Impacts of LULC on Climate Change

Rakesh Kumar Verma
Research Scholar, Department of Civil Engineering, Indian Institute of Technology, Roorkee, India
Email: verma.rakeshmni.983@gmail.com

Abstract
Drastic changes can be observed in LULC (land use and land cover) in the last few decades in the hilly region of Uttarakhand, due to the unexplored potential of its geographical area, resources and human technological prowess. The fate of the this great natural resource and an ecologically sensitive region is getting endangered due to extreme poverty and migration of people, which in turn is leading to unhindered exploitation of the resources without taking into consideration of the natural regeneration and ecological balance. The rapid pace of urbanization can be seen in the hilly towns which are posing a great threat to the ecological balance as the construction of housing, road, dams etc. is causing imbalance in the ecological sustainability of the region. Himalayan ecosystem is a kind of fragile environment which is more susceptible to these land use, land cover changes and its impacts on local climate. For the future prediction of Himalayan ecosystem and its sustainable utilization, it becomes a key importance to know its natural characteristics, its extent and location, predictability, sustainability and limitations of various LULC changes. Increased susceptibility to the LULC changes always provides a platform to the natural disasters and associate damages to the nation. The main feature of concerned are the river basins, snow cover and forest cover.

In this review paper, basically an attainment to associate the LULC changes to the climate change. Over a few decades, significant population growth, human migration, accelerated socioeconomic activities have boosted environmental changes. The climate impacts of these land use and land cover changes can be found in regional, local and global trends in modern atmospheric temperature records and other relevant climatic indicators. It becomes over prime
aim to detect the land use and land cover changes with great accuracy at an appropriate scale and in a timely manner, so we can better understand its impacts on climate and can be able to predict its future responses to climate and measures. National Research Council (NRC 2005) has recommended the broadening of the climate change issue to include LULC change processes as an important climate forcing. Regional climate impacts are also associated with the global climate, so it becomes a tremendous job to assess the regional behavior of climate on the basis of land use and land cover changes.

This review paper attempts to understand the impact of the landuse change and land cover depletion on the climate and ecology of the Himalayan Region.

Keywords
LandUse; Land Cover; Remote sensing and GIS; Change detection GIS techniques; Temperature trends; Response to Climate; Himalayan Region; Climate change

1 Introduction

1.1 Importance and Need of study

The last few decades, Himalayan Region had gone through a variety of land use and land cover changes, led to lots of changes in local climate, and hence the global changes in climate. These climate changes led to seasonal changes, water cycle changes (hydrological cycle change, snow cover change and melting, local and regional temperature change thus the global warming and glacial melting and overflowing of rivers. These changes play a vital role in preparing a platform for the various disasters, floods, cloudburst, GLOF (glacial lake outburst and flooding), desertification, and other regional and global changes. So the analysis and evaluation of various LULC changes and its correlation with the climatic variation, impacts and expected hazard estimation, becomes a very critical task in the present world, especially for a country like India, which is fighting to be counted in developing a group of nations.

The unpredictability of Indian monsoons will increase further if the global rise in temperature is not controlled immediately.
The frequency of extreme wet monsoon, currently witnessed in Uttarakhand and Himachal Pradesh, will also increase substantially. The water situation in river basins, especially that of the Ganga, will become erratic – there will be more runoff, that is more water flowing in the river, but wet seasons will become wet and dry seasons drier. By the 2050s, with a temperature increase of 2°C-2.5°C compared to pre-industrial levels, water for agricultural production in the river basins of the Indus, the Ganges and the Brahmaputra will reduce substantially, impacting the food adequacy for nearly 63 million people (World Bank report: Check global warming to prevent Uttarakhand-like disasters.

The report “Turn down the heat: climate extremes, regional impacts, and the case for resilience” by the World Bank, notes that the water available and flowing in the rivers will increase due to changes in patterns of rainfall and melting of glaciers. However, this is not necessarily an indication of more water availability for water security. The changes will mean more water during the wet season and lesser water than today during dry season. This will require huge investments for storing water for all purposes. “For such basins as the Ganges, another reason to strengthen water management capacities is that hydrological projections for the Indian monsoon region are particularly uncertain because of the inability of most climate models to simulate accurately the Indian monsoon,” states the report indicating that the human capacity to predict Indian monsoons is still abysmally low.

The knowledge of LULC change is instrumental in understanding the positive and negative aspects of change, controlling haphazard growth and degradation of the environment (Vishwa et al, 2013).

1.2 Recent studies and History of LULC change

India has about 6,392,000 ha of natural forest with an estimated deforestation rate of about 1.2% (Rao et al, 2000). The Himalayan region contributes 50% of the gross national forest cover (Maikhuri et al., 2000, Rao et al, 2000).
In central Himalaya (Uttar Pradesh Hill region), natural forests covered about 3,425,000 ha in 1995, with 2,382,000 ha under Reserve forest category, 801,000 ha under Civil Soyam forest category, 236,000 ha under Panchayat forests category and 2000 ha under Private forests category (Singh and Lal, 1995). The area represents a very fragile ecosystem threatened by erosion and landslides during monsoon season. Most parts of the central Himalaya are problematic and as they are geologically unstable with large parts of the geographical area under greater inclinations (Rao et al, 2000).

Land cover refers to the physical state of the land; an assemblage of biotic and abiotic components; a reflection of climate and the geophysical environment. It denotes the natural presence of different land surfaces such as having forests, grasslands, deserts, etc. The term land use refers to different uses of land by humankind. Land use denotes utilization of land by humans for different purposes and activities that may include settlements or built-up areas, agricultural land, pastures, transport and other infrastructure activities. Land cover/land use and its change reflect certain aspects of changing developmental patterns and environmental dimensions in an area. It defines where and what kind of development is influencing the utilization of land. These changes reflect on the relationship between climate conditions, environmental alterations and disaster vulnerability of the area (Turner & Meyer, 1994; Walker and Steffen 1997; Hansen et al. 1998; Bounoua et al. 2002; Fries et al. 2002; Bonan et al. 2004; Chakraborty et al. 2009).

The mountain systems are complex ecological entities endowed with a vast resource base for its populace; they also support livelihood and developmental activities in the adjacent lowland areas. These represent very fragile environments (Price, 1997; Jodha, 2000; Sati, 2006; Government of India, 2010; ICIMOD, 2010) that are highly sensitive to changes in hydrological and climatic aspects. Humankind is the most dominant agent of change in the earth’s environment at all the geographic scales (Turner & Meyer,
1994; Turner, 2001; Lambin et al. 2001; Sarma et al. 2008). Present development in technology and poverty makes it easier to interfere with natural resources and their uses as the wish of mankind. These changes are evidences of creation of a new climate era in the Himalayan region. Increased tourism, vast road network on hill slopes, widening of existing roads and highways, hydroelectric power plants and catchment area changes, deforestation (both planned and unplanned) are the possible regions for disturbing the existing land cover on Himalayan region which to be blame for climatic changes in the Himalayan region (Vishwa et al, 2013). Mountains also represent unique areas for the detection of climate change and the assessment of climate-related impacts. One reason for this is that, as climate changes rapidly with height over relatively short horizontal distances, so do vegetation and hydrology (Whiteman, 2000).

Patterns of tourism have become more diversified, with new activities added to more traditional recreation activities and destinations. As a consequence, even remote natural areas, in particular mountain regions in the Himalayas, the Andes and East Africa, are attracting increasing numbers of tourists, with a parallel boom in the development of tourism infrastructure and construction. This infrastructure is often located in attractive cultural and natural landscapes, often with negative impacts for those landscapes and the sensitive ecosystems that they support (Godde et al, 2000). Tourism is thus both a significant economic driver for many mountain communities, but also an industry capable of adversely affecting the environmental quality of mountains and uplands.

1.3 Advantage and uses of Remote Sensing Data for mapping, analysis and monitoring

The spatial and temporal change patterns of land use were quantified by interpreting remote sensing (RS) data and use a geographical information system (GIS). During the last 33 years, the vegetal cover was altered drastically with increasing population pressure (both human and animal), agricultural activities and industrial wood/raw material extraction activities. The
traditional rain fed agriculture on raising terraces has passed through a process of agricultural intensification, but this in turn reduced crop species diversity. Restriction on agricultural expansion by transferring large parts of vegetated areas to conservation, forestry under government control and unrestrained agricultural expansion on community lands which supported fuel, fodder and manure requirements has resulted in an unbalanced land use. This in turn led to deforestation and environmental degradation (Rao et al, 2000).

Satellite or airborne-based monitoring of the Earth’s surface provides information on the interactions between anthropogenic and environmental phenomena, providing the foundation to use natural resources better (Lu et al., 2004). The derivation of such information increasingly relies on remote sensing technology due to its ability to acquire measurement of land surfaces at various spatial and temporal scales. One of the major approaches to deriving land cover information from remotely sensed images is classification. Numerous classification algorithms have been developed since the first Landsat image was acquired in the early 1970s (Townshend, 1992; Hall et al., 1995). The advent of high spatial resolution satellite imagery and more advanced image processing and GIS technologies has resulted in a switch to the more routine and consistent monitoring and modeling of LULC patterns. Using remote sensing techniques to develop land use classification mapping is a useful and detailed way to improve the selection of areas designed to agricultural, urban and/or industrial areas of a region (Selçuk, 2003).

1.4 LULC change: How it affects climate?

Land cover is a fundamental parameter describing the Earth’s surface. This parameter is a considerable variable that impacts on and links many parts of the human and physical environments (Foody, 2002; Rawat et al, 2012). Accurate monitoring of land cover is a matter of utmost importance in many different fields. On the other hand, land use refers to man’s activities which are directly related to the land (Clawson and Stewart, 1965).
In the last few decades, conversion of grassland, woodland and forest into cropland and pasture has risen dramatically in the tropics (Houghton 1994; Williams 1994). This acceleration has spurred renewed concerns about the role of land-use change in driving losses in biological diversity, soils and their fertility, water quality and air quality. Also, land-use activities are calculated to contribute from 20–75% of all atmospheric emissions of important greenhouse gases (Penner, 1994). These concerns boosted the developing research opportunities in this field, and also raised a requirement of study of regarding the consequences of climate and human being. It is a matter of concern for a very long time that population growth causes the land scarcity and the conversion of forest land because of need of agricultural land and pastures’ development.

1.4.1 Role of Human in LULC change
Land use/cover dynamics are widespread, accelerating and significant process driven by human action and also produce changes that impact humans (Agarwal et al., 2002). Need of socioeconomic growth and environmental related issues and factors associated, influences change in land use/cover. When we talked about the land use and land cover, we look into different perspectives to identify the drivers of land use/cover change, their process and consequences. These changes reflect on the relationship among climate conditions, environmental alterations and disaster vulnerability of the area.

Following are the some man-made changes in LULC in last few decades:

1. Population growth and decline
2. Establishment of road network and widening of existing roads to facilitate tourism in forested and hilly areas
3. Establishment of new hydro-power stations that changes the flow pattern of rivers and affect nearby catchment area and surrounding forest
4. Rehabilitation and settlement of human being in nearby developed area
5. Migration of people, land tenure policies and other policies such as agriculture policy
6. Change in crop pattern, farming and agriculture
7. Industrial development and settlement of new hotels and residences
8. Urbanization and unplanned settlement over river banks

1.4.2 Forest cover change and effects on climate change
Forest ecosystems have important functions from an ecological perspective and provide services that are essential to maintain the life-support system on a local and global scale. Greenhouse gas regulation, water supplies and regulation, nutrient cycling, genetic and species diversity as well as recreation are only some examples of the services that forest ecosystems provide. The forests of Himalaya not only support millions of residents in the region, but also many more people residing in the Indo-Gangetic plains through water cycle regulation (Bruijnzeel and Bremmer, 1989; Hamilton, 1987; Rao et al, 2000). Thus the forest cover modification in any form like deforestation, loss due to forest fires, flooding of forest area, losses due to cultivation area requirements, development of horticulture, establishment of new industries, rehabilitation in forested area, and hydro-power generation, harms the forest ecosystem, thus the global scale changes can be seen in climate such as CO₂ increase thus the increase in temperature cause global warming, mosquito breeding and disease and also change in precipitation patterns.

1.4.3 Snow covers change and effect on climate change
Snow and ice are, for many mountain ranges, a key component of the hydrological cycle, and the seasonal character and the
amount of runoff is closely linked to Cryospheric processes. In addition, because of the sensitivity of mountain glaciers to temperature and precipitation, the behavior of glaciers provides some of the clearest evidence of atmospheric warming and changes in the precipitation regime, both modulated by atmospheric circulation and flow patterns over the past decades (Haeberli and Beniston, 1998; WGMS, 2000). Changes in climate have been shown to result in shifts in seasonal snow pack (Cayan, 1996; Dettinger and Cayan, 1995; Shrestha et al, 1998); glacier melt influences discharge rates and timing in the rivers that originate in the mountains.

The recent reduction of snow and glacier cover in the Himalaya may also be contributing to the higher rates of warming observed in the high-elevation regions of Nepal (e.g., Yamada et al. 1992; Kadota and Ageta 1992; Fujita et al. 1997). A reduction in snow and glacier cover in the high elevation will change the surface albedo of the region, which in turn will increase the surface air temperature, thereby acting as a positive feedback mechanism (e.g., Meehl 1994; Shrestha et al, 1998). The importance of snow and glacier cover variations is manifested by the effect of the Eurasian snow cover variations on the regional climate, mainly in the summer monsoon, as suggested by several empirical as well as model studies (Dey and Bhanu Kumar 1982, 1983; Khandekar 1991).

Studies on long-term variations in surface air temperature for the entire globe (Jones et al. 1986c; Hansen and Lebedeff 1987, 1988) as well as for the hemispheres (Angell and Korshover 1978; Jones et al. 1986a,b; Shrestha et al, 1998) have shown a rising trend during the last few decades. Similar results have been found in low-latitude regions in the Northern Hemisphere. Mountainous environments are considered sensitive indicators of climate change (Barry 1990; Stone 1992; Beniston 1994; Shrestha et al, 1998). Several studies in the Himalayas have found that glaciers in the region have retreated considerably in the last two decades (Higuchi et al. 1980; Miller 1989; Miller and Marston 1989; Yamada et al. 1992; Kadota et al. 1993; Shrestha et al, 1998).
Recent studies have identified the formation and growth of several glacial lakes, possibly due to fast retreat of glaciers, which could lead to catastrophic outburst floods (Vuichard and Zimmermann 1987; Shrestha et al, 1998). It is possible that global warming is responsible for the recent glacial retreat in the Himalayas, although precipitation changes may also be important. However, (Seko and Takahashi, 1991; Shrestha et al, 1998) have suggested that over the last decade, glacier fluctuation in the Khumbu Himal followed the fluctuations in air temperature more than those in precipitation. Mayewski and Jeschke (1979) have suggested that Himalayan glaciers have been retreating since 1850 A.D. It is possible that the cooling in 1940 observed in the global record caused re-advancing of these glaciers, and the warming after the mid-1970s resulted in accelerated shrinking in the past two decades. The Himalaya and Tibetan Plateau play an important role in regional climate, most particularly with respect to monsoon circulation. Links between the monsoon and other global-scale phenomena extend the implications of climatic variations in the Himalaya and in the Tibetan Plateau beyond the regional scale (Dey and Bhanu Kumar 1982, 1983; Barnett et al. 1988; Shrestha et al, 1998). Climatic changes in the Himalayan region could be a reflection of large scale climate changes, or they could even be driving them (Shrestha et al, 1998).

1.4.4 Climate Metrics: To assess the role of LULC change within climate change

LULC change effects must be assessed in detail as part of all future climate change assessments, including the forthcoming IPCC Fifth Assessment, in order for them to be scientifically complete. This includes not only climate effects in the regions where LULC change occurs, but also their role in altering hemispheric and global atmospheric and ocean circulations at large distances from the location of LULC change. We also conclude that a regional focus is much more appropriate in order to better understand the human effects on climate, including LULC change. It is the regional responses, not a global average, that produce drought,
floods, and other societally important climate impacts (Mahmood, et al, 2010).

Therefore, to address these recommendations and to further determine the role of LULC change within the climate system, Mahmood, et al, 2010 recommend, as a start, to assess three new climate metrics:

1) The magnitude of the spatial redistribution of land surface latent and sensible heating (see, e.g., Chase et al, 2000; Pielke et al, 2002). The change in these fluxes in the atmosphere will result in the alteration of a wide variety of climate variables, including the locations of major weather features.

For example, (Takata et al, 2009) demonstrated the major effect of land use change during the period of 1700–1850 on the Asian monsoon. As land cover change accelerated after 1850 and continues into the future, LULC change promises to continue to alter the surface pattern of sensible and latent heat input to the atmosphere.

2) The magnitude of the spatial redistribution of precipitation and moisture convergence (e.g., Pielke and Chase, 2003). In response to LULC change, the boundaries of regions of wet and dry climates can change, thereby affecting the likelihood for floods and drought. This redistribution can occur not only from the alterations in the patterns of surface sensible and latent heat but also from changes in surface albedo and aerodynamic roughness (see, e.g., Pitman et al. 2004; Nair et al. 2007).

3) The normalized gradient of regional radiative heating changes. Because it is the horizontal gradient of layer-averaged temperatures that forces wind circulations, alterations in these temperatures from any human climate forcing will necessarily alter these circulations. In the evaluation of the human climate effect of aerosols, for example, Matsui and Pielke (2006) found that in terms of the gradient of atmospheric radiative heating, the role of human inputs was 60 times greater than the role of the human increase in the well-mixed greenhouse gases. Thus, this aerosol effect has a much more significant role on the climate than is inferred when using global average metrics. We anticipate a similar large effect from LULC change. (Feddema et
al. 2005), for example, have shown that global averages mask the impacts on regional temperature and precipitation changes.

2 Remote sensing techniques and its application

Change detection is the process of identifying differences in the state of an object or phenomenon by observing it at different times. Essentially, it involves the ability to quantify temporal effects using multi temporal data sets. One of the major applications of remotely-sensed data obtained from Earth orbiting satellites is change detection because of repetitive coverage at short intervals and consistent image quality (Anderson, 1977; Nelson, 1983). The digital nature of most of the satellite data make it easily amenable for computer-aided analysis. There is a definite need for a change detector which will automatically correlate and compare two sets of imagery taken of the same area at different times and display the changes and their locations to the interpreter (Shephard, 1964). Remote-sensing change detection, defined by Singh (1989) ‘the process of identifying differences in the state of an object or phenomenon by observing it at different times’, provides a means to study and understand the patterns and processes of ecosystems at a range of geographical and temporal scales. While the knowledge of land-cover conditions at a given point in time is important, the dynamics or trends related to specific change conditions offer unique and often important insights, ranging from natural disaster management to atmospheric pollution dispersion.

3 LULC changes and climate change in hilly regions

The Indian part of Himalayas covering an area about 5 lakh km² (about 16.2% of country’s total geographical area) and forms the northern boundary of the country. The traditional definition of the Himalaya, sensu stricto, is that great range of mountains that separates India, along its north-central and northeastern frontier, from China (Tibet), and extends between latitudes 26°20’ and 35°40’ North, and between longitudes 74°50’ and 95°40’ East.
The Indian Himalayan Region (IHR) is spreading on 10 states (administrative regions) namely, Jammu & Kashmir, Himachal Pradesh, Uttarakhand, Sikkim, Arunachal Pradesh, Meghalaya, Nagaland, Manipur, Mizoram, Tripura, and hill regions of 2 states viz. Assam and West Bengal of Indian Republic. Starting from the foothills in the south (Siwaliks) the region extends to Tibetan plateau in the north (trans-Himalaya) comprising about 95 districts of the country. The region occupies the strategic position of the entire northern boundary (North-West to North-East) of the nation and touches almost all the international borders (7 countries) with India.

It contributes about 16.2% of India’s total geographical area, and most of the area is covered by snow-clad peaks, glaciers of higher Himalaya, dense forest cover of mid-Himalaya. The IHR (Institute for human reproduction) shows a thin and dispersed human population as compared to the national figures due to its physiography condition and poor infrastructure development but the growth rate is much higher than the national average.

The graphical information on IHR database and district maps of Indian Himalaya to depict the distribution of some demographic parameters are available with the ENVIS9 (Environmental information system) Centre at GBPIHED (G.B. Pant Institute of Himalayan Environment and Development). The relevant/subject specific information on the region is also available from the institutes working for the development of this fragile mountain.

3.1 LULC change on hilly region, impacts which led to disasters

Kedarnath and Rudraparayag region of Himalaya is seismically and ecologically very sensitive and delicate, even a minute change (anthropogenic or natural) can create a dangerous disaster. The fragile nature of the oldest crystalline basement of the Himalayan is very sensitive in case of landslides and any disaster (Sharma et al, 2013). The race between tourism industries, population growth, several hydroelectric projects are on the fast track in Uttarakhand district. After the constitution of Uttarakhand as State there is an increment of approx. 141% in populations of Uttarakhand. The development of hotels has
been done at the place of river which was left after the flood or sometimes by changing the path of the rivers. Currently there are 558 hydroelectric power projects are in pipeline those will affect to Bhagirathi (80%) and Alaknanda (65%), (Narayan, 2013, Director, Centre for Science and Environment). Due to the development of roads and Dam in between mountain, the incident of landslides has been inclined. The Rudraprayag district where Kedarnath is situated has already faced the problem of natural disasters 8 times for last 34 years. In the year of 2012 Okhimath area of Rudrapratap as also witnessed unprecedented damage to the life and property, infrastructure and landscape during September 13 to 16 due to torrential rainfall and cloud burst accident (Sharma et al, 2013).

A study by Sharma et al, 2013, is attempting to understand the recent intercession of human being in the nature and their consequences in Kedarnath and Rudraprayag valley using the satellite imagery and GIS approach, they concluded that there was no high signature of Glacier changes in the Chaurabari and Companion, these glaciers are still intact in the valley and only one middle moraine debris has washout by stream due to heavy rainfall. They also illustrated that unplanned settlement over the river bank and natural landscapes caused the temperature increase in the valley and changed the local climate which led to disaster in the valley.

3.2 Climatic changes, temperature trends in hilly region

Recent disasters and human involvement in the creation of LULC changes and thus the climate alteration, it is therefore important to understand the climatic trends in the Himalaya and their relationship with global trends. Unfortunately, the instrumental meteorological records from high elevations [i.e., greater than 4000 m above mean sea level (MSL)] of the Himalaya are relatively short i.e., 5–7 year; (Grabs and Pokhrel, 1992; Shrestha et al, 1998) and therefore provide only limited information on changes in high-elevation climate. Meteorological data from the Tibetan Plateau are also rare.
Studies on climatic trends, therefore, have to rely on records from stations south of the Himalaya or from outside the Tibetan Plateau. A study of the long-term trend in surface air temperatures in India by (Hingane et al. 1985) indicated an increase in mean annual temperature of 0.48°C over the past century. A study of changes in air temperature of Qinghai- Xizang (Tibetan) Plateau showed a decreasing trend from 1950 to 1970 and an increase after 1970 (Li and Tang 1986; Shrestha et al, 1998).

Some of the ongoing changes can be listed below, which are very pronounced in recent period of studies

1. Excessive raining and cloud burst
2. Monsoonal changes and change of precipitation patterns
3. Floods and drought condition, mainly floods are dominant in the Himalayan region
4. Rise in temperature and snow melting effects

3.3 LULC changes and Climate change: How they are linked?

Both LULC changes and its response to climate change are interrelated, both affect each other, drastic changes in land use pattern influence the factors affecting climate change like emission of CO₂, local temperature increase thus the global warming. Increase in temperature caused melting of snow and GLOF condition, thus influence the discharge in rivers, thus the flooding of river banks and nearby area (Floods). Floods change LULC pattern in the area. Increased temperature may cause forest fires, which also changes the LULC pattern, thus adding to the increase in again temperature rise and global changes of climate. Water cycle also changes when LULC pattern changed.

Assessing the impacts of urbanization and land use change on mean surface temperature is a challenging task. Several studies have attempted to assess the effect of urbanization and industrialization on temperature trends (Chung et al. 2004b; De and Prakasa Rao 2004; Gadgil and Dhorde 2005; Kumar et al. 2005; Dash and Hunt 2007; Dhorde et al. 2009; Sajjad et al. 2009; Tigga and Malini 2011; Singh et al, 2013). However, some studies have tried to
establish a link between some of the intense man-made activities in urban industrial areas and temperature trends and found increased size and densities of population, land use/land cover changes, reduction in the fraction of vegetative area exclusive use of fossil fuel combination and emission of waste heat from industries, automobiles and building construction activities (roads, buildings, reservoirs, etc.), excessive use of air conditioning, changing level of aerosols, etc., responsible for such urban–rural contrast in temperature trends (Bounoua et al. 2004; Ohashi et al. 2007; Oleson et al. 2008; Yilmaz et al. 2009; Singh et al, 2013).

Some of the urban locations are becoming increasingly vulnerable to natural hazards related to weather and climate (De and Dandekar 2001). Therefore, the study of urban climate is attracting significant attention in the present world (Catherine and Sue 2006). The studies have found differential rate of change in temperature over urban and rural areas and indicate that the warming tendency is more pronounced in urban areas than the surrounding rural areas (Tayan and Toros 1997; Chung et al. 2004a; Trusilova et al. 2008). Fujibe (2009) demonstrated that urban warming was not only detectable at large cities, but at slightly urbanized sites in Japan. All over the world urban areas are being affected by urban climate change. Increasing temperatures of Dhaka (Alam and Golam Rabbani, 2007), increase of 2°C temperature of Sao Paolo since 1993 (Edmilson et al. 2007), increasing tendencies of Beijing temperatures from 1977–2000 (Liu et al. 2007) and 1.5°C increase in annual mean temperature of Seoul during the last 29 years (Chung et al. 2004a) are the global examples of urban climate change.

Artificially induced climate change and global warming arising from anthropogenic-driven emissions of greenhouse gases and land-use and land cover change have emerged as one of the most important environmental issues among researchers in the last two decades (Kadio˘glu 1997; Arora et al. 2005; Singh et al. 2008). The emission of greenhouse gases has increased considerably since the industrial revolution (1750 onwards), with an increase of 70% between 1970 and 2004 (Singh et al. 2008;
Revadekar et al. 2012). The latest fourth assessment report of the Intergovernmental Panel on Climate Change (IPCC 2007) has concluded that the global mean surface temperatures have risen by $0.74 \pm 0.18 \degree C$ when estimated by a linear trend over the last 100 years (1906–2005). The rate of warming over the recent 50 years is almost double of that over the last 100 years (IPCC influences. Weather records from land stations and ships indicate that the global mean surface temperature has warmed up approximately by $0.6 \pm 0.2 \degree C$ since 1850 and it is expected that, by 2100, the increase in temperature could be $1.4^\circ$–$5.8^\circ C$ (Singh et al. 2008). Moreover, the world has witnessed changes in climatic condition at an unprecedented rate in past few decades. Available records show that the 1990s have been the warmest decade of the millennium in the Northern Hemisphere and 1998 was the warmest year.

4 Discussion

Rawat basically studied the LULC changes, but he gave some of important points. Here it is a very important issue to discuss that which month’s data are more suitable for our study, we have to be more conscious about the weather condition so that maximum utilization of data and more accurate will be the results, hence, The multi-temporal satellite imageries pertain to second week of October when the area is cloud free and snow cover is minimum as a prolonged gap in snowfall results in showing snow-cover only in those areas where it remains throughout the year. Also, the use of imageries of same season reduces the problems caused by changes in vegetation phenology and differential solar inclination that may cause variations in the reflectance values of same ground pixels (Rawat et al, 2013).

The multi-temporal satellite imageries have different spatial resolutions ranging from about 79m for the year 1972 to 23.5m for the year 2005. This does not allow us to obtain detailed and comparable land use classes. Therefore, this analysis is limited to broad land use classes that could be derived from these imageries. The satellite data for this area has certain handicaps and may lead to the incorrect classification as high relief
results in shadow areas and confusion between different land use classes such as barren rocky surfaces, water bodies and settlements (Rawat et al, 2013).

NDVI was calculated to enhance the spectral difference between different objects. The NDVI is based on the formula: \[ \text{NDVI} = \frac{(\text{NIR}-\text{R})}{(\text{NIR}+\text{R})} \] where NIR represents the spectral reflectance of objects in near infrared (0.7-0.8 micrometer) band while R represents the same in the red band (0.6-0.7 micrometer).

The pressure of expanding human activities on available land is reflected in the fact that officially declared notified area under revenue for the district of Kullu is just 10 per cent of the total geographical area, whereas the satellite based LULC classification calculates this to be about 15 per cent. The additional area indicates the encroachment of land onto the natural landscape. This entire expansion has taken place mostly in the lower elevations in the valleys, a lot of it in the vicinity of rivers. This was so, as the most favorable and advantageous locations have been already under occupation. This expansion on the marginal locations has increased vulnerability to disasters such as floods/flash floods (Vishwa et al, 2013). In their study author illustrated that LULC changes are directly or indirectly responsible for natural disasters in Himalayan region and also he evaluated the increased population pressure on natural resources and unplanned settlement over landscape areas which harms directly or indirectly to the Himalayan ecosystem thus the climate. The knowledge of spatial land cover information is essential for proper management, planning and monitoring of natural resources (Zhu, 1997; Agarwal et al, 2010).

Some limiting factors such as socioeconomic and policy forces caused these changes in natural resource management practices and the resulting land use patterns. The study showed that although development interventions such as World Bank aided Integrated Watershed Development Programme, etc., showed promising results in regenerating the resources; the lack of follow-up required after programme withdrawal might cause the deterioration of resources accrued during such regeneration.
activities. Such local impacts need to be considered in national policies and especially when time bound international aid based programs are to be implemented (Rao et al, 2000).

5 Conclusion
Change in LULC and climate change are interrelated, they both affect each other, change in climate modifies land use and land cover and change Land use and cover becomes a reason to change the climate. But human induced changes are very significant in changing the land use and land cover, so both mankind and climate play a drastic role in modification of land use and land cover. Change in local climate creates a way to drastically damages to the nature and humanity in the form of disasters, droughts and forest fires, tsunamis etc. So becomes a very important task to understand the correlation among both LULC change and climate.

Recently, the risk of natural disasters has increased in the area as a result of increasing anthropogenic activities. This trend is likely to increase in the future as the activities like pilgrimage, tourism, etc. will increase Himalayan region. The natural flow paths of the channels get obstructed due to the construction of man-made structures that results in deviation of the flow from its natural course (Dobhal et al, 2013). The knowledge of land use/land cover is instrumental in understanding the positive and negative aspects of change, controlling haphazard growth and degradation of the environment (Vishwa et al, 2013).

References
[3] Agarwal, Shivani; Puri, Kanchan; Areendran, G; Raj, Krishna; Govil, Himanshu; Mazumdar, Sraboni; Muni, Madhushree, 2010. Forest Change analysis of Jim Corbett
National Park, Uttarakhand: A remote sensing and GIS approach. pp. 2, 4, 6


[10] Mahmood, Rezaul; Quintanar, Arturo I.; Conner, Glen; Leeper, Ronnie; Dobler, Scott; Pielke, Roger; Beltran-Przekurat, Adriana; Hubbard, Kenneth G.; Niyogi, Dev; Bonan, Gordon; Lawrence, Peter; Chase, Thomas; McNider, Richard; Wu, Yuling; McAlpine, Clive; Deo, Ravinesh; Etter, Andres; Gameda, Samuel; Qian, Budong; Carleton, Andrew; Adegoke, Jimmy O.; Vezhapparambu, Sajith; Asefi, Salvi; Nair, Udaysankar S.; Sertel, Elif; Legates, David R.; Hale, Robert; Frauenfeld, Oliver W.; Watts, Anthony; Shepherd, Marshall; Mitra, Chandana; Anantharaj, Valentine G.; Fall, Souleymane; Chang, Hsin-I.; Lund, Robert; Treviño, Anna; Blanken, Peter; Du, Jinyang; Syktus, Jozef, 2010. Impacts Of Land Use/Land Cover Change on Climate
and Future Research Priorities. pp. 1, 4, 6, 12-17


[12] Peter, J. bLawrence; Thomas, N. Chase. 2013. *Investigating the Climate Impacts of Global Land Cover Change in the Community Climate System Model (CCSM 3.0)*.


[21] Chung, Y S; Yoon, M B; Kim, H S, 2004. On climate variations and changes observed in South Korea; 
Climatic Change 66 151–161.
