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LAND USE/LAND COVER CHANGE DETECTION USING REMOTE SENSING AND GEOGRAPHIC INFORMATION SYSTEM

D.K.Tripathi*

Abstract

In the present study an attempt was made to analyse the spatial pattern of Land Use / Land Cover (LULC) and their changes using modern spatial technologies of Remote Sensing (RS) and Geographic Information System (GIS). A micro level geo-hydrological unit of Bajel watershed, Almora district, Uttarakhand was selected as an area of study. In this study Land sat 5 TM image of year 1990 and Land sat 7 ETM+ image of year 2015 were processed in ERDAS Imagine 13.1 and Arc GIS 10.3 software to map out LULC and to detect changes in the study area. Maximum Likelihood Classification algorithm was applied for image classification. Five LULC classes were identified and mapped in the study area viz. Forest, Fallow land, River, Agriculture and Settlement. It reveals that , in the year 1990 the forest was the major LULC category in the Bajel watershed covering 31.34 km^2 (80.37%) area followed by fallow land, River, agriculture and settlement contributing 1.35 km^2 (3.46%), 0.58

Keywords:
Land use/ Land cover; Remote Sensing; Geographic information system; Landsat images; Maximum likelihood classification.

* **Associate Professor, Department of Geography, Kamla Nehru Institute of Physical & Social Sciences,Sultanpur-UP**

km^2 (1.48%), 5.27 km^2 (13.51%) and 0.45 km^2 (1.15 %) respectively. In the year 2015 the forest occupied 31.46 km^2 (80.68 %) area of the watershed whereas fallow land, River, agriculture and settlement observed on 0.36 km^2 (0.92%), 0.39 km^2 (1.00%), 5.99 km^2 (15.36 %) and 0.79 km^2 (2.02 %) area respectively. In order to detect changes in LULC class in the study area, pair wise comparison of both LULC maps were performed in ERDAS Imagine. The study also demonstrates the usefulness of RS and GIS techniques in LULC mapping and monitoring.

1. Introduction

Land is a vital component of natural ecosystem. Its use or misuse has a large consequence on quality of life in a region. It has been a very important aspect of central strategies for managing natural resources and monitoring environmental changes [1]. Its spatial pattern is an outcome of various physico-cultural factors and their utilization by man in time and space. Hence, LULC is an important component in understanding the interactions of the human activities with the environment and thus it is necessary to be able to simulate changes [2]. The reliable and up-to-date information on the status and changing trends of LULC is highly desirable by planners, geographers and decision makers for sustainable development planning and improving livelihood in the region. LULC changes are the most common cause of ecological destruction and productivity loss in the terrestrial ecosystem [3]. Change detection is an important tool of monitoring and managing environment and natural resources. It provides quantitative analysis of spatial distribution of LULC which contributes in planning and decision making process for sustainable development in any region [4]. With the development of RS and GIS techniques, it is now possible to monitor LULC of any region in a timely and cost-effective way [5]. LULC change detection is a technique used in RS to determine the LULC changes in a particular area between two or more time periods [4].Since past few decades, LULC related issues have attracted great attention of geographers, planners and decision makers [6],[7],[8]. RS and GIS based change detection studies have predominantly focused on providing the knowledge of how much, where and what type of LULC change has occurred [9]. Many studies on LULC mapping and monitoring by using RS and GIS techniques have been conducted by several researchers [10],[11],[12],[13],[14],[15],[16], [17],[18], [19] [20],[21],[22],[23] [24],[25], [26],[27] in different parts of India as well as abroad .

In the light of above facts, present study is an attempt to study the spatial pattern of LULC and their changes in Bajel watershed,Almora district ,Uttarakhand (India) using RS and GIS techniques .The results of this study may be incorporated by the decision makers in LULC planning and management in the study area.

2. Materials and Methods

2.1. Study area

The Bajel watershed was chosen for study which lies between 29^0 46'0" N to 29^0 49'30" N latitudes and 79^0 36'0" E to 79^0 43'0' E longitude and is located Takula block of Almora district Uttarakhand with an area of 38.98 km^2 (Fig.1).The elevation of the watershed ranges from 1350 and 2200 m above mean sea level. The slope in the study area ranges from 00 to 55^0. The climate is mainly cool temperate. As per census of 2011 total population of Bajel watershed is 611 with 136 households.

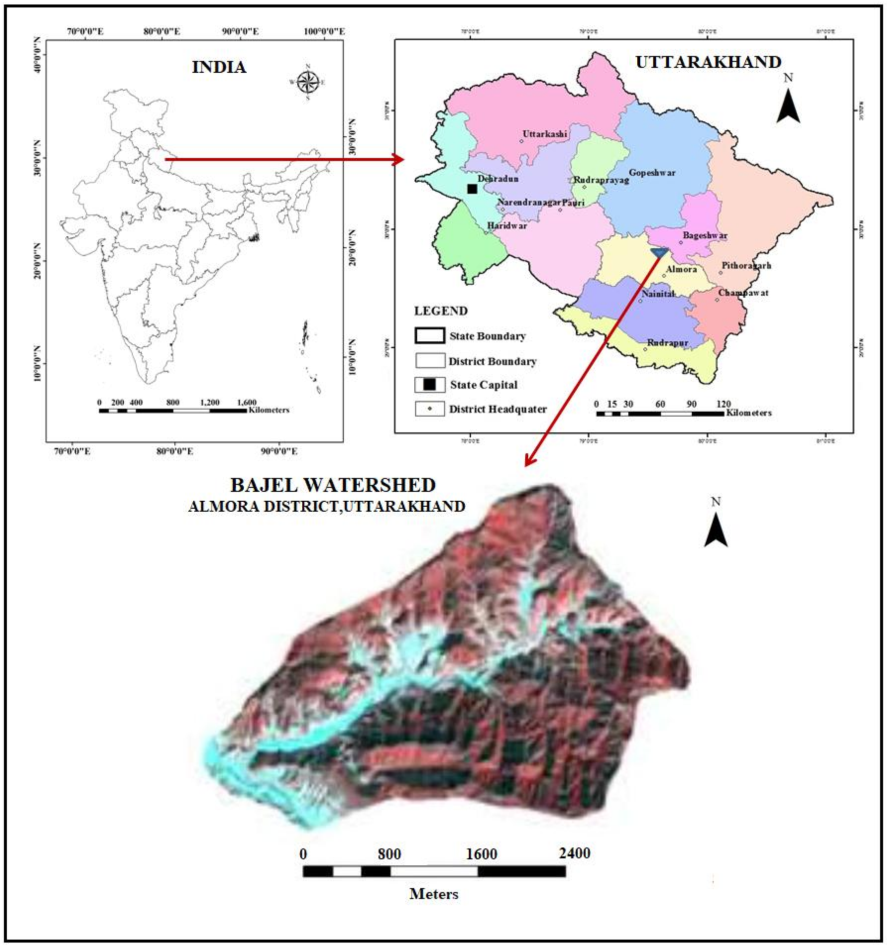


Figure 1 Location of the study area

2.2. Research materials

Following data/ research materials were used in this study-

1. Landsat 5 TM (Thematic Mapper) data (Band-4, 3,2; Resolution-30m), 1990 obtained from Global Land Cover Facility Site (GLCF).

2. Landsat 7 ETM + (Enhanced Thematic Mapper Plus) data (Band-4,3,2; Resolution-30m), 2015 obtained from Global Land Cover Facility Site (GLCF).

3. Survey of India topographical sheets of the year 1975 on 1:50000 scale numbered 53 O/9 and 53 O/10 .

4. Study area boundary map obtained from NRDMS, Uttarakhand Almora.

5. Training data collected from the field survey, 2016.

6. ERDAS IMAGINE version 13.1 (Leica Geosystems, Atlanta, U.S.A.) satellite image processing software.

7. ArcGIS version 10.3(ESRI) software.

8. GPS map 70 Cx (Garmin Tiwan) handset.

2.3. Methodology

The study was performed through the following methodological steps –

1. The Landsat 5 TM (1990) and Landsat7 ETM+ (2015) multispectral data (wavelength 0.45-2.35µm, 30 m spatial resolution were downloaded through internet from Global Land Cover facilities (GLCF) of NASA.The Landsat images provided by GLCF Network were radiometrically and geometrically (ortho-rectified with UTM/WGS 84 projection) corrected.
2. The different bands were stacked in ERDAS Imagine 13.1 to produce a False Colour Composite (FCC).
3. Subsetting of satellite images was performed to extract Area of Interest (AoI) taking georeferenced boundary map of the study area. The subset images then reprojected and co-registered to the UTM (WGS84) coordinate system with root mean square error less than 0.5 per image.
4. A reconnaissance survey of study area was carried out with SOI toposheets, hard copy of satellite data and GPS hand set following important landmark points for a general understanding of the geographical conditions of the study area. The training data was also collected from the fields regarding various LULC classes.
5. On the basic of information collected from reconnaissance survey and literature review [10] , a LULC classification scheme was developed and a legend was formed to identify the tonal behavior of the major LULC classes on the imageries. Five broad LULC classes were identified for further processing viz. Forest, Fallow land, River, Agriculture and Settlement.
6. Both images (Landsat TM 1990 and Landsat ETM+2015) were classified using Maximum Likelihood Algorithm in ERDAS Imagine 13.1 incorporating training data sets collected from various LULC classes.
7. The resultant thematic information on LULC for the years 1990 and 2015 were evaluated through accuracy assessment functions. In order to assess accuracy, 250 sample points were selected on reference image and analyzed in ERADAS Imagine software using accuracy assessment option in the classification dialog. The classified layers were compared with ground truth data and Google earth high resolution image and an error matrix was prepared. The quantitative assessment of maps accuracy was performed by computing overall accuracy and

Kappa Coefficient .It was performed in ERDAS Imagine 13.1 using overall accuracy and Kappa statistics methods.

8. In order to detect changes in LULC class in the study area, pair wise comparison of both LULC maps were performed in ERDAS Imagine.

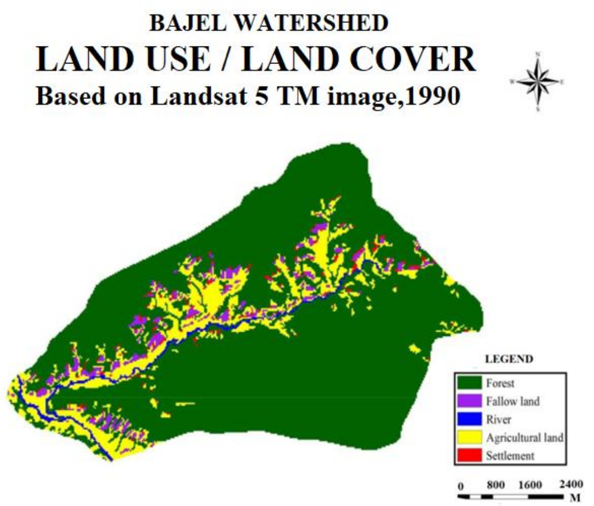
9. The statistical inventories were made in ArcGIS 10.3 for study the distributional pattern and changes in LULC of the study area.

3. Results and Analysis

The Landsat satellite images of years 1990 and 2015 were classified using Maximum Likelihood Algorithm and five LULC classes namely forest, fallow land, River, agriculture and settlement were identified and mapped in the study area (Fig.2 and Fig.3) .The overall accuracy results for LULC maps of 1990 and 2015 were obtained 91.22 and 89.99 percent respectively . The Kappa accuracy was estimated as 0.7983 and 0.7759 respectively for the LULC maps of the years 1990 and 2015. The pixel based LULC classification was computed and presented in Table 1. It reveals that , in the year 1990 the forest was the major LULC category in the Bajel watershed covering 31.34 km^2 (80.37%) area followed by fallow land, River, agriculture and settlement contributing 1.35 km^2 (3.46%), 0.58 km^2 (1.48%), 5.27 km^2 (13.51%) and 0.45 km^2 (1.15 %) respectively. In the year 2015 the forest occupied 31.46 km^2 (80.68 %) area of the watershed whereas fallow land, River, agriculture and settlement observed on 0.36 km^2 (0.92%), 0.39 km^2 (1.00%), 5.99 km^2 (15.36 %) and 0.79 km^2 (2.02 %) area respectively.

The study area, Bajel watershed has witnessed remarkable changes in LULC during research time span of 25 years (1990-2015). One of the most interesting changes was seen in forest cover. In the year 1990, the total area under forest was 31.34 km^2 (80.37%) which increased to 31.46 km^2 (80.68%) in 2015.Total increase in forest land was observed 0.12 km^2 (0.38%) during this period (Fig.4). One reason for the growth of forest could be reduction of fallow land which is either converted into agricultural land or green cover. This is a desirable change and should be maintained in the future. The fallow land has decreased from 1.35 km^2 (3.46%) in 1990 to 0.36 km^2 (0.92%) in 2015 (Fig.5). Total decrease was observed 0.92 km^2 (73.33%) during the research span. It denotes a good trend and efforts should be made to convert fallow land into green cover which can result into decreased soil erosion and ultimately leads to good river flow.

By comparing images of 1990 and 2015 it can be clearly noticed that the water volume in the river was decreased from 0.58 km^2 (1.48%) in 1990 to 0.39 km^2 (1.00%) in 2015 which accounts total 0.19 km^2 and 32.75% negative change (Fig.6). Besides increasing trends in forest cover, decreasing water volume in River could be caused by many other factors such as low rainfall, pumping of water from the river etc.



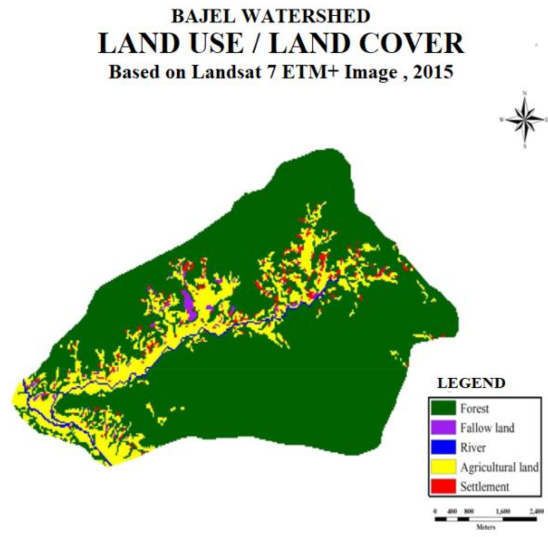
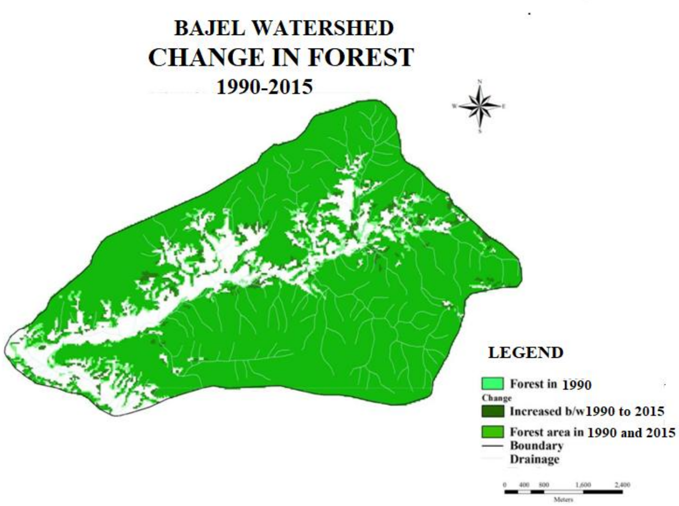


Figure 2

Figure 3



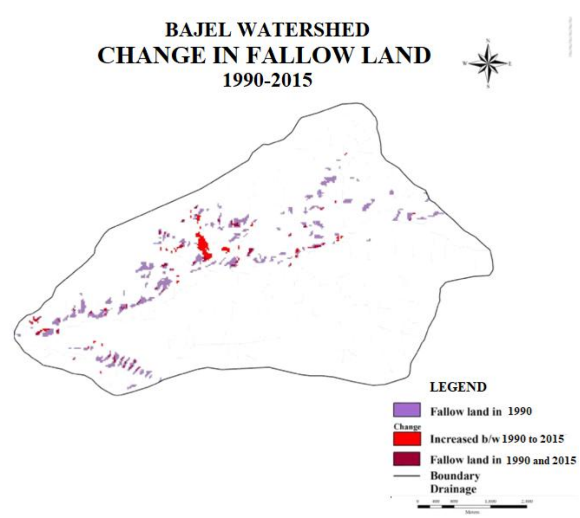
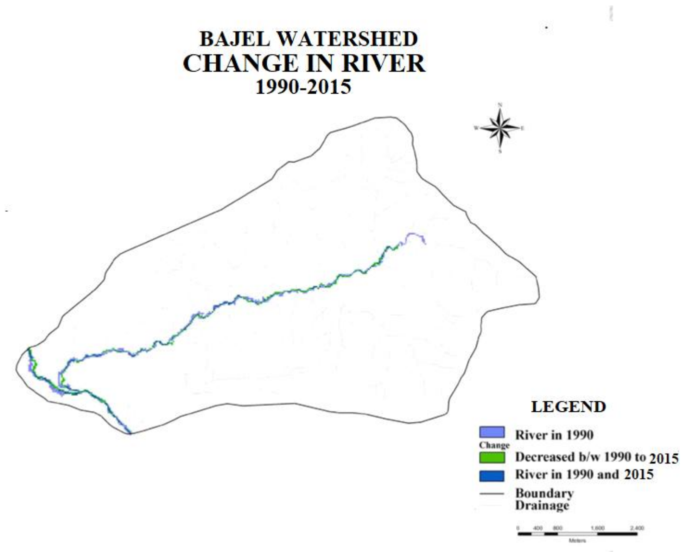


Figure 4 Figure 5



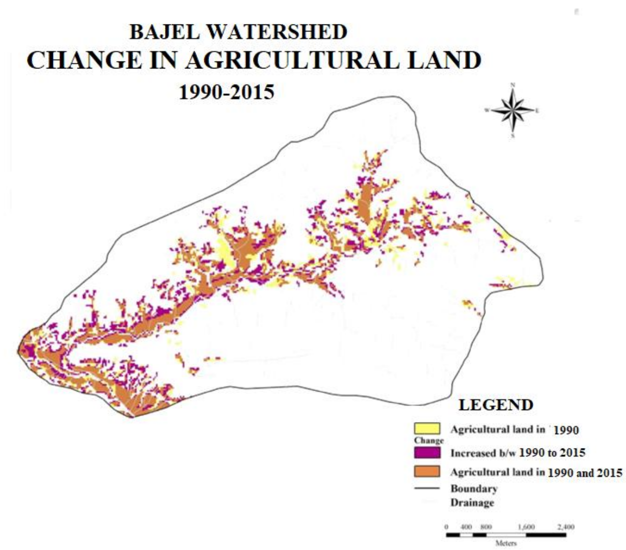
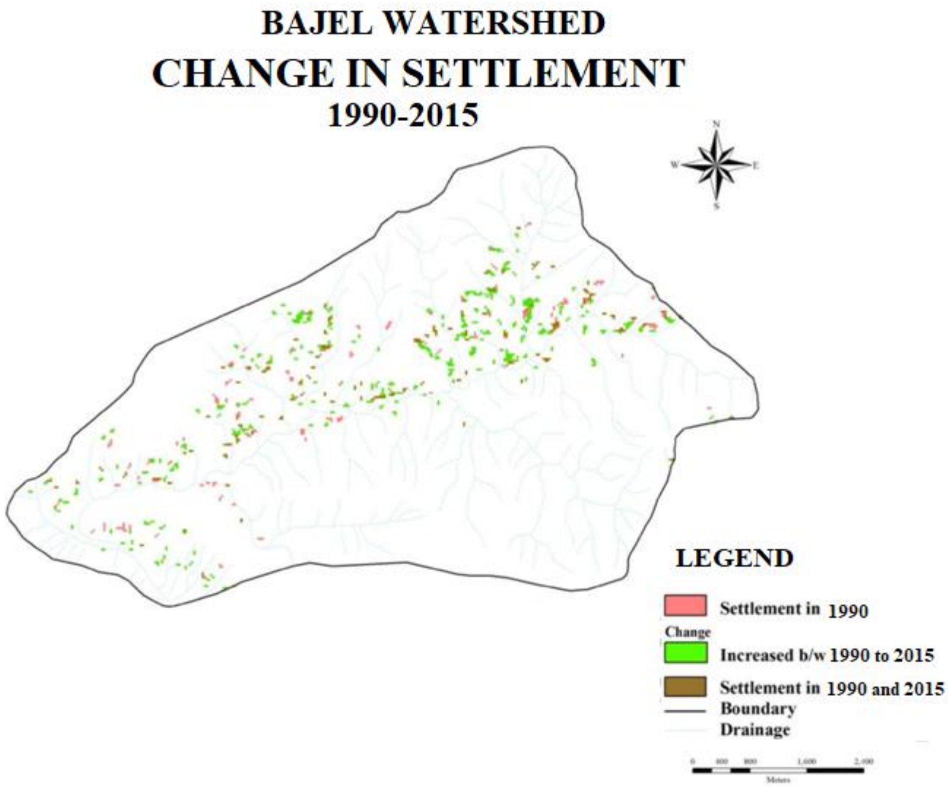


Figure 6 Figure 7

Table 1 –Land use / Land cover change detection in Bajel watershed,Almora district, Uttarakhand

Sl.No.	Land use/Land Cover Classes	1990		2015		Change (1990-2015)	
		Area (Km^2)	Area (%)	Area (Km^2)	Area (%)	Area (Km^2)	Area (%)
1	Forest	31.34	80.37	31.46	80.68	+0.12	+0.38
2	Fallow land	1.35	3.46	0.36	0. 92	-0.99	-73.33
3	River	0.58	1.48	0.39	1.00	-0.19	-32.75
4	Agriculture	5.27	13.51	5.99	15.36	+0.72	+13.66
5	Settlement	0.45	1.15	0.79	2.02	+0.34	+75.55
	Total	38.99	100	38.99	100	-	-

Figure 8



Between the years 1990 and 2015 agricultural land was slightly increased by 13.66 % (-0.19 km^2) which can be attributed to conversion of fallow land into agricultural land (Fig.7).As compared to other parts of the country it was not a drastic change which indicates low dependency on agriculture than other occupation . From the figure no. 8 and Table 1 it can be observed that the settlement has increased between the year 1990 to 2015 by 75.55 %(0.34 Km^2).Although , it does not denote the huge jump from 1990 in terms of total area change in settlement but it can alter the natural ecosystem through increasing pressure on existing resources.

4. Conclusion

This research work has amply demonstrated the utility of RS and GIS techniques for mapping and monitoring of LULC and their change detection. The spatial pattern and change detection in LULC could serve as a guiding tool in sustainable LULC planning and development in the study area. It may also be proved as a better input in environmental planning in the Bajel watershed.

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