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Research Article

CLIMATIC VARIABILITY AND ITS ECOLOGICAL IMPACTS USING SPACE TECHNOLOGY

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ABSTRACT
Doon valley in Dehradun district is one of the picturesque valley in Asia at the foot hills of the beautiful Himalayan range, whose lofty and young chain present many fascinating and natural scenic formation that have been attracting people of different disciplines and interests. The knowledge of climatic variations of Doon valley is essential as it is an environmentally sensitive area. Doon valley is well known for its pleasant climatic conditions and there seems to be much variability in its climate. The climatic situation has undergone a change as compared to last decade and fluctuations were observed even within 1-5 years gap. The ever changing dynamics with respect to space and time makes it essential to have systematic and updated knowledge. It helps in proper management and regulation of our natural resources. Significance of remote sensing is its ability to provide quick and accurate knowledge of the area. Keeping in view the significance of climate, a study was conducted on its varying trends and scenarios in Doon valley for last two decades (1990-2006) and geospatial database layers have been prepared during which varying facts came into knowledge. With span of time the valley has undergone many changes. Today the rate of climate change is much faster than any time in the past. This is continuously leading to many problems which are likely to increase in coming years. Erratic monsoons, delay of winters, lowering of temperature are some consequences of climate change. It has been observed that forest an important natural resource has also undergone change. Dense forest has converted to open forest and consequently open forest has converted to agricultural fields and scrub lands, as a result temperature variations were also seen in these areas. In these areas NDVI and temperature values were also observed and strong negative correlation was examined in between these two variables for 1990 in comparison to 2006.increasing concentration of NO_2 and SO_2 in the area show damaging effects on plants retarding their photosynthesis activity. As people are dependent on forests for their livelihood, food and medicines, hence any shift or depletion in forests will have serious ecological, environmental and socio-economic consequences.

Keywords: *Climate Change, Ecological Impacts, Remote Sensing & GIS*

INTRODUCTION
Climate is "average" weather for a given place or a region. It defines typical weather conditions for a given area based on long-term averages. Climate is an area's long-term weather patterns. Weather is always changing and climate is the synthesis (combination of all the elements) of weather at a particular place. Some climates have marked changes of weather type during the year. For example monsoonal place has warm, cloudy, wet weather in summer and cooler, sunnier, dry weather in winter. Although an area's climate is always changing, the changes do not usually occur on a time scale that is immediately obvious to us. Climate variability refers to the climatic parameter of a region varying from its long-term mean. With time and geographic location there are changes in the weather condition. Every year in a specific time period, the climate of a location is different. Some years have below average rainfall, some have average or above average rainfall. Variability may result from natural internal processes within the climate system (internal variability) or from variations in natural or anthropogenic external forces (external variability). By understanding, planning for and adapting to a changing climate, individuals and societies can take advantage of opportunities and reduce risks. Understanding climatic variability is important in developing countries where economical activities are largely dependent on the climate. For

example the characteristics of rainfall and high rates of evaporation exert a great influence on man's activities, particularly agriculture and also on water supply for domestic and industrial purposes.

Lamb (1966) has stated that meteorology is being confronted with a demand for climatic forecasting for which no adequate scientific basis yet exists and one of the reports (SMIC Report, 1971) that was required reading for many of the delegations were the study of Man's impact on climate. This report was written by an international group of distinguished scientists the year before. According to Wetherold and Manabe (1975) any mean surface temperature change would correspond to a very much larger temperature change in the Polar Regions. Zhang *et al.,* (1986) reported that there is reduction in rainfall and number of rainy days of local origin (Monsoon rain excluded)from Nilgiris in India and this occur mainly due to forest denudation in the region and conditions of local environment is primarily detrimental for local rains. Doon Valley has also experienced variation in climate from past years. The increase in maximum temperature coupled with increased frequency of extremely high temperatures in the last decades has shown some tendency of warming in the valley and its surroundings (Rawat, 1990). Thus there is an urgent need to systematically record and manage the climatic data and understand its variability. In the present study an attempt has been made to correlate the change in forest density along with temperature using geospatial approach i.e. how temperature varies if forest density varies along with time period.

The main objective of the work is to analyze varying climatic patterns in Doon Valley with the help of parameters like Temperature and Rainfall and to study the ecological impacts of varying climatic patterns in Doon Valley.

Study Area

Garhwal Himalayas are bestowed with incredible beauty of lofty snow clad peaks & verdant valley which are of great attraction for every nature lover sacred rivers; Ganga and Yamuna add natural charm and grandeur to this virgin beauty. Among various ranges which it covers one of them is Siwalik range. In the Siwalik range, a number of longitudinal valleys occur, they are known as duns. One of the largest is the Doon Valley. Doon Valley (Figure I) is located between $77^0 30^1$ to $78^0 20^1$ and latitude $30^0 5^1$ to $30^0 35^1$. It covers an area of approximately 500 Km being 20 Km wide and 76 Km long. The Doon Valley occupies 1,850 Km^2 bounded by the lesser Himalaya outer ridge to the north, the Siwaliks hills to the South, the Yamuna River in the West, and Ganges in the east.

The valley has a great potential for forests, particularly in the lower parts. Several centuries ago it was covered with dense forest, flowing stream but this all have been changed due to growing population fast expanding urban industrial areas and the rapid disappearance of water, has caused great degradation of the environment of the valley. Siwaliks foot hills are predominantly covered with rich vegetation parts of the Southern slope of the Mussoorie hills are also covered with rich forests. Changes in hydro geological & meteorological conditions occur so frequently here and responsible for the growth of various types of forest cover. Lowest slope of Shiwalik provide the best condition of Sal trees (S. robusta) as having large proportion of clay and better drainage and ideal conditions. The soil & climate of the Himalayan belt support subtropical and moist temperate forests of Chir pine (*Pinus roxburghii*), Burans (*Rhododendron arboretum*), Oaks (Quercus Species).

The climate of Doon Valley varies from sub-tropical in the plains to temperate in higher hills. The climate of a place is influenced by a variety of local physical features, as exposure the slope of the land and the vegetation.

MATERIALS AND METHODS

Methodology

For the present study data set used is meteorological data (for the time period of 1990-2006) including rainfall, temperature obtained from meteorological and Satellite data including Landsat TM 1990 October season and Landsat ETM+ November 2006.

Analysis of Climate Data

As both the climatic parameters (Temperature and Rainfall) which have been used in the present study are very important ones especially from ecological point of view where temperature which is used to be consider the most important climatic parameter in a country like India on the other hand the rainfall is second most important climatic parameter after temperature, the increase and decrease in the amount of rainfall greatly affect the other parameters also which directly hits the life.

Results of change in these two climatic parameters for the present study are shown in the form of graphs and tables and describe with relevant discussion.

Forest Density Change

This is well known fact that both temperature and rainfall together are commonly said to determine the type and density of vegetation at different altitudes. In the present study with the help of satellite data a comparison was made for change in forest area of different density classes for both 1990 and 2006 by using NDVI values. NDVI maps have been prepared for both time periods figure II and III and with the help of its values different forest density classes have been delineated table I.

Temperature Map

NDVI values obtained above were also compared with satellite derived temperature values (Landsat TM for 1990 and Landsat ETM+ for 2006) using 6^{th} band (thermal band) as thermal band acquires temperature data and store this information in form of DN numbers, using a two-step process where DN values got converted to degree Kelvin. The first step is to convert DN values to radiance values and second step converts radiance data to degree Kelvin, so temperature values obtained from temperature maps figure IV and V were compared with NDVI values.

RESULTS AND DISSCUSSION

Change Dynamics of Forest Density (1990-2006)

Table 2 clearly indicating that rainfall amount was more in 1990 as compared to 2006 and meanwhile increase in temperature noted for 2006 as compared to 1990. In the table it is shown the area of different high forest density classes of 1990 converted to low forest density classes in 2006. Table clearly depicting that in 2006 due to less rainfall (125.933 mm) and high temperature (21.058^0C) in comparison to 1990 where rainfall was (216.608mm) and temperature (20.325^0 C)was high, most of the high density classes converted to low density and total lost has been observed in their areas. Maximum lost observed where moderately dense forest (in 1990) changed to open forest (2006) and total loss of 2.624 sq kms area observed for this class.

Comparative Analysis of Satellite Observed Temperature and NDVI:

Observing both time data temperature maps figure 4 and figure 5 high temperature values were noticed for 2006 image ranging from 230.60 to 316 Kelvin in comparison to 1990 where values ranged from 205.05 to 306.65 Kelvin.

In the table III it is shown that with variation in forest density classes in 1990 variation also noted in temperature values in 2006 like if a density class in 1990 has high NDVI value and in 2006 low NDVI value noted for the same then high value of temperature noted for the same in 2006 as compared to 1990. From the table 3 this is concluded that there is a negative correlation between NDVI and temperature values as high value of NDVI signifies the presence of good vegetation density and low of poor so forest areas having high NDVI values i.e. high forest density will have low temperature values because of cooling effect of vegetation.

Temperature Rainfall Analysis

Observing the temperature trend of data (obtained from meteorological department) across 1990-2006 it has been observed that average temperature values was almost the same across 1990-2005 i.e. ranging

from 20.325 to 20.825^{0}C except 1997 where a decreased (i.e. 19.075^{0}C) has been noted but in 2006 a sudden rise 21.058^{0}C was observed in comparison to last year (figure VI).

Comparing the seasonal trend of both1990 and 2006 it is noted that in 2006 there was increase in temperature for every month except January, June and September this is because of cooling of atmosphere due to high rainfall in the same months or subsequent months shown in figure VII.

Similarly observing rainfall data variability between 1990-2006 it is noted that if in one year rainfall is more than in next year or next few years low value has been observed can see from dips and rise in graph figure VIII.

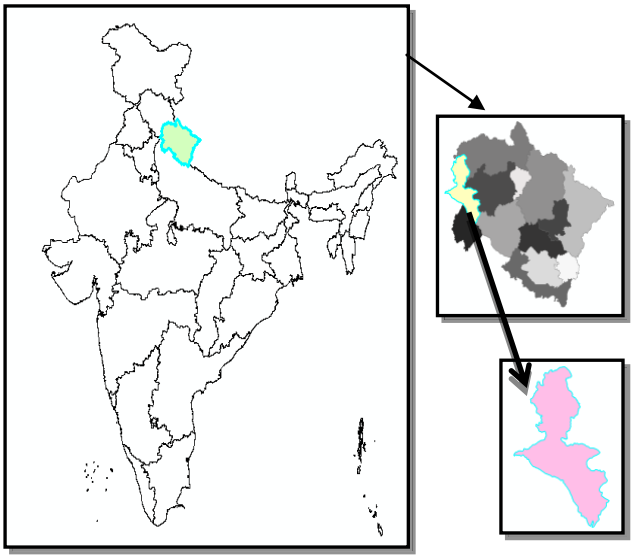

Figure I: Study area of Doon Valley

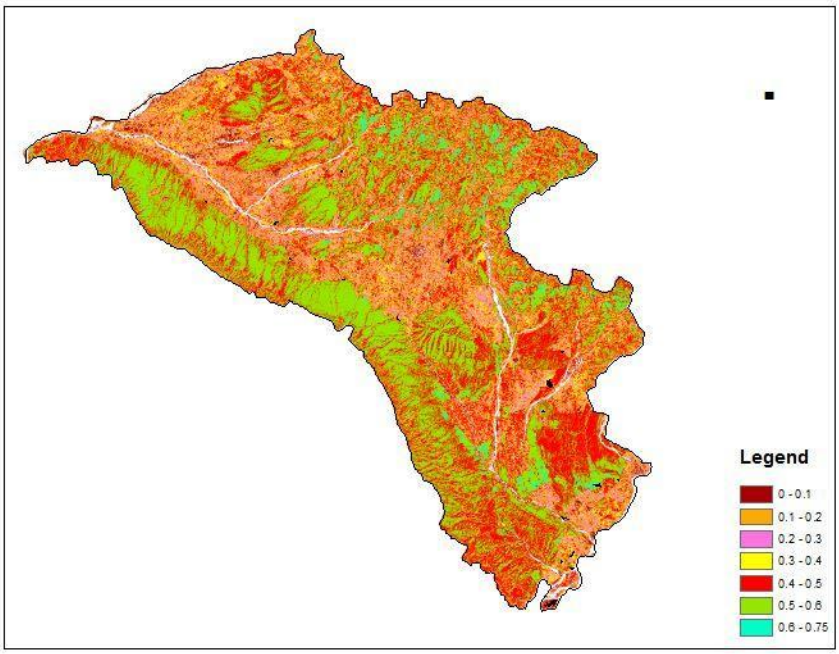

Figure II: NDVI map of 1990

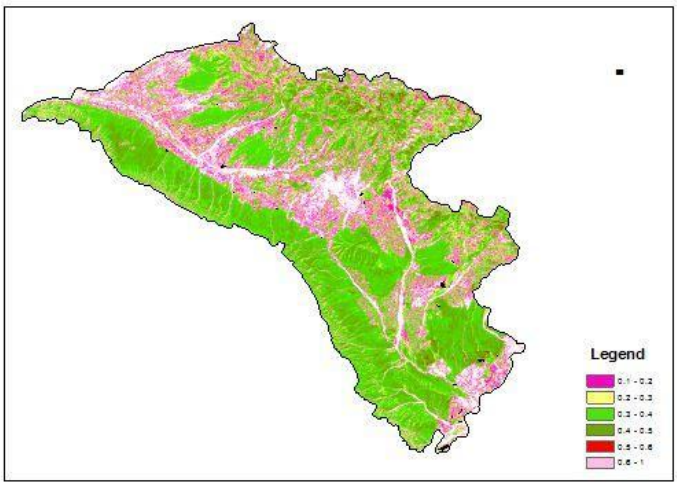

Figure III: NDVI map of 2006

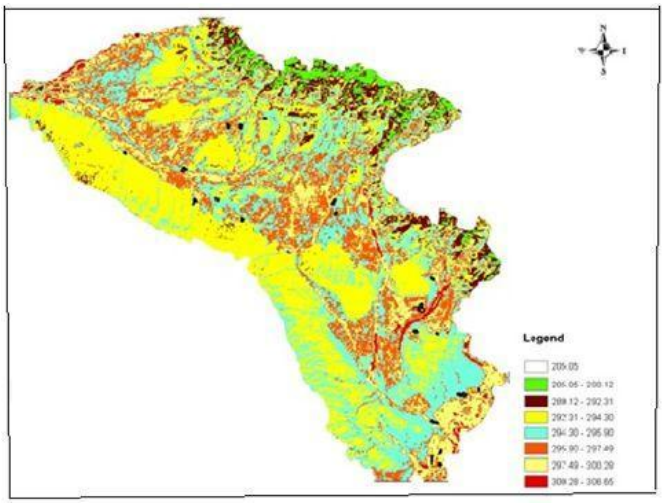

Figure IV: Temperature map of 1990

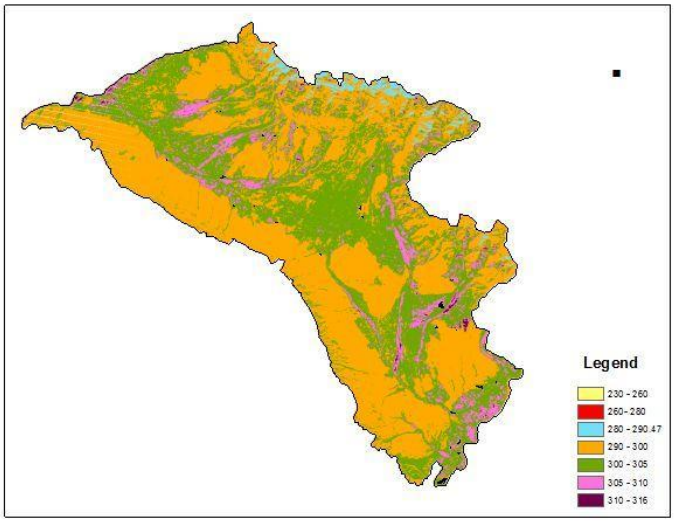

Figure V: Temperature map of 2006

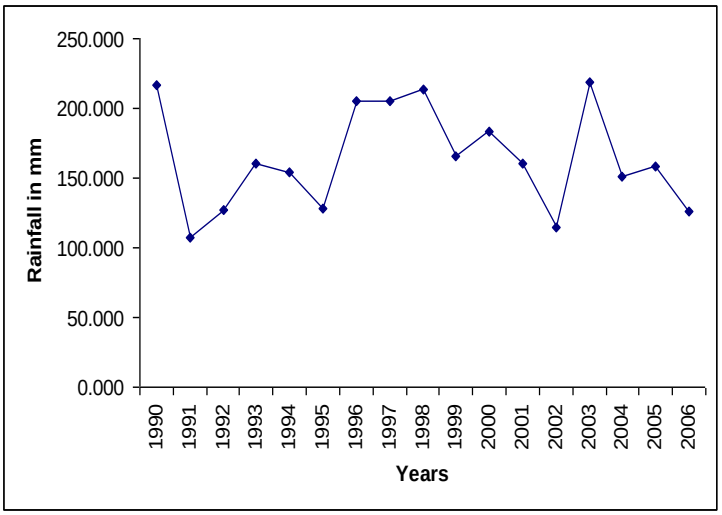

Figure VI: Temperature trend 1990-2006

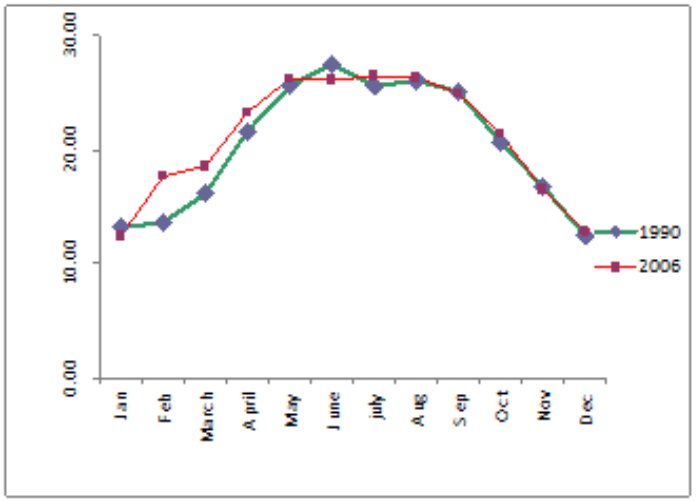

Figure VII: Comparative analysis of temperature trend in 1990 and 2006

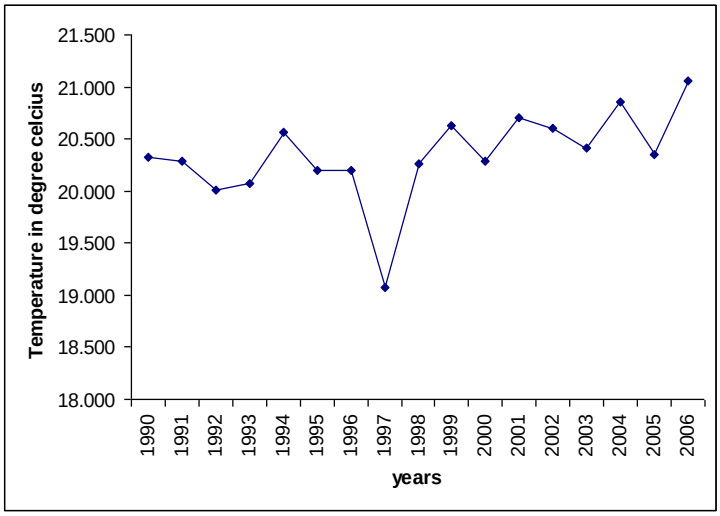

Figure VIII: Rainfall pattern 1990-2006

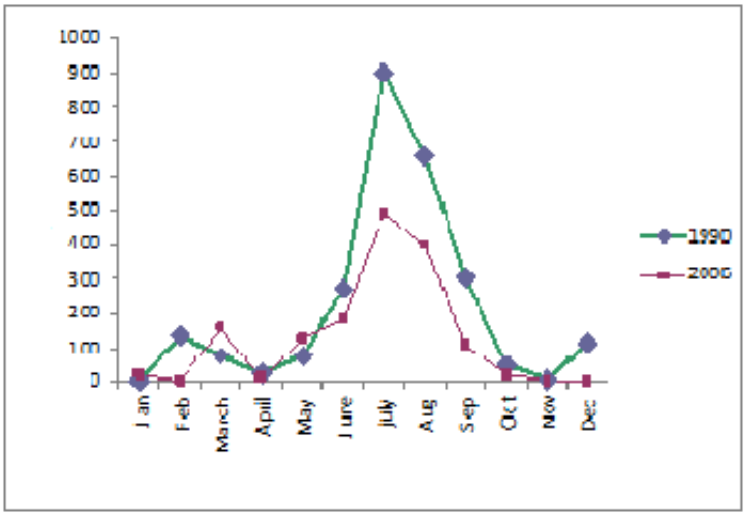

Figure IX: Comparative analysis of Rainfall trend 1990 and 2006

Table I: NDVI classes and vegetation density

NDVI Values	Density Classes
0-0.2	Open Forest
0.2-0.4	Dense Forest
0.4-0.6	Moderately Dense
0.6-0.7	Very Dense

Table II: Change dynamics of Forest Density

Class (Forest Density) 1990	NDVI (1990)	Temperature (1990) Kelvin	2006	NDVI (2006)	Temperature (2006) Kelvin
Moderately dense	0.4-0.6	294-298	Open	0.1-0.3	300-312
Moderately dense	0.4-0.6	294-298	Disappear	<0	300-312
Very Dense	0.6-0.7	292-296	Dense	0.2-0.3	298-304
Very Dense	0.6-0.7	291-296	Moderate	0.3-0.5	293-306
Very Dense	0.6-0.7	291-296	Open	0.1-0.2	296-304

Table III: Comparative analysis of Satellite observed temperature and NDVI

Class (Forest Density) 1990 Rainfall:-216.608 mm Temperature:-20.3250C	2006 Rainfall:-125.933 mm Temperature: - 21.0580C	Area (sq.km)
Moderately dense	Open	3.119
Open	Disappear	0.022
Very dense	Dense	1.65
Very dense	Moderate	0.515
Very dense	Open	0.541

It has also been observed clearly from the temperature and rainfall pattern during 1990 to 2006 that whenever amount of rainfall is less, temperature is high and vice versa. Observing the seasonal rainfall

trend during 1990 and 2006, it was noted that there was some unusual trend of rainfall although in monsoon season. Rainfall was almost half of 1990 period but in January, March, May it was high compared to 1990 figure IX and this resulted in low temperature in the same months in 2006.

Conclusion

It is well known fact that Doon Valley in Dehradun district is one of the picturesque Valley in Asia at the foothills of the beautiful Himalayas range. Having pleasant climate giving the presence of several natural scenic formations, but during last few decades a great variability has been noticed in its climate. The aim of the present study was to analyze that variability in Doon Valley during time period of 1990-2006 and its ecological impacts using geospatial approach. From the study it is concluded that a great variability is there in the pattern of both temperature and rainfall if rainfall is more in one year next year low value has been noticed no fixed pattern is there similarly for temperature also low in one year high in other depending on the rainfall pattern if rain is more temperature is low and vice versa. Due to varying climatic conditions ecology has been affected very much comparing the forest density change maps loss of different high density classes has been noticed for time period of 2006 on comparing it with 1990, and with this loss increase temperature values has been observed for those areas when satellite derived temperature values compared with NDVI values depicting loss of vegetation, biomass resulting increase in carbon concentration in the atmosphere so increase in temperature.

From the present study this can be concluded that as people are dependent on forests for their livelihood, food and medicines, hence any shift or depletion in forests will have serious ecological, environmental and socio-economic consequences. As Doon valley is an environmentally sensitive area so there is a need to protect this so it is essential to

- Conservation of forest, water resources.
- A forestation of denuded land and mineral areas.
- Check the mining and quarrying activities in the valley.
- Strict control over the use of fossil fuels.
- Control over increasing number of vehicles, urbanization, and new industrial set up.

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