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Land Use and Land Cover Change Detection for Urban Sprawl Analysis of Ahmedabad City using Multitemporal Landsat Data

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Abstract Land use and land cover change is the important factor for the urban growth analysis, and because of urban growth the city is sprawling in the haphazard manner. Because of urban growth and urban expansion there is loss of agricultural land and green area and this is directly responsible for the loss of water body. Here Ahmedabad city has taken as case to study the urban expansion and land cover change that took place in a span of 12 years from 1999 to 2009. Remote sensing methodology is adopted to study the geographical land use changes occurred during the study period. Landsat images of TM and ETM+ of Ahmedabad city area are used in this study. After image processing, supervised image classification has been performed to classify the images in to different land use categories. So knowledge about the land use and land cover is very important and useful for the urban planners and the government for preparation of future master plans and to implement these plans in the proper way.
Keywords *Land Use/Land Cover; Urban Sprawl; Urbanization; Remote Sensing*

1. Introduction

Land use land cover is the important factor for the urban expansion and the growth of the city. Land cover change directly affect the environment because of loss of green are and agricultural land the water body also becomes down. The reason behind the change in land cover is also the increase in the population of the city and because of this the city is spreading everywhere in the haphazard way. The transmutation in land cover occurs even in the absence of human activities through natural processes whereas land use change is the manipulation of land cover by human being for multiple purposes- pabulum, fuel wood, timber, fodder, leaf, litter, medicine, raw materials and recreation. So many socio-economic and environmental factors are involved for the vicissitude in land use and land cover. Land use and land cover change has been reviewed from divergent perspectives in order to identify the drivers of land use and land cover change, their process and consequences. Urban magnification, categorically the kineticism of residential and commercial land to rural areas at the periphery of metropolitan areas, has long been considered a designation of regional economic vitality. Geographical information systems (GIS) and remote sensing are well-established information Technologies, whose applications in land and natural resources management are widely apperceived.

Current technologies such as geographical information systems (GIS) and remote sensing provide a cost efficacious and precise alternative to understanding landscape dynamics. Digital change detection techniques predicated on multi-temporal and multi- spectral remotely sensed data have demonstrated a great potential as an expedient to understanding landscape dynamics to detect, identify, map, and monitor differences in land use and land cover patterns over time, irrespective of the causal factors. Recent ameliorations in satellite image quality and availability have made it possible to perform image analysis at much more immensely colossal scale than in the past. The information about the land use and land cover from past and present gives details of the land cover change. All the researchers identified that urban environments are most dynamic in nature. Information on urban growth, land use and land cover change study is very useful to local government and urban planners for the betterment of future plans of sustainable development of any area.

2. Study Area and Objective

The city of Ahmedabad was founded in 1411 AD as a walled city on the eastern bank of the river Sabarmati, now the seventh largest metropolis in India and the largest in the state. The present Ahmedabad City lies between 23.03°N 72.58°E. The city has no main physical feature only Sabarmati River is there and which divides the city into two parts one is walled city means old city and other is new Ahmedabad city which we can see in Figure 1.

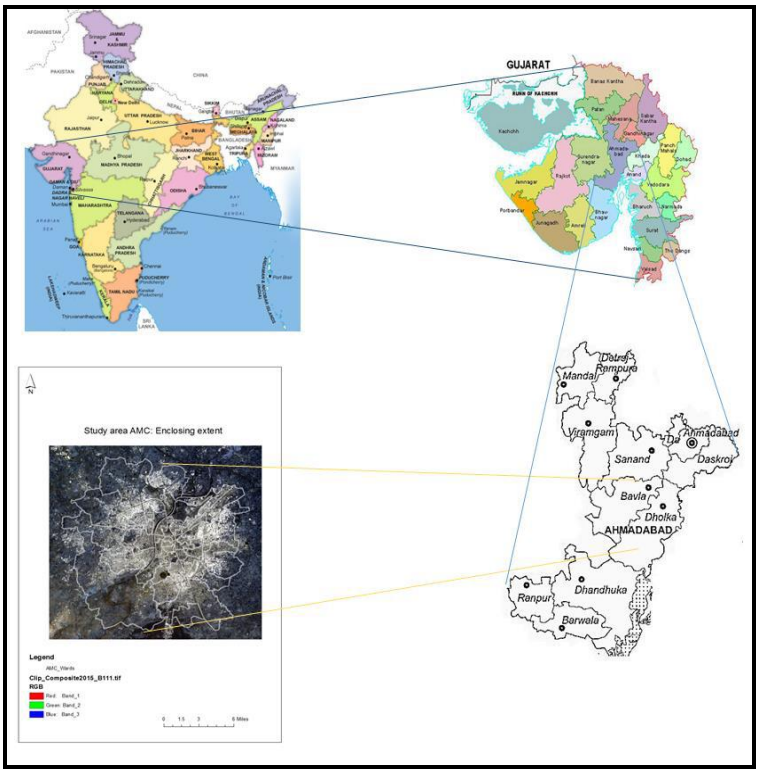

Figure 1: *Location of the Study Area*

Historically Ahmedabad has been one of the most important centers of trade and commerce in western India. The urban agglomeration (UA) population has increased from 3.31 Million in 1991 to 4.5 million in 2001 and the current population is 5.57 million (census 2011). The area of the city has also accordingly increased and is at present is 464 sq.km. as per Ahmedabad city master plan.

Objective of this study is analysis of the land use pattern and changes of land use pattern in Ahmedabad city between 1999 to 2011.

3. Material and Methods

Land use and Land cover maps is done in ARC GIS 10.1 software. The LU/LC pattern are studied and analyzed to detect the change in urban expansion and urban sprawl. The methodology adopted in detail is shown in the Figure 2.

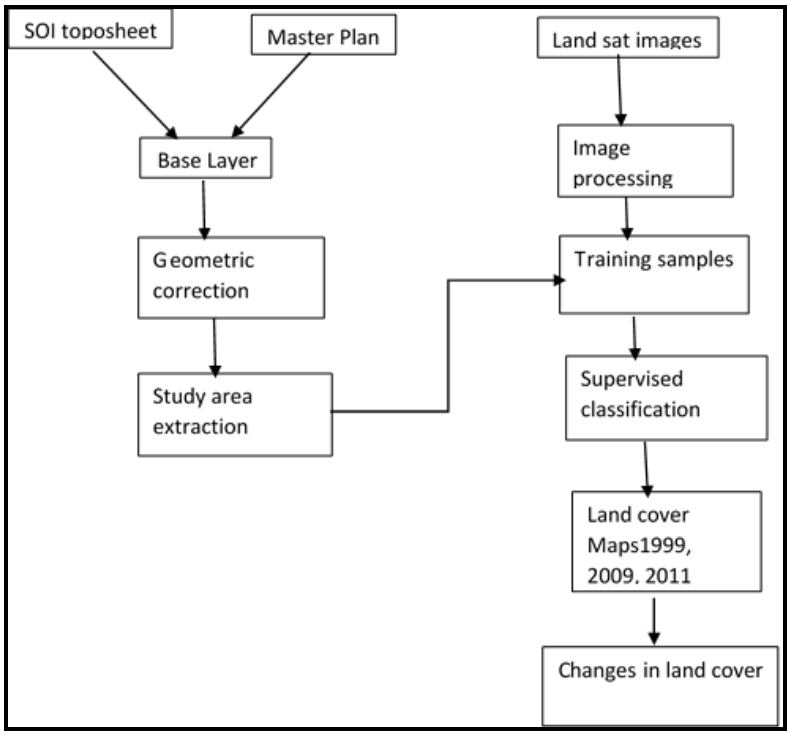

Figure 2: *Methodology Chart*

3.1. Data and Source

Urban growth was analyzed using temporal remote sensing data of the period 1999 to 2011. The time series spatial data acquired from Land sat look viewer (30m) sensors for the period 1999 to 2011 were downloaded from public domain (landsatlookviewer.org landsat.usgs.gov.in). Survey of India (SOI) topo-sheets of 1:50000 and 1:250000 scales were used to generate base layers of city boundary, etc. City map with ward boundaries were digitized from the Ahmedabad Municipal corporation map. The details of data collected is in Table 1.

Table 1: *Details of Data Collected*

Name	Data	Source
Primary	Satellite images May 1999,2009,2011	Land Sat 5TM 30 m resolution
Secondary	Master Plan, CDP	AUDA, AMC

The method involves i) Image analysis of remote sensing data (bands – green, red and NIR). ii) Selection of training samples (iii) loading these training polygons co-ordinates into pre-calibrated GPS, vi) collection of the corresponding attribute data (land use types) for these polygons from the field. GPS helped in locating respective training polygons in the field, iv) supplementing this information with Google Earth v) 60% of the training data has been used for classification, while the balance is used for validation or accuracy assessment. Land use analysis was carried out using supervised pattern classifier Accuracy assessment to evaluate the performance of classifiers (Mitrakis et al., 2008; Ngigi

et al., 2008; Gao and Liu, 2008), was done with the help of field data by testing the statistical significance of a difference, computation of kappa coefficients (Congalton et al., 1983; Sha et al., 2008) and proportion of correctly allocated cases (Gao & Liu, 2008). Recent remote sensing data (2010) was classified using the collected training samples. Statistical assessment of classifier performance based on the performance of spectral classification considering reference pixels is done which include computation of kappa (κ) statistics and overall (producer's and user's) accuracies. For earlier time data, training polygon along with attribute details were compiled from the historical published topographic maps, vegetation maps, revenue maps, etc. Application of maximum likelihood classification method resulted in accuracy of 80% in all the datasets. Land use was computed using the temporal data through ARC GIS. Land use categories include i) area under vegetation (parks, botanical gardens, grass lands such as golf field.), ii) built up (buildings, roads or any paved surface, iii) water bodies (lakes/tanks, sewage treatment tanks), iv.) Non built up barren land.

4. Results and Discussions

The Ahmedabad Urban Development Authority is in charge of land utilize arranging inside of its jurisdictional breaking points. As expressed over, the territory under AUDA might be seen as different subunits relying upon the authoritative jurisdictional cutoff points and degree of advancement. Of this, the region outlined as Ahmedabad Urban Complex comprising of AMC, outgrowth connecting AMC and territory liable to create in the ten years has been assigned as Ahmedabad Urban Complex This AMC city area has been taken for the study of land us land cover changes

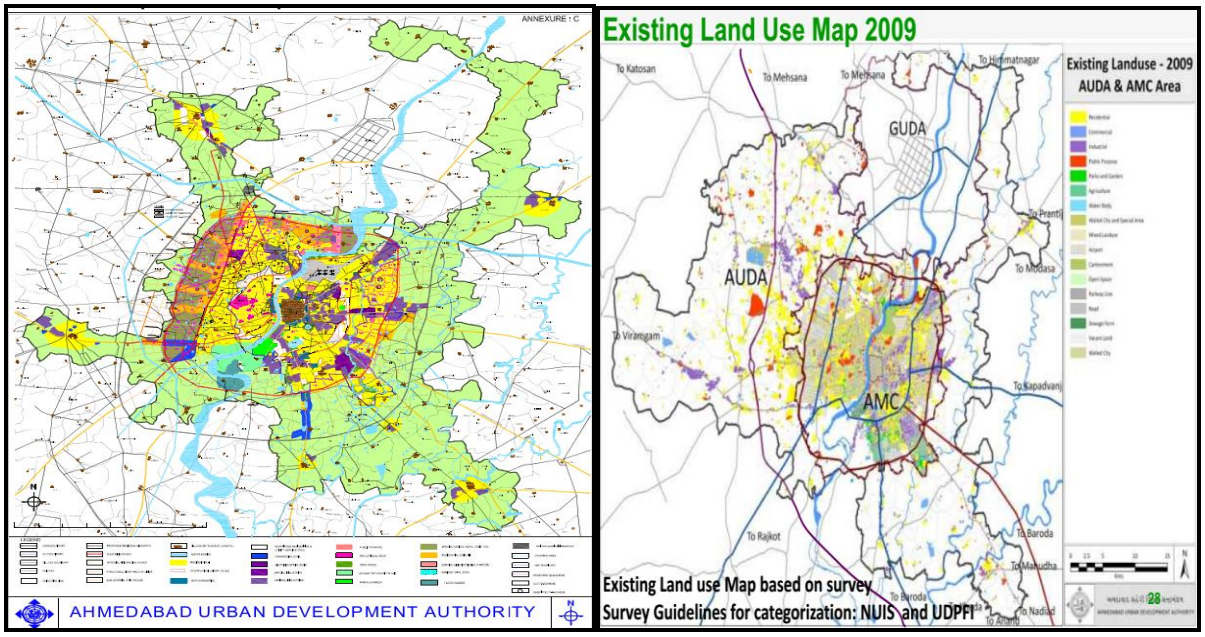

Figure 3: *Ahmedabad Urban development Master Plan (2009-2011)*

According to the State Government Policy, no major modern improvement inside of 24 kms of AMC point of confinement is allowed in AUDA zone. Considering existing advancement conditions a specific zone for modern utilize is assigned for light industry and in addition for general industry, alongside existing commercial enterprises at Vatwa, Naroda and Odhav (all lying within AMC), which forms nearly 10.38 percent. As per existing land use, more than one third (43%) of the total area is under residential use, followed by 15 percent of the area under the industries (Refer Figure 3).

Table 2: *Land use of the AUDA area*

Land uses	Total area (ha.)	% of Total area
Residential	8340.22	43.7
Walled city and village sites	645.56	3.38
General industrial	2006.51	10.51
Special Industrial	786.72	4.12
Commercial	263.06	1.38
Agricultural/recreational/open space	1643.6	8.61
Education	387.3	2.03
Area reserved	1955.37	10.25
Roads & highways	2117.67	11.1
water body	937.97	4.92
Total area	19084	100

Information on land use - land cover pattern, especially the extent and spatial distribution of the same is important for the preparation of the prospective Development Plan. The land use - land cover information helps in formulation of policies for urban development and to know the growth pattern of city. Using the classification system and employing both visual and digital analysis techniques and with limited field checks, the urban land use/land cover maps were prepared for the entire city region.

The classified images obtained after preprocessing and supervised classification which are showing the land use and land cover of the Ahmedabad city are given in the following Figures 5, 6 and 7. These images provide the information about the land use pattern of the study area. The yellow colour represents the urban built-up area, dark green colour shows the vegetation, blue colour shows the water bodies and tan color shows the Non built up barren land. Land cover map is also superimposed with the master plan map with the Google images which helps in accuracy checking in Figure 8.

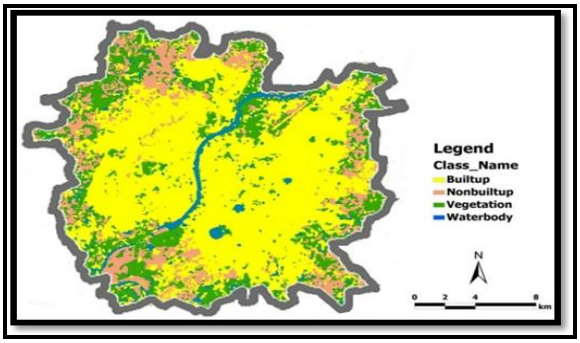

Figure 5: *LU/LC Classified Image of 1999*

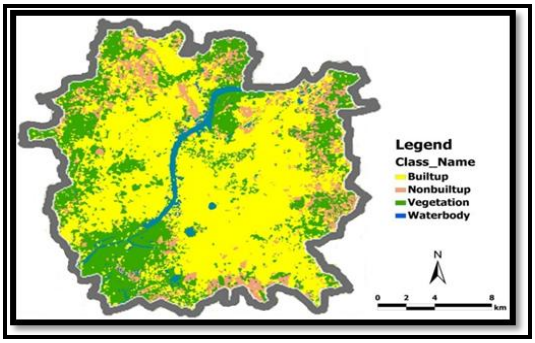

Figure 6: *LU/LC Classified Image of 2009*

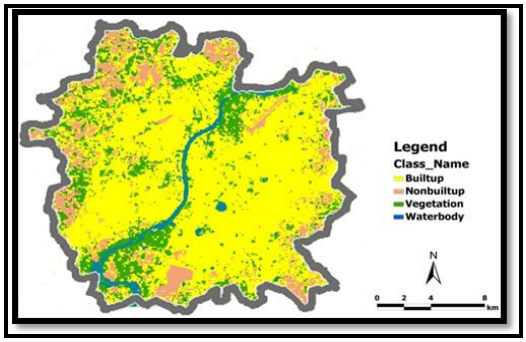

Figure 7: *LU/LC Classified Image of 2011*

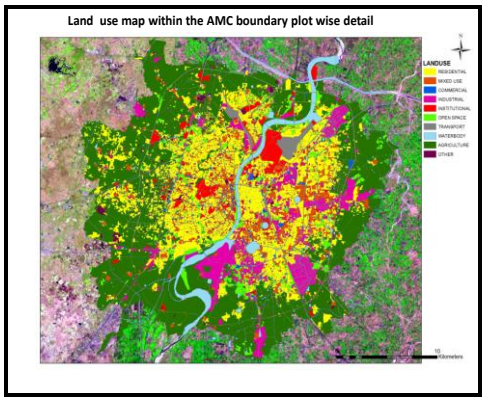

Figure 8: *Land Use Map within AMC Boundary*

4.1. Classification Accuracy Assessment

Each of the land use and land cover map was compared to the reference data to assess the accuracy of the classification. The reference data was prepared by considering random sample points, the field knowledge and Google earth. During the field visits a hand held GPS (Global Positioning System) is used to identify the exact position of the place under consideration with Latitude and Longitude and its type by visual observation. The ground truth data so obtained was used to verify the classification accuracy. Over all classification accuracy for 1999, 2009, and 2011 are 86%, 88% and 90% respectively. The Kappa coefficient for 1999, 2009, and images are 0.88, 0.79 and 0.81 respectively.

4.2. Change Detection Analysis

The urban change analysis presented in this paper was based on the statistics extracted from the four land use and land cover maps of the Ahmedabad city. The changes in land cover during the study period (four dates) can be observed clearly from the pie diagrams shown in Figure 9 to Figure 12.

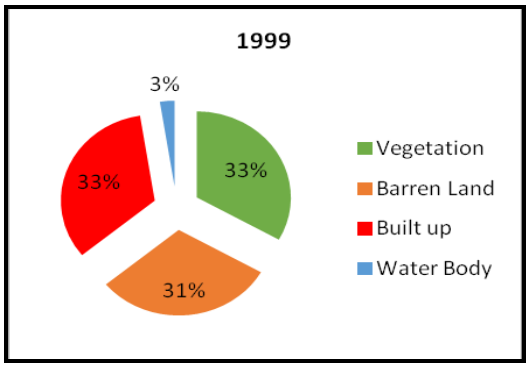

Figure 9: *Land cover in 1999*

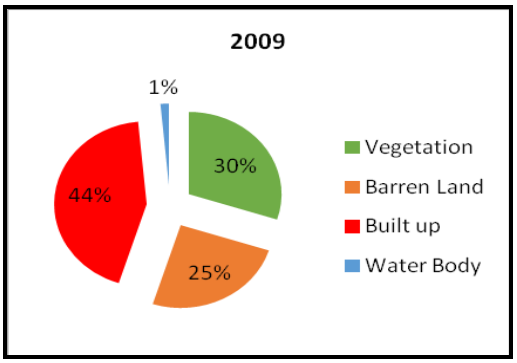

Figure 10: *Land cover in 2009*

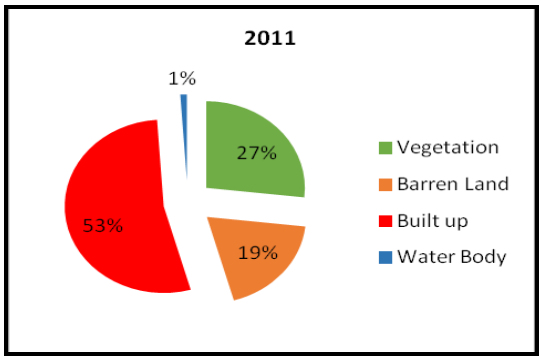

Figure 11: *Land Cover in 2011*

The built-up area as well as vegetation area has been changed drastically from 1999 to 2011. Built-up area has been increased by 22.51%, Vegetation has been decreased by 28.19% and barren area reduced by 24.26% the increase in built-up area has many reasons. Ahmedabad is famous for manufacturing industries, large numbers of industries are coming in to existence and corresponding infrastructure development leads to the increase of built-up area. Increase in institutional establishments and low cost housing are contributing to the loss of agriculture. There is a decrease in water body also by 28% over the study period. It was observed that real estate development is taking place along the Sabarmati river, because of that river water level got decreased and many chemical industries dumping their waste into the river. The results of change detection analysis are presented in the Table 3.

Table 3: *Land Use Changes Matrix of Ahmedabad City (1999-2011)*

Class	Area in Sq.km			Changes in Percentage Area	
	1999	2009	2011	1999-2009	2009-2011
Built up area	150.42	196.05	240.19	30.33506	22.51466
Water	11.26	6.713	4.82	-40.3819	-28.199
Vegetation	149.25	134.64	120.53	-9.78894	-10.4798
Non built-up	138.82	112.13	84.92	-19.2263	-24.2665

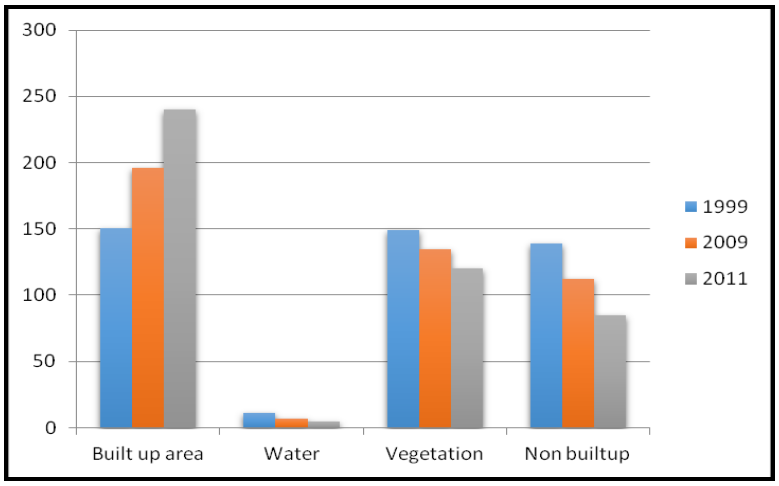

Figure 12: *Land Cover Changes (1999-2011)*

The proportion of land-use changes especially the percentage built-up area, which is a key metric to measure sprawl, were estimated across all the Ahmedabad Municipal corporation area The corresponding land-use changes within the AMC region are shown in Table 2. It was clearly evident that on an average the increase in built-up area from 33% to 53%, decrease in vegetation area form 33% to 27%. Growth of the built up area in the outer region of the city in 2009, towards North (Gota and Gandhinagar) and East Changodar and Sanand. Growth of the built up area in the outer region of the city in 2011, towards West (Ogani) and south East (Vatva). So it shows the increase in the urban area of the city from all the directions. North side city is growing because of Gandhinagar city and all the government and IT industries are situated there. The development along West side is due to the large number of manufacturing industries along this corridor specially Sanand Tata nano plant, and South east is due to the location of existing industrial estate Vatwa and Odhav.

5. Conclusions

Ahmedabad is the largest city and former capital of Gujarat. With a population of more than 6.3 million and an extended population of 7.2 million, it is the sixth largest city and seventh largest metropolitan area of India. Ahmedabad is located on the banks of the Sabarmati River, 30 km from the state capital Gandhinagar. It is experiencing a rapid urbanization. The urban sprawl is seen as one of the potential threats to sustainable development. This study attempted to identify such urban sprawls change for 1999-2011. Information on land use/land cover and possibilities for their optimal use is essential for the selection, planning and implementation of land use schemes to meet the increasing demands for basic human needs and welfare. This information also assists in monitoring the dynamics of land use resulting out of changing demands of increasing population.

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