

An Assessment of Land Use Land Cover Change Pattern in Patna Municipal Corporation Over a Period of 25 Years (1989-2014) Using Remote Sensing and GIS Techniques

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ABSTRACT: The knowledge of Land cover/Land use change pattern is very handy to get into the reality of anthropogenic pressure and dynamics of demography of a given area. For this purpose change detection technique is widely used to assess the driving forces of the changes. With only 11% of urban population Bihar is the least urbanized state of India (Census 2011) and being the capital and largest city of Bihar Patna is facing unprecedented burden of urban agglomeration. Therefore this study is aimed at understanding the land cover and land use change pattern in Patna Municipal Corporation area in last quarter century. Remote Sensing (RS) and Geographic Information System (GIS) are now providing new tools to monitor these fast changes. Landsat satellite images for the two base years 1989 and 2014 have been used for this study. Softwares like Google Earth Pro, GRGarmin, Erdas Imagine and ArcMap have been incorporated to prepare thematic map particularly for Patna Municipal Corporation (PMC). Land cover classification was done with the help of survey of India toposheet and satellite images, ground referencing was also done to check the accuracy of the classification. The results of this study were outstanding. The urban built-up area has nearly doubled in the past 25 years, water body has nearly halved while the forest cover has definitely increased. Fallow land decreased due to conversion to settlement and built-up area. Similarly agriculture land has also decreased considerably for the same reason.

KEYWORDS: Anthropogenic pressure, urban agglomeration, Remote Sensing, GIS, Change detection

I. INTRODUCTION

Earth has been changing since its origin and the landscapes have never been similar with the passing time and period. Man's presence on the surface of earth has significantly altered the natural environment thus resulting into visible change pattern in land cover/land use over time. Land use/Land cover assessment is one the most important parameters to meaningfully plan for land resources management. The knowledge of spatial land cover information is essential for proper management, planning and monitoring of natural resources (Zhu, 1997). Due to rapid urbanization Patna Municipal Corporation is suffering from intense load on its resources which is resulting in very fast change in its land cover/land use pattern. Some of the causes of urban expansion such as population growth, economic development, migration infrastructural innovations resulting in transformation of villages into towns, towns into cities and cities into metros (Singh, et.al, 2008). Urbanization in Patna Municipal Corporation is characterized by unplanned and uncontrolled growth leading to urban sprawl. Land use planning and the pattern of development, relationship between residential areas and industrial, commercial and office complexes have a considerable impact on the environment (Singh and Steinberg 1996). Most of all, appropriate infrastructure provision has not kept pace with economic growth. Consequently, the environment of urban areas, particularly of Patna Municipal Corporation (PMC) has been deteriorating rapidly.

Urban land cover types and their areal distributions are fundamental data required for a wide range of studies in the physical and social sciences as well as the municipal areas for land planning purposes (Stefanov, 2001). The Remote

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

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sensing and Geographical Information Systems (GIS) techniques combined together to detect urban encroachments is easier and faster than the traditional methods of surveying (Da Costa, 1999). The present study intends to monitor the changes in land cover/land use pattern because these changes have been recognized as important drivers of global environment change (Turner et.al, 1996). High temporal resolution, precise spectral bandwidths and accurate georeferencing techniques are factors that contribute to increase use of satellite data for change detection analysis (Jensen, 2004).

II. MATERIALS AND METHODOLOGY

Google Earth data for the present year (2014) and Survey of India Toposheet No. 72G/2 is used. PMC map* with 72 wards is used. (*Base MAP of PMC is as per 2001 Administrative command, the same base map and boundary is used by Department for International Development (DFID) UK for its developmental plans for Bihar with collaboration with the provincial government.

Table-1: Details of satellite data

Satellite	Sensors	Date	Resolution	Band	Path/Row
Landsat-4	TM	24/01/1989	30.0 m	3, 4	141/42
Landsat-8	OLI	06/02/2014	30.0 m	4, 5	141/42

Table-1 is showing details of LANDSAT data acquired from USGS website

A discrete georeferenced map of Patna Municipal Corporation is prepared from scratch with all the required parameters. KML file was created in Google Earth Pro with the help of Polygon tool according to reference base map of PMC with 72 wards. For georeferencing and shapefile conversion GRGarmin was used and required ground referencing was done. The landsat data were processed and geometrically corrected in Erdas Imagine. Then all these enriched data were processed in ArcMAP. For the year 1989 band 3 and band 4 (Red and NIR) of landsat-4 (TM) were used to make False color composite while for 2014 band 4 and band 5 of landsat-8 (OLI) were used for the similar purpose. After getting both the FCC training samples were created and then supervised classification was done using maximum likelihood algorithm and then the outcome was once again reclassified.

Patna is one of the oldest continuously inhabited places in the world and Patna Municipal Corporation (PMC) is located between Latitude: 25°33'22"- 25°39'2" North and Longitude: 85°31'12"- 85°15'5" East, it lies on the south bank of the River Ganges. PMC is approximately 21.3 km long (east to west) and 10.2 km wide (north to south). The Corporation area is important commercial centre. Due to its central position and expansion along river Ganges it has the additional advantage of transport of goods by river. The most important commodities manufactured in the PMC are electronic goods, while the service sector remains the main driving force for its rapid development.

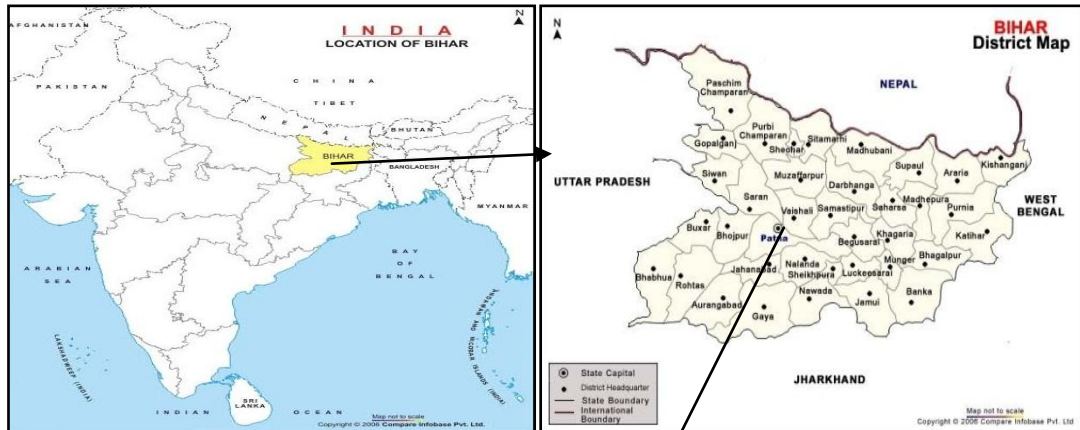


Fig. 1(a) Outline Map of India

Fig. 1(b) Outline Map of Bihar

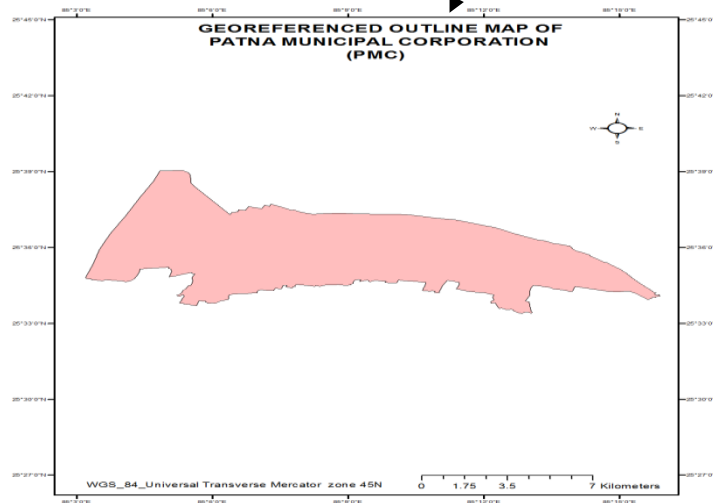


Fig. 1(c): Base map of the study area

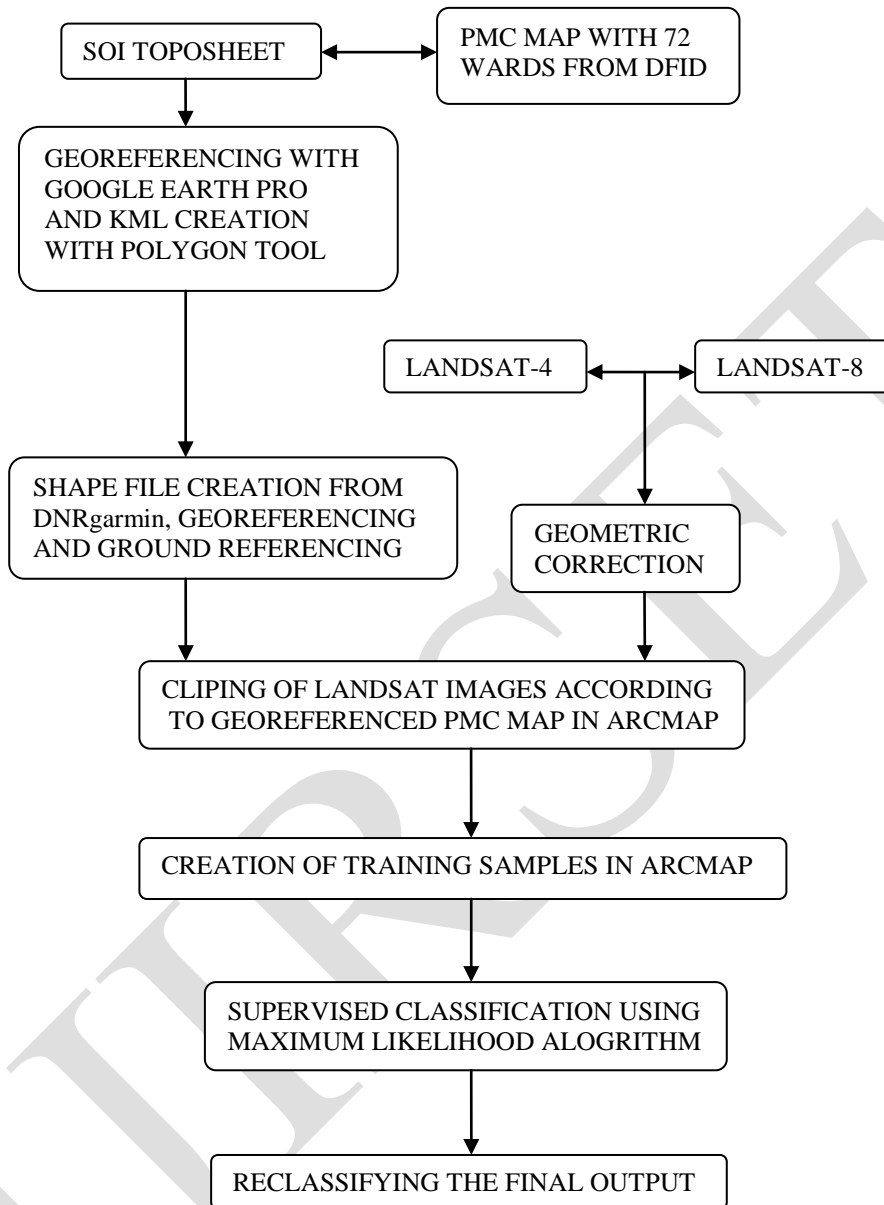
Georeferenced Map of Patna Municipal Corporation was created from scratch by required Ground referencing and incorporation of satellite data with the help of softwares like Google Earth Pro, DNR Garmin and ArcMap

The Patna Municipal Corporation (PMC) covers an area of nearly 100.54 km² according to our Remote Sensing and Georeferencing results. But according to urban development ministry of Bihar it is 99.45 km² while Patna Municipal Corporation's website states its area about 109.21 km². It is further divided into 72 wards. According to the 2011 census it had a total population of 16, 83,200. The density of population of the PMC is 16741 persons per km². The trends of population growth have been uneven in the period 1951-2011. The growth registered an increasing trend in the period 1961 to 1981 - from 28.52% to 64.14%. It reduced to 18.14% during 1981 to 1991, rising again in 1991 to 2001 to 48.97% and dropping again during 2001 to 2011 to 32.53%.

**International Journal of Innovative Research in Science,
Engineering and Technology**

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 10, October 2014



Flow chart: 1 Adopted Methodology

For understanding the whole process the above drawn methodology was adopted and for the final assessment ground referencing was also done and the results were cross checked to determine the validity of the whole applied process.

Table-2: Softwares used in study

Software Used	Functions
Google Earth Professional 7.1.1	For overlaying RAW map and creating Polygon generated outline KML file
DNR Garmin 5.04	Converting KML file to Shape file , Ground Truthing and Georeferencing
Erdas Imagine 9.2	Geometric correction of Landsat Images and Image clipping
ArcMap 10.1	Creating Georeferenced Map, FCC creation of Geometrically corrected Landsat images, Creating Training samples, Supervised Maximum Likelihood Classification and Reclassifying data and output MAP generation
MS Excel 2007	Graphs and Charts

III. OBJECTIVES

- The main objective is to analyse the nature and extent of land cover land use changes in Patna Municipal Corporation (PMC) between 1989-2014
- To create Remote sensing based LULC classification scheme for PMC
- To assess the location, nature, magnitude and rate of LC/LU change for the period of last 25 years
- And finally to examine the conflict in determining actual Area* of the PMC with the remote sensing data (*Different government and official records have variations up to 10% in determining Patna Municipal Corporation’s total area).

IV. LAND COVER LAND USE CHANGE PATTERN MODEL

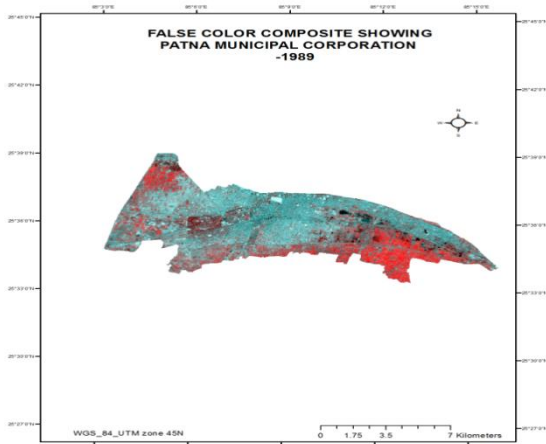


Fig. 2(a): FCC of PMC-1989

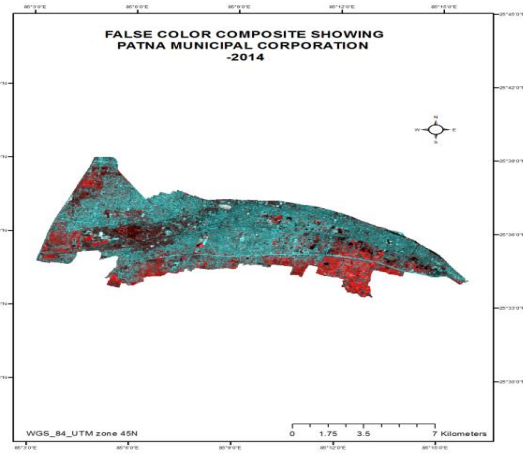


Fig. 2(b): FCC of PMC-2014

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Two bands of Landsat-4 Thematic Mapper (Band 3, Band 4) for the year 1989 and two bands of Landsat-8 Operational Land Imager (Band 4, Band 5) for the year 2014 were incorporated to make the false colour composite of Patna Municipal Corporation (PMC).

Table-3: Characteristics of land cover classes

Land Cover Class	Description	Characteristics on LANDSAT False Color Composite (FCC)
Urban Built-up	Settlement including residential and commercial; Concrete made structure	Different shades of Cyan
Water Body	Ponds, lakes and canal	Dark Bluish to Black
Fallow Land	Agriculture fields without crops	Greenish to Grey
Forest	Tall dense trees	Darkish red
Agriculture Land	Crop fields	Blood Red to Dull red

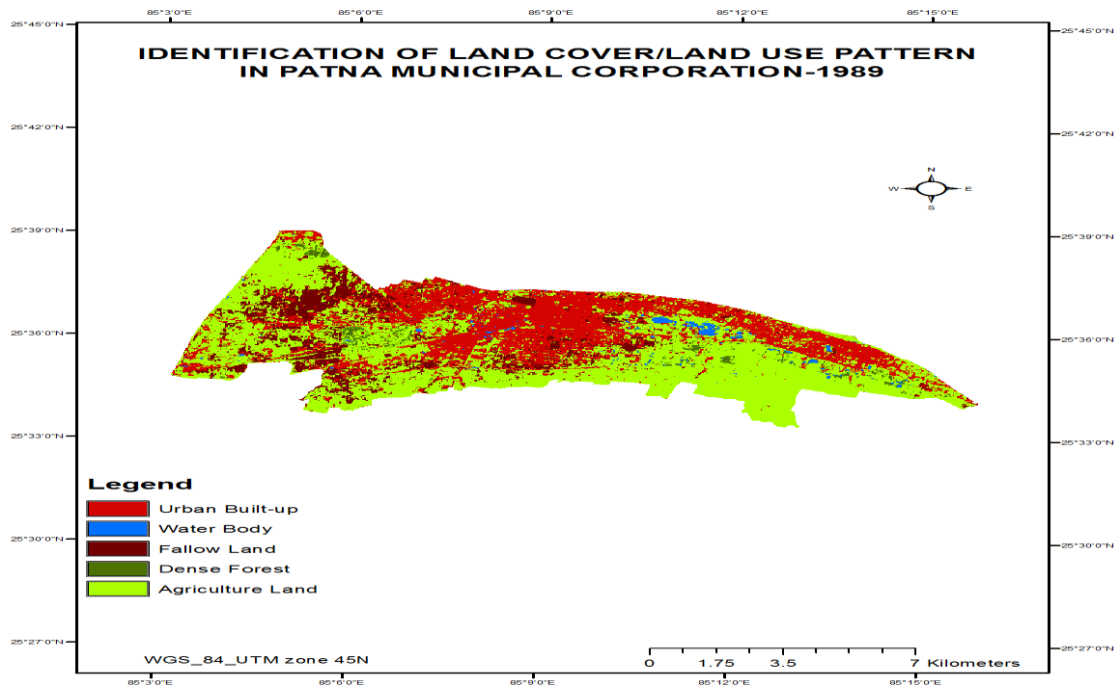


Fig. 3(a): Supervised classification of PMC-1989

Supervised classification with the help of Maximum likelihood algorithm was done in ArcMap. Fig. 3(a) is showing the five broad land use categories of Patna Municipal Corporation in 1989.

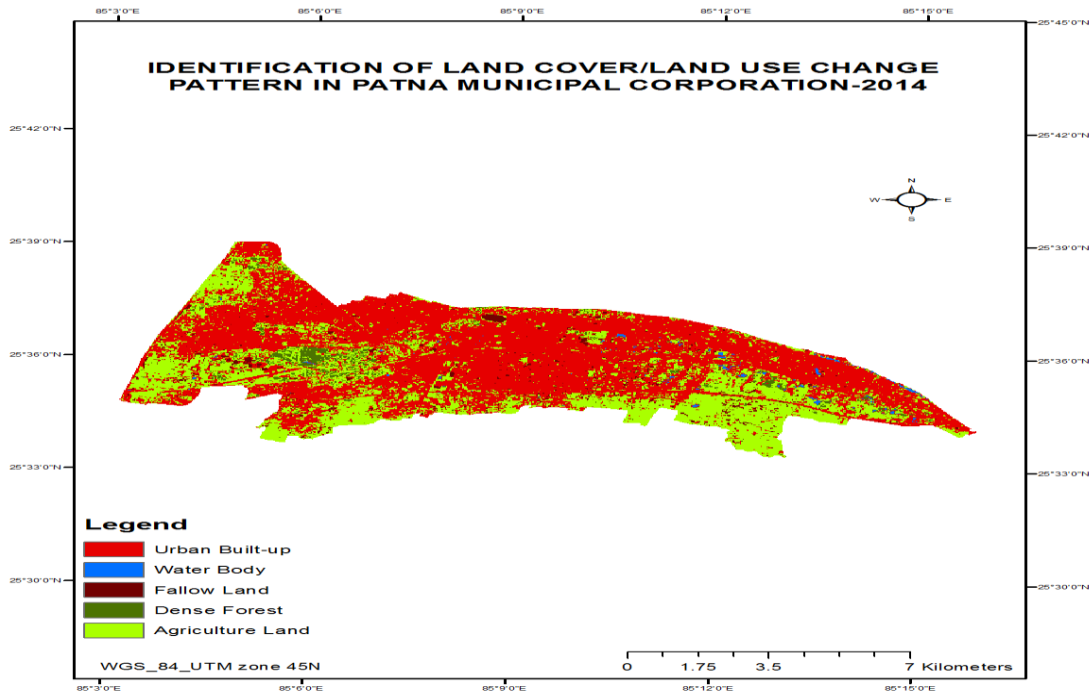


Fig. 3(b): Supervised classification of PMC-2014

Similar type of supervised classification using maximum likelihood algorithm was done in ArcMap for the present year (2014) for Patna Municipal Corporation Fig. 3(b) to determine the differences in land use land cover change pattern that has taken place in last 25 years.

Table-4: Number of training pixels for each land cover class used in classification

Land use/Land cover Class	Number of Training Pixels-1989	Number of Training Pixels-2014
Urban Built-up	34826	68733
Water Body	1404	679
Fallow Land	13773	3094
Forest	2045	3357
Agriculture Land	59676	35861
Total	11724	11724

V. RESULTS AND DISCUSSIONS

The results of this study indicate drastic changes in land cover land use pattern in Patna Municipal Corporation area in last 25 years. It is quite evident after comparing fig. 3(a) and 3(b) which is the outcome of maximum likelihood supervised classification of temporal changes that have occurred in this duration. The increase in built-up area and decrease in agriculture land can be identified at first site. But what is interesting is the intensity of transformation of these change patterns. This study has classified the whole LCLU pattern in five classes which are

1. Urban built-up area
2. Water body

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Vol. 3, Issue 10, October 2014

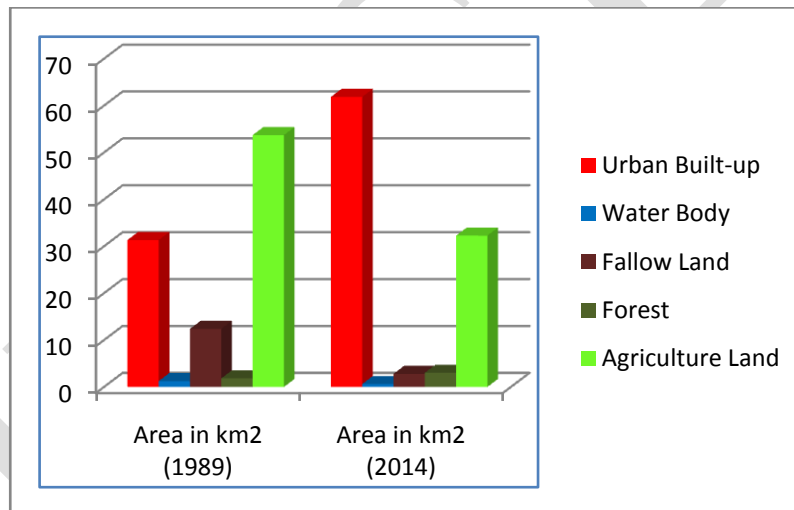
- 3. Fallow land
- 4. Forest
- 5. Agriculture land

The table below shows the statistical changes

Table-5: Statistical analysis of land cover/land use change Pattern in Patna Municipal Corporation during 1989-2014

Land Cover / Land Use Feature	Area in km ² (1989)	Area in km ² (2014)	Change (1989-2014) in Area km ²
Urban Built-up	31.343	61.859	+30.516
Water Body	1.263	0.611	-0.6519
Fallow Land	12.395	2.784	-9.611
Forest	1.840	3.021	+1.181
Agriculture Land	53.708	32.274	-21.434
Total	100.549	100.549	

Graph-1: Land cover/Land use change pattern in Patna Municipal Corporation during 1989-2014



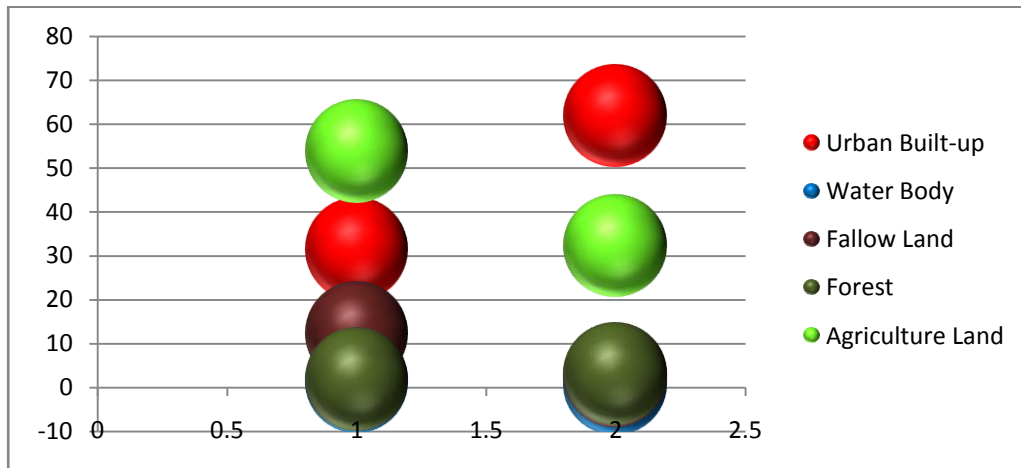
In this study it is found that in the period of 25 years the urban built-up area has nearly doubled in PMC. In 1989 it was 31.343 km² which in this period added 30.516 km² in it and now it stands on the top of the chart with 61.859 km² area that is 61.521% of the total area of Patna Municipal Corporation. The water body which is made up of ponds, lakes and canal has nearly halved. The maximum decline which is recorded is in fallow land it has remained nearly 1/5th of what it was in 1989. But surprisingly the forest area which is consisted by tall dense trees has increased more than 1.6 times in this period. But the largest quantitative decline is found in agriculture land which was reduced to 32.274 km² at present from 53.708 km² in 1989. Our study also found that the area of PMC is 100.549 km² which is very near to the official data of urban development ministry of Bihar government and that is 99.45 km². (It is noted here that PMC's official website states the area 109.218 km² and despite my repeated attempt the PMC's official refused to comment on it).

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Bubble Graph-1: Land cover/Land use change pattern in Patna Municipal Corporation during 1989-2014 with change detection.



VI. CONCLUSION

With the present study it has become evident that there is a major thrust in urbanization under the boundaries of Patna Municipal Corporation area which has resulted in the rise of secondary and tertiary sector of economy and a rapid decline in agricultural and fallow land. The decrease in water body also reflects the human encroachment in natural environment and the increase in forest cover is because of the government sponsored forestation programs in last quarter century. But because of the negligence the wetland ecology has suffered heavily so it is the need of the time to conserve and reestablish these shrunk areas of importance. Further the study also reveals that the area of PMC is near 100.54 km² which is near to urban development ministries report on PMC (99.45 km²).

ACKNOWLEDGMENTS

My sincere thanks to **Dr. Debjani Sarkar Ghose** of Patna Women's College for encouraging and supporting my work. I am also thankful to IJIRSET for considering my work for publication.

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