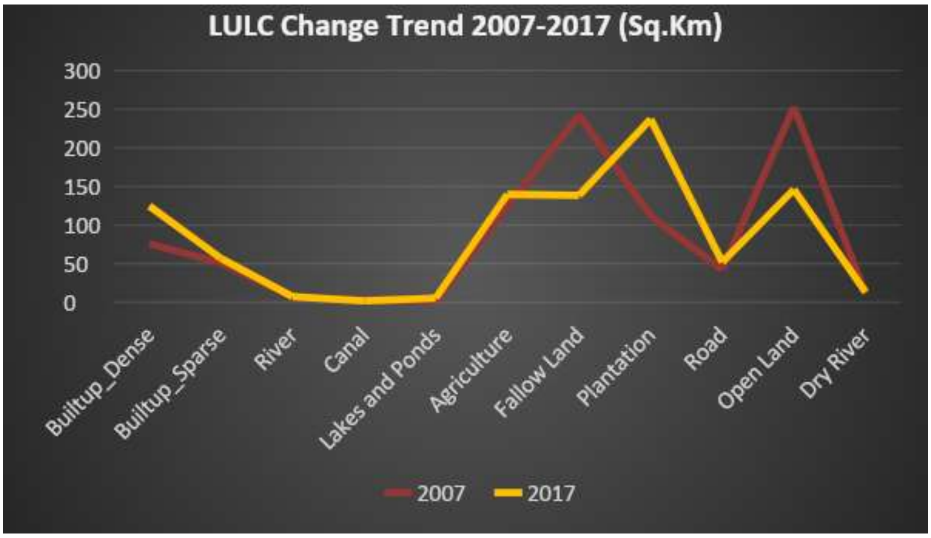
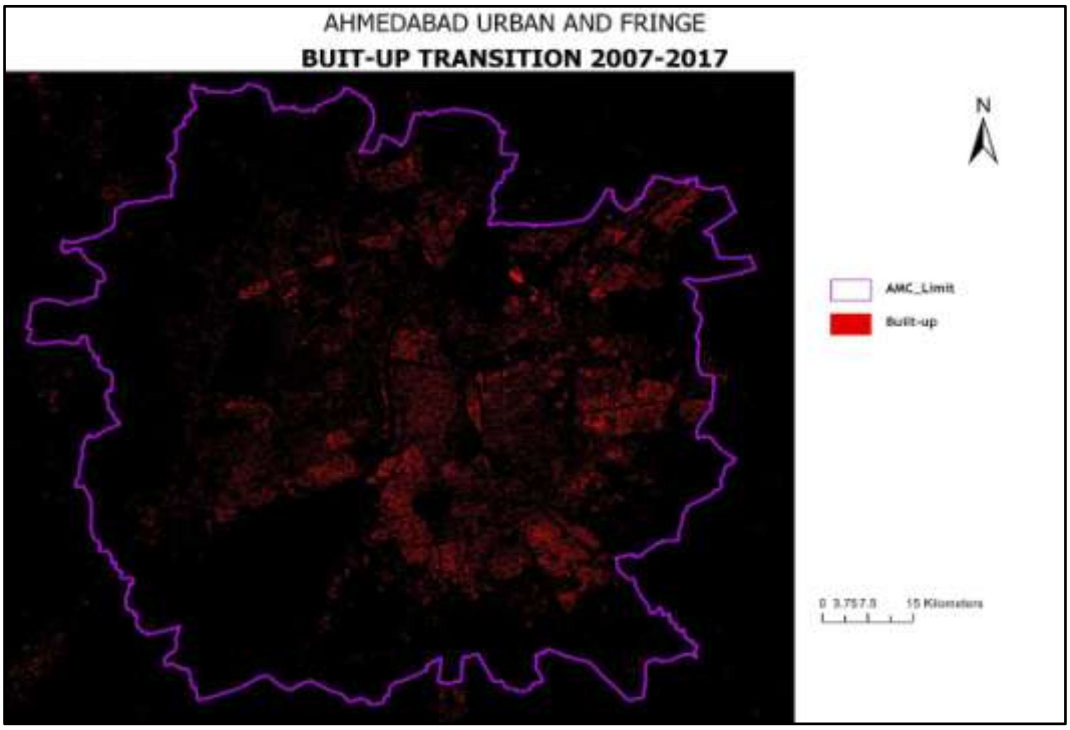


Over the years, there has been increase in built-up dense/sparse areas and agricultural land has been decreasing. There has been decrease in open land as well. There is no such drastic change in area covered by waterbody over the period.

RESULTS AND DISCUSSION:

Change Detection Analysis was carried out to identify how a given area has changed between two or more time periods. Below Map (6) shows that an increase in built-up areas which implies



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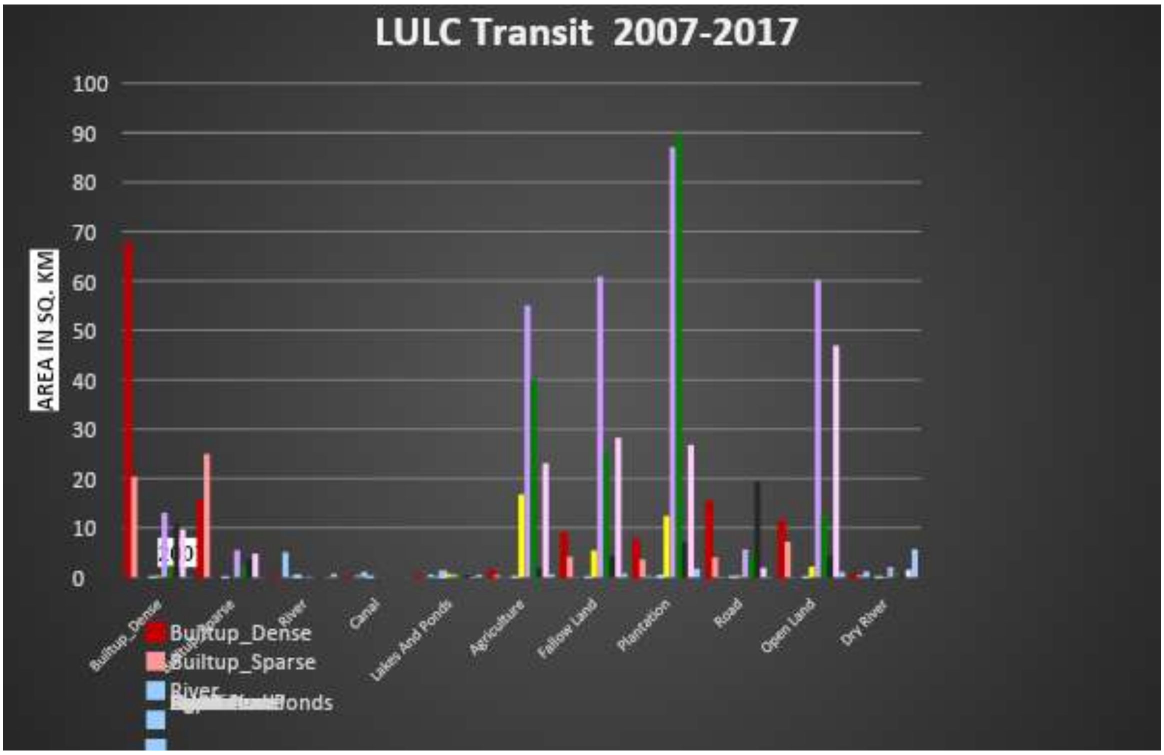
estation and loss of vegetation caused by clearing of land for building construction. Majority of the change is seen in built-up area as a result change detection analysis for built-up was carried out. The results are shown in the Map (6). Red colour in the map shows transition from Builtup sparse to built-up dense between the period 2007 to 2017.



Graph 3: LULC Transit (2007-2017)

In the map of 2017, all the fallow land which was present in 2007 (especially in the western part) got converted into different land-use (Majorly Built-up). So, in the map shown in graph (3), red colour shows the loss in fallow land over time while the yellow color shows no change and the green colour shows the pixels which got converted to fallow land.

Scrub and Fallow land. 100% accuracy is obtained in water class and also in Urban-Airport and Urban Plantation classes. The LULC map has been generated at 1:4,000 scale using Resourcesat-2 LISS IV high resolution multi-temporal datasets. This map is based on the standard methodology adopted for generating LULC maps at district level hence it would be a very useful input to several research studies over the study area.

DISCUSSION AND CONCLUSION:

In this study, a combined approach of satellite remote sensing images, GIS, and prediction models was explored to understand the spatial-temporal dynamics of LULC and future scenario in Ahmedabad city of Gujarat, India. For this purpose, LULC patterns were examined by using LISS IV images of respective years 2007 and 2017.

Firstly, the accuracy of LULC maps by the moderate resolution of multi-temporal LISS IV images. It is still not easy to include the unpredictable influence of other variables, like government policy or socioeconomic aspects. So, to achieve improved results, image quality should be increased, and new prediction models should be developed by incorporating more socioeconomic and physical variables. Moreover, this kind of study exhibited a high prospective to contribute towards the sustainable development and management of an area at the local as well as global level around the world.

Major steps of the research can be summarized as, the LULC mapping with hybrid classification approach and object-based classification has to be done for more accurate and sensitive results. Analyzing the quality and quantity of LULC change with the post classification technique is done in order to determine major LULC transformations.

From the year 2007 to 2017, major changes are seen in the land use classes like open land and green cover which has decreased by 11% and 4% respectively and built-up area has increased by 12% of the total area. The magnitude of changes in built up was recorded high in specific areas within the city limit like Gota, Thaltej, Science City and process of change has been shifted from core to periphery region.

Along with the increase of built-up are the distribution of population will also increase. This increase in the population will create the demand of the public amenities. Therefore, further analysis can be done to calculate the demand in the public amenities based on the increases in population with the increase in built-up area. After calculating the demand, based on the existing locations of the public amenities, locations for the new public amenities can be located by using Multi Criteria Decision making approach.

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