Landuse Landcover Change Detection of Dehradun Tehsil Using Landsat Data

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1. Introduction:

The total surface area of the earth is approximately 510 million km^2, of which 7 per cent (361 million km^2) is ocean and 29 per cent (149 million km^2) is land. Land is the basic life support system; it supports all forms of plant and animal life. It is the assemblage of biotic and abiotic components on the earth's surface and is one of the most crucial properties of the earth system (Turner *et al.* 1994). However, there remain remains only few landscapes on the Earth that are still in their natural state. Empirical studies globally have shown that anthropogenic activities are the sole reason that had significantly altered the Earth's surface. Man's presence on the Earth and his use of land has had a profound effect upon the natural environment thus resulting into an observable pattern in the land use/land cover over time.

The landuse and landcover (LULC) pattern of a region is an outcome of natural and socio-economic factors and their utilization by man in time and space. Land is becoming a scarce resource due to immense agricultural and demographic pressure. Hence, information on LULC and possibilities for their optimal use is essential for the selection, planning and implementation of land use schemes to meet the increasing demands for basic human needs and welfare. This information also assists in monitoring the dynamics of land use resulting out of changing demands of increasing population.

LULC change has become a central component in current strategies for managing natural resources and monitoring environmental changes. The advancement in the concept of vegetation mapping has greatly increased research on LULC change thus providing an accurate evaluation of the spread and health of the world's forest, grassland, and agricultural resources has become an important priority. Xiaomei, Y. and Rong Qing, L.Q.Y. (1999) noted that information about change is necessary for updating land cover maps and the management of natural resources. Singh (1998) too stated that change detection is the process of identifying differences in the state of an objector phenomenon by observing it at different times. It is an important process in monitoring and managing natural resources and urban development because it provides quantitative analysis of the spatial distribution of the population of interest. Macleod and Congation (1998) list four aspects of change detection which are important when monitoring natural resources:

a) Detecting the changes that have occurred,
b) Identifying the nature of the change,
c) Measuring the area extent of the change and
d) Assessing the spatial pattern of the change.

2. Remote Sensing and Geographical Information System in LULC Change Detection:

Even since the development of Remote Sensing (RS) techniques and invention of powerful software like Geographical Information System (GIS), data from Earth sensing satellites has become vital in mapping the Earth's feature. In situations of rapid and often unrecorded LULC change, observations of the earth from space provide objective information of human utilization of the landscape. Over the past years, RS and GIS are now providing new tools for advanced ecosystem management. Viewing the Earth from space is now crucial to the understanding of the influence of man's activities on his natural resource base over time. The collection of remotely sensed data facilitates the synoptic analyses of Earth system function, patterning, and change at local, regional and global scales over time; such data also provide an important link between intensive, localized ecological research and regional, national and international conservation and management of biological diversity (Wilkie and Finn, 1996).

3. Statement of the Problem:

Land use is a product of interactions between cultural back ground, state and physical need of the society with the natural potential of land (Karwariya & Goyal, 2011). Mother Nature provided abundant scope for income diversification and choices of livelihood option. Often, however, utilization objectives tend to override the socio-economic and environmental significance of the natural environment. One of the most relevant consequences of unsustainable landuse practice is their incompatibility with the diverse use of the natural environment, thereby adversely affecting the delicate balance between local economic interests, environmental functions and global biodiversity concerns (FAO, 2001). In the recent years, there has been much talked about the rapid denudation of green cover of the geographical area of our land that has threatened the livelihood of millions of poor people (Kotwal *et al.*, 2008). The area under present study (Dehradun Tehsil) witnesses a large scale transformation particularly to the built-up areas since the last two decades. With the declaration of statehood and Dehradun forming the provisional Capital of Uttaranchal (now Uttarakhand), the area has undergone large scale transformation in the landcover. Therefore, the area provides a most suitable condition to study the LULC change detection aided by RS and GIS.

4. Study Area:

Dehradun Tehsil is situated between 29° 56' 52" N to 30° 32' 54" N latitude and between 77° 33' 46" E to 78° 18' 03" E longitude. The Tehsil encompasses an area of 1882.22 sq. km. with an average elevation of 682 metres (2237 feet). The entire area can be divided into two distinct tracts, i.e. the montane tract and the sub-montane tract. Towards its north along the Chakrata tehsil the study area consists of entirely of a succession of mountains and gorges. Below the montane tract follows the sub-montane tract, popularly known as Dun Valley bounded by Shivalik hills in the south and outer scarp of the Himalayas in the north. The area experiences wide variety of LULC owing to its vastness in her geographical area as well as physiographic variations. The extreme north is occupied by mountain vegetation of alpine type to thickly forest *sal* (evergreen vegetation) towards the foothills. The southern slopes are mainly settlement areas and agriculture farmland and large tract of dry sands that are ejected by the south flowing rivers and tributaries.

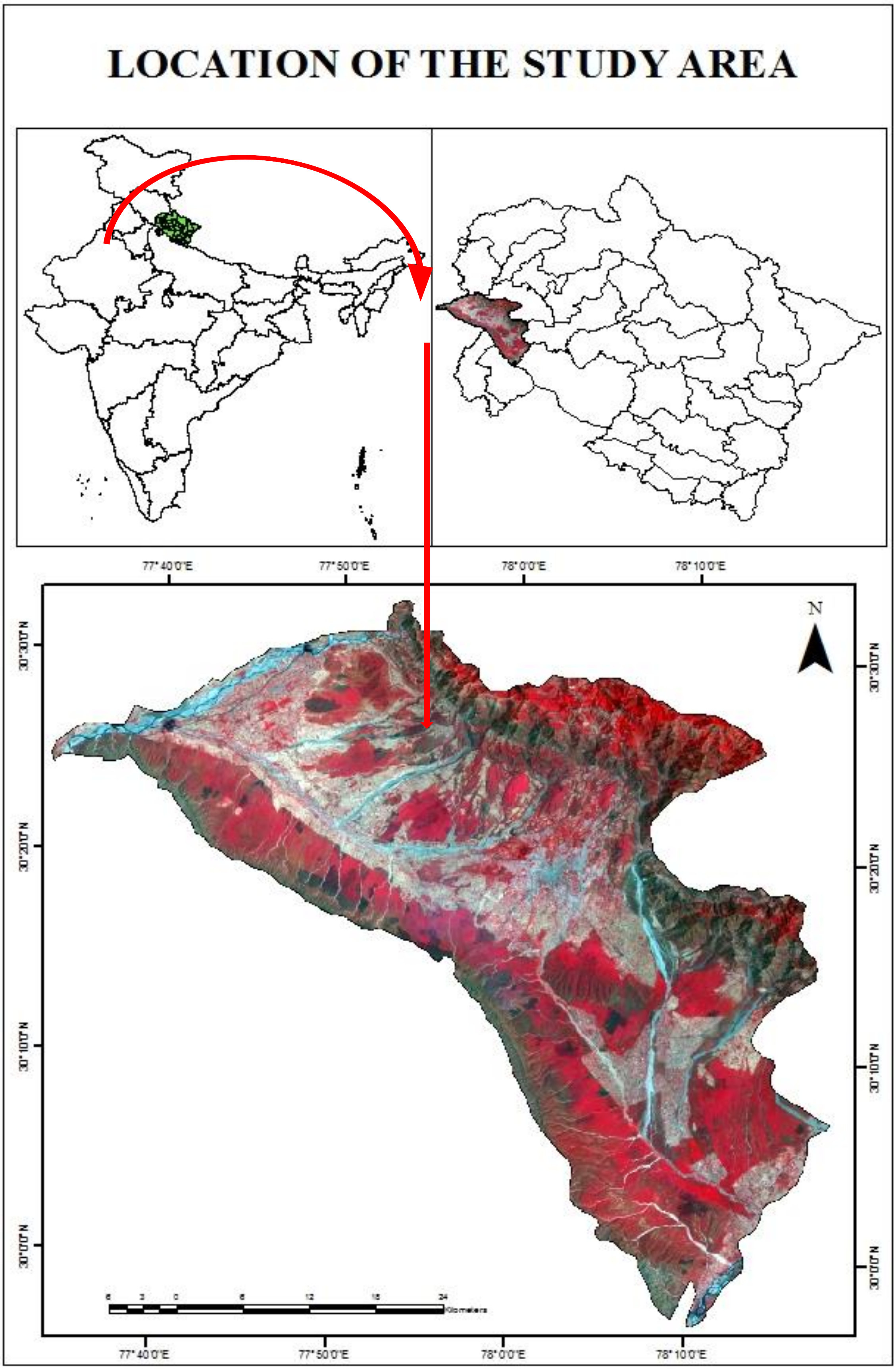


Fig-1: Location of the study area.

5. Objective of the Study:

The main objective of the study is to produce a LULC map of Dehradun tehsil at different temporal scale and to examine and identify the changes that have taken place during those periods. The specific objectives of the study are:

1. To create a landuse landcover map of the study area, and
2. To examine and identify the trend, nature and rate of landuse landcover change.

6. Database and Methodology:

Based on the objective and content of the study requisite, the Landsat satellite imageries for the year 1993, 2003 and 2013 were freely downloaded from the USGS Glovis website http://glovis.usgs.gov/index.shtml. Survey of India toposheet of 1:50,000 scale was used as a baseline map for generation of Area of Interest (AOI). The data specification and methodology performed are discussed in the subsequent paragraphs.

Table-1: Basic Information of the Landsat Satellite Images Used

Sensor	Date of Acquisition	Path/Row	Ground Resolution
LANDSAT-5 (TM)	22-05-1993	146/39	30 Meter
LANDSAT-7 (ETM)	10-05-2003	146/39	30 Meter
LANDSAT-8 (OLI-TIRS)	13-05-2013	146/39	30 Meter

The methodology for the following study is expressed by schematic diagram as given below:

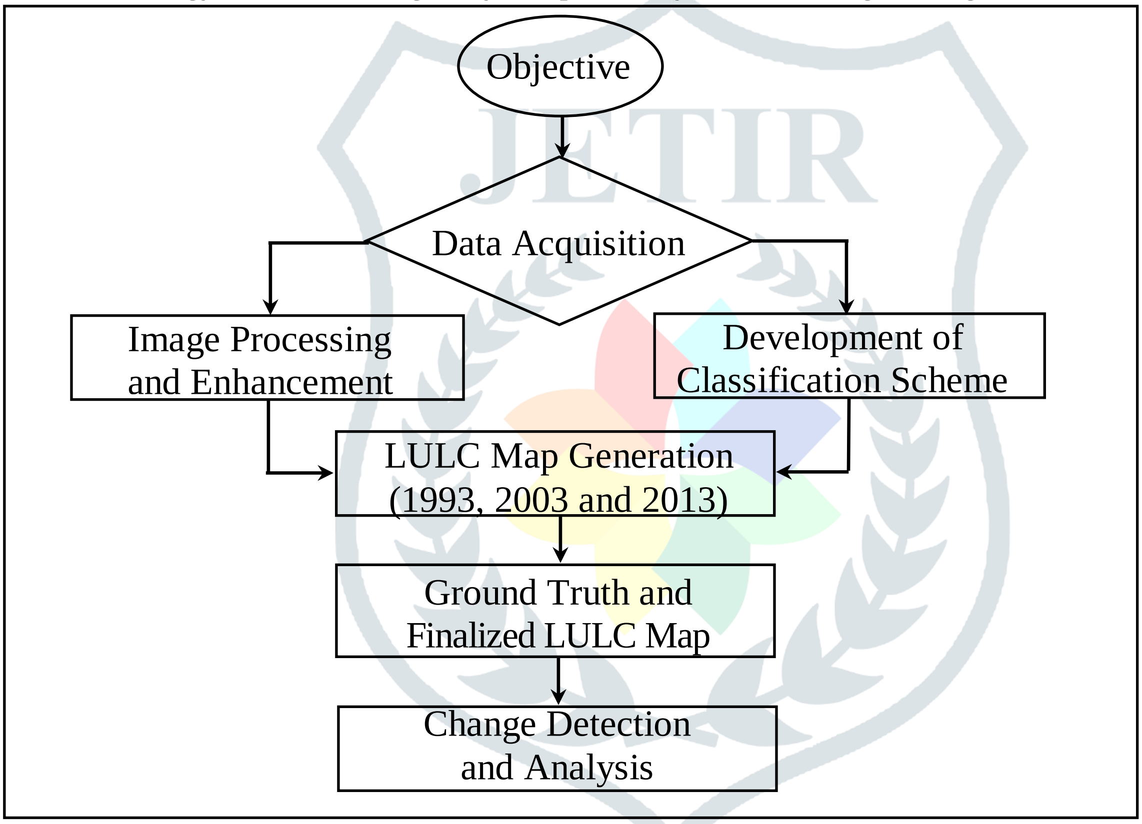


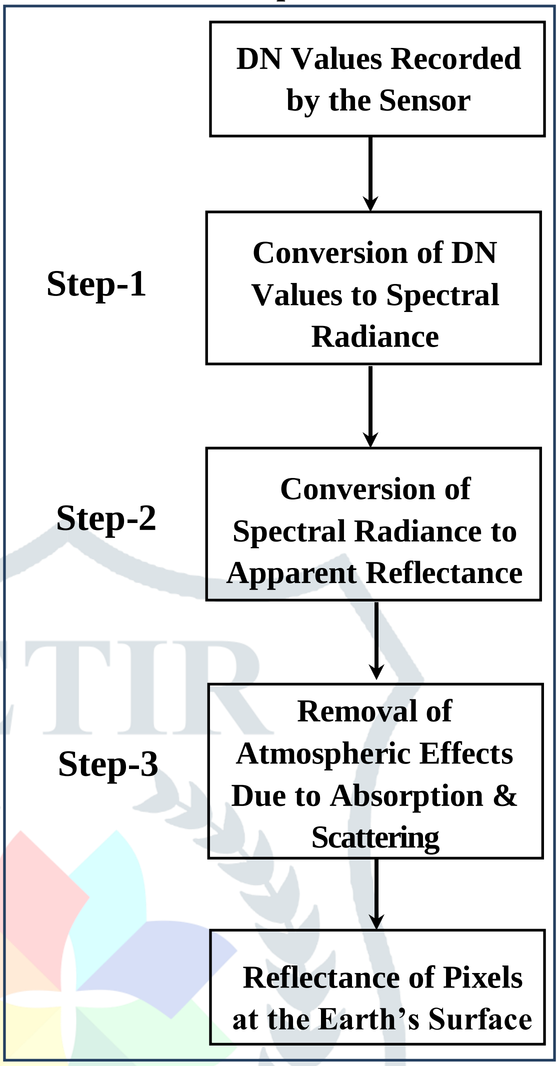
Fig-2: Schematic Diagram of Methodology Followed

Since the study of change detection is being carried out by using multi-temporal Landsat data with coarse resolution, the radiometric and atmospheric correction was felt much essential. Hence, pre-processed of raw data was performed before LULC classification was carried out.

a) Radiometric and Atmospheric Correction:

Digital sensors record the intensity of electromagnetic radiation (EMR) from each spot viewed on the earth's surface as a Digital Number (DN) for each spectral band. The exact range of DN that a sensor utilizes depends on its radiometric resolution. For example, a sensor such as Landsat MSS measures radiation on a 0-63 DN scale whilst Landsat TM measures it on a 0-255 scale and so on. However, the EMR recorded on the sensors are influenced by numerous factors. The corrections of such errors are essential before performing LULC change detection in order to gain more accuracy. Therefore, the radiometric and atmospheric corrections for the three Landsat data were radiometrically and geometrically corrected according to the steps as shown in the Figure-3. The formula used for the conversion of DN to Radiance and Radiance to Reflectance and finally the Haze removal are as shown below:

Fig-3: The Process of Radiometric and Atmospheric Correction



i) DN to Radiance:

The formula used in this process is as follows:

$$L_\lambda = ((LMAX_\lambda - LMIN_\lambda)/(QCALMAX - QCALMIN))*(QCAL - QCALMIN) + LMIN_\lambda$$

Where:

$L\lambda$ is the cell value as radiance
QCAL = digital number
$LMIN\lambda$ = spectral radiance scales to QCALMIN
$LMAX\lambda$ = spectral radiance scales to QCALMAX
QCALMIN = the minimum quantized calibrated pixel value (typically = 1)
QCALMAX = the maximum quantized calibrated pixel value (typically = 255)

ii) Radiance to ToA Reflectance:

The formula used in this process is as follows:

$$\rho_\lambda = \pi * L_\lambda * d^2/ESUN_\lambda * \cos\theta_s$$

Where:

ρ_λ = Unitless plantary reflectance
L_λ = spectral radiance (from earlier step)
d^2 = Earth-Sun distance in astronomical units

$ESUN_\lambda$ = mean solar exoatmospheric irradiances

θs = solar zenith angle.

iii) Atmospheric Haze Removal:

The Haze removal was carried out using a Model Maker in Erdas Imagine using the equation:

EITHER 0 IF ($n3_memory<0) OR $n3_memory OTHERWISE

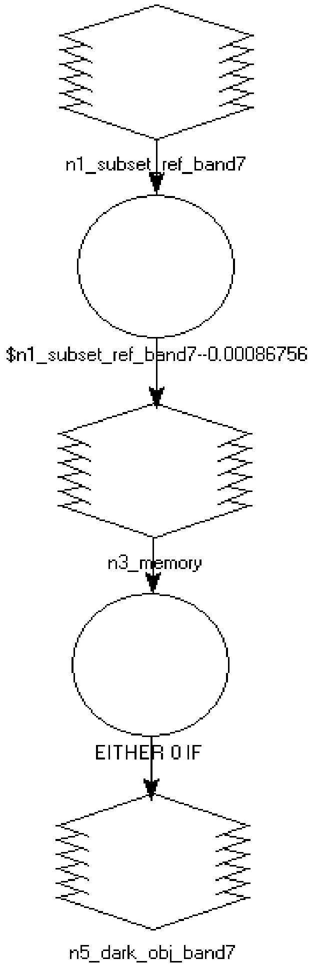


Fig-4: Model Maker for Haze Removal from Landsat Data

The values used for the conversion of DN to radiance and then to reflectance, to generate Top of Atmosphere reflectence for atmospheric corrections are as given below in Table-2.

Table-2: Landsat TM Spectral Range, Post-Calibration Dynamic Range and Mean Exoatmospheric Solar Irradiance ($ESUN_\lambda$)

Landsat TM Sensors (Q_{calmin} =1 and Q_{calmax} =255)

Band Units	Spectral Range µm	Center Wavelength	$LMIN_\lambda$ W/(m^{2}sr m)	$LMAX_\lambda$	$ESUN_\lambda$ W/(m^{2}m)
1	0.452-0.518	0.485	-1.52	193.00	1983.00
2	0.528-0.609	0.569	-2.84	365.00	1796.00
3	0.626-0.693	0.660	-1.17	264.00	1536.00
4	0.776-0.904	0.840	-1.51	221.00	1031.00
5	1.567-1.784	1.676	-0.37	30.20	220.00
7	2.097-2.349	2.223	-0.15	16.50	83.44

Landsat-7 ETM Sensors (Q_{calmin} =1 and Q_{calmax} =255)

1	0.452-0.514	0.483	-6.20	293.70	1997.00
2	0.519-0.601	0.560	-6.40	300.90	1812.00
3	0.631-0.692	0.662	-5.00	234.40	1533.00
4	0.772-0.898	0.835	-5.10	241.10	1039.00
5	1.547-1.748	1.648	-1.00	47.57	230.80
7	2.065-2.346	2.206	-0.35	16.54	84.90

Landsat-8 OLI-TIRS Sensors (Q_{calmin} =1 and Q_{calmax} =65535)

1	0.435-0.451	0.440	-63.17	764.98	1969.00
2	0.452-0.512	0.480	-64.42	780.08	1840.00
3	0.533-0.590	0.560	-58.99	714.29	1551.00
4	0.636-0.673	0.655	-49.96	604.96	1044.00
5	0.851-0.879	0.865	-30.31	367.10	225.70
7	2.107-2.294	2.200	-2.48	30.09	82.07

b) Image Classification, Ground Truth and Accuracy Assessment:

The atmospherically corrected images are then classified to generate LULC map. Both supervised and unsupervised classification method were used to have better accuracy. The LULC map was generated for three decadal time period considering the common class-Agricultural Land, Evergreen Forest, Deciduous Forest, Settlement, Water Bodies and Dry River Bed. The results of the classification were then tested for accuracy deriving the results of 72.5 percent for the year 1993, 78 percent for the year 2003 and 88 percent for the year 2013. The classification and LULC map are as shown below:

Fig-5: Landsat Images and the LULC Classified Maps of 1993, 2003 and 2013

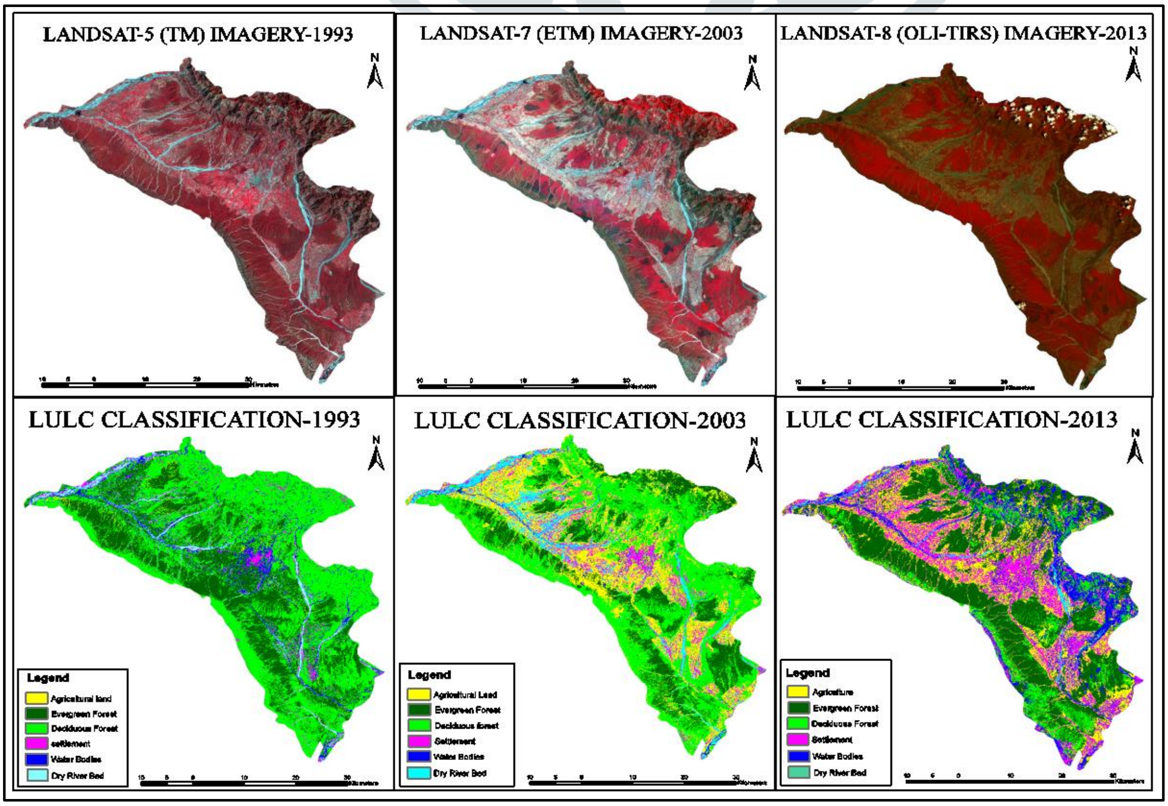
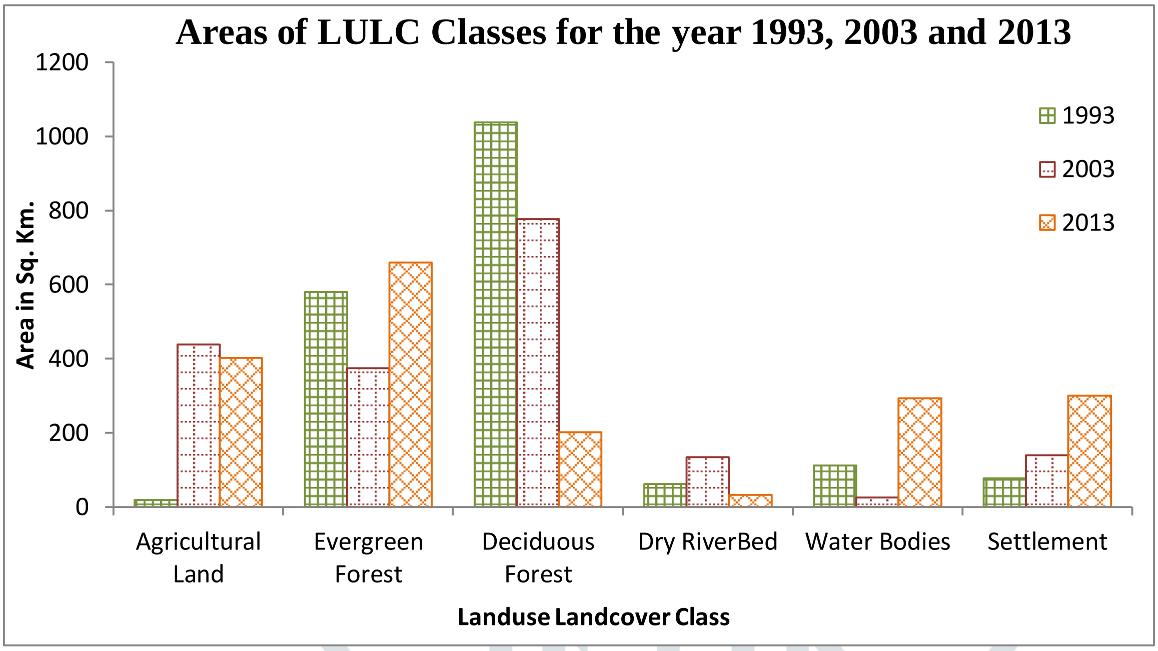


Fig-6: Areas of LULC Classes for 1993, 2003 and 2013 and their Changing Pattern

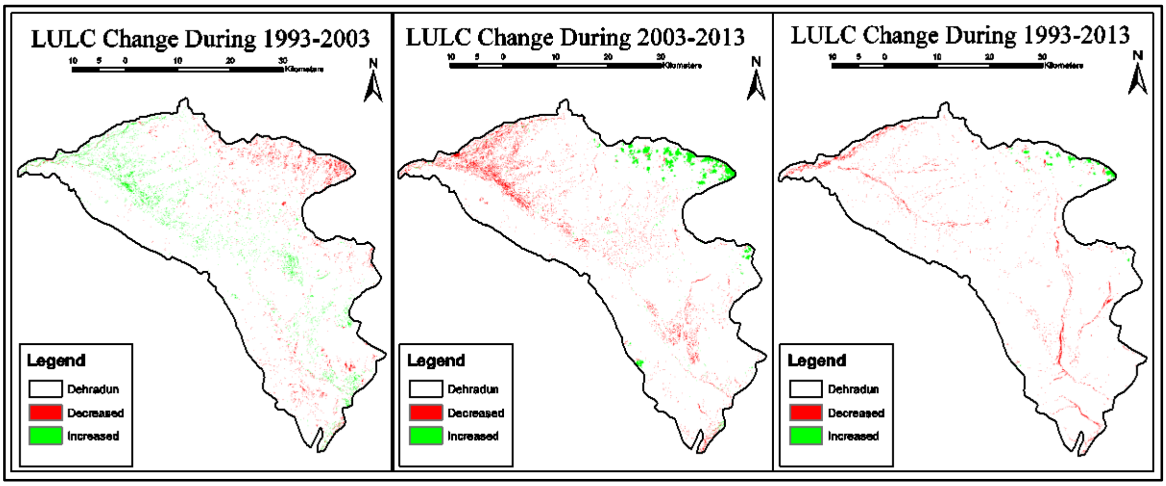


7. Results and Discussions:

Table-3:Comparative change of LULC in Dehradun Tehsil During 1993-2013

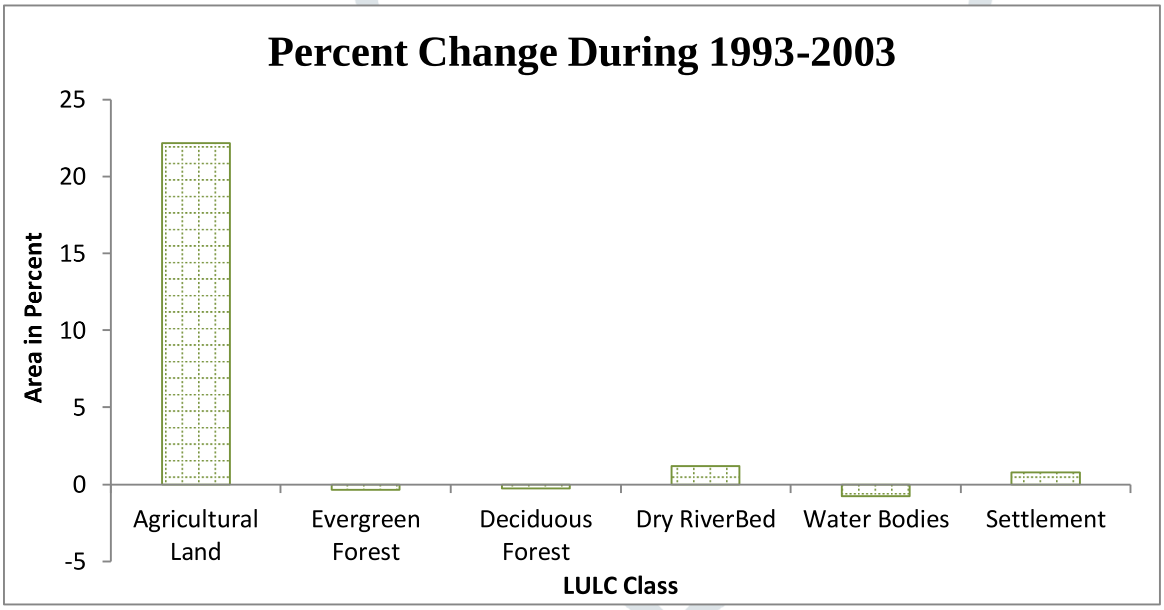
LULC class	Area in sq. Km			Change (in area sq. Km)		Change area in %	
	1993	2003	2013	1993-03	2003-13	1993-03	2003-13
Agricultural Land	18.91	437.99	401.73	419.08	-36.26	22.15	-0.08
Evergreen Forest	580.79	374.38	659.62	-260.40	285.23	-0.35	0.76
Deciduous Forest	1037.52	777.04	201.05	-260.47	-57.59	-0.25	-0.74
Dry RiverBed	61.89	134.95	33.18	73.06	-101.80	1.18	-0.75
Water Bodies	112.09	24.85	292.61	87.24	267.77	-0.77	10.7
Settlement	78.02	140.00	301.02	61.97	161.02	0.79	1.15
Total	1889.25	1889.25	1889.25	20.08	86.40	3.79	1.84

Fig 7: LULC Change during 1993, 2003 and 2013



The attribute data of supervised land use/land cover from the study area between years 1993 and year 2013 with regard to various features indicated significant changes in LULC classes. In the above table it shows that area under agriculture in 1993 was about 18.91 km^2. In 2003 it is showing 437.99 km^2 and In 2013 it reduced to 401.73 km^2.The percentage of agricultural land in 1993-2003 is increasing 22.15 in the reference of total area. But in 2003-13 it decrease -0.08 % of the total area. The decrease of agriculture land could be due to slow and steady growth of urbanization by the way of residential and commercial constructions.

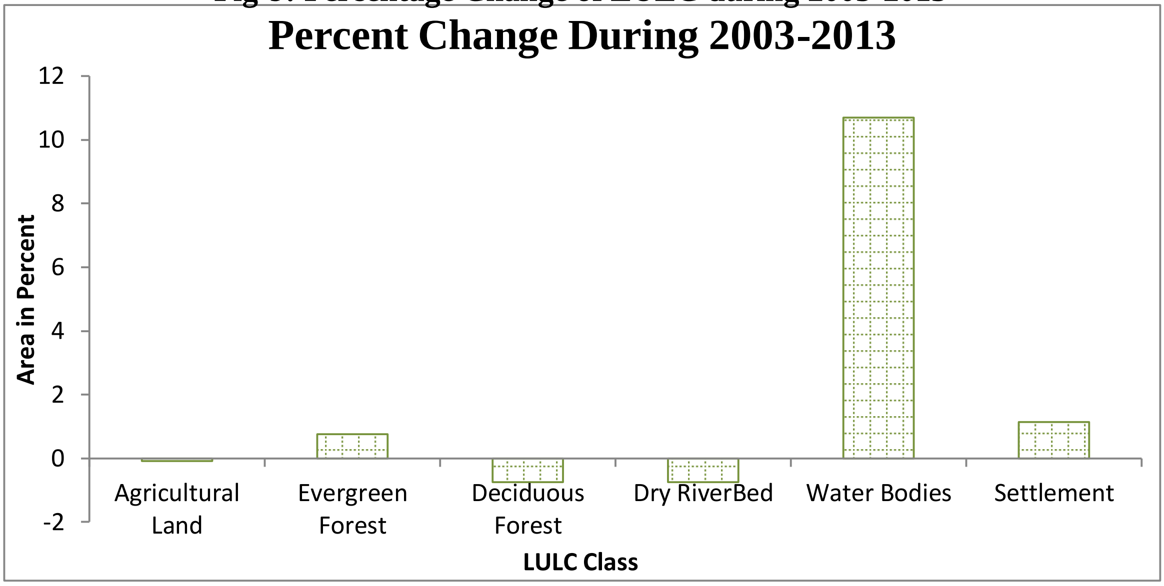
Fig-8:



Percentage Change of LULC during 1993-2003

In the above table it shows that area under Evergreen Forest in 1993 was about 580.79 km^2. In 2003 it is showing 374.38 km^2 and In 2013 it increased to 659.62 km^2.The percentage of Evergreen Forest in 1993-2003 is reducing 0.35 % in the reference of total area. But in 2003-13 it increase 0.76 % of the total area.

Fig-9: Percentage Change of LULC during 2003-2013



The table indicates that area under Deciduous Forest in 1993 was about 1037.52 km^2. In 2003 it is showing 777.02 km^2 and In 2013 it reduced to 201.05 km^2.The percentage of Deciduous Forest in 1993-2003 is reducing 0.25 % in the reference of total area. In 2003-13 it also decreases 0.76 % of the total area.

The above table shows area under Dry River Bed in 1993 was about 61.89 km^2. In 2003 it is showing 134.95 km^2 and in 2013 it reduced to 33.18 km^2. The percentage of Dry River Bed in 1993-2003 is increased to 1.18 % in the reference of total area. In 2003-13, it decreases 0.75 % of the total area.

In the above table it shows that area under water bodies in 1993 was about 112.09 km^2. In 2003 it is showing 24.85 km^2 and in 2013 it increased to 292.61 km^2.The percentage area of water bodies in 1993-2003 is reducing 0.77 % in the reference of total area. But In 2003-13, it increase 10.7 % of the total area.

The table indicates that area under settlement in 1993 was about 78.02 km^2. In 2003 it is showing 140 km^2 and in 2013 it increased to 301.02 km^2. The percentage of Settlement Area in 1993-2003 is increasing 3.79 % in the reference of total area. In 2003-13 it also increases 1.84 % of the total area.

8. Conclusion and Suggestions:

The study of landuse landcover depicts that there are so many spatio-temporal changes are found in the change detection of this study region. Landuse is directly link with human beings. Every change in landuse effects human beings and environment around us. The study reflects that after becoming Uttrakhand new state apart from Uttar Pradesh, Dehradun is the only becoming urban area in state. So our suggestions is that other area of Uttrakhand should also be developed. We should be concentrate on sustainable development for that we should use land in proper. It is therefore suggested that encouragement should be given to people towards the other area of state through the provision and forces of attraction that are available in Dehradun tehsil.

During study period water bodies area tremendously increase hence government should use it for irrigation and hydrological project. In Dehradun institutional and residential space are increasing due to its capital level establishment therefore government should establish institution in other area. In this study 2003-2013 observations are very alarming because dry riverbed area is reducing which may cause of any hazardous disaster. Dry river bed area encroaching by slum dwellers and land developers. Forest area is reducing continue so Government and People should emphasis on the thing that forest should be increase therefore it is suggested that policies aimed at supporting forest products prices provide an incentive to keep forests. It will also a source of revenue for government.

Land is main natural resource for life support system. The land and landcover changes are equally important elements of the larger problem of global and regional environmental changes. Remote sensing technology and satellite data are very helpful for the detection of changes in landuse \landcover between 1993-2013.This Project work demonstrates the ability of GIS and Remote Sensing in capturing spatial-temporal data. Attempt was made to capture as accurate as possible six land use land cover classes as they change through time. Except for the inability to accurately map out water body in 1972 due to the aforementioned limitation, the six classes were distinctly produced for each study year but with more emphasis on built-up land and forest land as it is a combination of anthropogenic activities due to it affects the other classes. However, the result of the work shows a rapid growth in built-up land between 1993 and 2013. The increase in the built up area is because of increasing demand for institutional and residential space for capital level establishments. Beside urban population of the valley has grown and is causing immense pressure for Built up area. The water dry River Bed (seasonal streams) has shown little change area due to encroachment slum dwellers and land developers. The decline in the area of the deciduous forest is due its conversion to farm land and builtup area. It was also observed that change by 2020 may likely follow the trend in 1993/2013 if all things being equal.

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