

Monitoring the Geo-environmental impacts of development in Rural Himalayas using Remote sensing and GIS techniques: A case study of Naini Lake region and nearby villages, district Nainital, Uttarakhand, India.

¹Hemant Singh Bisht, ²Yashi Tandon, ³Arvind Kumar, ⁴Udbhaw Sandilya, ⁵Bharti Singh,
Department of Geography, Delhi School of Economics, University of Delhi, New Delhi

Abstract

The Himalaya is considered as the Indian crown that is bestowed with many ecological, cultural, social and spiritual diversities. It is presently faced with the dilemma of maintaining a balance between development and environmental sustainability. The traditional resource use structure in Himalaya has been transformed considerably during the recent past, mainly owing to the growth of population and the resultant increased demand of natural resources in the region. The Lake Region of Nainital has witnessed to the massive transformations. The rapid land use changes have not only disrupted the fragile ecological equilibrium in the mountains through indiscriminate deforestation, degradation of land resources and disruption of the hydrological cycle, but also have significant and irreversible adverse impacts on the rural economy, society, livelihood and life quality of people dwelling in the lake region and its vicinity areas. This research paper focuses on assessing the extent of environmental change and the impact of development in the lake region of Nainital district with the help of satellite data and geo spatial information technologies.

Keywords - Kumaon Himalaya, Naini Lake region(Nainital), Rural Himalayan development, Environment Impact, Land use/Land cover Change detection, Normalized Difference Vegetation Index(NDVI), Normalized Difference Built up Index(NDBI), Deforestation, Urbanization, Hydrological change.

Introduction

Mountains cover approximately 24 % earth surface(UNEP-WCMC, 2002) and having 12% of the world population(Huddleston et al., 2003). They are a great source of variety of ecosystem services including freshwater, biodiversity and soil that sustain livelihood and supports large population and economy both in mountains and adjoining plains. However, the mountain regions have been marginalised in terms of rural development and sustainability .but, today we are experiencing emergence of significance of responsiveness of mountain ecosystem and environmental significance for rural development. Currently, mountain ecosystems are highly vulnerable to environmental change, population dynamics, economic globalisation and resultant exploitation of mountain resources. Recently, various changes emerged in resource use structure in mountain areas, particularly in developed and developing world in response to population growth changing economic dimensions, transforming political order and rapid urban growth. As a result, mountain region of the world are passing through process of rapid environment changes, socio-economic transformation leads to exploitation and depletion of natural resources. *The Himalaya* is ecologically fragile, tectonically active, economically underdeveloped and densely populated mountain ecosystem on the earth. The nature imposes several limitations in productions and developmental activities and efficiency of rural infrastructure of the region. The main occupation of the people of the region is agriculture and allied activities. About 75% of the regional population is primarily dependent upon traditional ecosystem even though availability of arable land is severely limited to production activity is considerably

production(Tiwari and Joshi, 2005).. This traditional agro-ecosystem is interlinked with forests, and the flow of biomass energy from forests to agriculture is mediated through livestock. During the recent years, as in other parts of Kumaon Himalaya, a variety of transformations in traditional resource utilization patterns have emerged mainly in response to increasing population pressures and the resultant increased demand of arable land, fodder, firewood, market forces, economic growth, land tenure policies, negative trends in agro-ecosystem, such as, decreasing agricultural productivity, declining carrying capacity of rangelands (Palni et al., 1998), expansion of cultivation on marginal lands, and environmental degradation and social disintegration, in the region (Ramakrishnan, 1972). As a result, the traditional land use pattern has changed leading to environmental degradation, ecological disruptions and livelihood insecurities in the entire region. Excavation of fragile slopes for road and house construction, removal of vegetation cover, extension of agricultural and horticultural activities to virgin forests, and such other anthropogenic processes initiated by the alternative resource utilization practices are leading to various kinds of environmental problems including the loss of forests and biodiversity, the disruption of the hydrological system and microclimatic changes (Roy and Tomar, 2000; Joshi et al, 2003).

The Nainital region is transforming in the last two decades in terms of settlement pattern,vegetation cover an attitude towards environment.The landuse and landcover change in Lake Region of Nainital is because of Tourist agglomeration, and cultural pilgrimage.The rapidly changing land use pattern and the resultant decrease in forest area have decreased groundwater recharge in the region (Ives, 1985, 1989). The large-scale depletion of forest resources is causing great damage to the underground water resources by reducing the water generating capacity of the land to springs and streams in the region.Water bodies area has drastically decreased from 2008,e.g. Naini lake area has decreased, all the minor water bodies got replaced by settlements, representing the curse of urbanisation (engulfed the core around which they formed). The areas with high altitude having poor accessibility are more vulnerable to soil erosion such as Dhaniyakot, Betalghat, Bhatronjkan, Bhirapani, Shhilekh and Josyura etc have shown less development as compared to the core and peripheral regions of the lake.

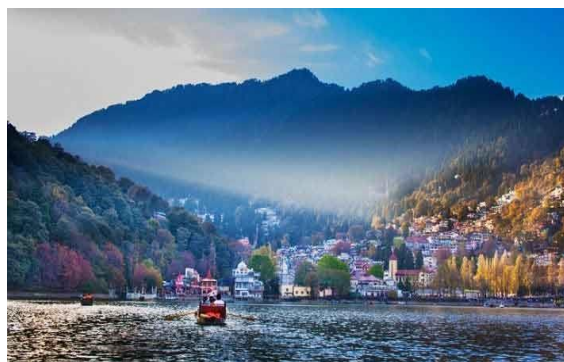
Study Area

Kumaun Himalayas, the west-central section of the Himalayas in northern India, extending 200 miles (320 km) from the Sutlej River east to the Kali River. The range, comprising part of the Siwalik Range in the south and part of the Great Himalayas in the north, lies largely within the state of *Uttarakhand* , northwest of Nepal. It rises to 25,646 feet (7,817 metres) at *Nanda Devi*, the range's highest peak, and 25,446 feet (7,756 metres) at *Kamet* , near the Chinese border. At elevations above 14,000 feet (4,300 metres), snow covers the mountains throughout the year. Glaciers and snowmelt feed the headstreams of the Ganges River in torrents that rush through gorges and steep-sided ravines.

District *Nainital* is a part of the micro-region of Kumaon Himalaya-East. It comprises part of hill patties, the bhabar and the plains. It is bounded on the north by district Almora, in the north-west by Garhwal, in the west by Bijnor, in the south by the newly created district of Udham Singh Nagar and in the east by district Champawat. It lies in latitude 29.39° North and longitude 79.45° East and covers an area of 4,251 sq km. The total population of Nainital District is 954,605 out of which urban population is 371,734 while rural is 582,871, as per Census 2011. This district is crisscrossed by many rivers and rivulets. *River Kosi*

enters in the district in the north near Khairana and flows in western direction till Betalghat from where it starts flowing southward. The district has three distinct geological regions of Lower Himalaya, Siwalik and bhabar. Nainital is a glittering jewel in the Himalayan necklace, blessed with scenic natural splendour and varied natural resources. Dotted with lakes, Nainital has earned the epithet of '**Lake District**' of India. The most prominent of the lakes is *Naini lake* ringed by hills. Nainital has a varied topography.

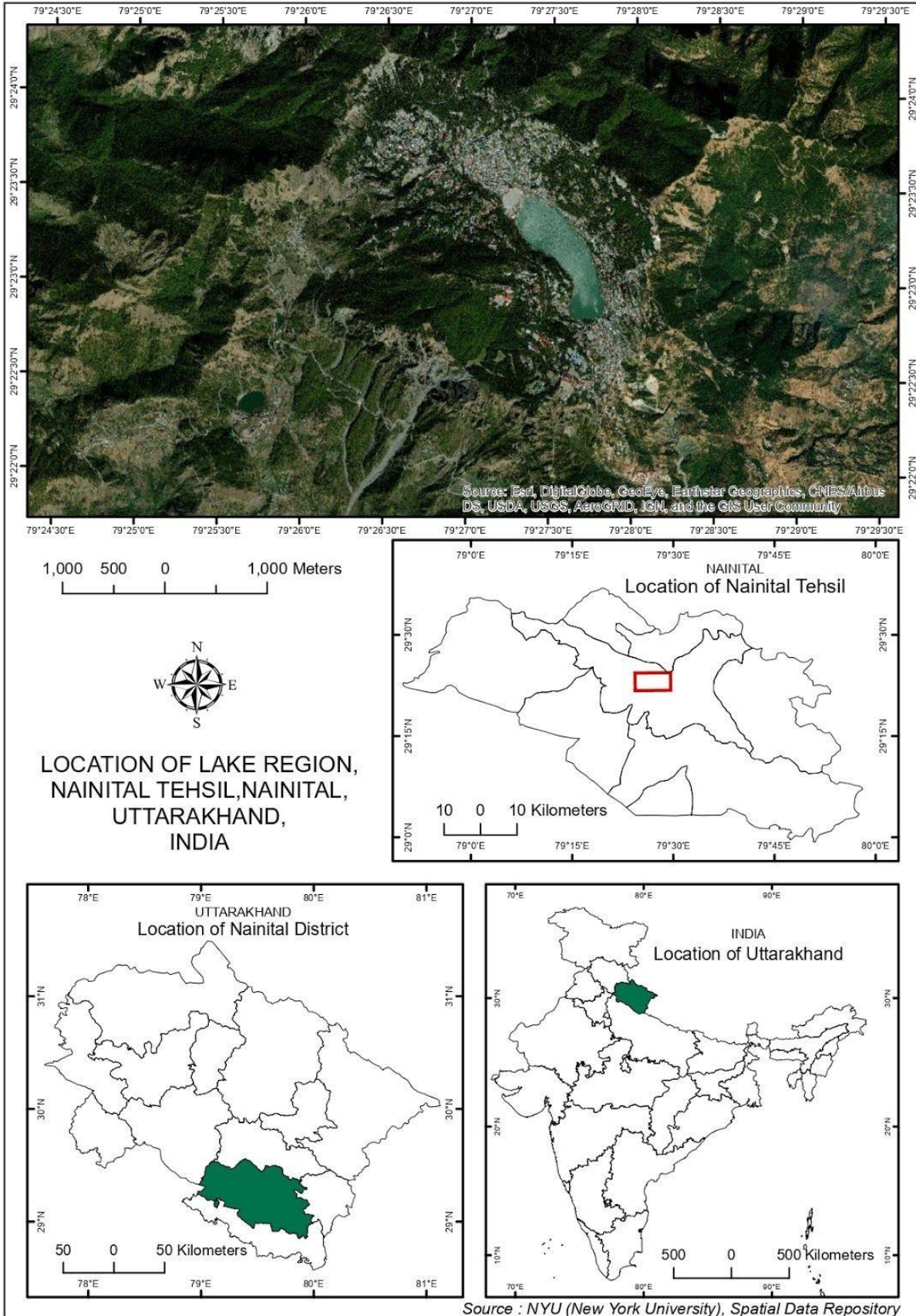
Some of the important places in the district are Nainital, Haldwani, Kaladhungi, Ramnagar, Bhowali, Ramgarh, Mukteshwar, Bhimtal, Sattal and Naukuchiatal. Nainital's unending expanse of scenic beauty is nothing short of a romance with awe-inspiring and pristine Mother nature. Nainital is the headquarter of Nainital District. It is also divisional Headquarter of Kumaon Division of Uttarakhand State. The Nainital district is further divided into Tehsils / Blocks / Community Development Blocks (C.D.Blocks) for administrative purposes. In India, the Block or C.D.Block is often the next level of the administrative division after the tehsil. There are 8 tehsils in the district Nainital (Census,2011), Haldwani, Ramnagar, Nainital, Lalkuan, Dhari, Kaladhungi, Kosya Kutauli, Betalghat.




Lake Region and its Nearby Villages of Nainital Tehsil

is the targeted area for this study. There are 250 villages and 4 towns in Nainital Tehsil (Census,2011). The nucleus of Nainital's exquisite beauty is its lake, which is heaven for water sports like yacht racing and canoeing. This tourist paradise is situated at the height of 6,350 feet above the sea level. On the edge of the lake temple, *Naina Devi* is situated. The sailing boats at the Nainital lake provide an excellent view. Nainital town is famous for sanitariums. It was used to be the summer seat of government of earlier undivided Uttar Pradesh. The

nearest railway station is Kathgodam at a distance of 35 km. The lake is surrounded by seven mountain peaks which are *Nayana* or *China peak* (8,569 feet), *Alma* (7,980 feet), *Sher Kadanda* (7,890 feet), *Lauria Kanta* (8,144 feet), *Ayarapatta* or *Dorothy peak* (7,640 feet), *Handi Bundi* (7,150 feet) and *Deopatta* or *Camel's Back* (7,990 feet). The city looks calm for shady bowers of the poplars and deodars (*Himalayan cedar*, *Cedrus deodara*). The nearby villages are highly influenced by the rapid urbanization and tourism in the urban core region of Nainital Lake region.



Profile of Tehsil Nainital :

Coordinates:	 29.39°N 79.45°E
Country	India
State	Uttarakhand
District	Nainital
Total Area	826.09 km.sq.
<i>Population(2011)</i>	
Total	1,50,389
Male	78,365 (52.11%)
Female	72,024 (47.89%)
Rural	93,583
Urban	56,806
Density	182
Sex-Ratio	919
<i>Languages</i>	
Official	Hindi
Other	Kumaoni
<i>Literacy</i>	
Total	78.79%
Male	83.72%
Female	73.41%
No. of Households	
Total	31590
Rural	18748
Urban	12842

Source: Census of India, 2011.

Literature Review

The rural development has always been one of the major factors which have contributed to the occurrence of natural disasters in mountainous areas where most common is landslide. Nainital, one of the most popular tourist destinations in India, lies in the state of Uttarakhand specifically in the region of Kumaon Himalaya. A lot of literary work has been done on Nainital as it is prone to natural disasters. According to Moseley and Malcolm J. (2003) , rural development means a process which tries to improve the living conditions mainly economically of rural population which lives isolated. India has shown great efforts in the recent Environmental Impact Assessment report (2016) where the Ministry of Environment and

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Forests (MoEF) has taken the EIA notification 2006 as a guideline and major tool for protecting the environment from the adverse effects of development According to Dayanand Ujalambe(2015) due to population explosion and increasing number of visitors, the population pressure on Nainital city has been increasing which resulted in soil erosion, deforestation which leads to landslides and ecological imbalance. Whereas, according to Rautela and Thakur (1999) and Rautela and Paul (2001) the erosion process of the region has been speed by the recent interventions of anthropogenic activities like mining, road and dam construction. The rural-urban migration along with unplanned growth has contributed in the development of slums in the state of Uttarakhand. (Census of India, 2001)

Currently, mountain ecosystems as well as mountain communities are particularly threatened by the ongoing processes of global environmental change, population dynamics and economic globalization and resultant exploitation of mountain resources described by the work of Borsdorf (2010); Ives and Messerli (1990). The work of V.K.Gaur , R. Chander, I. Sarkar, K.N.Khatti, H. Sinvhal (1985) on Kumaon Himalaya depicts the result of various investigations on approximately 250 local earthquakes in the region between and adjacent to the valleys of Bhagirathi and Yamuna rivers. The analysed result showed that the earthquakes occur in specific belts and areas of the Himalayas. One belt is in middle segment of Yamuna around 70 km long. Most of the earthquakes originate less than 10 km from the ground in this region. The sprawling and unplanned urban growth in fragile mountains has disrupted the critical ecosystem services, depleted natural resources, increased socio-economic inequalities and increased vulnerability of both towns and their nearby areas to a variety of natural risks said by Anbalagan(1993). The region of Kumaon Himalaya has been targeted to the development as a result large proportion of arable land is being encroached upon by the process of rapid urbanization and the expansion of infrastructure, services and economic activities in the region every year as described by Tiwari and Joshi(2005) . According to Prakash Tiwari (2008)who studied the Kumaon region and found that the changes in the land use pattern due to overpopulation and deforestation has resulted in pressure and over utilisation of resources which are adversely affecting the environment and the society of the mountain region.

Objectives

The study aims at presenting an overview of the process of development in mountainous areas and the trends and magnitude of landuse change over time.

- To assess the extent of environmental change and the impact of development in the Lake region of Nainital district and its nearby villages, Kumaon Himalaya, Uttarakhand with the help of satellite images and geo-spatial information technologies and methods.

Database and Methodology

Database

The study is based upon the information collected through various research articles, government reports published under various national and international institutions and government departments. The information gathered from various archives has been very helpful during the study. These have provided details about the events accompanying the process of development in the region.

Apart from them, Remote sensing imagery collected from Indian Geo-Platform of ISRO-Bhuvan has been our core tool in detecting the changes in vegetation, water quality, and environmental conditions over the

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years around Naini Lake and nearby villages. To fulfill the objectives, spatial data was analyzed using descriptive statistics and remote sensing technology.

Table-2 : Metadata of Satellite Images		
	2008	2015
Name of the Satellite	Resourcesat-2	Resourcesat-2
Sensor	LISS-III	LISS-III
Path	098	098
Row	050	050
Image acquired from	Resourcesat-2	Resourcesat-2
Date of pass	09/Oct/2008	09/Oct/2015
Spatial Resolution	0.000225 Degree	0.000225 Degree

Source : Indian Geo-Platform of ISRO-Bhuvan.

Methodology

In order to fulfil the objective, following methods and processes were used:

Data Preprocessing

The collected remote sensing data sets were imported in ERDAS Imagine, satellite image processing software. The layer stack option in the image interpreter toolbox was used to convert the image into False Colour Composite(FCC) for the study area. The study area was clipped/extracted from the images by taking the georeferenced boundary of the study area as AOI.

Land use land cover change detection and analysis

Satellite images were used for mapping and interpretation of its dynamics. The images of were classified in ERDAS Imagine to show land use/cover using unsupervised classification. Unsupervised classification is a pixel-based, computer-automated classification. The user specifies the spectral classes, created on the basis of numerical information of the imagery. It requires the least computational time with respect to other methods of classification. Four land use/cover classes were identified in the area: Dense forest, Scattered forest, Waterbody, Built-up area. The land use/cover maps show the spatio-temporal variation on existing satellite imageries.

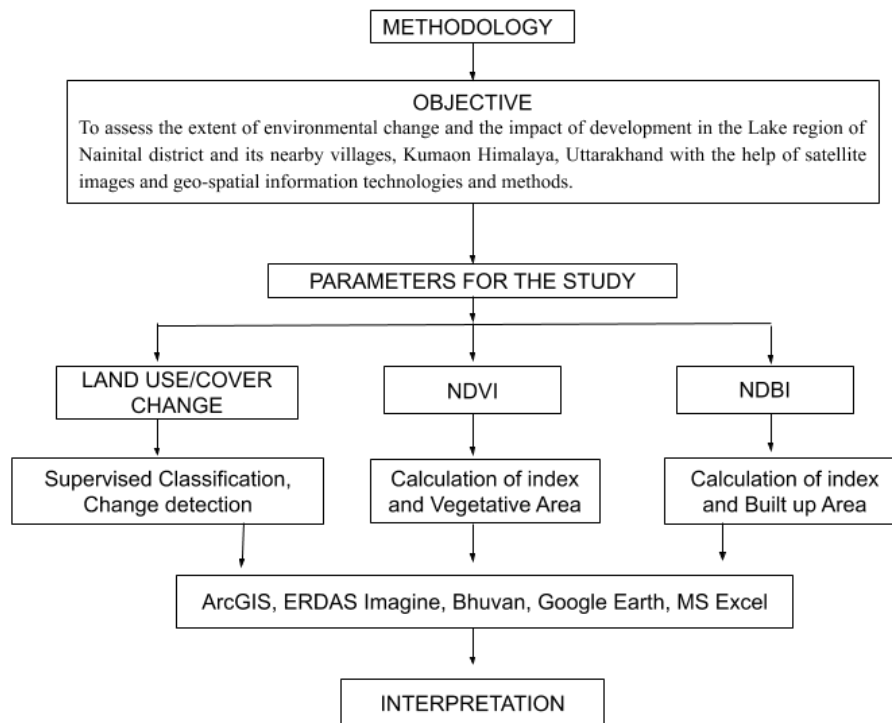


Figure-2 : Diagrammatic illustration of Methodology.

Indices and Band Ratios

In order to enhance the interpretability of the remote sensing data and image analysis, various indices were used such as Normalized Difference Vegetation Index (NDVI), Normalized Difference Water Index (NDWI) and Normalised Difference Built up Index (NDBI) to classify the satellite images. The indices were calculated using ERDAS Imagine 2014. For that we have chosen certain indicators such as NDVI, NDBI etc.

NDBI (Normalized Difference Built up Index) :- It is used to extract buildup features and have indices range from -1 to 1. Negative value of NDBI represent water bodies whereas higher value represent built up areas. These are the most common indexes to analyse the buildup areas. Through these we can figure out the changes occurred in an area over a period of time.

NDVI (Normalised Difference Vegetative Index) :- It is a simple graphical indicator that can be used to analyze remote sensing measurements, typically, but not necessarily from a space platform, and assess whether the target being observed contains live green Vegetation or not. The NDVI value varies between -1.0 and +1.0, higher the range nearer to positive, the higher level of vegetation. Whereas, range nearer to negative, the lower level of vegetation.

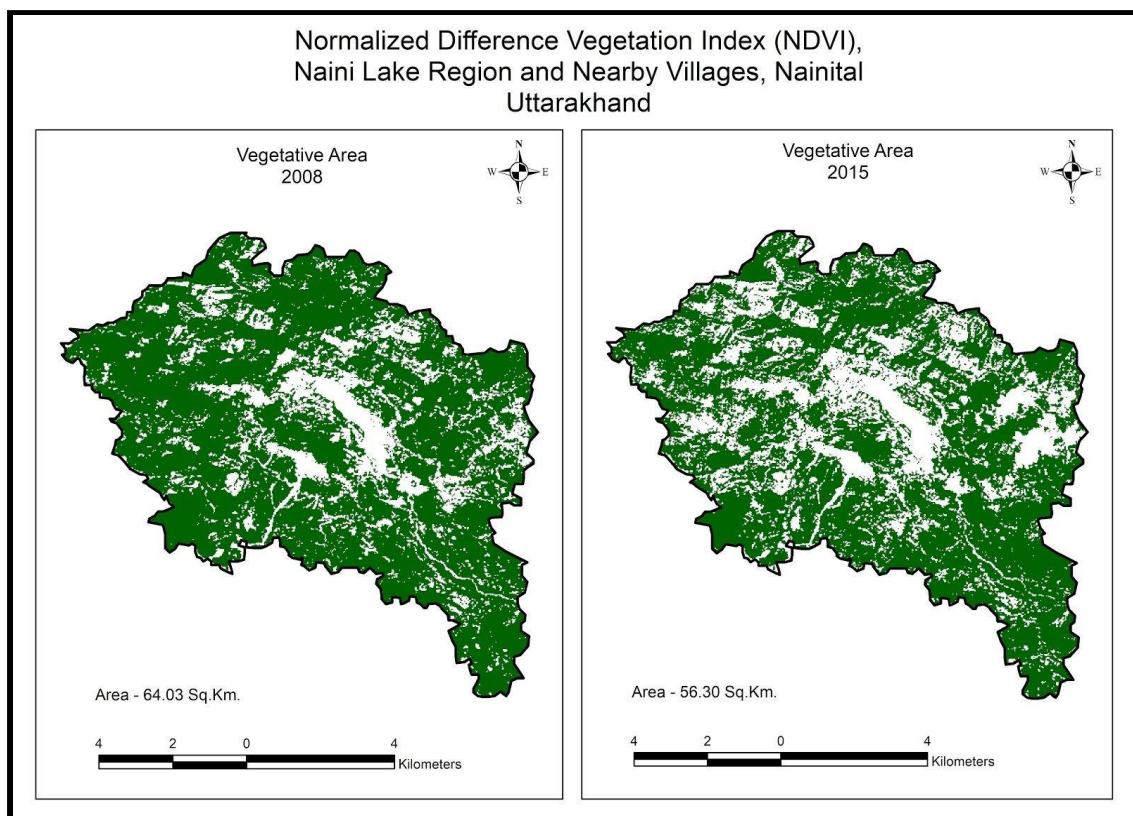
Results and Discussion

For the analysis of land use and land cover pattern in a particular feature in the Nainital Lake region through a particular period of time, various attributes were selected like NDVI, and NDBI.

NDVI Change Detection and Analysis

The first indicator is NDVI, which is a simple graphical indicator that can be used to analyze remote sensing measurements, typically, but not necessarily from a space platform, and assess whether the target being observed contains live green Vegetation or not. The NDVI value varies between - 1.0 and +1.0, higher the range nearer to positive, the higher level of vegetation. Whereas, range nearer to negative, the lower level of vegetation.

$$NDVI = (NIR - RED) / (NIR + RED)$$



Map-2: Comparative representation of NDVI of Naini Lake Region of Nainital and its vicinity.

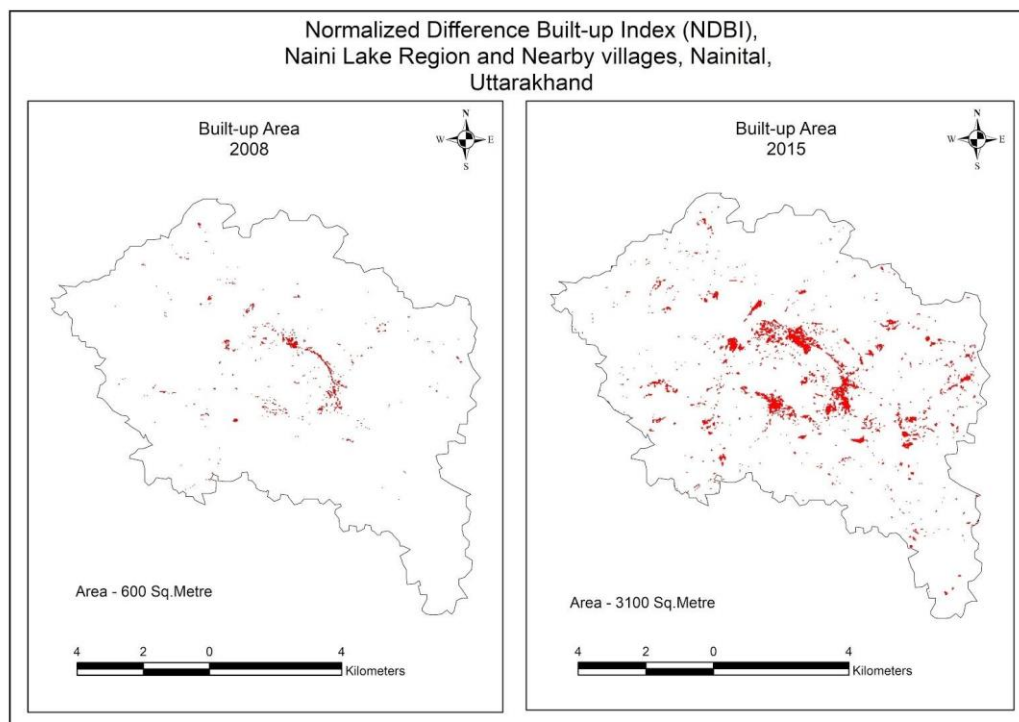
The NDVI data show that the major developments have taken place in the central region of Nainital and the development is usually scattered in nature which includes regions of Haldwani, Kathgodam, Ranibagh, Mangoli, Kaladhungietc. These are the regions for major developmental activities. The Lake Development Authority doesn't permit construction upto 10mtrs from the shores of the lake but this rule is being openly flouted in Lake Region of Nainital. The Lake region region of Nainital had a long genealogy of development since the colonial period. Many administrative headquarters and educational institutions were set up during the colonial period. So, This paved the way for the development of Lake region of Nainital and thus is known Publishing URL : <http://www.researchreviewonline.com/issues/volume-7-issue-89-september-2020/RRJ797838>

as one of the notable gateway towns on Uttarakhand serving the entire Kumaon region. The town is well connected by railways and National roadways and relatively nearer to planned airports. The landuse and landcover change in Lake Region of Nainital is because of Tourist agglomeration, and cultural pilgrimage. According to the NDVI data presented, comparison between the years of 2008 and 2015 vegetative cover shows that there were around 64.09 km² which got decreased upto 56.03 km² respectively. As a whole, the vegetation cover which was 78 percent in 2008 got decreased to 68 percent in 2015. Whereas simultaneously the non vegetation cover which was 22 percent in 2008 increased upto 32 percent. The areas with high altitude having poor accessibility are more vulnerable to soil erosion such as Dhaniyakot, Betalghat, Bhatronjkan, Bhirapani, Shhilekh and Josyura etc have shown less development as compared to the core and peripheral regions of the lake.

NDBI Change Detection and Analysis

It is used to extract buildup features and have indices range from -1 to 1. Negative value of NDBI represent water bodies whereas higher value represent built up areas. These are the most common indexes to analyse the buildup areas. Through these we can figure out the changes occurred in an area over a period of time.

$$NDBI = (SWIR - NIR) / (SWIR + NIR)$$



Map-3: Comparative representation of NDBI of Naini Lake Region of Nainital and its vicinity.

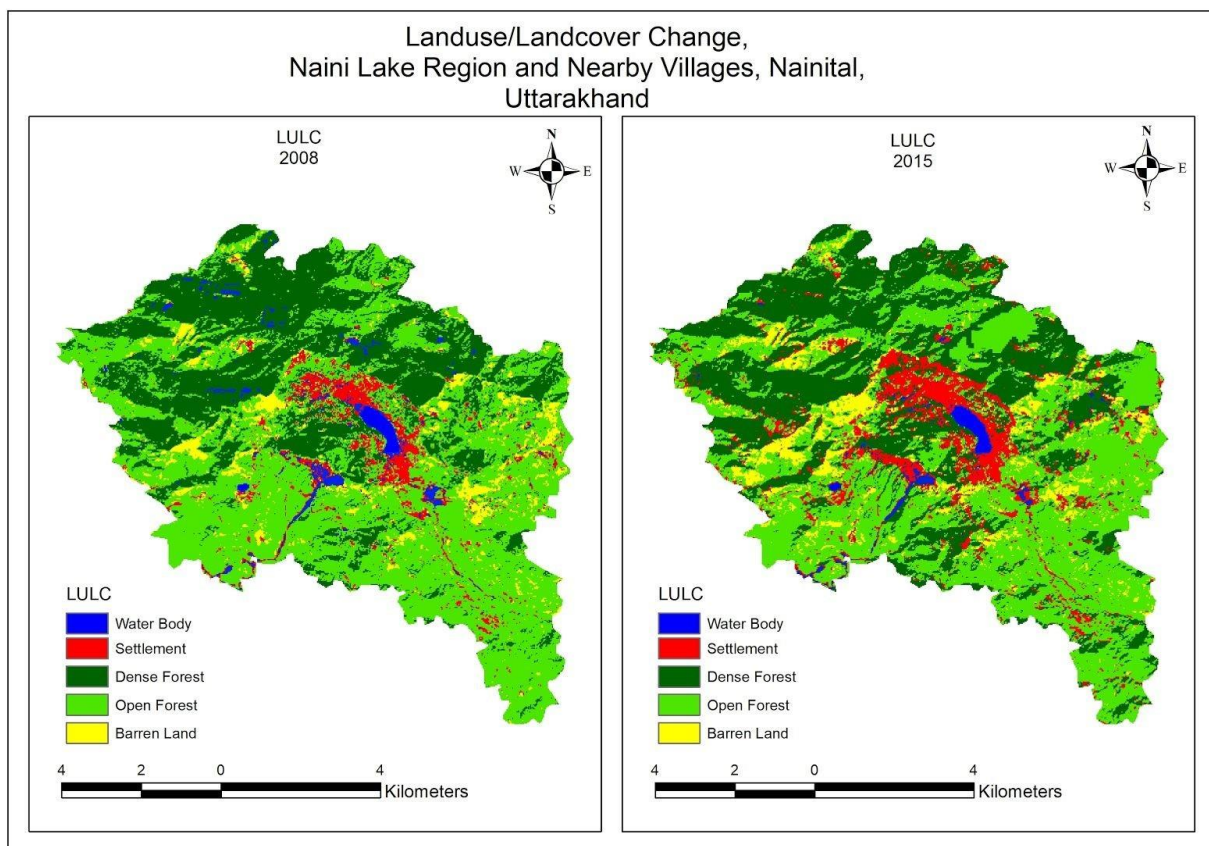
The NDBI data show that the major developments have taken place in the central region of Nainital and the development is usually scattered in nature which includes regions of Haldwani, Kathgodam, Ranibagh, Mangoli, Kaladhungi etc.. These are the regions for major developmental activities. The Lake Development

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Authority doesn't permit construction upto 10mtrs from the shores of the lake but this rule is being openly flouted in Lake Region of Nainital. The Lake region region of NainitalNainital had a long genealogy of development since the colonial period. Many administrative headquarters and educational institutions were set up during the colonial period. So, This paved the way for the development of Lake region of NainitalNainital and thus is known as one of the notable gateway towns on Uttarakhand serving the entire Kumaon region. The town is well connected by railways and National roadways and relatively nearer to planned airports. The landuse and landcover change in Lake Region of Nainital is because of Tourist agglomeration, and cultural pilgrimage.

The areas with high altitude having poor accessibility are more vulnerable to soil erosion such as Dhaniyakot, BetalghatBetalghat, Bhatronjkhan, Bhirapani, Shhilekh and Josyula Etc..have shown less development as compared to the core and peripheral regions of the lake.

Land use/Land cover Change Detection and Analysis



Map-4: Comparative representation of Land use/Land cover types of Naini Lake Region of Nainital and its vicinity.

Land use/Land cover, 2008

The land use interpretation for the year 2008 is based on the satellite data from Resourcesat1 . In 2008, out of the total geographical area 82.12 sq.km. of the Naini Lake Region, 33.15% (27.23 sq.km.) of the total area was under dense forests;. 53.47%(43.91 sq.km) was under open forest; .58% (4.59 sq.km)was identified as barren land; and 2.48% (2.04 sq.km.)of the total region was under water bodies and 4.35 sq.km. or5.29% was under settlement. Water bodies in the study area are present extensively in central, north-west and northern part. Water which gives impetus to origin of settlements, have played a similar kind of role in Naini lake region, which is clearly visible in radial settlement pattern around the lake. Naini lake region topology has two parts namely Mallital and Tallital, Northern part is called as Mallital while southern part as Tallital. Mallital is a charming area popular for its colonial architecture and wooded mountain trails, while Tallital is famous for its tourist attraction (Mall road). Settlements are majorly located around the north western and south eastern part of the Naini lake, indication of operating pull factors of clustering, e.g. tourist attractions and availability of employment opportunities (guide, hotelling, street vendors, transportation). Nainital Diocesan (present Sherwood college), the Oak opening boy's high school, St. Mary's convent and Wellesley College are some of the prominent historical educational institutions which also acted as magnets for urbanisation in this area.

Table - 3 : Area and amount of change in different land use/land cover categories in the Lake Region of Nainital and nearby villages during 2008 to 2015.

Land use/cover categories	2008		2015		Change 2008-2015	
	Area (in km ²)	%	Area (in km ²)	%	Area (in km ²)	%
Water Body	2.04	2.48	1.26	1.53	-0.78	-0.96
Settlement	4.35	5.30	8.36	10.18	4.01	4.89
Dense Forest	27.23	33.16	23.86	29.06	-3.37	-4.10
Open Forest	43.91	53.47	42.81	52.13	-1.10	-1.34
Barren Land	4.59	5.59	5.83	7.10	1.24	1.51
Total	82.12	100.00	82.12	100.00	0.00	0.00

Dense forest, according to FSI, is an area with tree cover of canopy density ranges between 40-70%. Naini lake region has a fair amount of dense forest in north and north eastern area, thus shows as the altitude increases the forest canopy increases with decreasing human interference. Dense forested areas are mainly located on the southern slopes of hills and mountains. Open forest, according to FSI, is an area with tree cover of canopy density ranges between 10-40%. These are majorly located in the southern part of Naini lake region, showing a trend of open forest availability with decreasing altitude. Barren land, according to FSI, are areas without any kind of tree cover and canopy density can be considered as barren land. Naini lake region has barren land majorly around settlement areas, showing an effect of pattern of urbanisation on the outskirts of the Naini lake, resulted from both anthropogenic and natural factors.

Land use/land cover distribution



Figure-3 : Land use/land cover distribution in the lake region of Nainital and nearby villages during 2008 and 2015.

Land use/Land cover, 2015

The land use interpretation for the year 2015 is based on the satellite data from Resourcesat1 . In 2015, out of the total geographical area 82.12 sq.km of the Naini Lake Region, 29.03% (23.84sq.km) of the total area was under dense forests; 52.13% (42.81sq.km) was under open forest; 7.06%(5.8sq.km) was identified as barren land; and 1.53%(1.26 sq.km)of the total region was under water bodies and 10.18% (8.36 sq.km) was under settlement. Naini lake is shrinking and its water becoming increasingly murky. The quality of water in the lake, which is the sole source of drinking water for the people of the town, has deteriorated alarmingly. The discharge of sewage into the lake and inappropriate construction activity in the lake's catchment areas are the villains of the piece. Monsoon overflow from the lake passes through the Balia nullah, which empties into the Balia ravine. "The Balia nullah controls the stability of the entire lower portion of the town between the outfall of the lake and the Brewery. The Naini Lake, sitting in the lap of mountains in Nainital, Uttarakhand, is visibly struggling. The water level of the lake has dropped drastically, exposing the lake bed in many areas. There are two reasons that the experts believe are making the lake shrink: obstruction in the subsurface recharge and increased abstraction of water to quench Nainital's thirst. Settlement area has doubled from 2008, indicating the increase in population and encroachment of humans

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in the surrounding areas of lake. Settlements have engulfed the water laden areas, pointing towards overexploitation and overuse of natural resources. Increase in population has led to problem of sewerage and solid waste; According to the District Urban Development Agency (DUDA) and Nagar Palika Parishad (NPP), Nainital has 10 main slums scattered across the town, accounting for about 21 per cent of the total population. Many of these slums lie within the catchment area of the lake. Moreover, Nainital does not have sewage treatment facilities. It has to expand its sewer network, and provide decentralised sewage treatment plants (STPs) and on-site treatment in low density areas. Dense forested areas have decreased from 2008, indicating an infiltration of human beings in the interior parts of forests. Dense forested areas which are hard to penetrate, covers almost 52% area of the region. Open forested areas has marginally decreased from 2008, (53.47- 52.13%). Barren land has increased from 2008, mainly around settlement areas, showing adverse impacts of urbanisation and industrialisation (tourism industry, hotel industry, transport industry). These processes has led to overexploitation, overuse and over extraction of natural resources mainly of water and forest, resulted in conversion of pasture lands to non- pasture lands, decreased fresh water availability, decreased soil quality and several other interlinked impacts.

Land Use/Cover change detection and Analysis

Data shown in table 3 and figure 4 & 5 states that both positive and negative changes occurred in land use/cover pattern of Nainital lake region and nearby villages. During the 2008-2015 extent of water body in study area has decreased from 2.04 sq. km in 2008 to 1.26 sq. km in 2015 which covers .96% of total study area. The settlement area is showing increasing trend and has increased from 4.35 sq. km in 2008 to 8.36 sq. km in 2015 which accounts for 4.89% of total area of study. The dense forest area has decreased from 27.23 sq. km in 2008 to 23.86 sq. km in 2015 which accounts for 4.10% of total study area. The open forest area is also showing declining trend and it reduced from 43.91% in 2008 to 42.81% in 2015 which accounts for 1.34% of study area. The barren land has been increased from 4.59 sq. km in 2008 to 5.83 sq. km in 2015 which accounts for 1.51% of total study area.

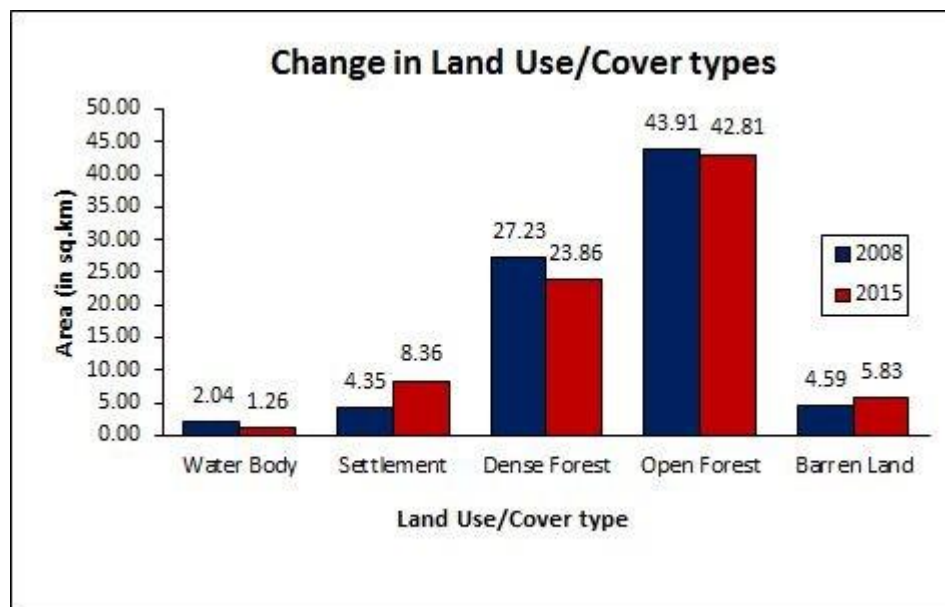


Figure-4: Comparative diagrammatic illustration of Land Use/Cover change in sq. km during last 7 years (2008-2015) in Naini lake region and nearby villages.

Water bodies area has drastically decreased in 2015 from 2008, e.g. Naini lake area has decreased, all the minor water bodies got replaced by settlements, representing the curse of urbanisation (engulfed the core around which they formed). Naini lake is shrinking and its water becoming increasingly murky. The quality of water in the lake, which is the sole source of drinking water for the people of the town, has deteriorated alarmingly. The discharge of sewage into the lake and inappropriate construction activity in the lake's catchment areas are the villains of the piece. Monsoon overflow from the lake passes through the Balia nullah, which empties into the Balia ravine. "The Balia nullah controls the stability of the entire lower portion of the town between the outfall of the lake and the Brewery. The Naini Lake, sitting in the lap of mountains in Nainital, Uttarakhand, is visibly struggling. The water level of the lake has dropped drastically, exposing the lake bed in many areas. There are two reasons that the experts believe are making the lake shrink: obstruction in the subsurface recharge and increased abstraction of water to quench Nainital's thirst. Settlement area has doubled from 2008, indicating the increase in population and encroachment of humans in the surrounding areas of lake.

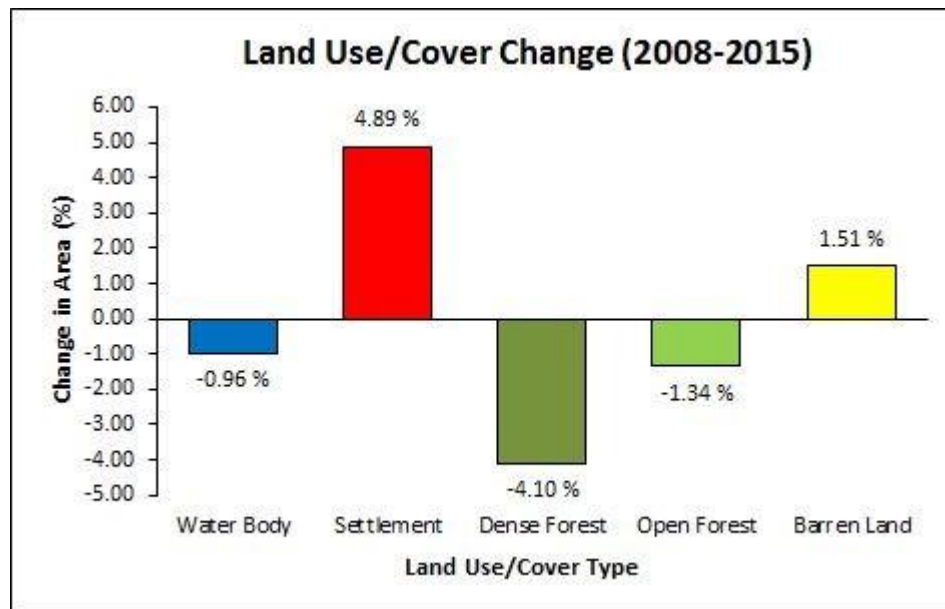


Figure-5: Diagrammatic illustration of Land Use/Cover change in percentage during last 7 years (2008-2015) in Naini lake region and nearby villages.

Settlements have engulfed the water laden areas, pointing towards overexploitation and overuse of natural resources. Increase in population has led to problem of sewerage and solid waste; According to the District Urban Development Agency (DUDA) and Nagar Palika Parishad (NPP), Nainital has 10 main slums scattered across the town, accounting for about 21 per cent of the total population. Many of these slums lie within the catchment area of the lake. Moreover, Nainital does not have sewage treatment facilities. It has to expand its sewer network, and provide decentralised sewage treatment plants (STPs) and on-site

treatment in low density areas. Dense forested areas have decreased from 2008, indicating an infiltration of human beings in the interior parts of forests. Dense forested areas which are hard to penetrate, covers almost 52% area of the region. Open forested areas has marginally decreased from 2008, (53.47- 52.13%). Barren land has increased from 2008, mainly around settlement areas, showing adverse impacts of urbanisation and industrialisation (tourism industry, hotel industry, transport industry). These processes have led to overexploitation, overuse and over extraction of natural resources mainly of water and forest, resulted in conversion of pasture lands to non- pasture lands, decreased fresh water availability, decreased soil quality and several other interlinked impacts.

Conclusion

In recent years, dynamics of land use and land cover pattern has suffered a noticeable change in the Himalayan region. The 'Lake region' in Nainital district of the Kumaon Himalaya has not only seen disruption of hydrological change, devastation of forest and biodiversity but also have affected productivity of rural ecosystem and livelihood security to the rural households particularly marginalized dwellers. Process of land transformation has been very significant mainly because of intensified rate of urbanisation, uncontrolled population growth that is further aggravated by Laminar flow of Government policies to gain the highest level of revenue from Tourism Industry without taking ecosystem into cognizance. The study manifests that process of land transformation has been very crucial and rapid land use changes have recently taken place. On the one hand, There has been a drastic decrease in the proportion of catchment area of water bodies i.e from 2.48 percent in 2008 to 1.53 percent in 2015 while noticeable increase in the concentration of Barren land and settlement area on the other i.e from 5.59 percent to 7.10 percent and from 5.30 percent to 10.18 percent respectively. This sudden increase in the concentration and intensity of barren lands and settlement areas is the product of uncontrolled pace of urbanization, unsystematic ways of formulating developmental policies without taking the environment into cognizance and following un judicious methods and dimensions to ensure profit to the extreme. Rural transformation is not a static rather dynamic phenomena and it can not be stagnated but its long term effect and irregularities while formulating many different actions can be checked properly through rural urban land use planning, consolidated land use policies, a comprehensive climatic vulnerability assessment and mapping of the region, a detailed zone mapping of areas at high risk and a cumulative framework for the conservation of water resources. The Mountain inhabitants have also noticed a serious vulnerability to their abodes, health insecurities and uneven weather phenomena. The recent upheaval in the population standards and introduction of new modes of economic practices have posed a serious threat to the local handicraft industries that had been the identity in the nearby areas of lake region. The quality of life of people, mode of rural economy and societal practices have suffered a revolutionary change rather than evolutionary change because it took place very swiftly and majority of population is unable to cope with this change.

Based on the observations made in the field and interpretations made on the basis of several satellite images using various indicators like NDVI, NDBI and land use/land cover change, the paper throws light on the impact of development on the environment in the Lake Region and its surrounding areas situated in Nainital District of Uttarakhand State. The overall result that came to light is that there is a serious threat to the lake region and areas in its vicinity from an environmental point of view. The modes and approaches of using resources have not only seen a noticeable change but also a greater stress of using resources in a planned and judicious manner has arrived at its forefront. The Process of urbanization, transformations in Settlement pattern and development of the tourism industry need to be regularly checked and addressed to minimize

the extent of environmental instability and ecological imbalance i.e in complementary with the unplanned urbanization and population pressure.

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