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Land-Cover Change Analysis of Garur Ganga Watershed Using GIS/Remote Sensing Technique

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ABSTRACT

Land-use change and Land-cover classes in Garur Ganga watershed of Bageshwar district in Uttranchal State during the periods 1963 -1996 and 1986-1996 were analyzed through Survey of India Topographical Sheet and visual interpretation of LANDSAT 5 TM image bands 2, 3 and 4 using Geographical Information System (GIS). The detailed analysis have revealed that the area under agriculture and settlement increased from 34.98 to 42.34%, whereas the forest and barren land show a declining trend. Expansion of agriculture land and builtup areas have been found to be maximum in the 1200-1600 m elevation zone with 7-14° slope class. The loss of vegetation cover has been estimated to be 5.07% between 1963-1996 and 0.81% between 1986-1996.

Introduction

The land-use change significantly due to various physical and socio-economic factors. The land-use pattern of an area is directly related with the level of techno-economic advancement and the nature and degree of civilization of its inhabitants (Whyte, 1961). Land-use is a dynamic phenomenon, and both its value and pattern changes from one particular point of time to another and also from one geographical unit to another, with varying efficiencies, abilities, priorities and needs (Bisht and Tiwari, 1996). The changes in land-use or land-cover due to natural and human activities can be observed using current and archived remotely sensed data (Luong, 1993). The information on land-use/ land-cover patterns, their spatial distribution and changes over a time scale are the prerequisite for making development plans (Dhinwa *et al.* 1992). In view of the pressure exerted by increasing population, need for mitigating increasing demand of land resources, appropriate scientific land-use planning and land management strategies could provide the alternative for the sustainable development of any region (Saxena *et al.* 1990). Remote sensing data provides detailed and cost effective information with respect to spatial distribution of vegetation types and land-use. The parameters like, tonal

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variations of image, land and hydrological features have been taken into account for interpretation.

The present study deals with land-use mapping in Garur Ganga watershed using remote sensing data, topographical maps, Census of India, revenue records and ground trurh data. It is an attempt to derive useful information for the watershed management by analyzing land-use/ land-cover dynamics in the study area on a time scale.

Study Area

The Garur Ganga watershed falls within the geo-coordinates 29°50'23" to 29°55'56" N and 79° 2'59" to 79° 30'4" E. The watershed having an area of 82.62 km^2 (Fig. 1), which is presently administered under Garur block of district Bageshwar, Uttaranchal (a newly created state). There are 63 revenue villages and the total population of the watershed is 14524 person in the year 1991 with a density of about 175 person/ km^2. Mica and chlorite schists, gneissic schists, biotite schists and gnisses, marble, granites and pegmatites are the major rock types of the area which falls under Almora and Berinag nappe. The elevation ranges between 1090 and 2520 m from mean sea level. The Climate of the area falls is sub-tropical to temperate zone with a mean annual precipitation of about 169.45 cm (recorded between October 10, 1997 to September 30, 1998) and average monthly temperature ranges between 4.72 - 27.41° C. About 72% of the total population of the watershed is engaged in agricultural activities. The Garur Ganga watershed is almost centrally located in the Uttaranchal and represents the maximum diversity, phenomenal, physical and cultural obtainable in the entire Kumaun Himalaya.

Methodology

Visual image interpretation of satellite data (LANDSAT 5 TM, 2, 3 and 4 band combination) of April and October for the year 1986 and April and December for the year 1996 on 1:50,000 have been visually interpreted for analyzing land use changes. The base map as well as the land use map for the year 1963 have been derived from Survey of India Toposheet. Ground verification were made for confirming the landuse units. Simple macro language (SML) programs of Arc/Info (ESRI, U. S.) Geographical Information System (GIS), mathematical and statistical operation in 'table' and 'dbase' have been used to derive land acreage and the amount of changes on it. The changes in the extent of different land use categories during the period from 1963 – 1996 and 1986 – 1996 have also been carried out.

Results and Discussion

Land-use/land-cover Dynamics

Only three broad land-use and land-cover types are discernible from 1963 Survey of India Topographical map, however for the year 1986 and 1996 detailed classification is available in remote sensing data. Area under major land-use or land-cover categories are calculated for the year 1963, 1986 and 1996. Cultivated areas include agricultural land and settlement area inclusive of community land, and cultivable wasteland. Forest areas include village panchayat forests as well as forests under the jurisdiction of the State Forest Department. Barren and other lands include rocky surface, steep slopes, scrubs.

Agriculture/Settlement

Table 1 and Fig. 2 show changes in various categories of land-use between 1963-1996 and 1986-1996, derived by spatial intersection. Increase in agriculture/builtup area (+7.37%), between 1963-1996 is mainly due to an increase in population by 44.27% between 1951-91. An increase of about 1.35% in agriculture/settlement area over the period 1986 - 1996 (Table 1) has been noticed. The major changes have been found in the proximity of settlements, considering 1 to 1.5 km buffer zone for each settlement area. It has been found that encroachment on marginal lands for cultivation took place due to population pressure, decrease in per capita land holding size and fragmentation of land holdings.

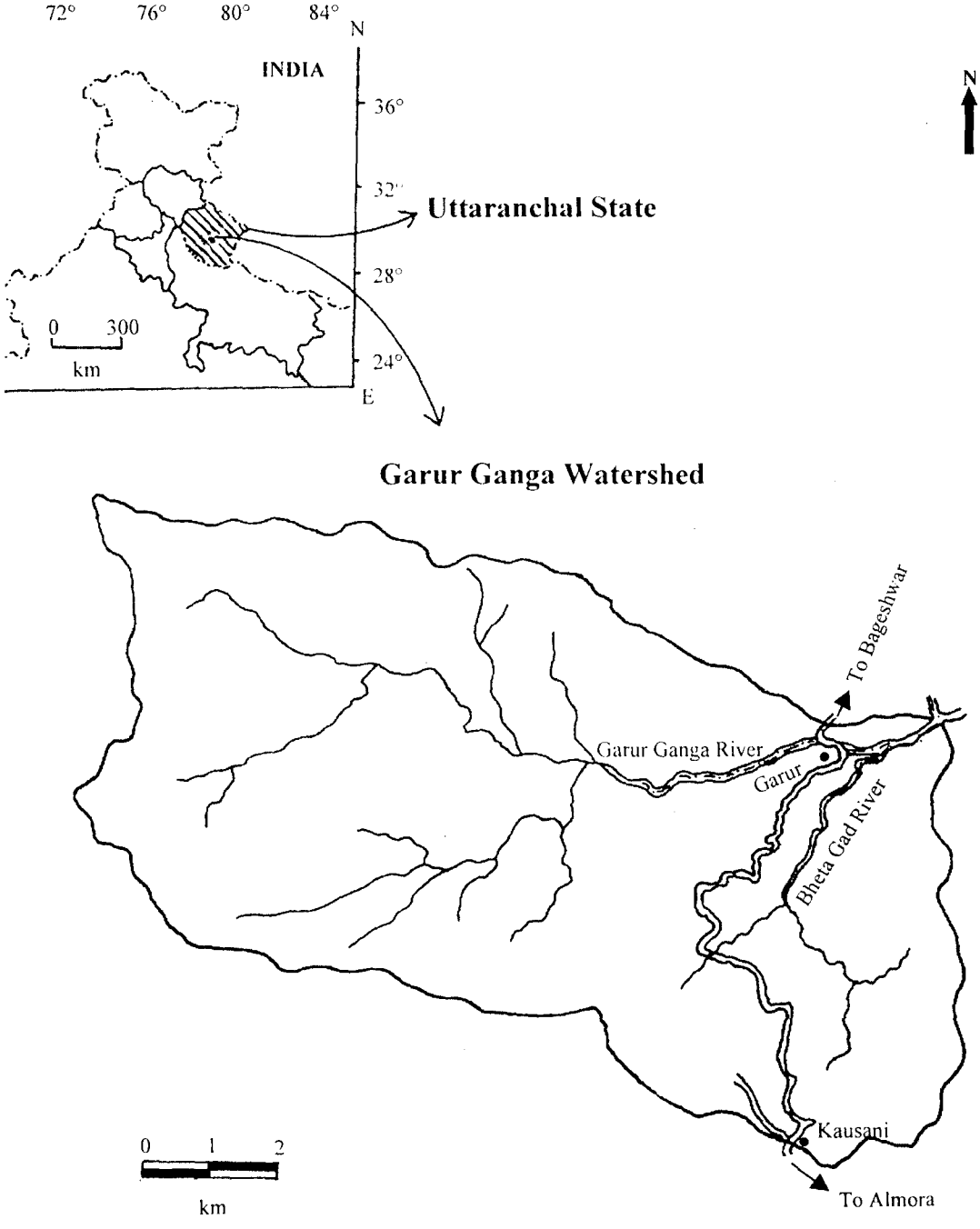

Fig. 1. Location of The Study Watershed

Table 1: Land-use status and changes between 1963-1996 in Garur Ganga watershed

Land-use type	1963		1986		1996		Changes (%)		
	Area (km^2)	Area (%)	Area (km^2)	Area (%)	Area (km^2)	Area (%)	1963-86	1986-96	1963-96
Agriculture/ settlement	28.89	34.97	33.87	40.99	34.98	42.34	+6.02	+1.35	+7.37
Forests	50.11	60.65	46.59	56.39	45.92	55.58	-4.26	-0.81	-5.07
Barren	3.00	3.63	1.38	1.67	1.09	1.32	-1.96	-0.35	-2.31
Others	0.62	0.75	0.78	0.95	0.63	0.76	+0.2	-0.19	+0.01

Land-cover dynamics in relation to the elevation and slope zone show that the largest proportion of agricultural land has been found between 1200-1600 m altitude and further more, substantial agricultural extention has been recorded in this elevation ranges during the period 1963-1996. This may probably because the availability of land at lower elevations is less and at the same time nearly all cultivable land at the lower elevation had already been brought under cultivation. With respect to the slope, maximum proportion of cultivated land has been found between 7-21° slope class, moreover the extension of agriculture land has also been recorded to be higher within this slope class.

Barren land

Area consisting of rocky surface, steep slopes and land poorer in sub-soil moisture are the form of barren land. The sloppy land lying within the village boundaries designated as *'Benap'* (non measurable) land are mostly barren in the year 1963 and gradually brought under cultivation through illegal encroachments by the nearby villages. The area covered under barren land decreased by 2.31% between 1963-1996 and 0.35% between 1986-1996 (Table 1). The direct effect of reduction of barren land, also used for open grazing, could be observe as increasing biotic pressure on forests.

Forests

Detailed classification of forest cover are not available in detail for the year 1963, it was possible to interpret the major forest types by satellite imagery for the years 1986 and 1996. The analysis of forest cover change between 1963-1996 and 1986-1996 show a decrease from 60.65% in 1963 to 56.39% in 1986 and 55.58% in 1996 (Table 1). Forest, a major land-use category, covering an area of 55.58% (1996) of the total geographical area of the watershed, is lower than the required cover (60%) for mountainous areas under the National Forest Policy (Joshi *et al.* 1983, Saxena *et al.* 1990). Further, the forest cover with more than 40% crown density is much less than the total forest cover.

The analysis of the data shows that the degraded forests exists on the periphery of settlement and agricultural lands indicating human encroachment and other biotic interference. The main cause of forest degradation may be illegal felling of pine trees (*Pinus roxburghii*) and some broad-leaved species. Large scale commercial felling of pine trees has been carried out between 1980-1982 and a few patches of pine trees have also been removed and thinning/lopping is carried out during 1995 for large scale tea plantation (Fig. 2).

Conclusion

The land-use system is highly dynamic which undergoes significant changes according to the changing socio-economic and natural

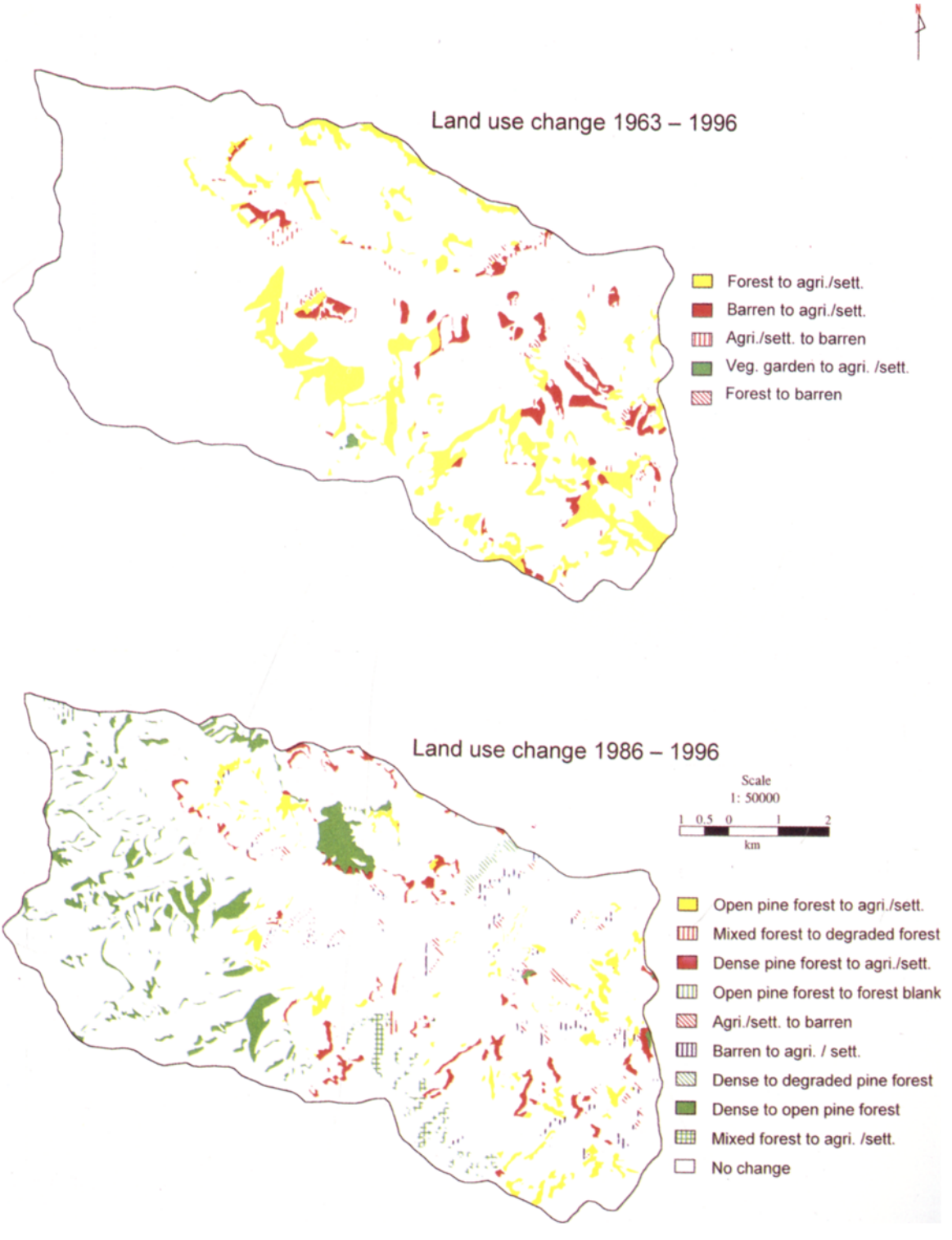

Fig. 2. Land use change

environment. The changes in any form of land-use is largely related either with the external forces and the pressure builtup within the system. Transformation of marginal lands from forests and barren areas into agriculture is basically to fulfil ever-increasing demand of food, fuel wood, fodder and timber. The process of rapid land transformation has not only brought about an ecological crisis in the region but has also threatened the agricultural economy of the watershed through accelerated soil erosion, deforestation and reduction in ground water recharge (Bisht, 1997). In the present investigation, land under agriculture and settlement has increased significantly at the cost of reduction of forest land and partly of barren land. Major changes have also been detected in forests especially dense forest to open forest and forest blank.

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