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Research Paper

Land Use and Land Cover Change Detection Using Geospatial Technology: Case of Kaliasot Watershed area, Bhopal and Raisen District (M.P.), India

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Abstract: In the present study, Land use and Land cover (LU/LC) categories has been classified in the form of thematic maps to analysis change detection in the Kaliasot watershed area, belongs to Bhopal and Raisen district of Madhya Pradesh. Based on Remote Sensing (RS) and Geographic Information System (GIS) techniques, the study is an attempt to identify various Land use and Land cover classes and monitor the changes in land use / land cover patterns from 2009 to 2018 within the Kaliasot watershed area. To prepare land use / land cover maps, the satellite data of IRS 1D LISS-III of years 2009 and 2018 has been used for interpretation through ArcGIS and Erdas Imagine software. Using Maximum Likelihood classifier Supervise Classification technique is applied to prepare land use / land cover maps of the study area. The accuracy of the mapping is verified using Google Earth satellite data through linkages in Erdas Imagine and selected field observations. During the study it is observed that six land use / land cover classes i.e. agriculture, built-up area, waterbodies, river, industrial area, and land with/without scrub area has been identified. As the Bhopal is capital of Madhya Pradesh, it is observed that encroachment along the riverbank and haphazard urbanisation has been increased rapidly during last two decades. In the study area, major changes in land use / land cover classes are observed as conversion of major agriculture area into built-up area between the year 2009 and 2018. The mapping results indicate that built-up area and industrial area has been increased 35.86% (68.93 km^2) and 0.12% (0.25km^2) respectively. However, agriculture land and land with/without scrub have decreased by -35.96% (-69.01 km^2) and -0.41% (-0.79 km^2) respectively. The analysis and findings of the study highlights appropriate planning and policy implications for the sustainable land use / land cover management in the Kaliasot watershed using geospatial technology.

Keywords: Land use change; RemoteSensing; GIS,Spatial data, Google Earth

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INTRODUCTION:

The process of Land use and Land cover classification and its change detection is a dynamic phenomenon. Asselman, (1995) describe "The study of Land use/Land cover (LU/LC) changes is very important to have proper planning and utilization of natural resources and their management". Most of the Land cover changes of the present and the recent past are due to human activity. Prakasam,(2010) with his research found that "Land use/Land cover change involves either direct or indirect modification of the natural habitat and impact on the ecology of the area. It is observed that Land use/Land cover greatly affected by population pressure". In the same way Voogt and Oke, (2003) describes, "Population growth, industrialization and urbanization have rapidly changed the land use / land cover". Conventional methods used for gathering secondary data such as demographic data, census data and analysis of environmental samples are not adequate for multi complex environment studies (Maktav et al. 2005); since many problems often presented in environmental issues and great complexity of handling the multidisciplinary data set; we require new technologies like satellite remote sensing and Geographical Information Systems (GIS). It has been proved that Land use /Land cover patterns changes with time, can be easily mapped using satellite remote sensing temporal data. Sharma et al.,(2001) with their paper describes, "Quantification of such changes is possible through GIS techniques even if the resultant spatial datasets are of different scales/ resolutions". Conventional surveying method like aerial photograph, field survey etc. of any area takes long time and more cost. Therefore in GIS environment using satellite remote sensing data, study of changes in Land cover can be achieved in less time, at low cost with better accuracy. Findings of such studies have helped in understanding the pattern and dynamics of human activities with time. Mostly land cover maps are prepared for planning and management purposes. Csaplovics, (1998) and Foody describe, "Due to synoptic view, map like format and repetitive coverage, satellite remote sensing imagery is a remarkable source for gathering quality data on land cover information on local, regional and global scale; Foody, 2002)". To develop an action plan for land resource development, change detection analysis is very crucial in monitoring the changes.

The main objective of this study is to detect the impact of rapid development on Land use /Land cover changes in Kaliasot watershed area in terms of urbanization, industrialization and other natural resources between last 10 years (2009 and 2018) using temporal data. According to Mundhe et al., (2014), Land use and Land cover change has become an important component in current strategies for managing natural resources and monitoring environmental changes for sustainable environmental planning and management.

Study Area

The present study was conducted in Kaliasot watershed of Bhopal and Raisen district, which is situated in Huzur tehsil of Bhopal district and Gairatganj tehsil of Raisen district, Madhya Pradesh, (India). Area is bounded by latitudes $23^0$6'N to $23^0$13'N and longitudes $77^0$23' E to $77^0$35'E covered in Survey of India (SoI) toposheet no. 55 E/8 & 55 E/12. The total geographical area is about 192 sq.km. Delhi-Bombay and Delhi-Chennai railway route and National Highway no. 12 passes through the area, which connect the area from other part of the country. The watershed covering the part of Mandideep block of the Raisen district of Madhya Pradesh, which is highly industrialized and the cause of contamination of water resources may be due to improper disposal

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of municipal, urban and industrial waste. Figure 1: shows location map of the study area. The average annual rainfall in the study area is about 1009.29 mm.

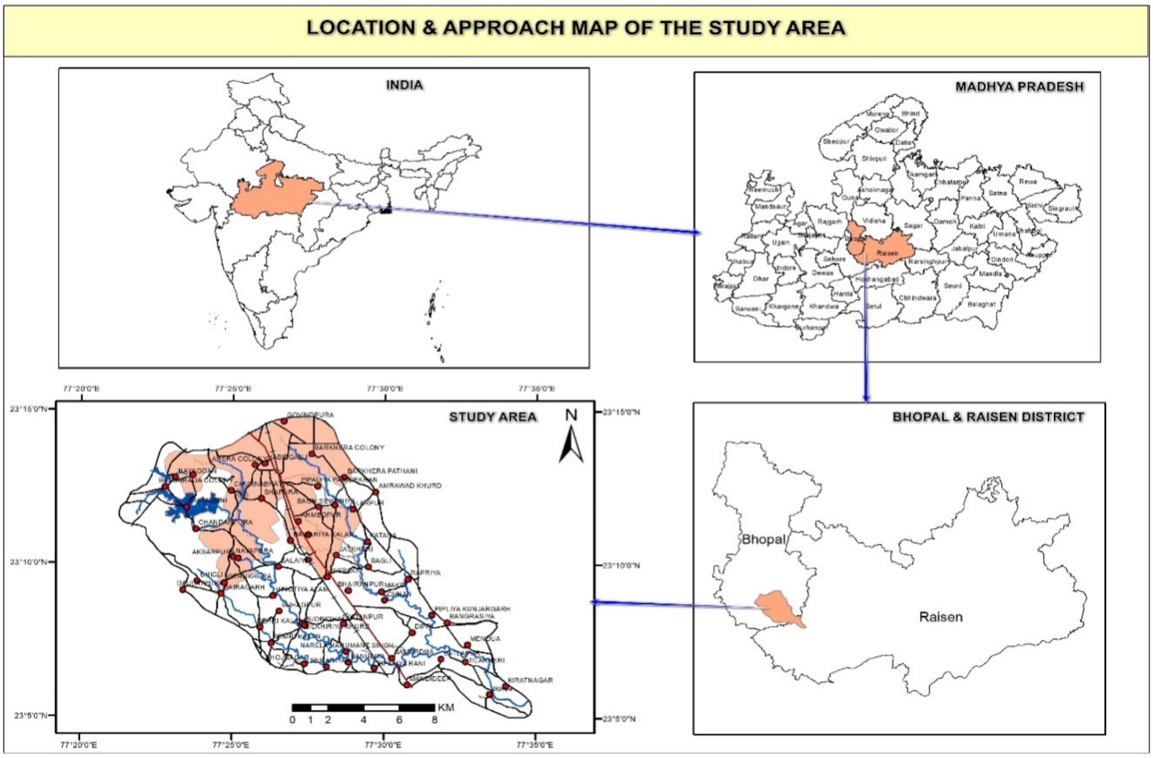

Fig. 1: Location Map of Study area

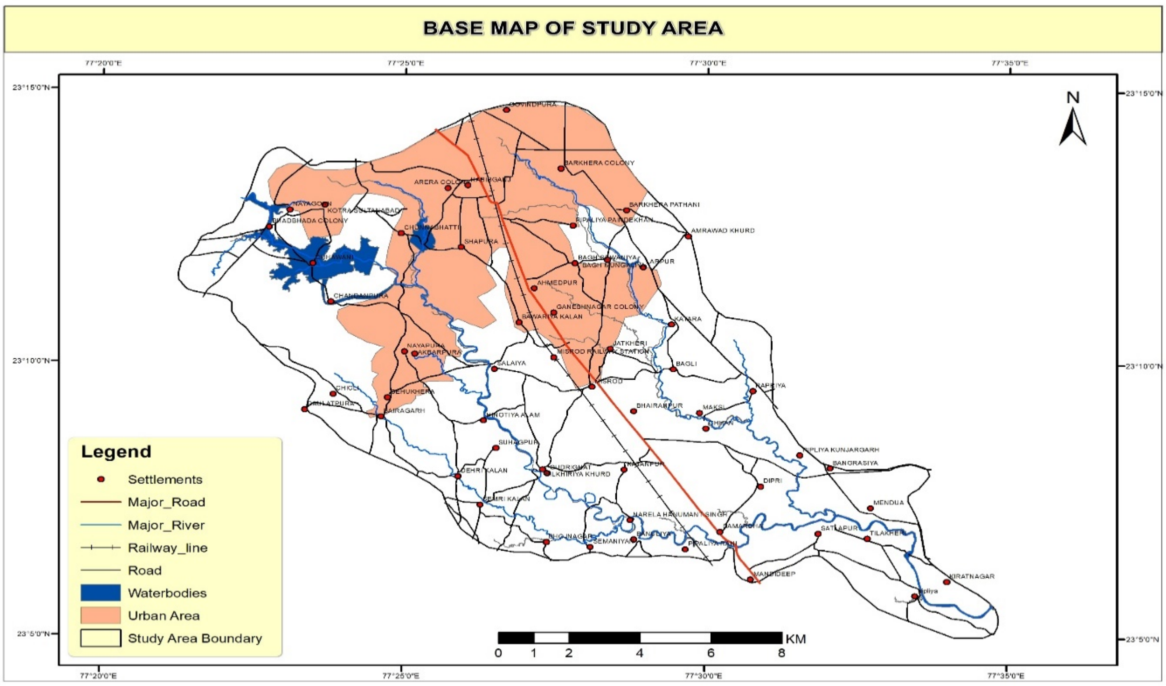

Fig. 2: Base Map of Study area

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MATERIALS AND METHODS

During the study, Survey of India (SoI) Toposheet No's 55 E/8 and 55 E/12 were Geo-referenced and processed in ArcGIS environment for the preparation of base map (Figure: 2) of the area. The satellite images of the study area were downloaded from Bhuvan website, IRS 1D LISS III image at path (097) and row (056) with the cloud cover less than 10%, spatial resolution of 24 m × 24 m, acquisition date (23-Oct-2009 and 02-Feb-2018 respectively). Satellite image has masked as per study area Area of Interest (AOI) as shown in Figure: 4 and 5. The satellite images were classified based using ground truth points and Google Earth support with ERDAS Imagine 2015 software (Figure: 6 and 7). The flowsheet of methodology adopted in the present study is given in Figure: 3**.**

To make the change analysis of the study area, two images from the satellite IRS 1D LISS III 2009 and 2018 has been taken. Data has been extracted from the multi temporal satellite images and toposheets. Key for interpreting satellite imagery elements shown in Table: 1.

The satellite data was enhanced before classification using appropriate algorithm such as histogram equalization, linear stretching etc. in Erdas Imagine 2015 to improve the image quality and to achieve better classification accuracy. In supervised classification, spectral signatures are developed from specified locations using AOI tools, in the image. These specified locations are known as "training sites or signature" and are defined by the user. Generally, a vector layer is digitized over the raster scene using visual interpretation element like tone, texture, shape, size, association etc. The polygon feature are used to digitise different Land use types and overlaying as vector layer. Spectral signature of an image are used as training sites to identify the land use class for the AOI.

Table: 1. Interpretation Key for Satellite Imagery Elements

Elements /LU/LC Category	**Interpretation* technique**	**General description**
Agricultural land	Pixel reflection varies from light red to bright red and green in colour. Area under this category follows regular shape with scattered to continuous pattern.	This category involves land under crops, fallow, plantations.
Water bodies	Water bodies include those pixels reflecting dark blue to light blue and cyan colour in standard FCC.	This category comprises areas with surface water in the form of ponds, lakes, drains and canals etc.
River	It appears light blue to dark blue in colour.	This is a natural course of water following a linear contiguous pattern.
Built-up land	It is having regular pattern and appears in cyan/white colour.	This category includes urban and rural settlements, transportation, and recreational utilities.
Industrial area	It is having regular pattern, big size and appears in cyan/white colour.	This category includes piece of land for manufacturing
Plantation/ Land with/without scrub	It exhibits bright red to dark red colour, smooth to medium texture and contiguous to non-contiguous pattern.	This is categorized as scattered plants.

*Characteristics of colour reflection of pixels are with reference to standard False Colour Composition (FCC).

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The Land use maps pertaining of two different periods were used for post classification comparison, which facilitated the estimation of changes in the Land use category and dynamism with the changes. Post classification comparison is the most commonly used quantitative method of change detection (Jensen, 1996; Mas, 1999) with fairly good results. Area statistics of each Land use category is calculated in sq.km. in attribute table. The Land use/Land cover classes include agriculture, built-up, industrial, waterbody, river, and land with/without scrub area etc. were identified on the basis of the visual interpretation of the satellite imagery and with the help of filed checks. For the years these datasets were digitize, classified and analyse to obtain Land use/Land cover statistics for each of these classes.

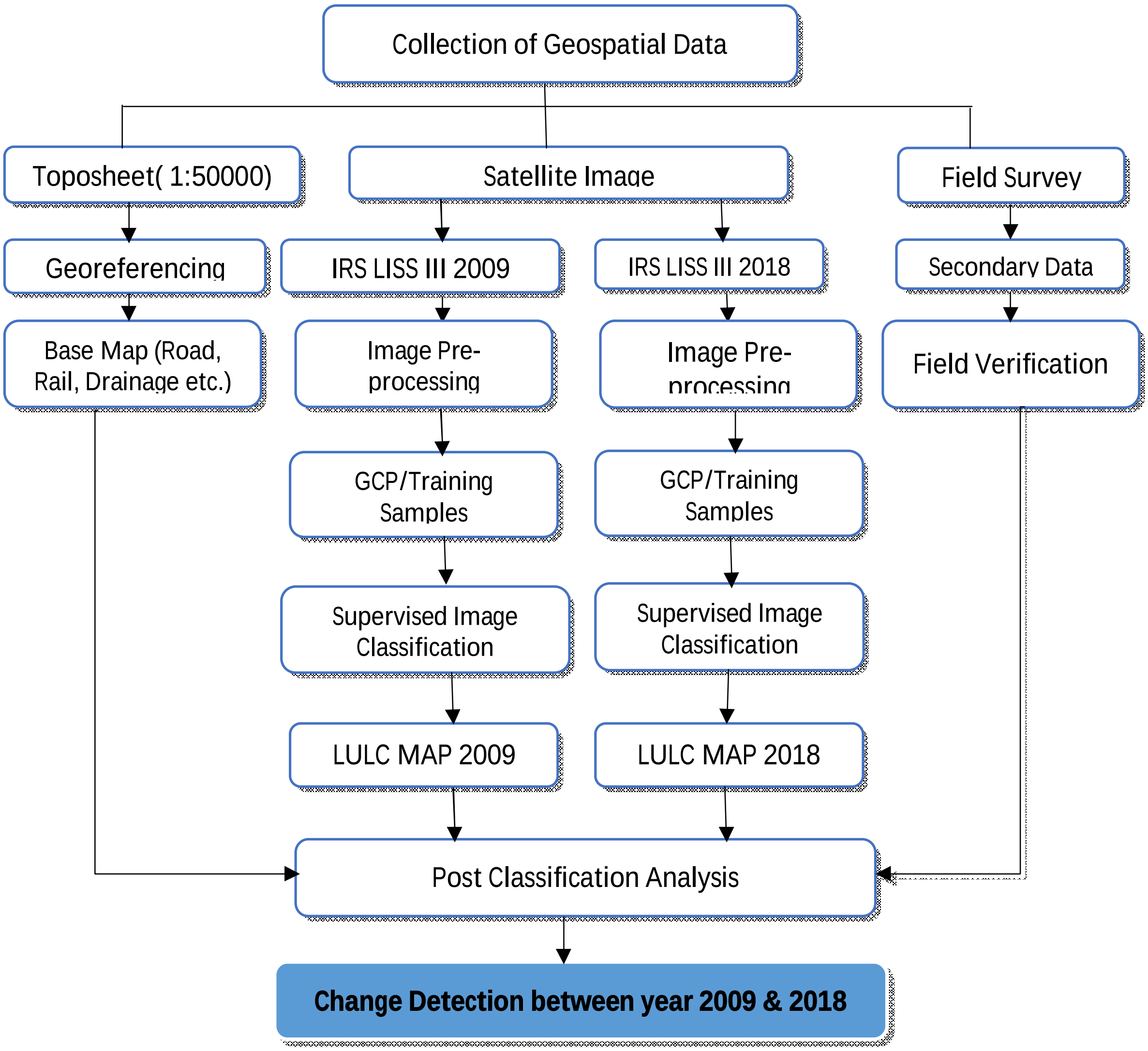

Fig.3: Flowsheet of Methodology followed in the present

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RESULTS & DISCUSSION:

For present study, Kaliasot watershed area is taken for identification of spatial pattern of land use / land cover. With the help of multiple data sets of IRS 1D LISS III, latest technologies like Remote Sensing and GIS is used to quantify land use / land cover. On the basis of image interpretation, of remote sensing imagery, field surveys, and existing study area conditions, land use / land cover categories have been classified into six categories, such as agriculture, built-up, industrial, waterbody, river, and land with/without scrub area (Figures 4 and 5).

Land use / Land cover (LU/LC):

Land use /Land cover map have been prepared from satellite data analysis in Erdas Imagine (Fig.4 & 5). In Land use /Land cover analysis, six major classes were identified in the area which includes agriculture, built-up, industrial, waterbody, river, and land with/without scrub area.

Land-cover classification scheme:

To prepare the land use / land cover map from satellite imageries, a classification scheme, known as maximum likelihood classifier is used which defines the land use / land cover classes was considered. The numbers of land use / land cover classes are preferred, based on the requirement of a specific project for a particular application (Arora and Mathur, 2001; Saha et al., 2005). Six major land use / land cover classes were chosen for mapping the entire watershed area viz; agriculture, built-up, Industrial, waterbody, river, and land with/without scrub land (Table 1).

***Post processing: Supervised classification*:**

After the preparation of classification scheme one of the most widely used image classification technique, i.e., maximum likelihood classification was adopted for mapping six land use/cover classes. Before the selection of training samples, empirical analysis of satellite imagery; google earth images and SOI toposheet of the watershed were look over carefully. For most of the classes, a minimum number of training samples were 50-60.

Field survey and accuracy assessment:

A field survey was conducted for ground verification of doubtful areas with the help of GPS and local guides in different parts of watershed covering all the land use / land cover classes.

LU/LC change detection:

Land use / land cover map of 2009 and 2018 were classified thereafter; post-classification change detection technique was used for analysing the changes. In the last few decades, many change detection methods have been developed viz; image differencing, post classification change matrix, comparison technique and principal component analysis (Lu et al., 2004). Change matrix presents important information about the spatial distribution of changes in land use / land cover (Shalaby and Tateishi, 2007). Table-2: showing the overall changes in land use / land cover classes between 2009 to 2018, which is generated from classified images of 2009 and 2018.

Results from the classified image of 2009 illustrate that more than 74 % of the area was covered by agriculture, whereas land with/without scrub share was 5.37%. Built-up land occupied 15.92%; industrial area covered 2.14% while river and water bodies collectively covered 2.3% area. In 2018, the area under built-up and industrial has fairly grown and covered 54.04% collectively. Agricultural lands and land with/without scrub area covered 38.22% and 4.96% area respectively (Table 3).

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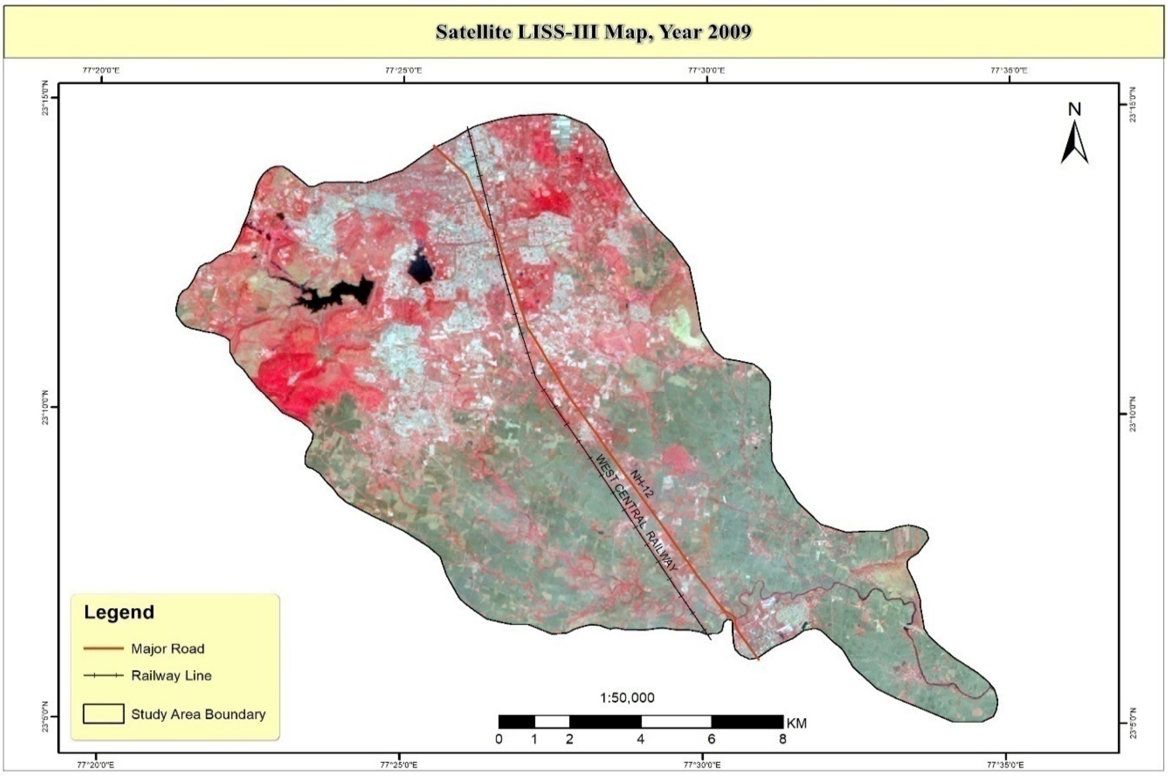

Fig. 4: Satellite Map-2009

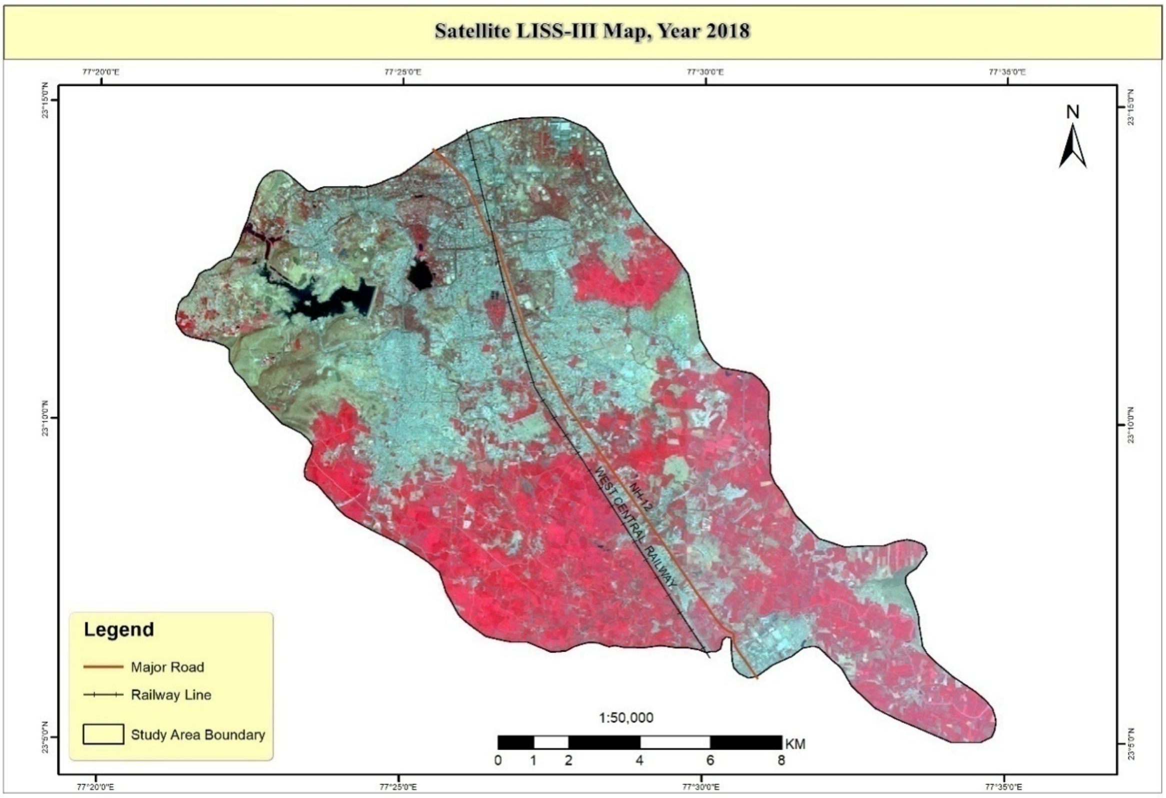

Fig. 5: Satellite Map-2018

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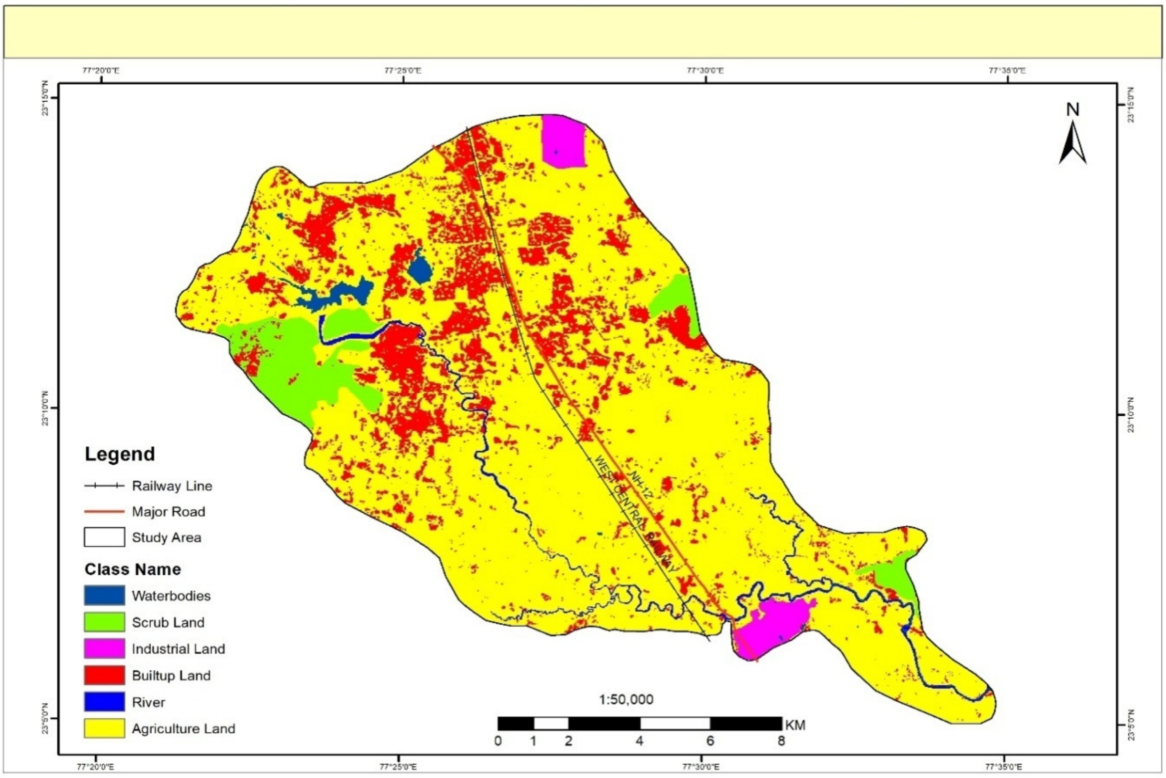

Fig. 6: Land use/ Land cover Map-2009

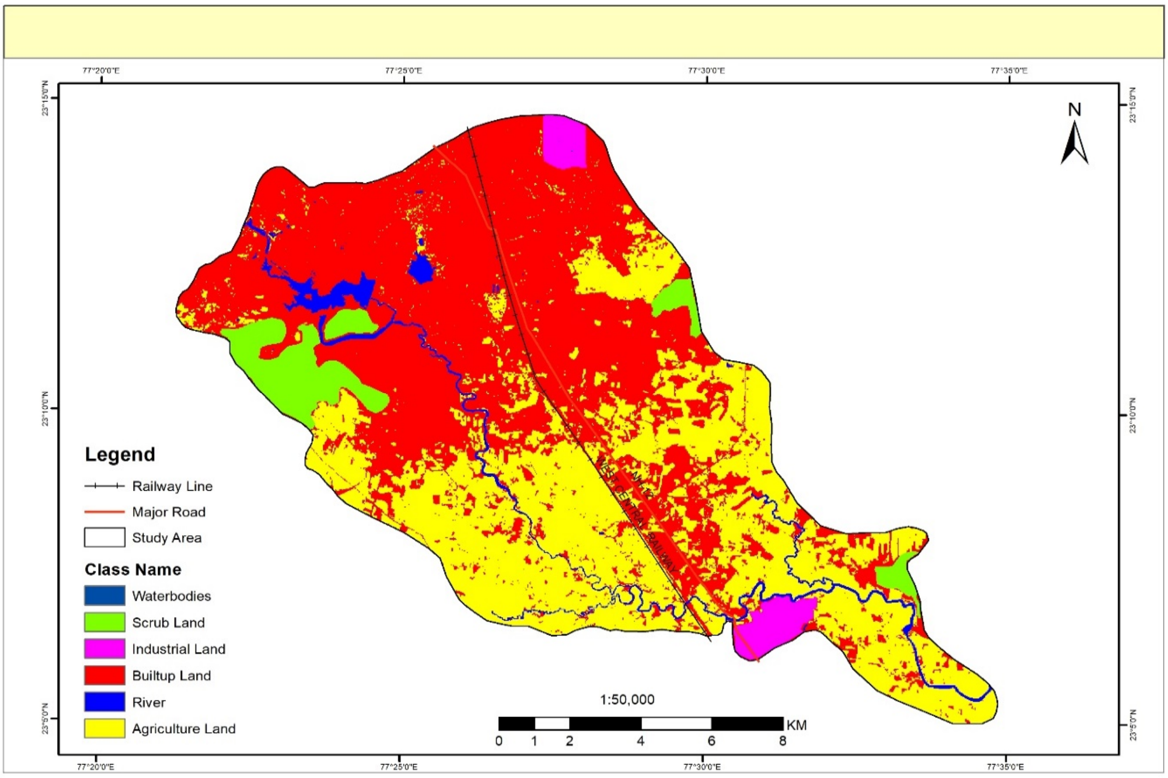

Fig. 7: Land use/ Land cover Map-2018

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Table 2: Land use / Land cover change analysis, 2009-2018

Land use/Land cover Feature	Area in(sq.km) 2009	% of the Area (2009)	Area in(sq.km) 2018	% of the Area (2018)	Change rate between (2009-2018) in %	Change rate between (2009-2018)in Sq. km
Agriculture	142.32	74.18	73.32	38.22	35.96	69.00
Built-up land	30.60	15.92	99.52	51.78	-35.86	-68.92
Industrial land	4.10	2.14	4.34	2.26	-0.13	-0.24
Land with / without scrub	10.31	5.37	9.52	4.96	0.41	0.79
Waterbody	1.88	0.99	2.27	1.19	-0.20	-0.39
River	2.79	1.40	3.02	1.58	-0.17	-0.23
Total	**192.00**	**100%**	**192.00**	**100%**		

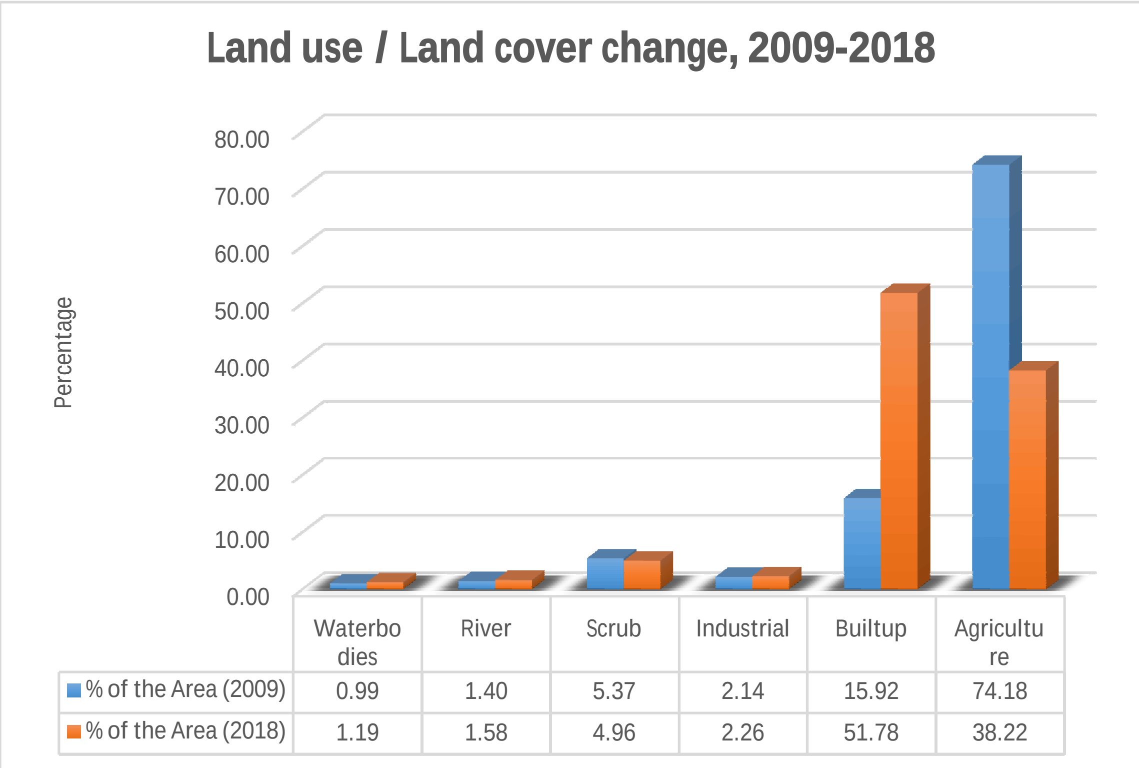

Fig. 8: Land use / Land cover change, 2009-2018

CONCLUSION:

On the basis of Remote Sensing technique coupled with GIS environment; change detection in land use / land cover have been systematically analysed by using satellite images of 2009 and 2018. During this 10 years period a significant changes in the Land use /Land cover pattern have

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been recorded. The study revealed that the major changes occurred in agriculture, built-up and industrial land. The features namely agriculture and land with/without scrub indicated a decreasing trend, whereas the features like built-up land and areas under industrial land indicated an increasing trend. The main reasons for this are due to the changes in the pattern of agricultural activity and increased activity of urbanization. In general, the Land use /Land cover data during the study period (2009 to 2018) of the study area indicated certain significant changes, which may not show any significant environmental impact. However, these land use / land cover trends need to be closely monitored for the sustainability of environment management in future. Residential / Commercial / Industrial areas (built-up) were found to occupy the highest area (103.86 Km^2, 2018) compared to other Land use categories. Mixed urban/ mixed rural and agriculture land were noticed in almost all parts of the study area. Change detection analysis brings out the actual land loss and land gain on Residential / Commercial / Industrial, Mixed urban, Agriculture land, waterbody and Land with scrub as shown in Figure 8 with graph. Of course, the aerial extent of waterbody such as river and lakes/dam/ponds has been maintained without neither any loss nor gain during 2009 and 2018 but encroachments have been observed in many places. It was also observed that the population growth has caused the major change of crop land, land with scrub and plantation into Built-up area, mixed urban and other urban areas in Bhopal and Raisen districts. This was verified in the field through the field observation and with the help of Google Earth.

This study proves that integration of GIS and Remote Sensing techniques is an effective tool for urban planning and management. The quantification of Land cover changes of Kaliasot watershed area is very useful for environmental management groups, policymakers and for common people to better understand the surrounding.

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