

Land Use Land Changes in Land Area of Dehradun City, Uttarakhand, India: Analysis Using Digital Maps and Remote Sensing Techniques

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Abstract— After 2000 revolutionary changes have been seen in Dehradun city that time Dehradun formed the capital of Uttarakhand state. A sizable amount of immigration from rural areas and nearby adjoining states such as Uttar Pradesh, Haryana, Punjab, and Delhi has also resulted in the gradual expansion of Dehradun city. Earlier Dehradun was famous for its Litchi fruit & good quality rice grains. Almost up to the year 1990 exporting litchi and rice to all the parts of India and now the condition of the city is that even the people of Dehradun not get sufficient supply. It is due to decreasing agriculture land, the cultivation is affected. The aim of this paper is to recognize changes in built-up areas and open areas of Dehradun city using the geographical information system to analyze land use changes of the period 1998, 2008 & 2017. To achieve the objectives three digital images The satellite image downloaded from earth explorer USGS of the year 1998, 2008 & 2017 has been taken to calculate the areas of three main categories they are built-up, vegetation & non-built-up area. The areas changes in three years gap 1998-2008, 2008-2017 and 1998-2017 have been calculated. The downloaded images converted into shape files of the study area as per Dehradun municipal map 2011 using Arc GIS10.3 and last ERDAS for classification of buildup and open areas.

The researcher found a lot of changes in these categories. One category decreases with the time where other increases. There is a lot of new development occurred during the two later periods i.e. 1998-2008 & 2008-2017. In the period 1998-2008 vegetation area decreases 15.31% from overall vegetation where built-up 8.89% increases and 6.41% non-built-up area increases. (Refer to Table 5.2 graph 5.5). In the period 1998-2017 the 38.36% vegetation decreases. Where built area increases prominently 32.45% from the year 1998 and 5.91 % increase in non-built-up area. The result of the study shows the open area is decreased and built up area is increased in the last 20 years

Keywords— Revolutionary changes, immigration, expansion, earth explorer, development

I. INTRODUCTION

The post-Independence period of India has witnessed a radical transformation of the urban scene. Particularly, during this period, the million of cities start to grow quickly; in several cities the population was increased by more than fifty per cent in a decade period. This fast growth of cities is not possible to provide within the existing boundaries of the cities.

Study area Dehradun (30^o 32'N latitudes and 78^o 04'E longitudes), a class I (having > 100,000 population) city of medium size located in the fertile tract of near the Himalayan foothills in the NW part of Uttarakhand in North India was carefully chosen as the study area. (Refer to fig 1) Dehradun

is a well-known tourist spot. It is situated at 60 km from Haridwar. It is Capital of Uttarakhand since Nov 9, 2000, and located in Garhwal region. Uttarakhand is divided into two regions and 13 districts. Regions are Kumaon and Garhwal. Dehradun is one of the districts. The city further distributed into sub-divisions and blocks. City covers an area 58.46 Sq. km. nearly half of the land is used for residential purposes and other for commercial areas, educational institutes, and research institutes, industrial areas, transport nagar, secret ate, and defense related areas, recreational and open spaces. As per the municipality, this city is further divided into 60 wards as per the municipality 2011 map. Population of Dehradun was 574840 referred Government census department of India (2011). In 1980, Dehradun called the 'city with green hedges and grey hair'

Or we can say A green, tranquil, cool, clean, sleepy town surrounded by rivers and forests with no apparent population pressure. After 2000 when Dehradun become a capital of Uttarakhand the people immigrated from Haryana, Uttar Pradesh, and Garhwali for jobs and better living facilities. As the Population increases it's just obvious to accommodate the population demand of housing is also increases. To fulfill the demand of shelter the vegetation and barren land is converting into built up areas. And concrete jungle has been seen ever where. Overcrowding and traffic is the major problem faces city today.

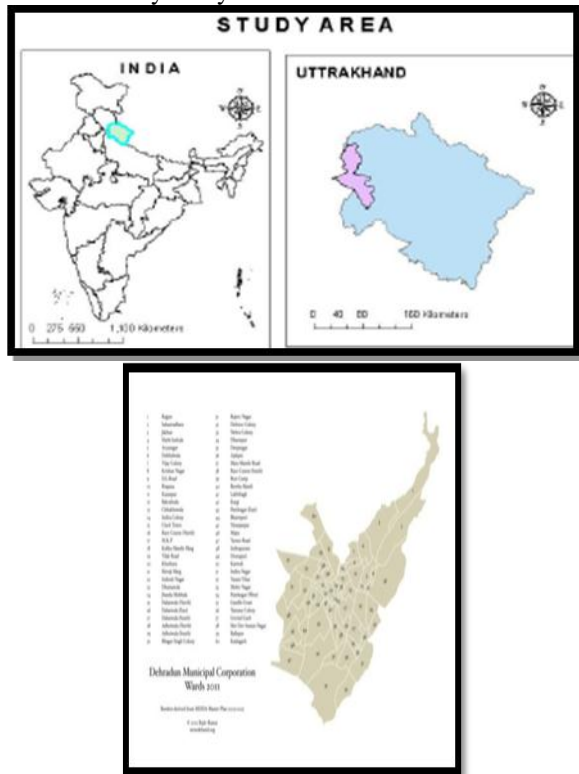


Fig 1: Study Area of Dehradun

With the rising Population, to accommodate the people, the demand for housing is increasing continually. To fulfill the increasing requirement of housing, cutting of trees is increasing. Green lands are converting to the buildup areas. To fulfill the increasing housing demands builders are making more mid-rise housing apartment. The development leads to the disappearance or decline of vegetation land to build up uses. As the city built up areas expand, vegetation is pushed outwards and most of the cultivated area is using for residential purposes. These newly developed residential areas have hardly any infrastructure services. One sees the illogicality overcrowding and vast amount of partially developed land. The natural landscape close to the city is destroyed. Today mostly in all the cities of India the need to provide shelter to the increasing population is making the city expand along its boundaries, along the roads submerge

many colonies, villages and small towns along its path. around the Dehradun, Regions have changed to build apartments, universities, schools & colleges, shopping complexes, hotels, restaurants, and factories without keeping in mind harmony with the neighboring environment.

Bindal river and Rispana River are Dehradun city Center Rivers (refer fig 2). The present status of the rivers is that they converted into Slum. These rivers are highly polluted with the city solid wastes refer to fig 3 and fig 4. The mud and waste collected in these two rivers finally go into the Ganga River.



Fig 2 : Rispana river 20 years ago



Fig 3: Rispana river Now



Fig 4 : Bindal river Now

Earlier the Dehradun city was full of vegetation and greenery. It's one of the famous tourist places. (Fig 5). Various forms of urban development are taking shape on the 'green fields' which is within the commuting range of the city. The city congestion and crowding is deteriorating city environment (fig 6)



Fig 5 : View of Dehradun 20 years ago



Fig 6 : View of present Dehradun (road congested)

In the present study, a Geographical Information System (GIS) is used to study the changes in the land areas with the urban growth. This is used to forecast the future growth and requirement of the land accordingly.

II. OBJECTIVES

The main objective is to generate the changes in land use / land cover as per the 2011 municipal map of Dehradun.

The study has been done to detect the changes of three particular years i.e. 1998, 2007, 2017

Study of the growth of built-up areas as compared to vegetation areas & non-built up areas. Of last 19 years.

III. METHODOLOGY

To prepare LULC maps and detect changes, the following three broad categories were considered:

- 1) Built-up Area
- 2) Non-Built up Areas and
- 3) Vegetation Area

Accuracy assessments were performed on the three classified LULC maps to measure the degree of fidelity to ground reality. Finally, changes in LULC during the time periods of the study area were detected along with interclass changes. Refer fig 7 for detailed methodology layout.

IV. DATA PROCESS AND DATA USE

LANDSAT-5 "TM" and LANDSAT-8 "OLI" Sensors are used. The LANDSAT-5 imagery is of October 1998 and October 2008, and LANDSAT-8 is of October 2017 with 30 m & 15 m multispectral bands and the panchromatic band are respectively used. The WGS84" and UTM zone is used at 44 North. ERDAS IMAGINE 2014 is used. In the context of accuracy assessment, the image is classified pixels to the total number of a particular category.

A. Assessing LU/LC of Year 1998, 2008 & 2017

Based on collected images and analysis in 1998, vegetation class founded the largest category with coverage of 27.38 Sq.km, i.e. 47.78% of the total study area. The Built up area with 06.72 hectares (11.72 %) and agricultural land and open fields, 23.21 sq. km. (40.50 %) occupied Second and third position respectively (Refer to Figure 8, Table 5.1 & Graph 5.2).

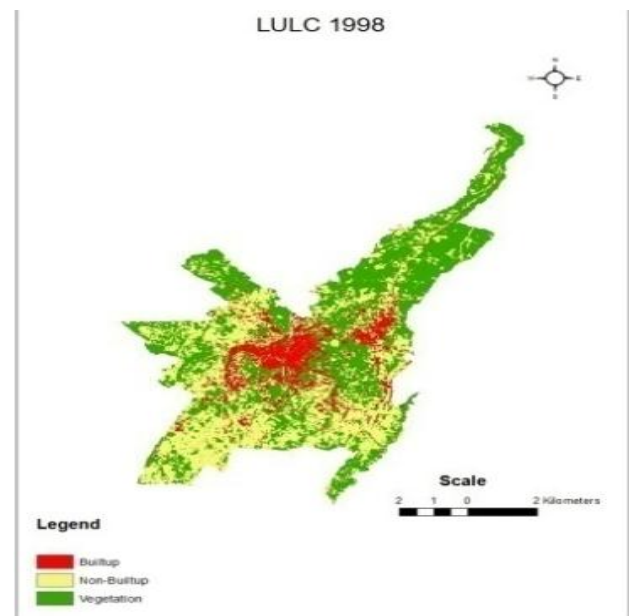


Fig 8 : Land use area classification in 1998 of Dehradun

In, 2008, non-built-up areas founded the largest category with coverage of 26.89 Sq.km, i.e. 46.93 % of study area. Agricultural and open lands and vegetation class, 18.60 Sq.km (32.45 %) second in area coverage and built up area is with 11.82 Sq. km (20.62%). (Refer Figure 9, Table 5.2 & Graph 5.3).

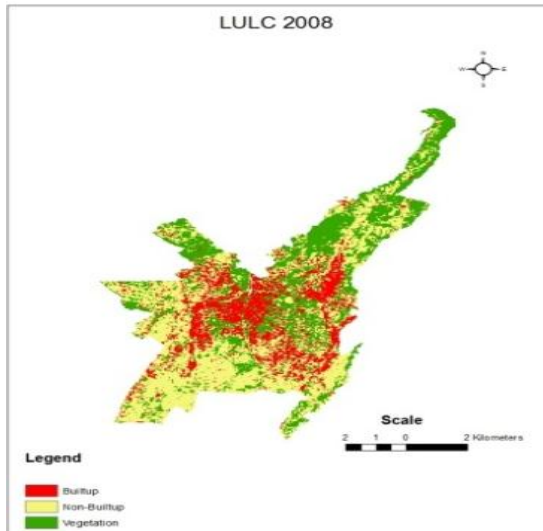


Fig 9: Land use area classification in 2008 of Dehradun

In 2017, non-built-up areas are the largest category with 26.60 Sq.km coverage, i.e. 46.21 % of study area. Built up area is second with 25.32 sq. km i.e. 44.18 percent and vegetation class stands third with 5.39 Sq.km (9.61 per cent) area coverage. Below results are presented in form of maps and charts. (Refer Figure 10, Table 5.2 & Graph 5.4).

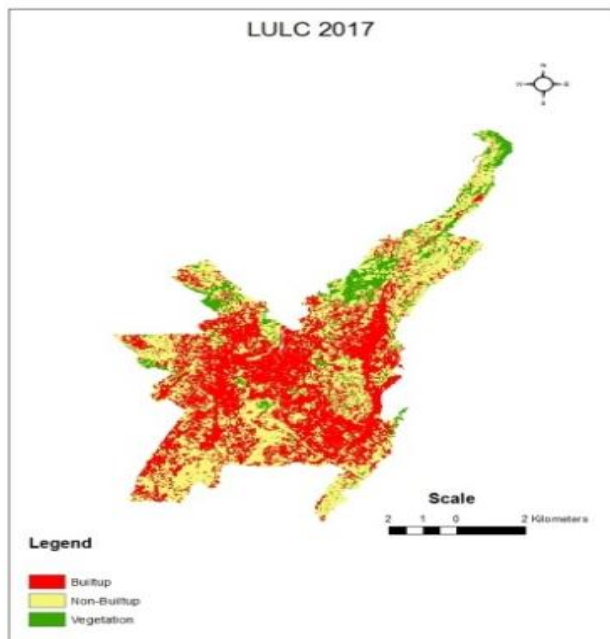
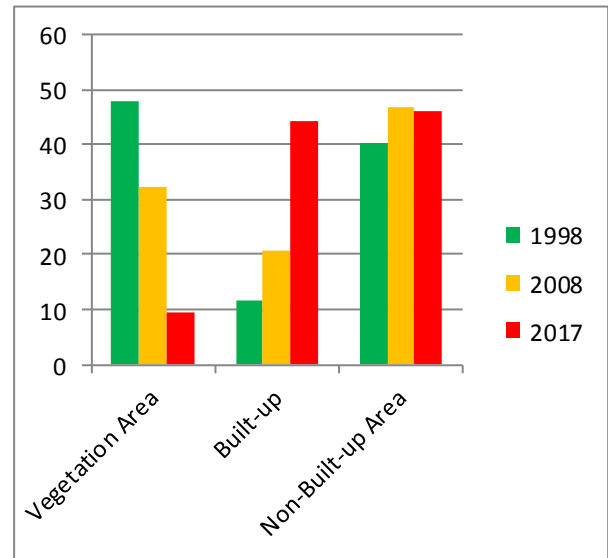
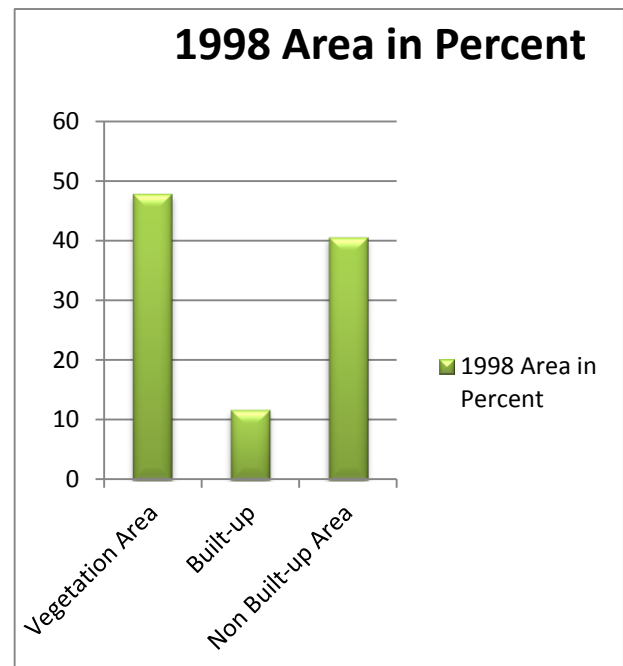


Fig 10 : Land use area classification in 2017 of Dehradun

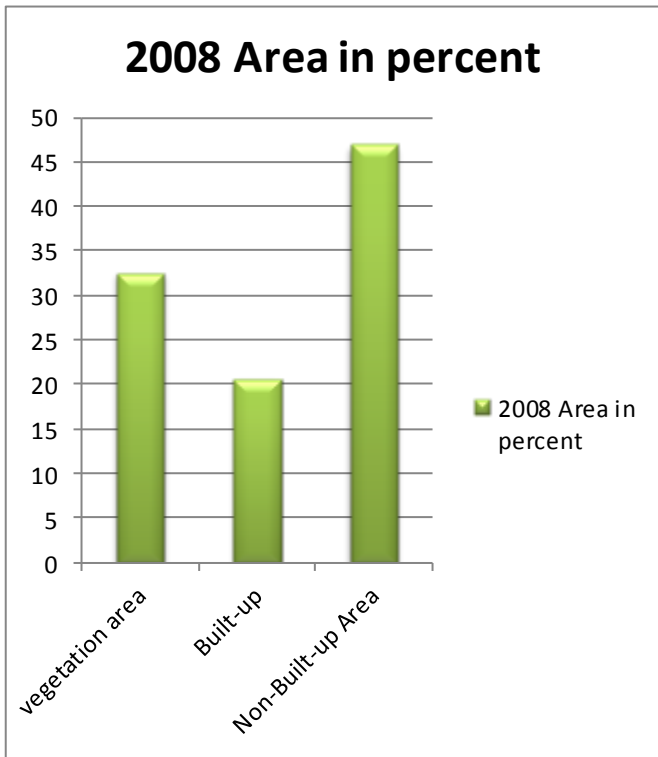
As per graph 5.1 land use/land cover in 1998 vegetation land area is maximum and built up area is minimum(refer green color in graph 5.1). In opposite to 2008 in 2017 the vegetation area is minimum and built up is maximum (refer red color in graph 5.1).



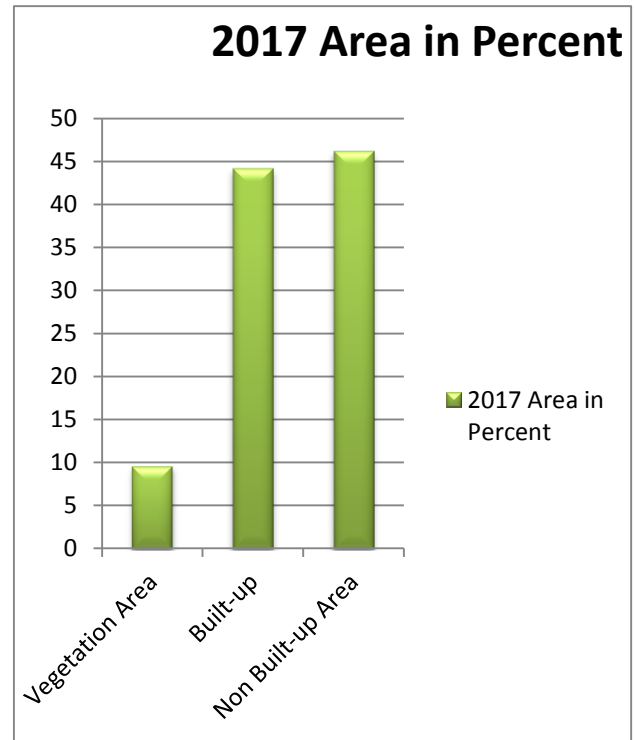
Graph 5.1: percentage (1998, 2008 & 2017) Land use/Land Cover area in



Graph IV.2: Land use/Land Cover Area Classification of 1998 of Dehradun



Graph IV.3: Land use/Lane Cover Area Classification of 2008 of Dehradun



Graph IV.4: Land use/Lane Cover Area Classification of 2017 of Dehradun

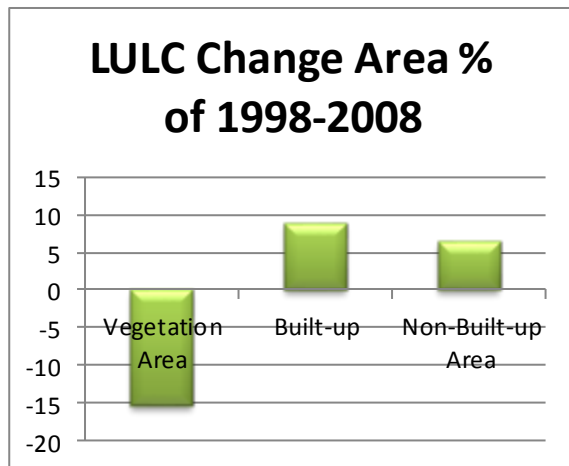
Table IV.1: Land use/Lane Cover Classification area graph in percentage (1998, 2008 &2017)

<i>Land use Class</i>	<i>1998</i>		<i>2008</i>		<i>2017</i>		<i>Characteristic features</i>
	<i>Area (Sq. km)</i>	<i>Area %</i>	<i>Area (Sq. km)</i>	<i>Area %</i>	<i>Area (Sq. km)</i>	<i>Area %</i>	
<i>Vegetation Area</i>	27.38	47.78	18.60	32.45	5.39	9.61	<i>Forest, farms</i>
<i>Built-up</i>	06.72	11.72	11.82	20.62	25.32	44.18	<i>Urbanization</i>
<i>Non-Built-up Area</i>	23.21	40.50	26.89	46.93	26.60	46.21	<i>Barren land, open areas, Agriculture land, water bodies</i>
<i>Total</i>	57.31	100	57.31	100	57.31	100	-

Conversion of Land use and Land cover (1998, 2008&2017)
 LULC of Dehradun city has undergone through important changes in the year 1998-2008. The vegetation area from 1998 to 2008 is decreased by 15.33 % and built up area and non built up area is increased by 8.9% & 6.43% respectively (Refer table 5.2 & Graph 5.5).

Table 5.2: Area Change detail in Different LU/LC Categories changes of the period 1998-2008

Land use Class	1998	2008	Change Area %
	Area %	Area %	
Vegetation Area	47.78	32.45	-15.33
Built-up	11.72	20.62	+8.9
Non-Built-up Area	40.50	46.93	+6.43
Total	100	100	

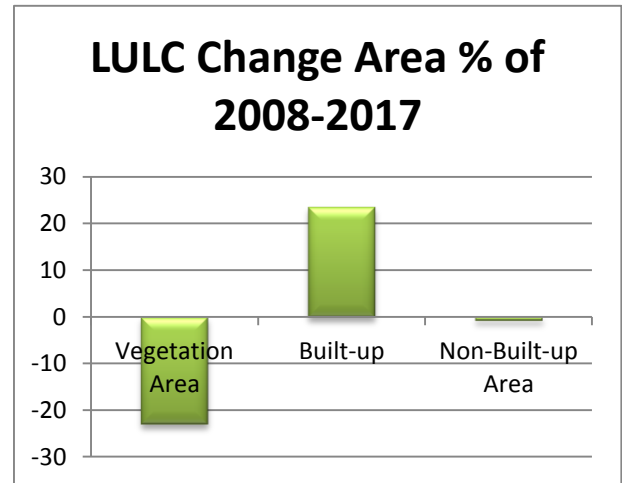


Graph IV.1: Land use/Lane Cover Classification (1998-2008)

LULC of Dehradun city has undergone through important changes in the year 2008-2017. The vegetation area from 2008 to 2017 is decreased by 22.84% and built up area is increased by 23.56% & non-built up area decreased by 0.72% respectively (Refer table 5.3 & Graph 5.6).

Table IV.3: Area Change detail in Different LU/LC Categories changes of the period 2008-2017

Land use Class	2008	2017	Change Area %
	Area %	Area %	
Vegetation Area	32.45	9.61	-22.84
Built-up	20.62	44.18	+23.56
Non-Built-up Area	46.93	46.21	-0.72
Total	100	100	



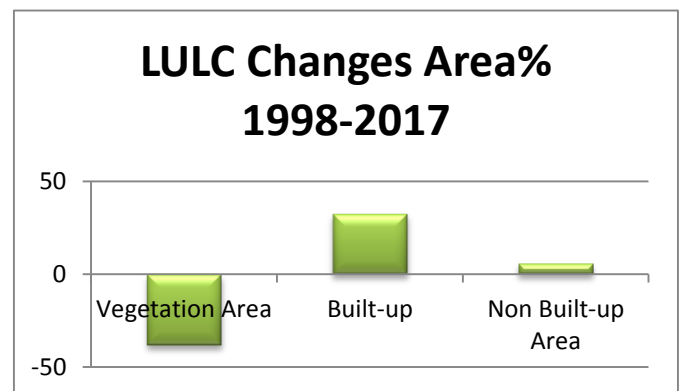
Graph IV.2: Land use/Lane Cover Classification (2008-2017)

LULC of Dehradun city has undergone through important changes in the year 2008-2017. The vegetation area from 1998 to 2017 is decreased by 38.17% and built up area is increased by 32.46% & non-built up area increased by 5.71% (Refer table 5.4 & Graph 5.7)

Table IV.4: Area Change detail in Different LU/LC

Land use Class	1998	2017	Changes Area%
	Area %	Area %	
Vegetation Area	47.78	9.61	-38.17
Built-up	11.72	44.18	+32.46
Non Built-up Area	40.50	46.21	+5.71
Total	100	100	

Categories changes of the period 1998-2017

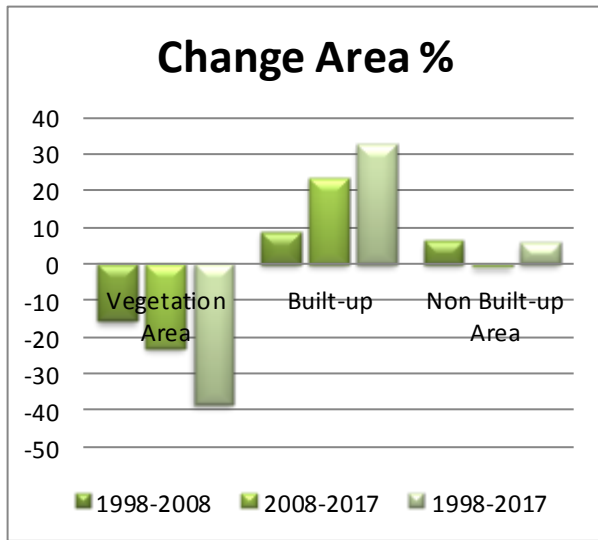


Graph 5.7: Land use/Lane Cover Classification (1998-2017)

LULC of Dehradun city has undergone through important changes in the year 2008-2017. The vegetation area from 1998 to 2017 is decreased by 38.17% and built up area is increased by 32.46% & non-built up area increased by 5.71% (Refer table 5.5 & Graph 5.8)

Table 5.5: Changes Area% of 1998, 2008, 2017

Land use Class	1998-2008	2008-2017	1998-2017
Vegetation Area	-15.33	-22.84	-38.17
Built-up	+8.9	+23.56	+32.46
Non Built-up Area	+6.43	-0.72	+5.71



Graph IV.8: Land use/Lane Cover changes in percent

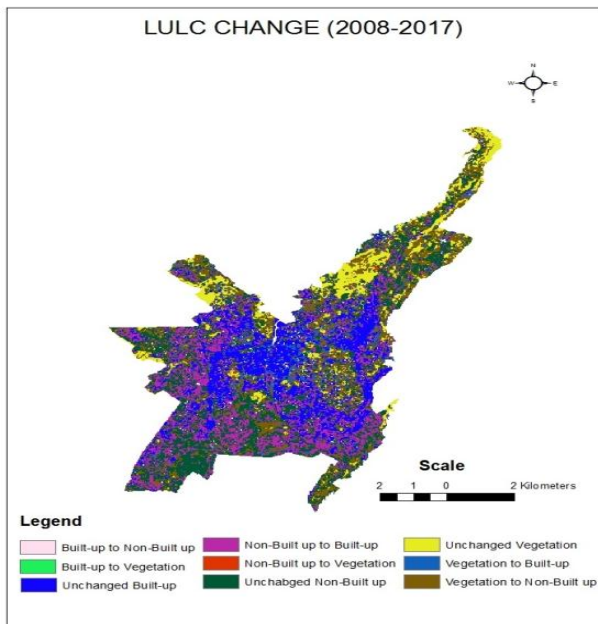


Figure 11: Inter- type changes of LU/LC (2008- 2017)

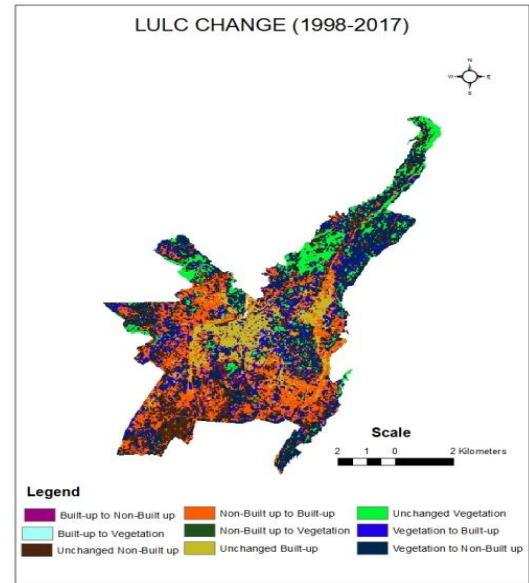


Figure 12: Inter-type changes of LU/LC (1998- 2017)

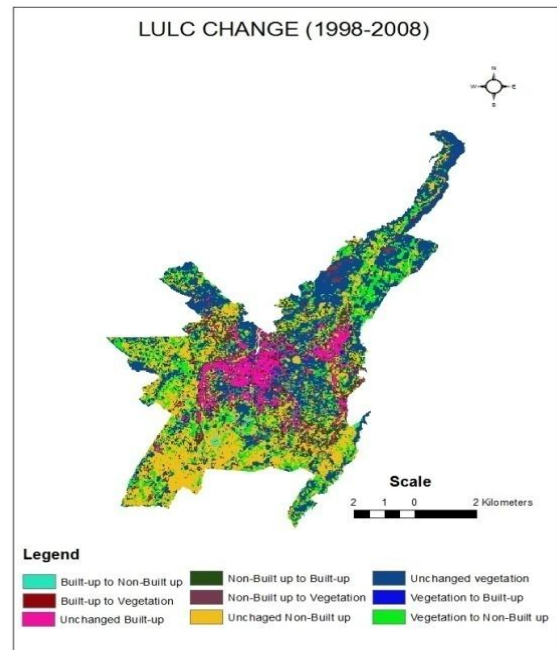


Figure 13: Inter- type changes of LU/LC (1998- 2008)

Inter type change lands of period 1998-2017, 2008-2017, 1998-2017: (fig 11-13)

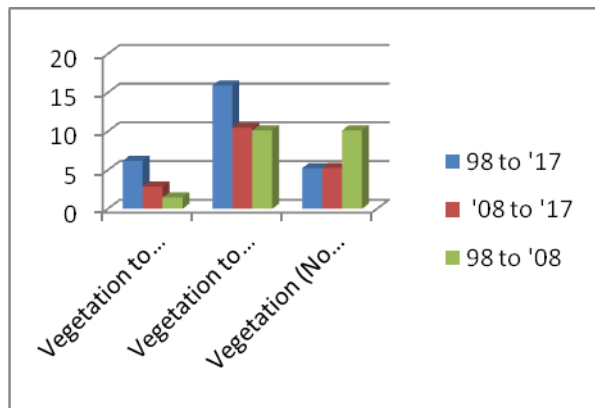
Inter change of vegetation land

In the year 1998-2017, 2008-2017, 1998-2017 The land area in sq. km. unit converted from the vegetation to build up area, non-built up area and the area with no change has been

described below in Table 5.6 and graph 5.9 represents the 15.9336 sq km. is converted to non built up area and 6.2037 converted to built up area.

Table IV.6: Land use/Land Cover Classification Area converted from vegetation 1998-2017, 2008-2017, 1998-2017

Conversion in Sq. km	Area Converted from '98 to '08	Area Converted from '08 to '17	Area Converted from '98 to '17
Vegetation to Built-up	1.4544	2.8611	6.2037
Vegetation to Non Built-up	10.1376	10.4535	15.9336
Vegetation (No Change)	15.7869	5.2857	5.2416



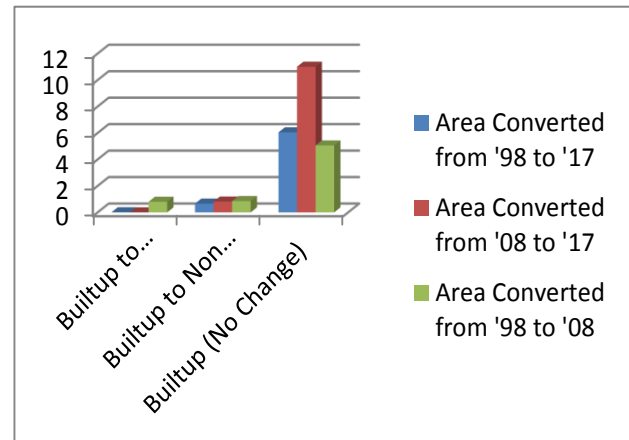
Graph IV.9: Land use change analysis of 1998-2017, 2008-2017, 1998-2017

Inter type change of Built up land In the year 1998-2017, 2008-2017, 1998-2017

The land area in sq. km. unit converted from the buildup area to vegetation to , non-built up area and the area with no change has been described below in Table 5.7 and graph 5.10 represents the .0117 sq km. is converted vegetation area and 0.6624 converted to non-built up area.

Table IV.7: Land use/Lane Cover area covered from built-up 1998-2017, 2008, and 2017, 1998-2017

Conversion in Sq. km	Area Convertedd from '98 to '08	Area Converted from '08 to '17	Area Converted from '98 to '17
Built-up to Vegetation	0.8064	0.0036	0.0117
Built-up to Non Built-up	0.855	0.8181	0.6624
Built-up (No Change)	5.0607	11.007	6.048



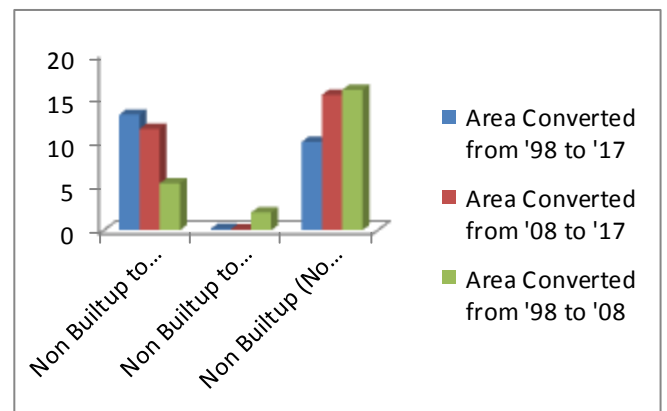
Graph IV.10: Land use change analysis of built up areas 1998-2017, 2008-2017, 1998-2017

Inter type change of Non- Built up land In the year 1998-2017, 2008-2017, 1998-2017

The land area in sq. km. unit converted from the buildup area to vegetation to, non-built up area and the area with no change has been described below in Table 5.8 and graph 5.11 represents the 5.3073 sq km. Converted to build up area and 2.007 converted to vegetation area.

Table IV.8: Land use/Lane Cover Conversion of non-built up areas (1998-2017, 2008-2017, 1998-2008)

Conversion in Sq. km	Area Converted from '98 to '17	Area Converted from '08 to '17	Area Converted from '98 to '08
Non Built-up to Built-up	13.0698	11.4597	5.3073
Non Built-up to Vegetation	0.1368	0.1008	2.007
Non Built-up (No Change)	10.0017	15.3261	15.894



Graph IV.11: Land use change analysis of non built up areas 1998-2017, 2008-2017, 1998-2017

V. RESULTS AND DISCUSSION

The three digital images of the year 1998, 2008 & 2017 of Dehradun city has been taken to calculate the areas of three main categories they are built-up, vegetation & non-built-up area. The areas changes in three years gap 1998-2008, 2008-2017 and 1998-2017 have been calculated. The researcher found a lot of changes in these categories. One category decreases with the time where other increases. There is a lot of new development occurred during the two later periods i.e. 1998-2008 & 2008-2017. In the period 1998-2008 vegetation area decreases 15.31% from overall vegetation where built-up 8.89% increases and 6.41% non-built-up area increases. (Refer to Table 5.2 graph 5.5). In the period 1998-2017 the 38.36% vegetation decreases. Where built area increases prominently 32.45% from the year 1998 and 5.91 % increase in non-built-up area. (Refer to Table 5.3 graph 5.6)

In the period 2008-2017 the changes in the land use, category, vegetation area decreases with 23.05% from overall vegetation in 2008. Built-up area increases with 23.55% and there is no change in the non-built-up class. (Refer to Table 5.4 graph 5.7) . The analysis shows the built-up area increases in the Dehradun city in two periods between 1998 - 2008, 2008-2017. In this period maximum land is converted / encroachment into the built-up area from vegetation category.

In 2000 Uttarakhand became the state of the Republic of India with Dehradun as capital. Since it become a state capital its act as a magnet with the pace of development. So city maximum land encroachment for the development purpose like housing, infrastructure, and utility takes place after 2000. The population of Dehradun increases drastically that effect in rapid urbanization. The city required more and more houses which lead to increasing encroachment of agricultural and forest land for infrastructure development. To fulfill the increasing demand for housing in the city the multistoried residential apartment are in trend nowadays. The vertical development is increasing day by day. Builders are building eight to nine stories mid-rise apartment. Only at the outer skirts, the land for independent houses is left.

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Authors Profile

Ar. Bindu Agarwal, a qualified architect, was born and brought up in Chandigarh, did her graduation in Architecture in 2000 and post graduation in Architecture in 2012 .She is presently pursuing her PhD in Architecture from Himgiri Zee University, Dehradun on the topic "Socio-economic impact assessment of the land changes Architectural style of residential buildings in Dehradun, Uttarakhand, India."



After a few years of professional work in the field of Architecture and Interior, She joined the DIT University and Himgiri Zee University as a visiting faculty member in the Department of Architecture and Planning since 2008. After that she joined graphic Era Hill University, Dehradun, India since 2013 where she became the Assistant Professor and then Associate Professor. In her long and accomplished academic career spanning 10 years, Ar. Bindu taught and guided students of Architecture at undergraduate levels. Architectural Design, History of Architecture and Theory of Architecture, Estimation & Costing, Disaster Management and Building Construction and Building Materials are her favorite subjects for teaching and research work.

She has guided more than 10 B.Arch Thesis projects and authored more than 24 research/ technical papers of which more than 10 have been published in refereed journals.

She has been an inspecting many architectural institutions for academic approvals from Govt. Institute. She had been involved in the curriculum, time table and organizing committee member of different university programmers. Ar. Bindu is enjoying reading, writing and teaching. It is very refreshing and relaxing for her to engage in writing & teaching.

At present, since August 2013 she is working as an Associate Professor at the School of Architecture & Planning of Graphic Era Hill University, Dehradun.

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