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# Analysis of land transformation and land degradation using Remote Sensing and GIS

**A.S.Mukhomedjanov[1]* and A.P.Shriwastav**
**Institute of Geography and Geology, The State University of Urgench, Uzbekistan*
*Institute of Agriculture and Animal Science, TU, Chitwan, Nepal*

## Abstract

Land-use and land-cover change is a general term for the human modification of Earth's terrestrial surface. The present study aims at interpretation, identification, mapping and analytical studies of land characteristics to integrate all these attributes for better understanding of land use/land cover change and various land degradation types of Dehradun district for the last two decades using remote sensing and geographical information system (GIS). The results indicated that in the last two decades, three distinct features have characterized the study area that are increasing population growth rate, migration to the urban areas and rapid rise in population; continued dependence of a very large proportion of the population on the land resources; and increasing degradation and depletion of land resources with a consequent declines in the productive capacity of the land. If the present trend continues it will lead to severe degradation of natural resources and hence, it calls for proper land use policy. Remote sensing and GIS can be an effective tool for natural resource assessment, monitoring and management.

**Key words:** remote sensing and GIS, land use change, degradation and demographic factors

## Introduction

One of the clearest manifestations of human activity within the biosphere has been the conversion of natural landscapes to highly managed ecosystem, such as croplands, pastures, forest plantations, and urban area (Ramankutty et al., 2002). Though humans have been modifying land to obtain food and other essentials for thousands of years, current rates, extents and intensities of land use and land cover change (LU/LC) are far greater than ever in history, driving unprecedented changes in ecosystems and environmental processes at local, regional and global scales (DeFries et al. 2004). These changes encompass the greatest environmental concerns of human populations today, including climate change, biodiversity loss and the pollution of water, soils and air. Monitoring and mediating the negative consequences of LU/LC change while sustaining the production of essential resources has therefore become a major priority of researchers and policymakers around the world (Global Land Project, 2005).

Biodiversity is often reduced dramatically by LU/LC change. When land is transformed from a primary forest to a farm, the loss of forest species within deforested areas is immediate and complete. Even when unaccompanied by apparent changes in land cover, similar effects are observed whenever relatively undisturbed lands are transformed to more intensive uses, including livestock grazing, selective tree harvest and even fire prevention (Meyer and Turner, 1994). Research also demonstrates that species invasions by non-native plants, animals and diseases may occur more readily in areas exposed by LU/LC change, especially in proximity to human settlements. Vegetation removal leaves soils vulnerable to massive increases in soil erosion by wind and water, especially on steep terrain, and when accompanied by fire, also releases pollutants to the atmosphere. Other environmental impacts include the destruction of stratospheric ozone by nitrous oxide release from agricultural land and altered regional and local hydrology (Turner et al. 1990 and Ruddiman, 2003).

While land cover may be observed directly in the field or by remote sensing, observations of land use and its changes generally require the integration of natural and social scientific methods (expert knowledge, interviews with land managers) to determine which human activities are occurring in different parts of the landscape, even when land cover appears to be the same. High rates of

population growth, poverty and resource degradation, in many instances, have been mutually reinforcing processes. A major issue in sustainable development in Uttarakhand has therefore been the growth in population and its attendant causes and consequences. In the present study assessment of land transformation and land degradation of Dehradun district was carried out along with the analysis of the demographic features.

## Study area

The district Dehradun is situated in the north-west corner of the Uttarakhand state (Fig. 1) and lies between 29º 58' to 31º 2' north latitudes and 77º 34' to 78º 18' east longitudes. Doon valley is a intermontane valley surrounded by lesser Himalayas in the North and Siwalik ranges in the south. Physiographically Dehradun can be divided into five units namely mountains, hills, piedmont plains, river terraces and flood plins. Geologically the study area is is comprised of phyllites and shales and alluvium. Old and recent flood plains have been formed by the deposition of the river at the lower side.

## Materials and methods

The methods of land-change science include remote sensing and geospatial analysis and modeling together with the interdisciplinary assortment of natural and social scientific methods needed to investigate the causes and consequences of LULCC across a range of spatial and temporal scales. Remote sensing is an essential tool of land-change science because it facilitates observations across larger extents of Earth's surface than is possible by ground-based observations.

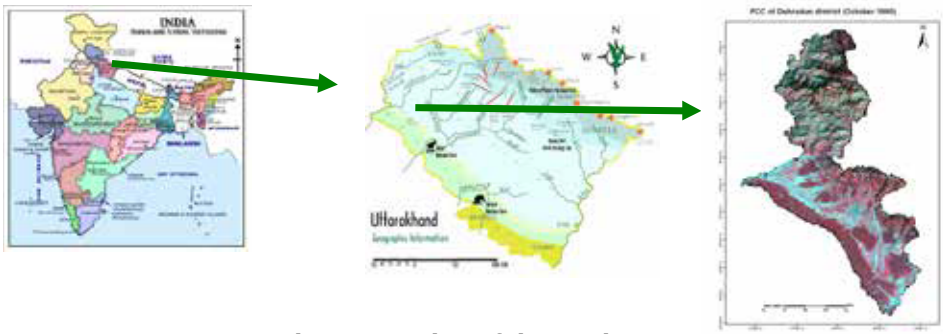


**Fig. 1: Location of the study area**

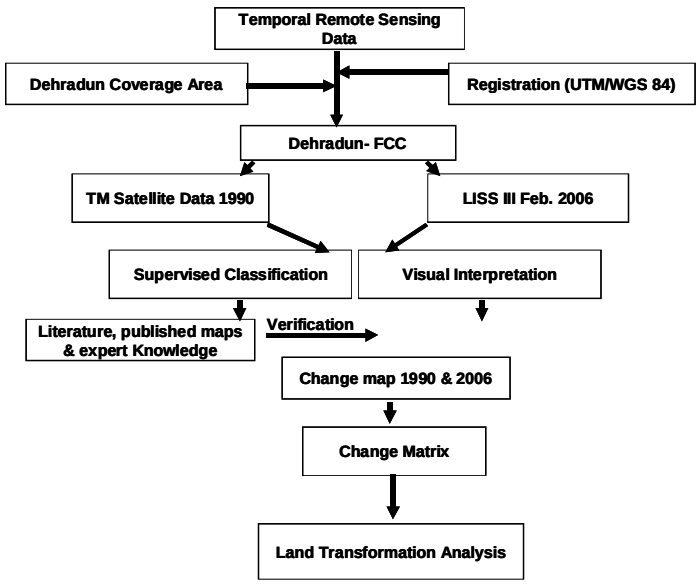


**Fig. 2. Flow chart showing the methodology**

The present study aims at interpretation, identification, mapping and analytical studies of land characteristics to integrate all these attributes for better understanding of land use/land cover change of Dehradun district for the last two decades. Various land degradation types were also visually interpreted using visual interpretation keys, so as to estimate the degraded areas. We have used IRS LISS III FCC of November 2005 and February 2006, TM satellite data of October 1990, Survey of India topographic map No. 53 F/15, 53 J/4 and 53 J/3 in the scale of 1:50,000. IRS LISS-III FCC imagery of February 2006 and TM data of 1990 were interpreted individually making use of the interpretation keys. Verification was carried out using ground truth and published information. Change matrix was prepared to analyse the land transformation. The detailed methodology is given in figure 2. Further, land use/land cover, and characteristics of various physiographic units were recorded so as interpret the land degradation types and severity. Census of India data of various time periods were used to study the demographic characters of Dehradun and to understand its impact on the land degradation.

## Results and discussion

Remote sensing technology can be effectively utilized for change detection and monitoring activities. Ideally, the change detection procedures involve remotely sensed data acquired by the same sensor, having same spatial resolution viewing geometry, spectral bands and time of the day. It is observed that in 1990 the major land cover category was forest (40%) followed by scrub land (36%) and agriculture (11%). The spatial extent of forest area was spread over both in valley and mountain (Fig 3 & 4). Scrub land was mostly in the mountain slopes and majority of the agriculture land was observed in the valley. However, in 2006 (Fig. 5 & 6) mixed land use has under gone tremendous decrease in area which occupies only 2% of the geographical area followed by slight decrease in forested area (39%). The agricultural activity has gone up and it covers nearly 13% of the area with no change in scrub land status (36%). One of the most conspicuous change was noticed in settlement which has gone up from 3% to 6% of the study area, indicating the land conversion and pressure on natural resources of the region.

The results of land use/land cover change matrix indicated that forest cover has undergone both conversion and density reduction. It is estimated that 933, 974 and 160 ha of forest area has been converted into settlement, agriculture and mixed land use (agriculture & settlement), respectively during 1990-2006 (table 1). Owing to the demand for settlement 9,658 ha mixed land use and 22 ha of agricultural land have been converted into settlement. A significant finding of the study is that scrub area in the mountain region has been transformed into agriculture (303 ha) and the area under agriculture has witnessed intensification. As a result of these changes area under forest has declined by 1.7 %, scrub land by 0.3 per cent. On the other hand, a remarkable increase in the settlement area (122 per cent) was noticed followed by agriculture (17.5%) in the study area during 1990-2006 (Fig. 7).

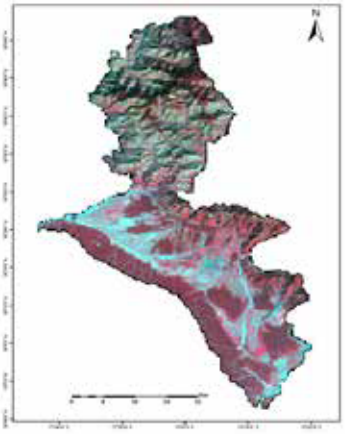

Fig. 3: FCC of Dehradun District (October 1990)

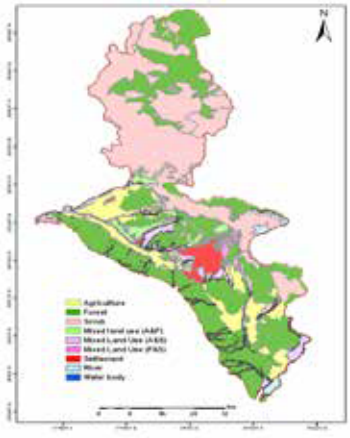

Fig. 4: Land use/land cover map of Dehradun District (1990)

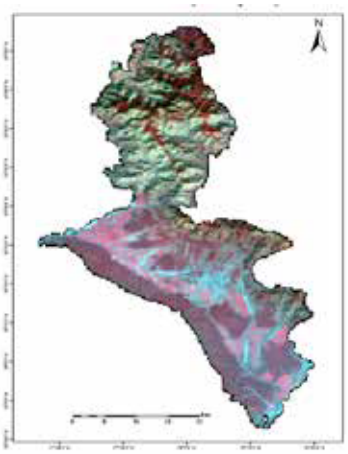

Fig. 5: FCC of Dehradun District (February2006)

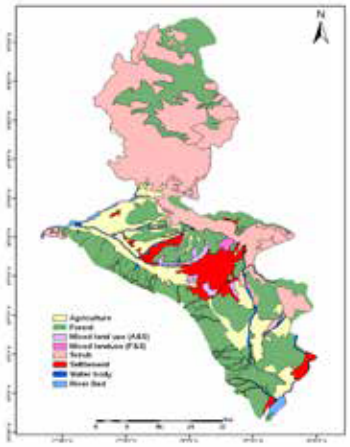

Figure 6: Land Use/Land Cover map of Dehradun District (2006)

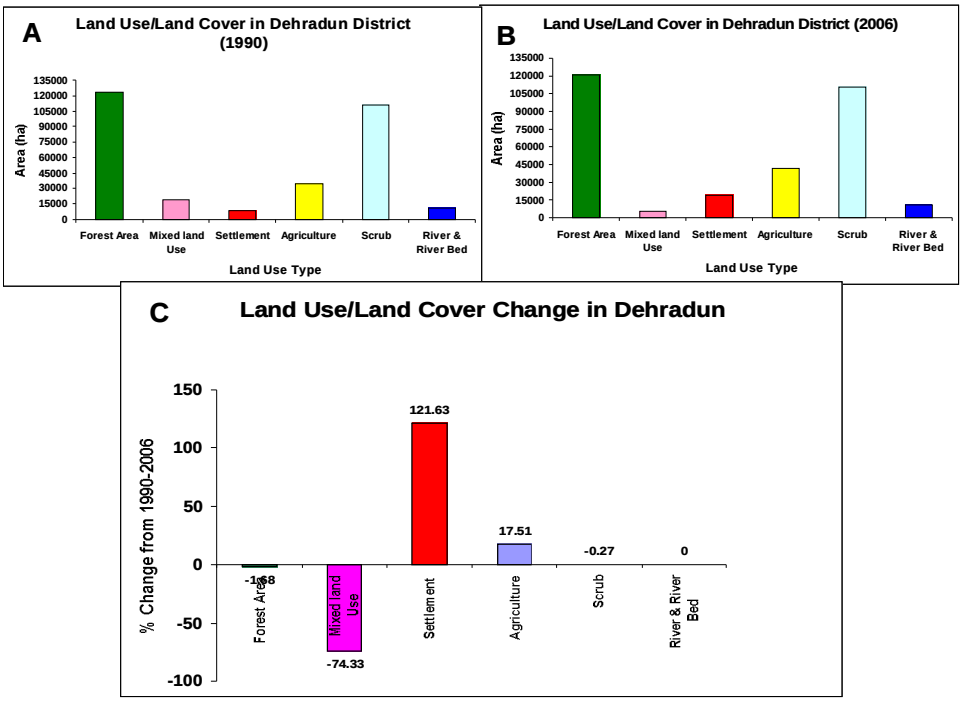


Fig. 7: Land Use/Land Cover Change (%) in Dehradun from 1990 to 2006

Further land degradation assessment using remote sensing data indicated that majority of the land cover area is under some form of degradation especially moderate to severe degradation in the Himalayan mountain. The change analysis of degradation types indicated that the degraded land in Dehradun has increased by 2063 ha in 2006 which was estimated to be 179198 ha in 1996. This means, during the period under study nearly 0.67% of new area has been brought under degraded land category. It is observed that gully erosion is the dominant form of degradation. It is a serious concern that in 2006 nearly 58.85 % of the area is subject to some form of degradation and only 41.15% of the area is free from degradation.

The analysis also indicated that majority of the degraded areas are located in the forested and mixed land

use category. Gully erosion has increased as a result of forest density reduction and disturbance of scrub land for various activities in the mountain areas. Rills become prominent in the sloppy areas where intensive agriculture is practiced.

The demographic analysis of the Uttarakhand and Dehradun using census of India statistics indicated that during the seventies and eighties, dramatic declines were seen in mortality rates while fertility rates remain more or less stable at high levels. The result has been a rapid rise in population and growth rates that has historically never been experienced over such a short period of time. Environmental deterioration, poverty, and migration have been the obvious consequences.

In Dehradun urbanization as a process is relatively a recent phenomenon mostly due to immigration. The un-sustainability of mountain agriculture has contributed to out migration into more productive areas in the plains, to urban areas where there are seemingly more opportunities. Urbanization is generally regarded as an indicator of opportunities for employment in non-agricultural sectors and much of the service sector employment in Dehradun is generated in urban areas in the plains. As a consequence of this rapid change in land use is observed and Dehradun district is being converted into the dense settlement. With the increase in demographic pressure on agriculture land, marginal land (scrub land) has been brought into agriculture with intensification of already existing agricultural land. Similarly, the dense forest of the Doon valley is also going to be converted either into the settlement or agricultural land in the future (Sati and Kumar, 2004).

## Conclusion

Thus, it can be concluded that the land use/ land cover of Dehradun district has undergone conspicuous change during 1990-2006 as a result of demand for settlements and food production. The study suggested that the forest should be protected in order to maintain the ecological balance. The settlement area should not be allowed to increase at the cost of productive land. However, nothing can be achieved unless and until we check the population growth. Economic transformation appears therefore as the key to effectively slow down population growth. The basis for economic transformation essentially is searched within the context of mountain specificities. If the present trend continues it may lead to severe degradation of several natural resources of the Doon valley and in this context remote sensing can play a vital role in aiding land use policy options and conservation efforts.

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