

Evaluating Land Use/Land Cover Change Dynamics in Bhimtal Lake Catchment Area, Using Remote Sensing & GIS Techniques

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Abstract

The present study was aimed at the assessment of forest cover and land use changes in the catchment area of Bhimtal lake situated in the Kumaun region of Uttarakhand, India using multitemporal Landsat satellite images. The Landsat satellite images of year 1996 to 2015 were acquired and subjected to supervised classification into four different classes viz. urban, agriculture, forest and water body. The classified maps were verified through random field samples and google earth imagery. The images of study area were categorized into four different classes viz., settlement area, agriculture area, forest area and water body. The results revealed that during last 20 years, the settlement area has been increased from 9.70% to 18.38%, agricultural area has increased from 44.32% to 47.63% and forest area has been decreased 43.58% to 31.47%. The findings from the study will be useful for lake and landscape planning and can serve as a potential source of information to the policy makers of Uttarakhand.

Keywords: Bhimtal lake; Land use pattern; Remote sensing; GIS techniques

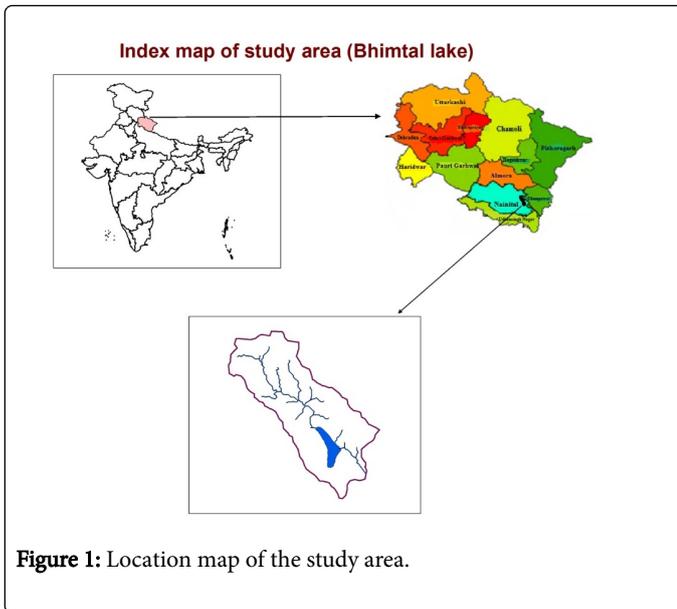
Introduction

Land use change analysis is an important tool to assess global change at various spatio-temporal scales Lambin [1]. Land use is affected by economic, cultural, political, historical and land-tenure factors at multiple scales. The increase in urbanization and anthropogenic activities have put an increasing demand on the limited land and soil resources for agriculture, forest, pasture, settlement and increasing industrial land uses. Uttarakhand is facing a serious problem of natural resources scarcity, mainly that of water resources because of increasing population growth and industrial development [2]. Land use change influences sediment, hydrologic and nutrient regimes which in turn influence aquatic biota and ecological processes in lake ecosystem [3]. Increasing settlements and other land use changes related to population growth alter the hydrological regime of freshwater body by increasing the peak flow and volume of surface runoff, while decreasing infiltration [4]. The aquatic biodiversity of Uttarakhand lakes is destroying due to agricultural runoff, municipal and industrial waste water discharges from the catchment areas of lakes and it's also received high sedimentation and nutrient load because of forest cover is reducing in an around areas of lakes. It helps to enhance the eutrophication process and reduced the water volume of lakes [5,6]. The water quality of lakes is decreasing due to drastic rise in urbanization in the catchment basin of lake surroundings and very low dispersion and high mobilization rates, which results in sediment influx into the lake affecting both biodiversity and productivity in near shore habitats in lakes [7-9]. Application of remote sensing and GIS data made possible to study the changes in land use and land cover of selected area and it consumes less time and cost providing better accuracy [10]. Remote sensing and geographical information systems (GIS) provide methods for analysis of land use changes and helps for proper land use planning and modeling. GIS provides a flexible environment for collecting, storing, displaying and analyzing digital

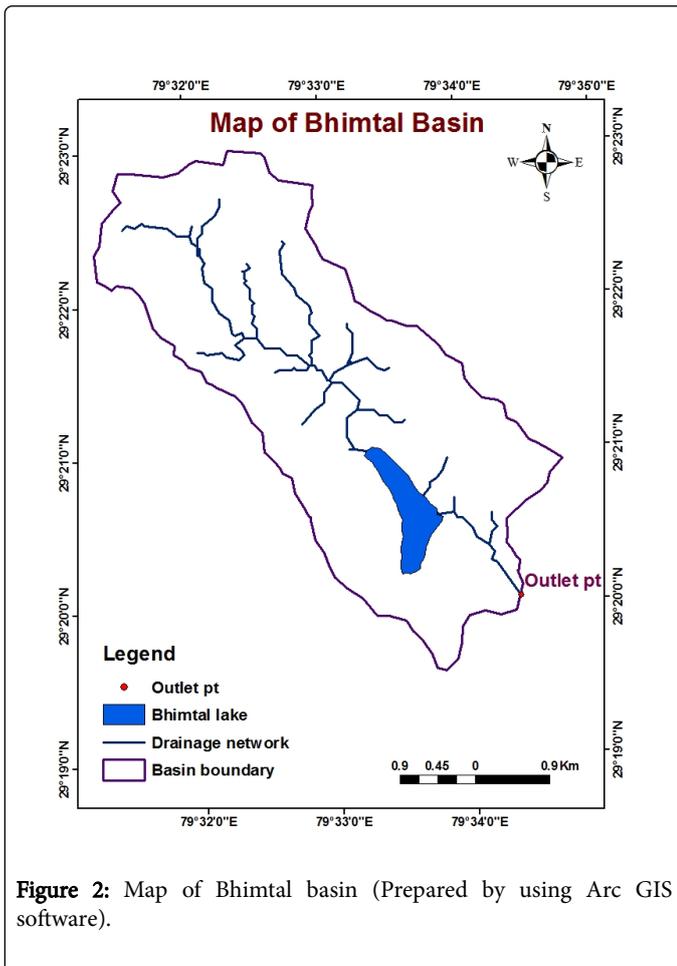
data necessary for change detection [11-13]. Remote sensing imagery is the most important data resources of GIS. Bhimtal Lake is situated in the lesser Himalaya region of Uttarakhand in India. The water quality has been showing degrading trend due to fast changing land use pattern in its catchment basin of Bhimtal lake since past ten years after developing Uttarakhand as a new state [14]. The constructions in the lake catchment have substantially increased the sediment input to the lake. Because of these anthropogenic activities, the eutrophication process has been occurring and water quality also degraded of the lake [15]. Accurate land cover change information is necessary for understanding main factors causes and environmental consequences of such changes. Therefore, the present study was made to estimate the change detection analysis of land use and land cover pattern around the catchment area of Bhimtal lake, Uttarakhand with the help of remote sensing and GIS techniques. It easily detects the changes in land use pattern rate and the changes that have taken place during the last two decades (1996-2015) in the Bhimtal town.

Material and Methods

Bhimtal lake is situated between 29°21'N latitude and 79°24'E longitude in Kumaun region of Nainital district in Uttarakhand state (Figure 1). It is a popular hill station of the Indian state of Uttarakhand (at 1332 m above of mean sea level) in the lesser Himalayan zone because an island used as a fish aquarium towards the outlet, gives it a distinction among all the Kumaun lakes. The annual variation of the mean monthly temperature ranges from 15°C to 29°C in the summer season and 4°C to 18°C in the winter season. Moreover, the Bhimtal region receives average amount of rainfall every year. In the month of July, it has been recorded as 377 mm, making it an ideal environment for cultivation [15].



Methodology



For performing land use/cover change detection, a post-classification detection method was employed. A change matrix was produced with the help of ERDAS Imagine 9.2 software. DEM and basin of study area was prepared with the help of Arc GIS 9.3 software (Figure 2). To make the change analysis of the study area, five images from the satellite LANDSAT ETM (path-row: 145-40) 1996, 2000, 2003, 2010 and 2015 was used which was obtained from earth explorer. Area statistics of each land use category was calculated in km² and % in attribute table in ERDAS IMAGINE 9.2 (Table 1). Recoding method was also done for converting pixel value into proper class. This software consists of accuracy assessment tool. The land use and cover map should be in raster format to run this tool. By applying random points in accuracy assessment window we got accuracy report which contains overall classification accuracy. Ground checking was also done by collecting GPS points to make the confirmation of result obtained for different land use characteristics.

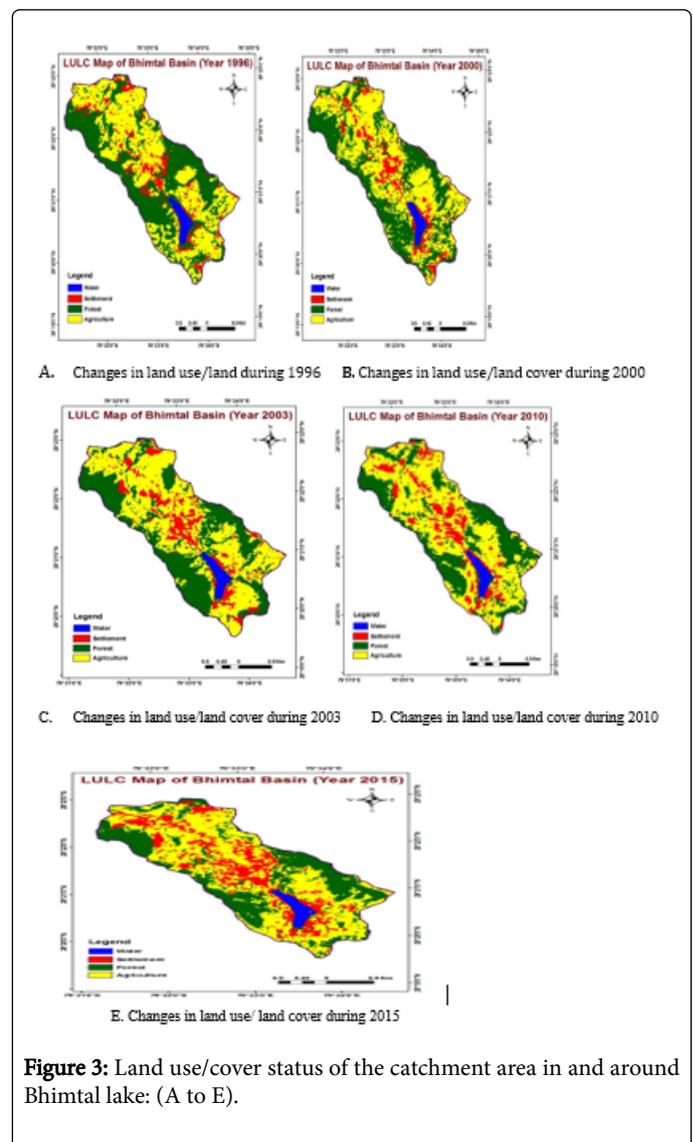
Result and Discussion

Bhimtal lake receives lot of inorganic and organic pollutants from different sources like construction activities, tourism development and domestic discharge etc. However, the indiscriminate construction activities e.g. industrial units, hotels, resorts and residential flats and houses occurred mainly in mallital industrial areas, tallital areas and other hilly terrains of catchment basin of Bhimtal lake [14]. In the study area the major land use/land cover categories identified and mapped were settlement area, agricultural area, forest area and water body with the help of satellite Landsat ETM of 1996, 2000, 2003, 2010 and 2015. The change detection map was presented in Figure 3. About 9.70% of the area was occupied by settlement land during 1996, 1.63% during 2000, 1.77% during 2003, 2.01% during 2010 and 2.77% area was occupied by settlement during 2015. Forest covered 6.61% area during 1996, 6.17% during 2000, 5.72% during 2003, 5.18% during 2010 and 4.74% area was covered during 2015. Agricultural field covered 6.73% area during the year 1996, 7.03% during 2000, 7.29% during 2003, 7.58% during 2010 and 7.28% during 2015. The data of land use/land cover changes between 1996 to 2015 were presented in Table 1. The analysis of land use/land cover of Bhimtal for different time periods, indicated substantial changes. Major changes have taken place particularly in the built-up land and forest areas. The Bhimtal lake also reduced its area because of sedimentation from its catchment area [14]. The land use/land cover map showed that the settlement around the mallital valley has increased between 1996 to 2015 from 9.70 km² to 18.38 km². The agricultural land has also increased between 1996 to 2015 from 44.32 km² to 47.63 km² in mallital valley and island zone (Figure 4). On the other hand, forest cover reduced from 43.58 km² to 31.47 km² between 1996 to 2015 around the Bhimtal lake. Bhimtal forest was covered by temperate and tropical trees in the past but in past 20 years demographic pressure insist the people to cut the trees down and has given a new face lift resulting open forest is decreased (12.11%) because of conversion of forest area into agricultural land.

Land use/land cover categories	1996		2000		2003		2010		2015		Change analysis	
	Km ²	(%)										
Water	0.36	2.40	0.34	2.25	0.39	2.57	0.40	2.60	0.38	2.52	*n.t	n.t
Settlement	1.47	9.70	1.63	10.93	1.77	11.66	2.01	13.25	2.77	18.38	1.3	8.68
Forest	6.61	43.58	6.17	40.63	5.72	37.70	5.18	34.16	4.74	31.47	1.87	12.11
Agriculture	6.73	44.32	7.03	46.19	7.29	48.07	7.58	49.99	7.28	47.63	0.55	3.31
Total	15.17	100	15.17	100	15.17	100	15.17	100	15.17	100		

Table 1: Area and amount of change in different land use/land cover categories in the catchment area of Bhimtal lake during 1996 to 2015. * n.t-not traceable.

The decrease in dense forest warrants immediate attention as it provides sustainable environmental conditions for existing flora and fauna of that area. The deforested and fallow lands have given way to the immense growth of Lantana an irritant weed. On the other hand, settlement was increased by the rate (8.68%), which is very obvious due to human population growth. The main settlement was found in the towns of this area at mallital valley. In the year 2015 the double crop area was converted to agricultural land and some new land use/land cover category like aquaculture area was created and some settlements were covered with vegetation. This suggests that vegetation and agriculture area was increased but dense forest decreased because of population growth as urban population increased in comparison with the year 1996. The similar observation was observed at the catchment of Agara Lake in Bangalore [16]. Once surrounded by orchard and agricultural fields, catchment had undergone major changes due to the development of new roads and settlements. There is no traceable change in water body as it constitutes about 0.36 km² to 0.38 km² in 1996 and 2015. The 35.84% of total lake basin was found converted in to swamps or a wetland from March to May. There was evidence to show that the depth of Bhimtal lake reduced due to rock silt erosion from surrounding hills terrain and other catchment areas during the rainy season [14]. There was a sufficient siltation at the bottom especially during monsoon season. The islands, swamp and dry land part in and around the lake has a total area about 20.0% of the total basin area of the lake [14]. Slopes are cut for construction of buildings and deforestation makes the land vulnerable to landslides. The process of erosion is causing siltation and sedimentation in Bhimtal Lake. The shrinking of the Lake has become a major problem not only in Bhimtal but also in other lakes like Nainital, Sat Tal, Naukuchiyatal, etc. The Bhimtal Lake had an area of 60.00 ha in 1904 but is now reduced to 46.26 ha [17] and the capacity of the lake has declined by over 50,000 cubic feet. With the rise in eutrophication the transparency level of the water is degrading affecting the water ecosystem.



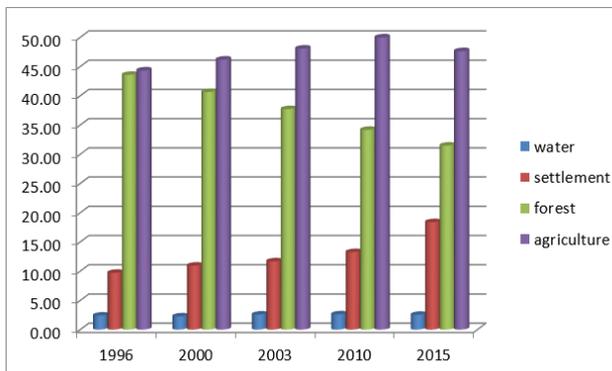


Figure 4: Changes in land use/land cover from 1996 to 2015.

Conclusion

Bhimtal Town advocates that multi-temporal satellite data such as Landsat ETM are very useful to detect the changes in land use quickly and accurately. Under utilization of potential land, increased population, and land conversion are the main causes for the changes in land use pattern during the past 20 years in the Bhimtal. The present study concluded that the major land use in the Bhimtal town area is built-up land. During the last two decades, the area under built-up land has been increased 8.62% due to construction of new buildings on agricultural and vegetation land. The area under agricultural land has increased by 3.31%. Forest has been decreased 12.11% because of human population growth. The approach adopted in this study clearly demonstrated the potential of GIS and remote sensing techniques in measuring change pattern of land use/cover in town area. There is a need for local land use planning and design with conservation practices of the study area.

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