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URBAN EXPANSION AND ITS IMPACT ON GREEN SPACES OF DEHRADUN CITY, UTTARAKHAND, INDIA

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Abstract

Urbanization is on increase because of heavy population pressure, industrialization, and better job opportunities in plane areas compared to Himalayan terrain. The urbanization has also added hypertension because of very fast life and lack of recreational opportunities within easily accessible distances. Deforestation is the permanent destruction of indigenous forests and woodlands. The term does not include the removal of industrial forests such as plantations of gums or pines. Deforestation is clearing of forests on a massive scale, often resulting in damage to the quality of the land. Urbanization is one of the major causes of the deforestation. Urban green space planning is an important component of urban ecosystems; provide many environmental and social services that contribute quality of life in the cities.The green spaces are said to be the lungs of the urban ecosystem. The process of urbanization led to natural landscape change. In the process tree cover, green spaces and wetlands were recklessly converted into built-up areas in the past and the process is still going on. Due to availability of required infrastructure, Dehradun was named interim capital of the nascent Himalayan state of Uttarakhand in 2000. Other regions of Uttarakhand is also experiencing rapid urbanization. The hill districts adjoining Dehradun district have witnessed a four-fold increase in the number of towns between 1901 and 2001. The population of Dehradun registered increase of 41.08 % between1961-1971, 32.84 % between 1971-81, 25.39 % between 1981-91 and during 1991-2001 it increased by 52.45 %. The temporal imaging of remote sensing data and socio-economic data of 1982 will be used for overall spatial monitoring.

Keywords: Urbanization, Deforestation, Remote Sensing, Temporal Imaging

Introduction

Remote Sensing and GIS tools have become important in management of urban environment. A number of studies have demonstrated this (Rashid and Sokhi, 1995; Sokhi, 2001; Subudhi, 2001). Remote sensing has been recognized worldwide as an effective technology for the monitoring and mapping the urban growth and environmental change. The main advantage of satellite remote sensing is its repetitive and synoptic coverage. That is very much useful for the study of urban area. It helps to create information based on land use, land cover distribution, urban change detection, monitoring urban growth and urban environmental impact assessment. Satellite images enable us to better understand some of the intrinsic components of urban ecosystems and the interactions within whole urban environment. Remote sensing technology can be put to best use if it is incorporated with GIS. It can assist in the automation of interpretation, change detection, map compilation and map revision functions.

Remote Sensing is widely regarded to be useful to get a spatial overview. Qualitative information is usually only indirectly related to measurable parameters such as vegetation indices. Any environmentally compatible urban planning must begin with a comprehensive look on the use of land. So, the planners need detailed information about the extent and spatial distribution of various urban land uses, housing characteristics, population growth patterns, urban sprawl, existing condition of infrastructure, utilities etc. For planning of these utilities in a better way, planner needs the total information in a map and information related to these aspects for perspective planning and management. GIS helps in collating spatial and statistical data that can be used in inventorying the environment, observation of change and constituent processes and prediction based on current practices and management plans. The need of the hour is to create an information system of urban development to retrieve, integrate and create various planning scenarios for decision making. The remote sensing (RS) and geographic information system (GIS) technology is appropriate for creating such type of information system

This case study shall provide an insight into the spatial changes that have taken place over time with respect to urban green space against the increasing urban sprawl i.e. the trends in urban expansion. It is expected to give an idea on municipal wards that have crossed the critical values of built-up green space ratio and effort will be made to see how RS and GIS can assist in urban green space planning for effective conservation and management strategies. The study will also try to explore role of RS and GIS in green space planning and the causes and consequences of changing green space cover in Dehradun urban areas.

Vegetation is an important feature of any landscape. Natural vegetation is a resource of great value to humankind unlike other resources it can be kept perpetually productive. It plays extremely important role in urban ecosystem, influencing many sub-systems linked with water, soil, air etc. However, increasing population and the rapid urbanization processes are converting more and more green spaces into impermeable concrete surfaces. Deforestation is a world-wide phenomenon mainly due to the increasing demand of other land use categories. Human activities derelict the green spaces and put urban area in a deprived state of "green services". Consequently, the urban areas experience water scarcity, air and water pollution, warming, apart from many other problems. A number of studies suggest that the development of green areas improves the urban environmental conditions (Meenatchi Sundaram, 2002).

Urban forests or urban greens are one of such resources, which are responsible for various environmental, social and educational benefits to the human society. The concept of green spaces in environmental and conservation planning of urban areas is relatively new. This term has been preceded by the term Urban Forestry. The urban forestry refers to all activities involving planning, creation, conservation and management of trees, grasses and other forms of vegetation within the urban built-up land or on the land in the immediate surrounds of such urban centers (Tewari, 1995). Urban forestry is about managing the urban green spaces as an ecological entity.

There have been attempts to increase the green spaces in the urban areas with the aim of improving the environmental conditions through urban forestry, silviculture, afforestation, social forestry, horticulture etc. It is observed that such activities help in improving green spaces but attempts on the integrated urban green space planning are missing. Such attempts would deliver functionally more effective and aesthetically pleasing environment. In order to plan and implement such programmes a number of parameters such as ownership, soil types, water availability, topography, micro and macro climatic conditions, size and nature of the city etc. need to be considered (Meenatchi Sundaram, 2002).

Importance of green spaces

Trees, grasses and other forms of vegetation that grow in urban and suburban settings on public and private lands constitute urban green spaces. The green spaces within the urban agglomerations affect the city's inhabitants and their spatial extent. These green spaces within and in the immediate surroundings of built-up land provide benefits that enrich the quality of life. They help conserve biodiversity and play a key role in improving the livability of our towns and cities. Urban green spaces are not only important component in housing areas, but they also have positive impact in business, leisure, retail and other commercial land uses (www.ces.iisc.ernet.in).

Urban green spaces emphasize the diversity of urban areas by reflecting different communities they serve and meeting their varying needs. Urban green spaces moderate the impact of human activities by absorbing pollutants and releasing oxygen. They provide clean air, and water to improve the urban climate and maintain the urban ecosystem equilibrium. The value of tree in urban forest is not for wood products, but for ecological, social and public health. (Levent et al., 2004).

Urbanization is on increase because of heavy population pressure, industrialization, and better job opportunities in urban areas compared to rural areas. This has brought in its wake a number of undesirable environmental impacts such as air pollution, water pollution, noise pollution, soil pollution etc. The urbanization has also added hypertension because of very fast life and lack of recreational opportunities within easily accessible distances (Mahajan, 1981). In this context, green spaces can play a vital role. Green spaces have significant impact on city's environment to which they provide a host of climate buffering services. Removing green cover short circuits the natural cycles and releases the energy used to power these cycles, thereby negatively affecting the environment. Without green spaces, cities become hotter and dryer, the air pollution increases, the wind is stronger, dust is more damaging, energy consumption increases and people are less comfortable and unhealthy. Urban green space planning is an opportunity to bring principles of vegetation ecology into the city, more than just planting individual trees, grasses or other vegetation (Singh, 2002).

Urbanization and urban sprawl

Throughout the world, particularly in developing countries, significant urban expansions have been recorded during last five decades. Urbanization has been observed in terms of spatial expansions due to population increase. Urbanisation is a universal process, resulting in accelerating the growth of urban centres. This process occurs due to economic development opportunities linked to big cities and other urban centres (Rawat, 2000). Urban sprawl is also referred as irresponsible, and often poorly planned, development that destroys green space, increases traffic, contributes to air pollution, leads to congestion with crowding and does not contribute significantly to revenue. Increasingly, the impact of population growth on urban sprawl has become a topic of discussion and debate. Population growth is a key driver of urban sprawl. The rapid growth of urbanization combined with the explosive population growth has made urban areas and their surroundings, the areas of dynamic change with increasing demand on urban land services. As the limited land resources in the city get used, the pressure mounts on the surrounding environs of fertile lands causing faster rate of land conversion from rural to urban. This results in uncontrolled spatial expansion of the city as well as problem of providing basic public services and facilities (www.ces.iisc.ernet.in).

This rapid growth rates of many cities, combined with their huge population base, are pushing the cities to unprecedented sizes, These processes have modified the natural features of a city and its surroundings (geography, topography and climate) in three main ways: firstly by conversion of land to urban uses, secondly by extraction and depletion of natural resources, and thirdly by disposal of wastes in the urban area (Daly and Cobb, 1989). As the cities expand, through conurbation process, prime agricultural land, wetlands and forests (in and around the city) are transformed into land for housing, roads, industry, etc. The increasing numbers of studies have come to conclusion that the fundamental capacity of the natural capital to support the humanity on this earth itself reached the threshold because of the rapid conversion of the biophysical elements in the urbanization process (Janson et al., 1994).

The studies on urban development patterns and their impacts on ecosystem dynamics should focus on how patterns of urban development alter ecological conditions (e.g. species composition) through physical changes (e.g. patch structure) on an urban to rural gradient. The use of gradient analysis for studying urban-to-rural gradient of land-use intensity to explain the continuum of green space change from city centre to non-urban areas might help to explore ecosystem effects of different urban configurations, but current applications do not differentiate among alternative urban patterns (Alberti et al., 1999). Most studies of the impacts of urbanization do not differentiate among various urban patterns. Planners need this ecological knowledge, so that their decisions can minimize impacts of inevitable urban growth. Spatial pattern is one (of very few) such environmental variable, which can be controlled to some extent by land use planning. Design strategies for reducing urban ecological impacts will remain poorly understood and ineffective if spatial pattern are not addressed in ecological studies of urban areas.

Study area

The city of Dehradun is situated in the south central part of Dehradun district. Dehradun city lies at 30° 19’ North latitude and 78° 20’ East longitude. The area under the administrative control of the Dehradun Municipal Board is 38.04 sq. km. The Dehradun municipal board was divided into 34 wards according to the 1991 Census. Two intermittent streams viz. Rispana River and Bindal river, on the east and west respectively marks the physical limits of Dehradun Corporation. The city is located at an altitude of 640 m above MSL. The lowest altitude is 600 m in the southern part and the highest altitude is 1000 m in the northern part. The site where the city is located slopes gently from north to south and south west and is heavily dissected by a number of seasonal streams and nallas (Rajeshwari, 2006).

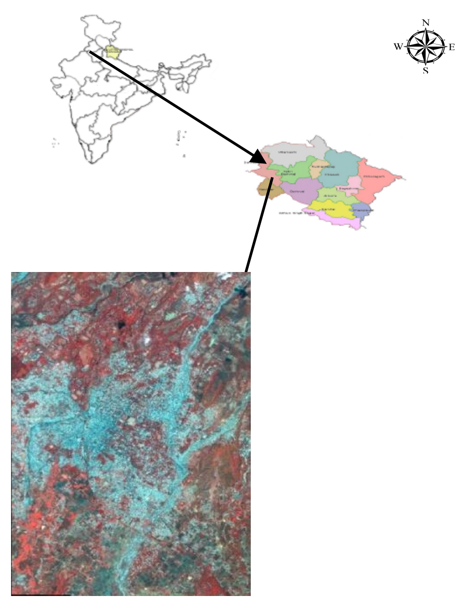
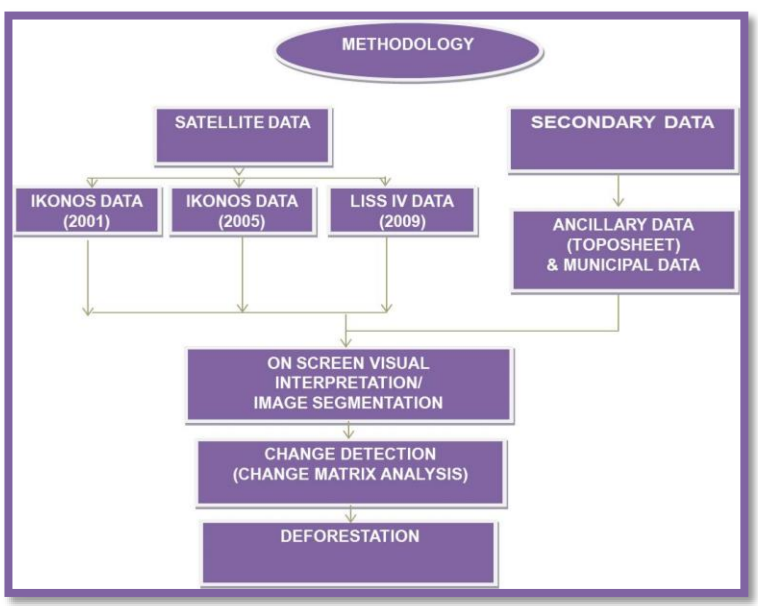


Fig 1: Study Area of Dehradun City

The drainage of the city is borne by the rivers Bindal and Rispana. In summer, the maximum temperature is 36° C, and the minimum temperature is 16° C whereas in winter it varies from 23° C and 5° C respectively. In summer the heat is often so intense that the temperature on a particular day may rise up to over 42° C. January is the coldest month and the minimum temperature occasionally falls down to a degree below the freezing point. Inversion of temperature is a conspicuous phenomenon, due to the location of the city in the valley. The average annual rainfall of Dehradun is 2183.5 mm. About 87 per cent of the rainfall is through monsoons and is received in the months from June to September. July and August are the months of heaviest rainfall. The relative humidity is the highest during the monsoons, normally exceeding 70 per cent on an average. The driest part of the year is usually during the summer season, when the relative humidity becomes less than 45 per cent.

Method and methodology

This work has been done with the help GIS and image processing software viz; Arc GIS 10.1 and ERDAS Imagine 14. Satellite data has been procured from NRSC, Hyderabad. Survey of India toposheet No. 53 J/3 and 53 J/4 on 1:50,000 scale covering urban sprawl of Dehradun city of the available years will form the basis of initial delimitation of the study area. Guide Map of Dehradun City of 1982 available on 1:20,000 scale will also be used for better scale coverage. Satellite imageries have been geo-corrected by ground control points. Onscreen visual interpretation technique has been followed for classification. Urban development monitoring and mapping are necessary to make effective policy for development of unplanned areas. But monitoring and mapping requires reliable data at regular intervals. Momentum of urban growth has out-paced the traditional techniques of surveying and mapping.



An important component of the methodology for the present study will be the use of Remote Sensing (RS) and Geographical Information System (GIS) techniques. As is well known, these are important tools for change detection that can help in more tangible insights into underlying processes involving land cover and land use changes. These are useful in many applications such as land use changes, habitat fragmentation, rate of deforestation, urban sprawl, and other cumulative changes through spatial and temporal analysis techniques (Ram Chandra and Kumar, 2004). Visual interpretation is one of the most commonly used techniques for mapping and analysis of land use/land cover.

The spatial data on land ownership, water availability etc. data will be taken from respective agencies and integrated in GIS domain using overlay analysis. The maps will be compared with the latest information to understand change detection in green space and built-up areas by using remote sensing, GIS, Global Positioning System (GPS) and geospatial data interpretation techniques. Ground visits would be undertaken for first-hand information collection. All data will be visually interpreted. The municipal ward map shall be overlaid over these temporal layers and integrated with ward-wise temporal population data to analyze the changes in green space/ built-up area. Primary data will be collected through the responses of local people and NGO's using questionnaire, inventories etc.

Results

The IKONOS imagery (2000) has been classified in GIS domain. The land use/land cover map has been given below. The statistics are given in table and graph. In 2000 vegetation area is 24.81%, impervious class is 32.36%, follow land is 29.82%, agricultural land is 01.01%.

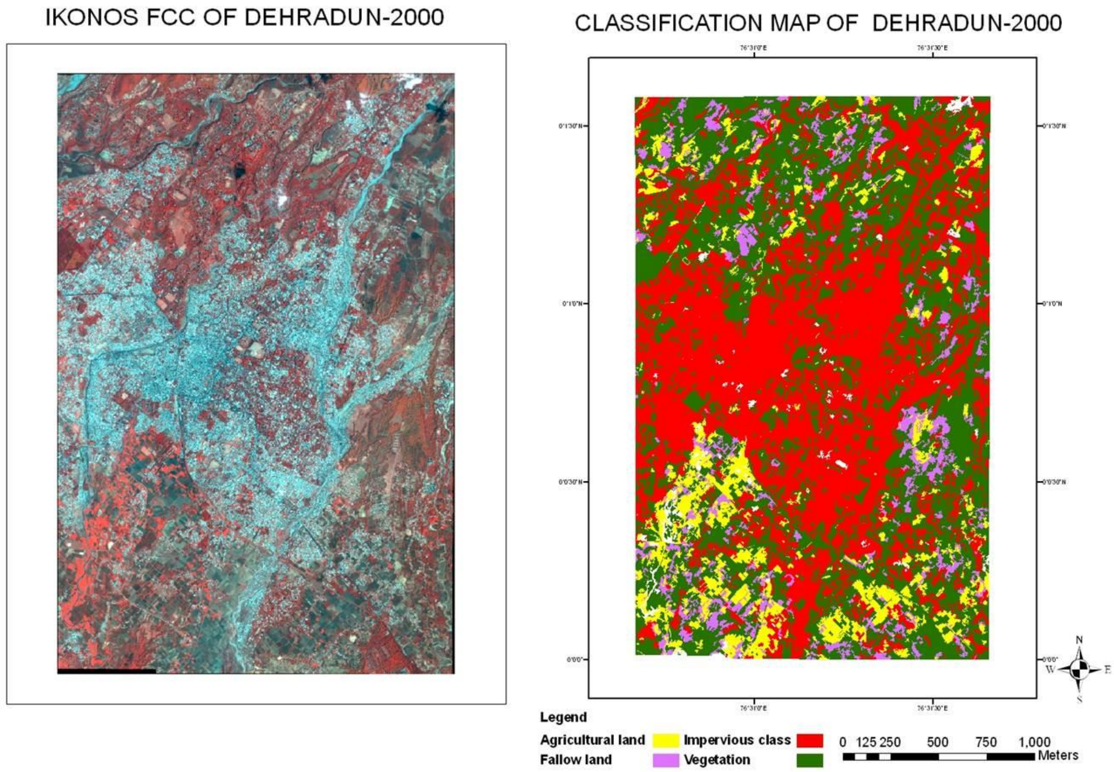


Fig 2.1: FCC and Classification map of Dehradun in year 2000

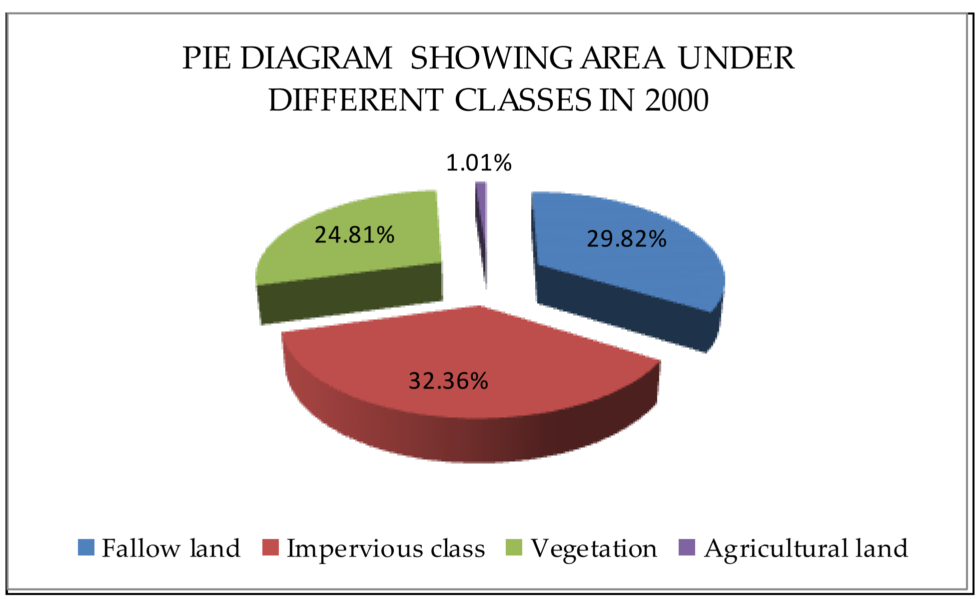


Fig 2.2: Pie Diagram of different classes in year 2000

Table1.1: Showing statistics of different classes in year 2000

Year 2000		
Class	**Area (ha)**	**Area (km^2)**
Fallow land	3007.18	30.07
Impervious class	3263.95	32.64
Vegetation	2502.36	25.02
Agricultural land	101.66	1.02
	8875.15	**88.75**

Table 1.2: Showing statistics of different classes in year 2000

CLASS		**Area (ha.)**	**Area (km^2)**
Fallow land	Fallow land	987.23	9.85
Fallow land	Impervious class	1091.87	10.90
Fallow land	Vegetation	829.13	8.27
Fallow land	Agricultural land	96.00	0.96
Impervious class	Fallow land	898.12	8.96
Impervious class	Impervious class	1970.16	19.66
Impervious class	Vegetation	365.11	3.64
Impervious class	Agricultural land	28.01	0.28
Vegetation	Fallow land	328.36	3.28
Vegetation	Impervious class	1091.28	10.89
Vegetation	Vegetation	934.25	9.32
Vegetation	Agricultural land	97.12	0.97
Agricultural land	Fallow land	31.23	0.31
Agricultural land	Impervious class	15.53	0.16
Agricultural land	Vegetation	32.81	0.33
Agricultural land	Agricultural land	22.01	0.22
			88.00

The IKONOS imagery (2005) has been classified in GIS domain. The land use/land cover map has been given below. The statistics are given in table and graph. In 2005 vegetation area is 20.04%, impervious class is 40.22%, follow land is 24.22%, agricultural land is 03.52%.

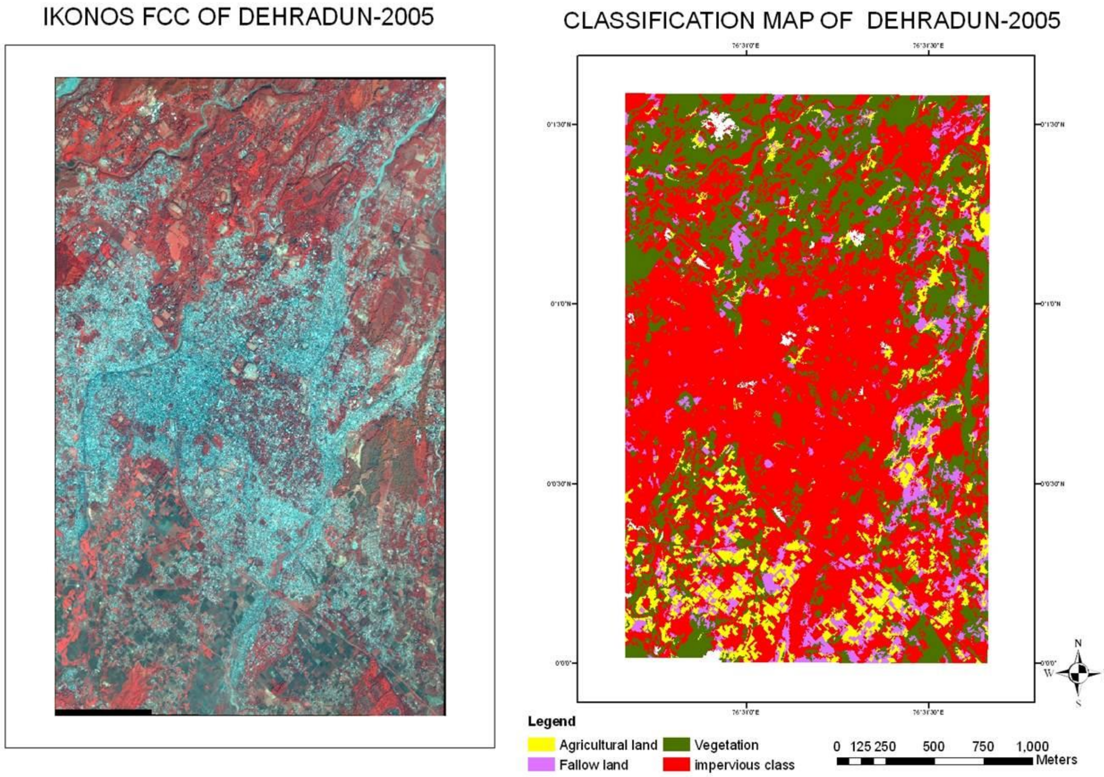


Fig 3.1: FCC and Classification map of Dehradun in year 2005

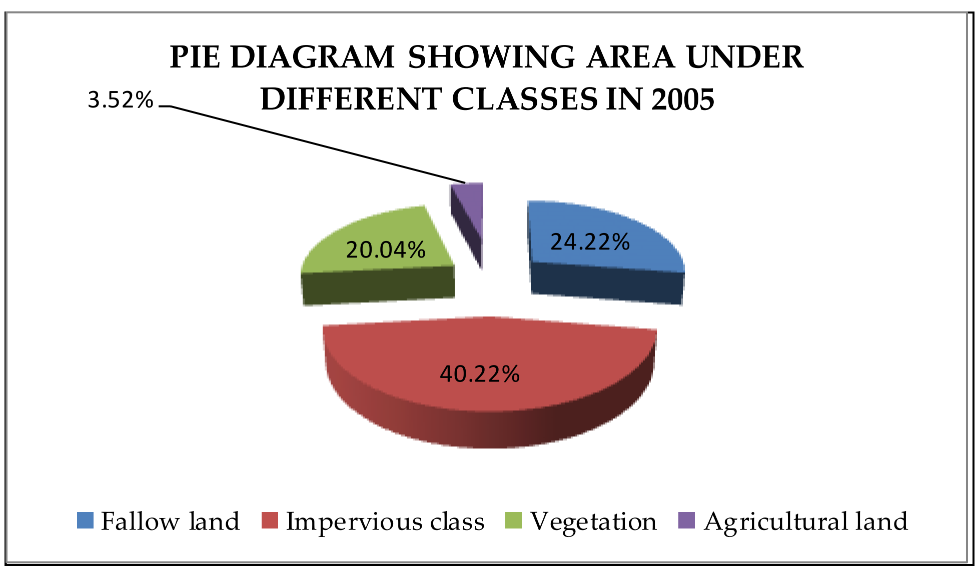


Fig 3.2: Pie Diagram of different classes in year 2005

Table 2.1: Showing statistics of different classes in year 2005

2005		
Class	**Area (ha)**	**Area (km^2)**
Fallow land	2415.63	24.16
Impervious class	4021.98	40.22
Vegetation	2051.36	20.51
Agricultural land	351.25	3.51
	8840.22	**88.40**

Table 2.2: Showing statistics of different classes in year 2005

Class		**Area (ha.)**	**Area (km^2)**
Fallow land	Fallow land	972.69	9.49
Fallow land	Impervious class	472.06	4.61
Fallow land	Vegetation	308.40	3.01
Fallow land	Agricultural land	558.86	5.45
Impervious class	Fallow land	815.29	7.96
Impervious class	Impervious class	1767.01	17.24
Impervious class	Vegetation	365.25	3.56
Impervious class	Agricultural land	101.92	0.99
Vegetation	Fallow land	235.66	2.30
Vegetation	Impervious class	1057.25	10.32
Vegetation	Vegetation	1233.71	12.04
Vegetation	Agricultural land	519.60	5.07
Agricultural land	Fallow land	48.48	0.47
Agricultural land	Impervious class	23.43	0.23
Agricultural land	Vegetation	460.34	4.49
Agricultural land	Agricultural land	77.26	0.75
			88.00

The LISS IV imagery (2009) has been classified in GIS domain. The land use/land cover map has been given below. The statistics are given in table and graph. In 2009 vegetation area is 15.25%, impervious class is 49.04%, follow land is 20.49%, agricultural land is 03.24%.

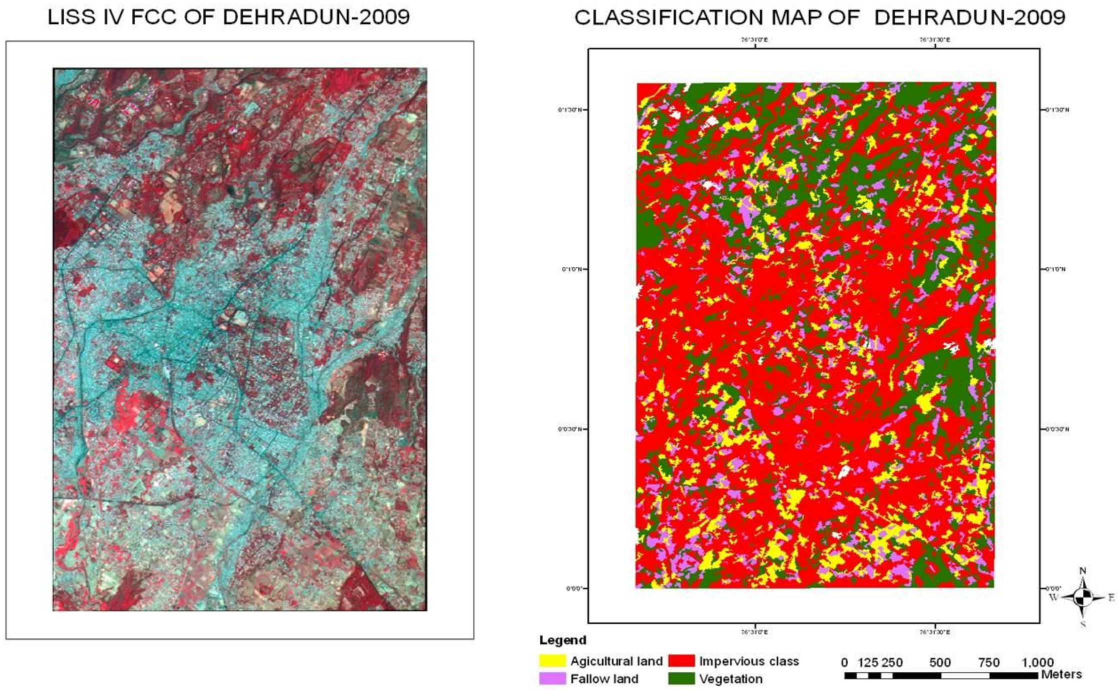


Fig 4.1: FCC and Classification map of Dehradun in year 2009

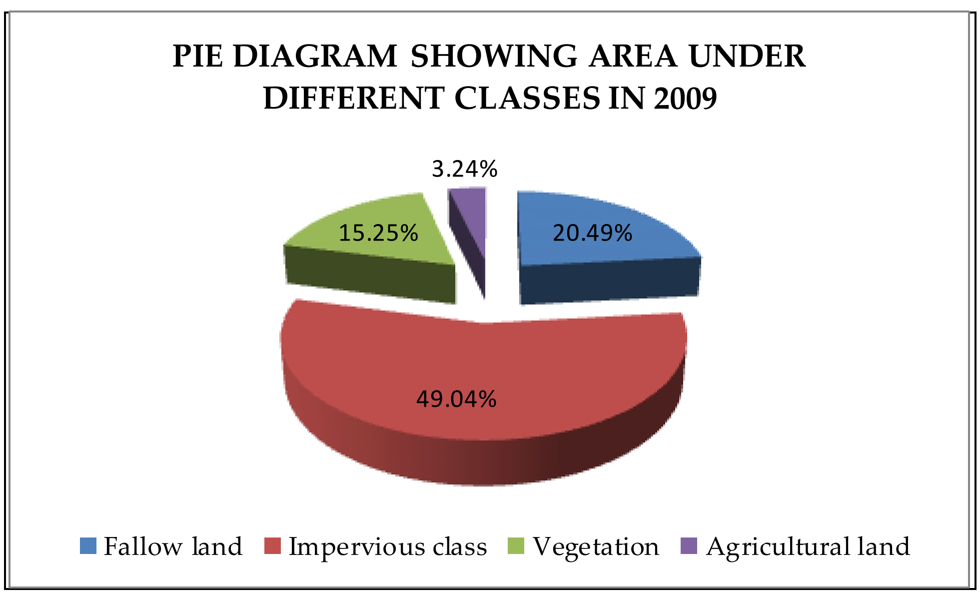


Fig 4.2: Pie Diagram of different classes in year 2009

Table 3.1: Showing statistics of different classes in year 2009

Year 2009		
Class	**Area (ha)**	**Area (km^2)**
Fallow land	2079.47	20.79
Impervious class	4901.96	49.02
Vegetation	1547.36	15.47
Agricultural land	324.56	3.25
	8853.35	**88.53**

Table 3.2: Showing statistics of different classes in year 2009

Class		**Area (ha)**	**Area (km^2)**
Fallow land	Fallow land	725.2928	7.15
Fallow land	Impervious class	786.3456	7.75
Fallow land	Vegetation	680.544	6.71
Fallow land	Agricultural land	811.448	8.01
Impervious class	Fallow land	352.15	3.47
Impervious class	Impervious class	350.0032	3.64
Impervious class	Vegetation	398.8224	3.93
Impervious class	Agricultural land	26.256	0.25
Vegetation	Fallow land	330.8512	3.26
Vegetation	Impervious class	2536.23	25.02
Vegetation	Vegetation	464.4	4.48
Vegetation	Agricultural land	431.69	4.25
Agricultural land	Fallow land	8.3136	0.08
Agricultural land	Impervious class	29.7344	0.29
Agricultural land	Vegetation	948.48	9.35
Agricultural land	Agricultural land	37.352	0.36
			88.00

Area statistics on Yearly basis

Table 4.1: Showing statistics of different classes in yearly basis 2000, 2005, 2009

Class	Area (km^2)		
	2000	**2005**	**2009**
Fallow land	29.82	24.22	20.49
Impervious class	32.36	40.22	49.02
Vegetation	24.81	20.04	15.25
Agricultural land	1.01	3.52	3.24
Total	**88.00**	**88.00**	**88.00**

Land use/land cover change during 2000-2009

Major changes have occurred in vegetation class which has been changed into impervious class during 2000 to 2009. Agriculture lands lightly increases during 2000 to 2009.

Table 4.2: Showing statistics of different classes on Yearly basis between 2000 and 2005

2000	2005	Area (km^2)
Fallow land	Impervious class	10.9
Fallow land	Vegetation	8.27
Fallow land	Agricultural land	0.96
Impervious class	Fallow land	8.96
Impervious class	Vegetation	3.64
Impervious class	Agricultural land	0.28
Vegetation	Fallow land	3.28
Vegetation	Impervious class	10.89
Vegetation	Agricultural land	0.97
Agricultural land	Fallow land	0.31
Agricultural land	Impervious class	0.16
Agricultural land	Vegetation	0.33
		48.95

Table 4.3: Showing statistics of different classes on Yearly basis between 2005 and 2009

2005	2009	Area (km^2)
Fallow land	Impervious class	4.61
Fallow land	Vegetation	3.01
Fallow land	Agricultural land	5.45
Impervious class	Fallow land	7.96
Impervious class	Vegetation	0.96
Impervious class	Agricultural land	4.49
Vegetation	Fallow land	2.30
Vegetation	Impervious class	10.32
Vegetation	Agricultural land	5.67
Agricultural land	Fallow land	0.47
Agricultural land	Impervious class	0.23
Agricultural land	Vegetation	3.56
		49.03

Table 4.3: Showing statistics of different classes on Yearly basis between 2000 and 2009

2000	2009	Area (km^2)
Fallow land	Impervious class	7.75
Fallow land	Vegetation	6.71
Fallow land	Agricultural land	8.01
Impervious class	Fallow land	3.47
Impervious class	Vegetation	3.93
Impervious class	Agricultural land	0.29
Vegetation	Fallow land	3.26
Vegetation	Impervious class	25.02
Vegetation	Agricultural land	4.25
Agricultural land	Fallow land	0.08
Agricultural land	Impervious class	9.35
Agricultural land	Vegetation	0.35
		72.47

Conclusion

As the urban area of Dehradun is growing at a fast rate, so up-to-date information on land and people is needed to monitor and manage the quality of urban environmental. The paper shows that Dehradun has experienced environmental deterioration in one decade especially in vegetative areas due to unplanned urban expansion. Remote sensing data and GIS technique is very useful for extraction of information like built-up areas, open green space, urban land use mapping that are important attribute for assessing the urban environmental quality for a big urban agglomeration. There should be a larger role of public for planning and designing the urban land use pattern and other associated activities in order to have a healthy urban environment for the good quality of life.

Utilization of remotely-sensed imagery for monitoring urban sprawl and changes in the distribution and fragmentation of green space can aid in development of growth plans for communities. Remotely-sensed data, used in conjunction with other tools currently available to land use planners will permit a more comprehensive approach to managing urban growth and green space. These data also may serve to identify areas of intrinsic value to be reserved from development and establish management regimes such as development boundaries that limit the extent of urban sprawl and subsequent loss and fragmentation of green space.

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