Spatio-Temporal Analysis of Pulivendula Mandal, Andhra Pradesh, India using Remote Sensing and GIS

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ABSTRACT

Land use refers to the way in which land has been used by humans and their habitats such as Agriculture, settlements and Industry. Land cover is defined as the assemblage of biotic and abiotic components on the Earth's surface and is one of the most crucial properties of the earth system. The Land Use Land Cover is a dynamic phenomenon and which need to be monitored to assess the resources and proper management of the same. The changes occurred over different time intervals give a better idea for which change detection using spatial technologies is an appropriate method. Change Detection studies is a process of identifying and analyzing the differences of an object or a phenomenon through monitoring at different times within the equivalent corresponding visual representations. The study area i.e. Pulivendula mandal, is located on the North-West region of the district of Y.S.R. Kadapa district, Andhra Pradesh, India and is bounded by longitudes $78^0$8'00'' & $78^0$18'00'' East and latitudes $14^0$20'00'' & $14^0$30'00''North with intended boundary falling in Survey of India open series maps numbering D44G03 and D44G07. The geographical extent of the study area is 18,156.149 Ha and inhabited by 20 village settlements. The geology of the study area is mainly covered by three types of formations i.e. Gulchheru quartzites, Vempalli and Tadipathri formations.

The Satellite Imageries acquired in different time intervals 2001 and 2011 are used for Spatio-Temporal analysis using image processing and GIS techniques in ERDAS Imagine and Arc GIS Softwares among five classes. The Land Use/ Land Cover maps thus generated using Maximum Likelihood decision rule in image processing and GIS techniques on both the imageries are thoroughly compared for change detection. The changes in the classes namely Forest Land, Agricultural Land, Water, Built up and Barren lands are identified with shift from one class to the other are detected and the reasons are being identified through field visits. The LULC studies in the present paper ensure future scope of the study area in environmental perspective, sustainable management of resources and future planning.

KEY WORDS:
Land Use Land Cover, Change Detection, ERDAS, Arc GIS, Pulivendula Mandal

Introduction:

Land use refers to the way in which land has been used by humans and their habitats (such as agriculture, settlements, industry). Land cover defined as the assemblage of biotic and abiotic components on the Earth's surface is one of the most crucial properties of the earth system. The interaction of land cover with the atmosphere, which leads to regulation of the hydrologic cycle and energy budget, these are mainly disturbed land (Defries et al., 2002). Land cover refers to the physical characteristics of earth's surface, captured in the distribution of vegetation, water, soil, and

other physical features. Land use /land cover change has become a central component in current strategies for managing natural resources and monitoring environmental changes. (Harshika A. Kaul and Ingle Sopan 2012). Over the years, remote sensing has been used for land use/land cover mapping in different parts of India. (Gautam and Narayanan, 1983: Sharma et al., 1984: Jian, 1992: Brahabhatt et al., 2000). The advancement in the concept of vegetation mapping has greatly increased research on land use/land cover change thus providing an accurate evaluation of the spread and health of the world's forest, grassland, and agriculture researches become an important priority. Accurate and up-to-date land cover change information is necessary to understand and assess the environmental consequences of such changes.

The Satellite remote sensing data with their respective nature have proved to be quite useful in mapping land use/land cover patterns and changes with time. Remote sensing (RS) and Geographic information System (GIS) are now providing new tools for advanced ecosystem management. The collection remotely sensed data facilities the synoptic analyses of Earth- system function, pattern, and change at local, regional and global scales over time; such data also provide an important link between intensive, localized, ecological research and regional, national and international conservation and management of biological diversity. (Wilkie and Finn, 1996). Inventory and monitoring of land use/land cover changes are indispensable aspects for further understanding of change mechanism and modelling the impact of change on the environmental and associated ecosystems at different scales. (Turner et al., 1995; William et al., 1994). Remote sensing is valuable data source from which land use/land cover change information can be extracted efficiently. In the past two decades, there has been a growing trend in the development of change detection techniques using remote sensing data. Underlying causes of LULC changes leading to deforestation and land degradation include rapid economic development, population growth and poverty. (Giri et al., 2003, Bolland et al., 2007).

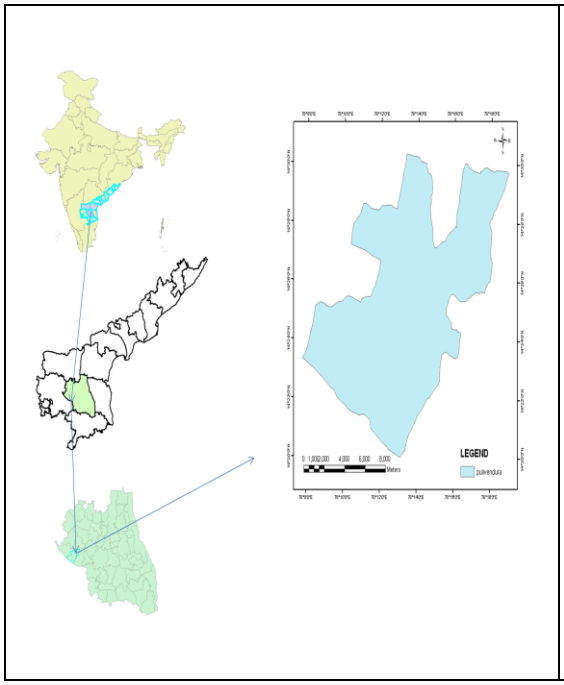


Fig. 1. Location Map

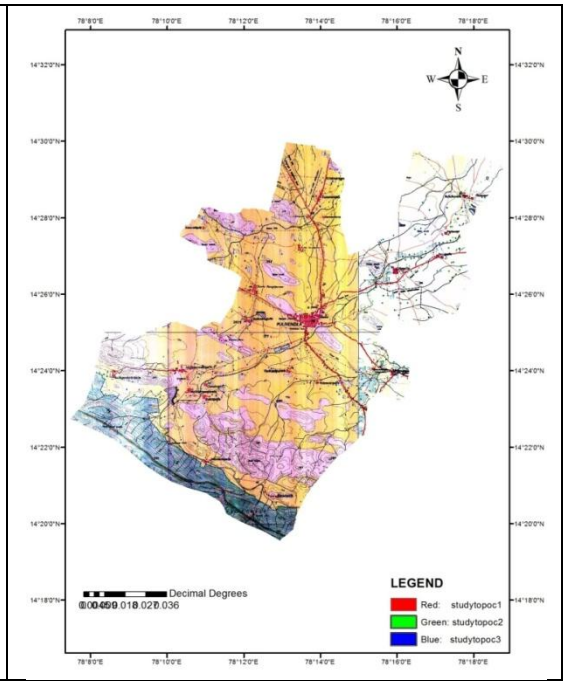


Fig.2. Topomap

Change detection is a process of identifying and analyzing the differences of an object or a phenomenon through monitoring at different times. (Singh 1989; Mouat et al., 1993). A wide range of applications can be benefited from the study of change process over a specified area at different

times. (Md. Abdul Halim et al., 2008). Application of remotely sensed data made to study the changes in land cover in less time, at low cost and with better accuracy (Kachhwaha 1985) in association with Geographical Information System(GIS) that provide suitable platform for data analysis, update (Star et al., 1997; McCracker et al., 1998; Chilar 2000). Change detection has become an essential task for image analyst and GIS professionals across industries and disciplines. Change detection is either changes in the land itself or objects on the land, it provides information that is important when making decisions that affect land use. The change detection has manually visually comparing images, or analyzing images pixel by pixel can be labour intensive and time consuming and can be lead to misidentification and other inadvertent errors (Lillesand, T.M. et al 2000).

The collaboration of remotely sensed data and field observations can accomplish land cover classification and change detection. This paper entails classifying the land use/land cover of the Mandal in LANDSAT and IRS LISS-III scenes from 2001 and 2011, and assessing the changes that have occurred between them. Successful utilization of remotely sensed data for land use and land cover change detection requires careful selection of appropriate data set and methods. Recently the functioning of the real estate's people and property promoters are bringing a disaster to forest area and agriculture land. This is an unhealthy situation of land management, in this context studies on land use land cover change detection are essential to understand the existing situation and plan for the future.

Study Area:

The study area i.e. Pulivendula mandal, is located on the North-West region of the district of Y.S.R. Kadapa district, Andhra Pradesh, India and bounded by longitudes $78^0$8'00'' & $78^0$18'00'' East and latitudes $14^0$20'00'' & $14^0$30'00''North with intended boundary falling in Survey of India open series maps numbering D44G03 and D44G07. The geographical extent of the study area is 18,156.149 Ha and inhabited by 20 village settlements. The climates is semi arid and the land is suitable for commercial crops like sunflower, groundnuts, banana, sweet lemon and lime that are grown in surrounding villages. Banana and sweet lemons are exported to other states of India. The town's main drinking water resources is Chitravathi Dam, Parnapalli. The climatic conditions of the study area as its minimum temperature in November-January at about 28-20^0. The hottest temperature ranges between the 40-45^0C ranges during April-May. Ahobilapuram, Atchavalle, Bakarapuram, Boggudupalle, Brahamanapalle, Chinnarangapuram, Erraballe, K.Velmavaripalle, Kachivaripalle, Karampalle, Kanamvaripalle, Korrapadu, Peddarangapuram, Polepalle, Pulivendula, Ragimanupalle, Rastamarripalle, Rayalapuram, Ulimella and Yerragudipadu are important villages in the study area.

Geology & Geomorphology of the study area:

The study area is mainly covered with the three types of formations i.e. Gulcheru formation, Vempalli formation and Tadipathri formations. Gulcheru formation is charecterised by quartzite and conglomerate that form the lowest bed of the Cuddapah Super group. The formation lies over the basement of granitoids with a thin conglomerate base, grits and quartzite with thin shale partings at places. Pebbles are of diverse shape, size, orientation and composition. Primary sedimentary structures like bedding, cross bedding, ripple marks etc, are seen in quartzite. Vempalli formation is followed by Gulcheru formation and the contact is generally conformable consisting of dolomite, mudstone/shale, cherty dolomite and basic flows. The dolomitic limestone is bedded and appears white to grey and on weathering, they appear dark. The spectral characteristic of this formation is from light to medium tone. The drainage is usually internal and sub-surface and the vegetation is moderate with thick soil and hummocks. Tadipatri Formation comprises predominantly shale with intercalated bands of sand stone and intrusive basic sill bodies. The

spectral characteristics are medium to darker in tone. The drainage appears dendritic which is dense, the vegetation being moderate and pediplain topography.

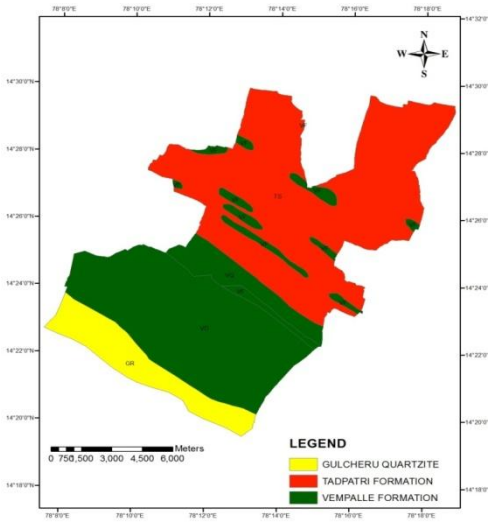


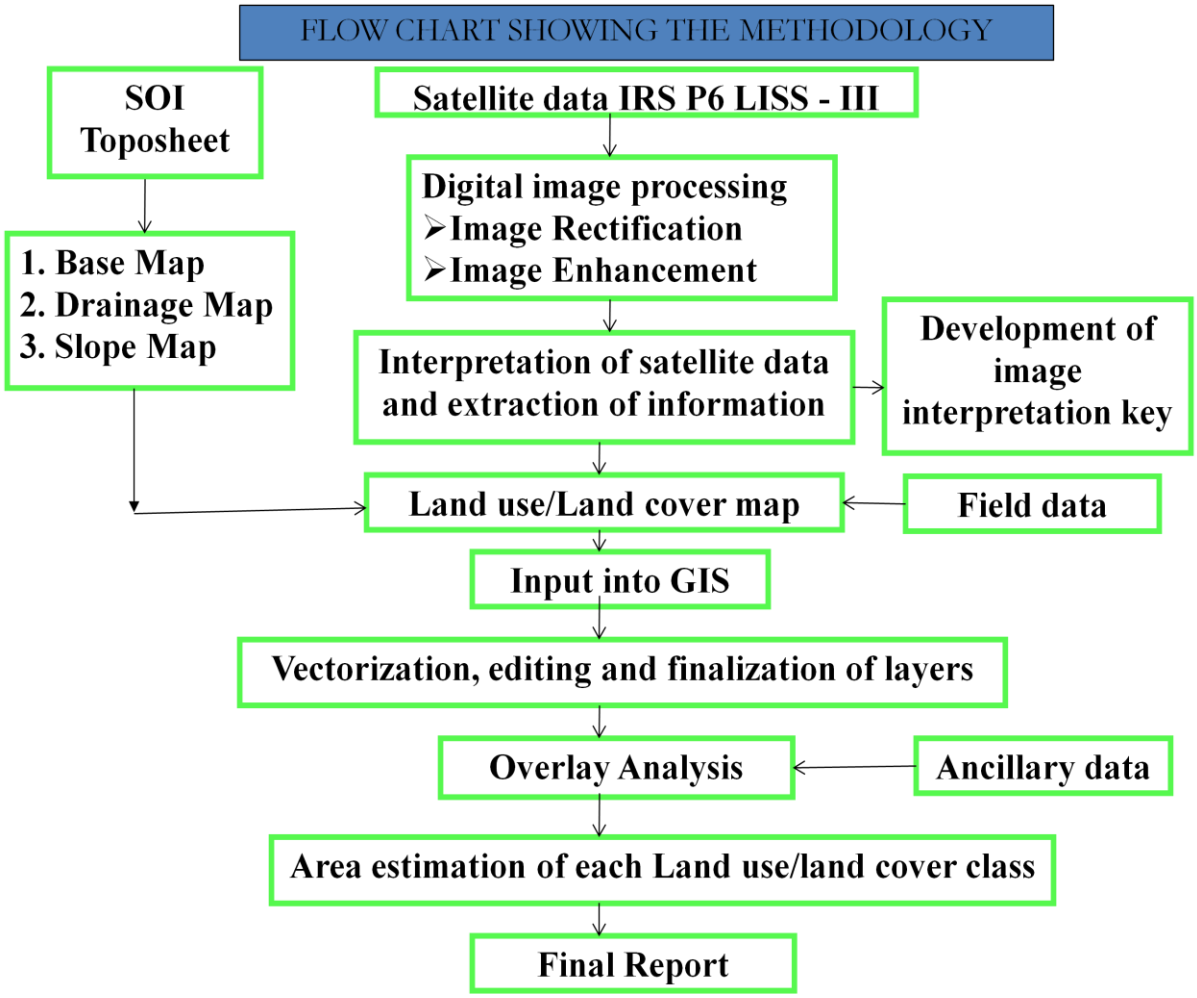
Fig. 3: Geology map of Study Area

Objective:

The main objective of the present study is to analyze the nature and extent of land use/land cover changes in Pulivendula mandal for a brief period of 10 years during 2001-2010 and to identify the reasons behind the changes in cropping patterns, land resources, forest cover, water resources, etc., by using satellite data, collateral data and field data.

Methodology:

The study has made use of various primary and secondary data. These include Survey of India open series maps numbering D44G03 and D44G07 at 1:50,000 scale for the preparation of Base Map. The satellite imageries LANDSAT and IRS LISS-III geocoded data were used as input for change detection. The Remotely Sensed data were visually and digitally interpreted by using the image interpretation elements (such as tone, texture, shape, pattern, association etc.) and Arc GIS software was used for processing, analysis and integration of spatial data to reach the objectives of the study.



Remote Sensing Data:

Digital data for the present study, open data LANDSAT-2001 and the Indian Remote Sensing (IRS P6) Linear Image Self Scanner (LISS-III) images, for 2011 is purchased from National Remote Sensing Centre, Hyderabad, India. The imageries were used for identification of changes between different times for the identified classes viz, Forest Land, Agricultural land, Water, Built up and Barren lands in the study area.

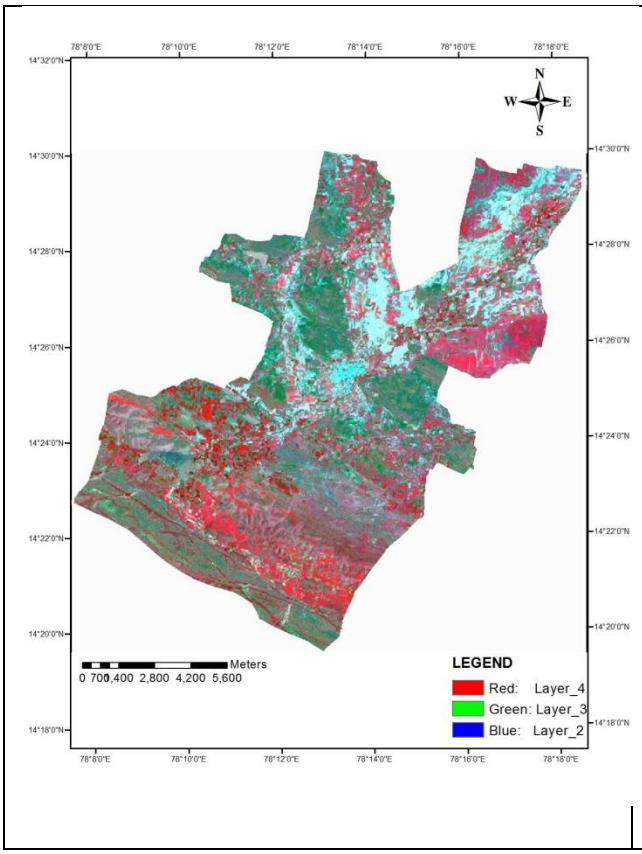


Fig 4: Landsat 2001

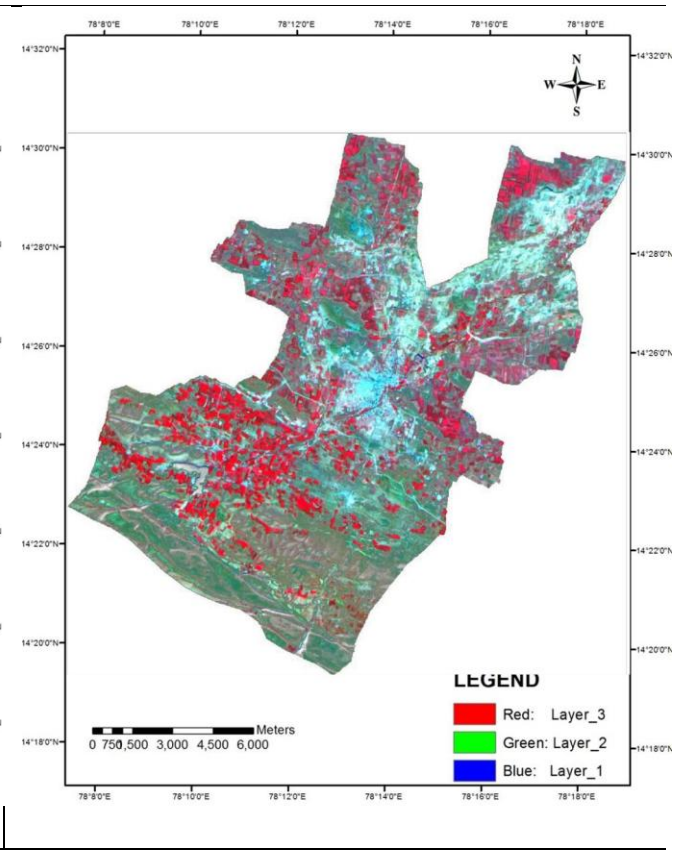


Fig 5 : IRS P6 LISS-III 2011

The workflow of the present study is through a process of creation of base map with the help of rectified SOI Toposheets and followed by classification of the Satellite data sets LANDSAT-2001 and IRS P6 LISS-III-2011 in to five classes. The five classes identified here under with the classification scheme followed here are based on the concepts and principles of Cartographic Generalisation.

S.No.	Land use/cover types	Description
1.	Forest land	Areas covered with mature trees, shrubby plants and other plants growing close together.
2.	Agricultural Land	Rain fed cropping, planted and irrigated cropping areas.
3.	Water	Area covered with River and lakes.
4.	Builtup	Areas that have been populated with Residential, Commercial, Industrial and Transportation facilities.
5.	Barren land	Mountainous or hilly areas and degraded agricultural land.

Table 1: Land use/ Land cover Classification scheme

The methodology of classification in the present study followed is supervised classification through training sites, using maximum likelihood algorithm. The Maximum Likelihood decision rule is still one of the most widely used supervised classification algorithms (Wu and Shao, 2002; McIver and Friedl, 2002). It is considered to give very accurate results (Mengistu, 2007; Reis, 2008).The areal extent of the classified data is thoroughly scrutinised with the regular field visits and inquiry with the inhabitants for both the observation time data sets. Vectorization of the identified five classes is processed in to shape files of the study area for the two corresponding years 2001 and 2011 for

easy and quick statistical analysis. The corresponding attribute data is automatically generated with the topology building of the vector data for the given two different time satellite data. Attribute information thus obtained, is further processed for various statistical analysis and interpretations. Based on the results and the various opinions, inferences and experiences drawn during field visits from the inhabitants were thoroughly incorporated while drawing the conclusions in the present study for its efficacy, relevance and accuracy. The changes thus identified were documented and explained for the two time data sets pertaining to 2001 and 2011 are discussed in the subsequent chapter.

Results & Discussions:

The attribute data of land use/land cover from the study area between years 2001 and year 2011 with regard to various features indicated significant changes in feature classes (Table 2). The data indicates that the area under agriculture has been increased from 18.63% in 2001 to 20.1% in the year 2011. An increase of 1.47% area under agriculture has been indicated. This is interesting observation made during this investigation. The area investigation is traditionally known for groundnut, sweet lemon, lime, banana plantation etc. In recent times farmers have been encouraged to go for mixed plantations with two or three commercial crops at a time. This has an advantage of less expenditure and more profit realization. This can be attributing to the increased awareness of the farmers in the commercialization of agriculture.

S.No	Classes	2001		2011	
		Ha	%	Ha	%
1	Forest land	11184.09	61.6%	8932.82	49.3
2	Agricultural Land	3382.57	18.6%	3647.81	20.1
3	Water	148.85	0,8%	104.53	0.6
4	Builtup	1591.39	8,8%	3691.39	20.3
5	Barren Land	1849.24	10.18%	1779.58	9.8
	Total	18156.14	100	18156.14	100

Table 2: Attribute data of supervised classification of change detection images

The area under forest in the year 2001 was 61.6% whereas the area considerable decrease to 49.3% in the year 2011. This is a net decrease of 12.3% which can be attributed to the declining trend of forest in the study area. Another natural environment under water has shown a slight decrease from0.82% in the year 2001 to 0.6% in the year 2011. This can be attributed the activity of cultivation and also due to plantations like mixed crops.

The feature class under Built up land have increased considerably, the area recorded under the settlements in the year 2001 was 8.8%, this has gone up to 20.3% in the year 2001, a net increase 11.5%.

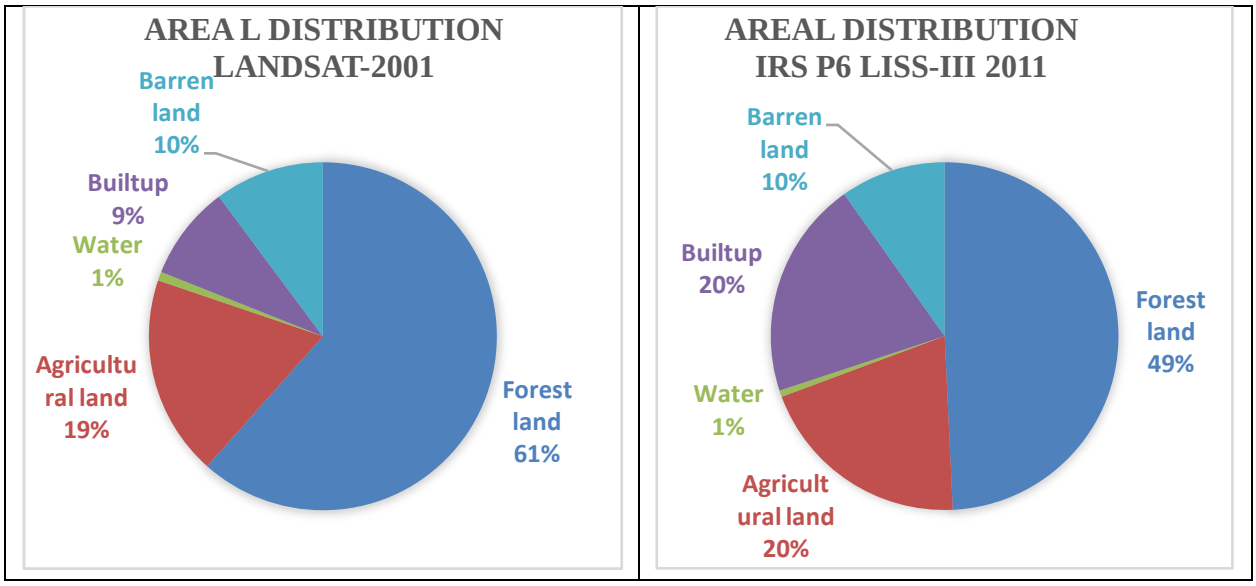


Fig 8: Pictorial representation of LU/LC classes

This is a natural consequence of increased urbanization and resultant construction activity in terms of residential area, commercial establishments including education institutions, hospitals, storage facilities, etc. Another natural feature Barren land have shown a slight decrease from 10.18% in the year2001 to 9.8% in the year 2011, a decrease of 0.4%, this can be attributed to the activity of cultivation, plantations and settlements.

Conclusion:

The significant changes in the land use/land cover during the study period between the years 2001 to 2011 recorded some interesting observations. During the time span the significant observations as per environment is concerned are the natural systems represented by forest land, water and Barren land indicated significant change.

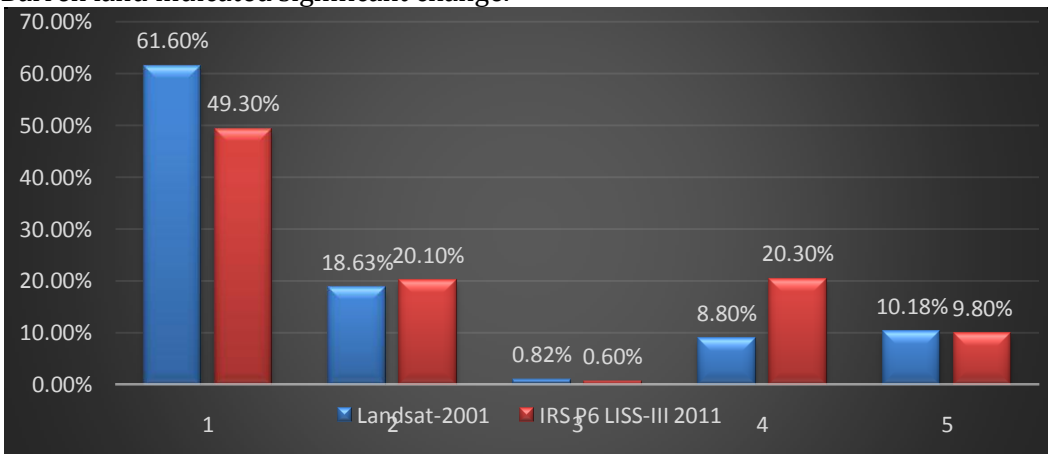


Fig. 9: Percentage changes in LU/LC during 2001-2011

The features namely Agriculture and Builtup indicated an increase trend. The reasons attributed for this are due to the changes in the pattern of agriculture activity and urbanization.

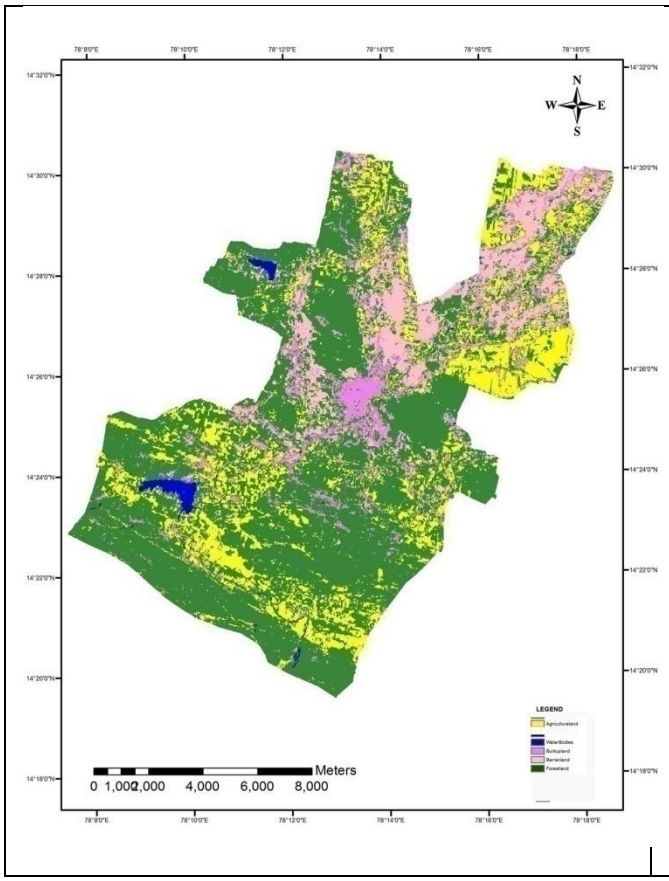


Fig 6: LULC- 2001

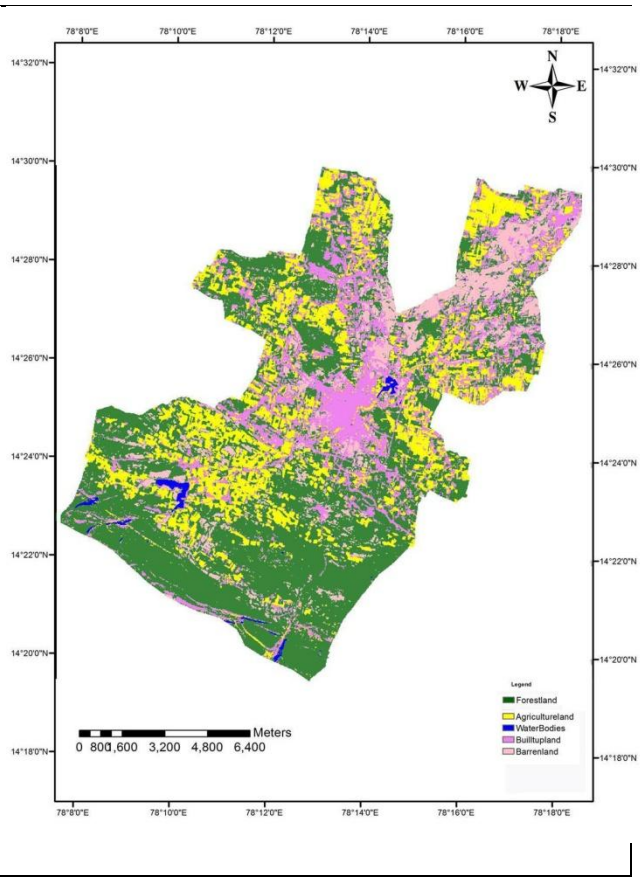


Fig 7: LULC- 2011

In general the land use/land cover data during the study (2001-2011) of the study area indicated significant changes which may show significant environmental impact. However, these trends need to be closely monitored for the sustainability of environment in future.

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