



REVIEW OF RESEARCH

ISSN: 2249-894X

IMPACT FACTOR : 5.7631 (UIF)

UGC APPROVED JOURNAL NO. 48514

VOLUME - 8 | ISSUE - 9 | JUNE - 2019



CHANGES IN CLIMATE AND CROPPING PATTERN IN CHAKRATA REGION OF DEHRADUN DISTRICT (UTTARAKHAND HIMALAYA)

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ABSTRACT:

Mountain areas are most important agro-ecosystem supporting human life of all across the globe. Besides, mountains are rich source of biodiversity, possess enormous potential for sustaining agriculture system, including horticulture and animal husbandry. The agriculture system of this mountain region is characterized by high dependence of the people on local resources and locally developed technologies. However, climate change and its impacts have become crucial in Himalayan environment for the survival of the majority of the population. In recent past, the reduction in crop diversity, decline of the traditional crops has been observed. Though there are many reasons of this decline, climate change is considered most important this decline. In this paper a modest attempt is being made to understand the nature of climate and land use changes in study area.



KEYWORDS: agriculture system, including horticulture and animal husbandry.

INTRODUCTION :

Climate, as one of the dominant natural phenomena, has significant influence on human society. The climate not only plays important role in meeting basic necessity of food, it also impacts all their economic, social and cultural activities. The seasonal and regional patterns of climate have shaped the living and livelihood patterns of human society since the beginning of civilization. The climatic conditions had dominant influence in the initial phases of agricultural practices. But development of science and

technology helped human society to some extent overcome some of the limitations imposed by natural conditions including climatic conditions. The symbiotic relationship between climate, as one of the key component of natural systems, and human society began to change with industrialization in 19th century and assumed important dimensions in last century. This relationship has become crucial due to accumulation of greenhouse gases threatening climate change and global warming and surpassing the limits of human

tolerance (Raghunandan, 2010). The increased concentration of greenhouse gases (GHGs) particularly carbon dioxide (CO₂), as a result of massive fossil fuels consumption, use of chlorofluorocarbons (CFCs), deforestation and other land use changes etc, have resulted in increase of earth surface temperature which is considered the primary cause of climate change (Khan, 2013). It has been reported that climate of the earth has warmed by approximately 0.6°C between 1910 and 1945 and from 1976 onward, the rate of warming has been double in

the later period as compared to earlier period (Indian Forester, 2003). The shifting weather patterns are threatening food production, rising sea levels have increased the risk of catastrophic flooding thus making impacts of climate change global in scope and unprecedented in scale (UNEP, 2012).

Uttarakhand Himalaya which is part of Hindukush Himalayan mountain system lacks in long-term and widely representative data about climatic parameters. Given the large climatic and altitudinal variation, the limited numbers of climatological observatories are not sufficient to provide data for different regional units of Uttarakhand. However, the evidences that are available show increase in temperature, decrease in annual rainfall, reduction in rainy days/year, change in rainfall rhythm, increasing trend of drought years, drastic reduction in snow cover, shifting of vegetation lines, reduction in ground water recharge etc (Kumaun University, 2011a). It has also been observed that a shift has taken place in timings of monsoon rains from July/August to August/September, timings of winter rainfall has shifted from December/January to January/February and average winter temperature has changed resulting in early flowering of Rhododendron (UCOST, 2010). Climate change signatures can also be noticed in the form of late arrival of monsoon, long spells of dry winters, increasing frequency of forest fires in winters and early fruiting of native trees (Rawat, 2011).

The issue of climate change has acquired prominence in recent times due to increasing evidence of global warming that has adversely affected the relationship between physical and human environment.

REVIEW OF LITERATURE

The issue of climate change has drawn attention of academics, governments, non-governments organizations, media and common citizen since its impacts have been felt in every sphere of life. While the issue of environment has been discussed in academic circles with reference to sustainable development since 1970s, it gained prominence with the publication of World Commission on Environment and Development Report in 1987 (WCED, 1987). However, more serious concerns regarding environment have been expressed since 1990s with the issues of global warming and climate change dominating the deliberations at global level. The increased concentration of greenhouse gases (GHGs) particularly carbon dioxide (CO₂), as a result of massive fossil fuels consumption, use of chlorofluorocarbons (CFCs), deforestation and other land use changes etc, have resulted in increase of earth surface temperature which is considered the primary cause of climate change. It has been widely acknowledged that anthropogenic activities, more than anything else, have contributed towards concentration of green house gases (GHGs) in earth's atmosphere. It has been scientifically proved that increase in concentration of GHGs has led to 'warming of the earth's surface and atmosphere, threatening to change the climate and impact the entire earth system in an unprecedented manner' (Shukla, et al., 2002). From shifting weather patterns that threaten food production, to rising sea levels that increase the risk of catastrophic flooding, the impacts of climate change are global in scope and unprecedented in scale (UNEP, 2012).

In case of India, there is clear evidence of global warming in 20th century and this is going to accelerate in 21st century (Srinivasan, 2012). It has been reported that 'all India mean annual temperature has shown significant warming trend of 0.05°C/10yr during the period 1901-2003, the recent period 1971-2003 has seen relatively accelerated warming of 0.22°C/10 yr which is unprecedented due to warming during the last decade' (Kothawale and Kumar, 2005).

A study by Dash and Hunt (2007) shows that while maximum temperature has increased by about 0.75°C all over India, it has been rising sharply over North India in last two decades

RESEARCH METHODOLOGY AND DATA COLLECTION

The basis for the selection of the area was primarily its backwardness and heavy dependence on climatic factors for its primary economic activity of agriculture. The second important criterion was the large share of scheduled tribe (56% of total population) and scheduled castes (34% of total population). Thus both the categories add up to 90% of total population, a very significant characteristic with reference to whole of Uttarakhand

The study was primarily aimed to assess the nature of climatic change and the changing cropping pattern in study area. Therefore the data related to these two broad themes have been collected and analysed. Since the region does not have a well recorded climatic data and a properly maintained weather observatory, the long-term climate data collected and analysed in similar geographical locations of other parts of Uttarakhand (e.g. Almora, Nainital, Mussoorie,) have been used to understand general trend of climatic change/variability.

The secondary data on these parameters have been taken from Forest Working Plans, District Statistical Handbook, tehsil and block offices.

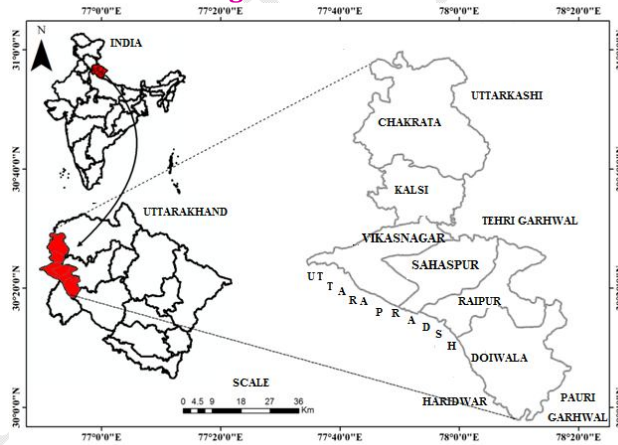
RESEARCH OBJECTIVE

- ❖ To study the nature of climatic change on Agriculture in the study area, and also comprehend the adaptation mechanism of coping strategies adopted by community in response to climatic variability

STUDY AREA

The area selected for the present study is located in western part of Uttarakhand Himalaya which is a part of Central Himalayan region of India. The area comprises Chakrata and Kalsi development blocks of Dehradun district and forms north-western hilly tract of the district (Fig.1). Covering an area of about 1000 kms². It extends from 30°26' North latitude to 31°2' North latitude and from 77°38' East longitude to 78°4' East longitude. Study area is bordered by Uttarkashi and Tehri Garhwal districts of Uttarakhand state in north and east, the valley area of Dehradun in the south and by Sirmaur district of Himachal Pradesh in the west. It is a mountainous tract where altitude ranges from less than 500mts to above 3000mts from mean sea level.

Fig 1: STUDY AREA



Source: ArcGIS9.3 Software

CLIMATE

The climate in Chakrata varies from sub-tropical to temperate as altitude varies from less than 500mts to more than 3000mts in central portion and north-east portion of the study area. Slope directions and relative height have made significant difference in local climatic conditions in the region. The impact of the alignment and height of mountain ranges can be noticed in the rainfall pattern locally as deeper river valleys generally receive less rain as compared to gentle slopes and higher mountain areas.

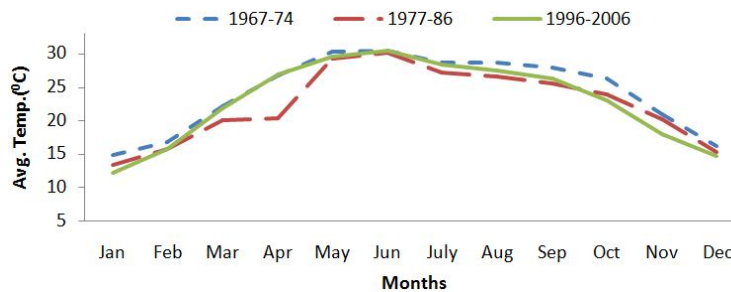
Traditionally the study area has been experiencing three distinct seasons in a year. There are winter season from October to March, the summer season from April to Mid- June and the monsoon season from Mid-June September, respectively. However people have been experiencing shorter winter

season since last decade and half. The October and March months are generally milder than earlier, at the same time summer. Temperature sometimes goes beyond 40°C up to a height of 1600mts but higher areas experience comfortable weather with summer temperature around 30-32°C (Management Plan, 1997a).

TEMPERATURE

The temperature data of Chakrata town was available for continuous 19 years period and in order to understand the trend in average temperature, it was divided in two time periods i.e. 1987-1995 and 1996-2005. The data show that the average temperature was lower in later period (Fig 2). The summer months of April, May and June experience occasional thunderstorms and hail.

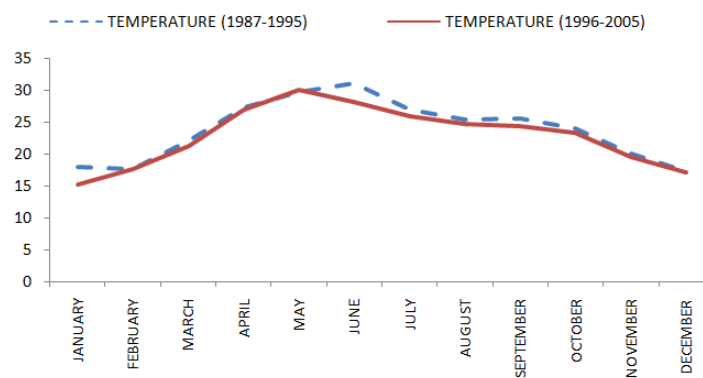
Fig 2 Chakrata : Monthly Average Temperature for different period



Source: Forest Working Plans for different periods Department of Forest, Government of U.P. and Govt of Uttarakhand

The available temperature data for Chakarata reflect a mix trend with regard to maximum and minimum temperatures. For example the data for the period 1987-95 and 1996-2005 show that the average maximum temperature has remained constant whereas the average minimum temperature has been lower during 1996-2005 (Fig.3). But there has been exception during the months of May and August when it has been higher as compared to the earlier period of 1987-2005.

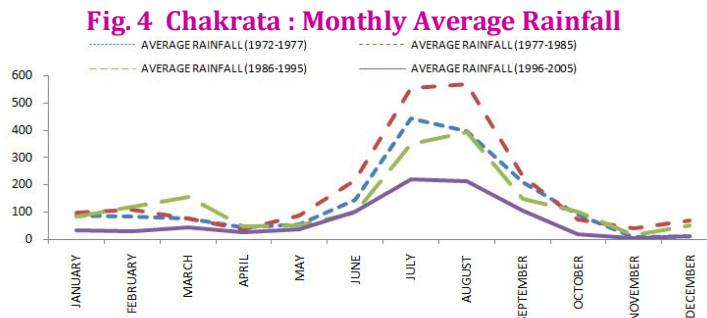
Fig 3 Chakrata : Monthly Average Maximum Temperature



RAINFALL

In case of rainfall, the available data are for longer duration. For example in case of Chakrata, the annual rainfall data are available from 1972 to 2005 and a discernable decreasing trend can be noticed during this period except between 1982 and 1987. The total annual rainfall was registered as 3045mm in 1987 but has consistently decreased thereafter and has been lower than 1200mm after 1991 (Fig.4). The rainfall data was calculated according to months and then classified in four time periods in order to

compare the trend. It emerged that rainfall was generally higher during 1977-1985 but is decreasing in 1986-95 and 1996-2005 (Fig). In case of Chibro where data are available for three different time periods viz. 1967-74, 1977-85 and 1996-2006, the annual rainfall has shown increasing trend from 1981 onward (Fig. 4) but fluctuations can be seen in monthly averages. Thus an indication of significant change in rainfall and marginal variations in temperature based on available limited data can be noticed in the study area.



Source: Forest Working Plans for different periods, Department of Forest, Government of U.P. and Govt. of Uttarakhand

LAND USE

The hill topography, steep slopes, fast runoff of rainfall water and limited availability of good quality soil has confined the agriculture operations to gentle slopes and land stretches along the water channels. According to the latest statistical data of 2013-14, the forests are the most prominent (43.34% of total land use) among all the land use categories. The second most important land use category is that of culturable waste land (32.32%) followed by land under orchards, trees and bushes (6.94%) and the land under net sown area (6.77%). The data of land use of last two decades of Chakrata reveal some other very interesting trends (Table I). The data show that the forest area covered more than 70% of land during 1991-92 and 1998-99 but it declined to 43% in 2011-12. At the same time the land under agricultural waste land category increased tremendously from 3.82% (1991-92) to 8.99% (1998-99) and to 32.38% (2013-14). The data under above two categories look more as the result of classification or the definition of particular category rather than the sudden shift in the actual area of more accurate figures. On the whole the data on land use, in the study area, show that the agriculture area has been declining while agricultural waste land is increasing. There is no significant change in other land use categories.

Table1: Land use Classification (in percentages)

Land use category	1991-92	1998-99	2013-14
Total reported area (in hectares)	96,358	94,569	1,53,348
Area under Forests	74.88	72.24	43.44
Area not available for cultivation	1.57	1.73	2.67
Other Uncultivated land excluding fallow lands	5.31	9.06	44.55
(a) Permanent Pastures & Grazing land	N.A	N.A	5.23
(b) Land under tree crops & groves	1.49	0.07	6.94
(c) Culturable waste	3.82	8.99	32.38
Fallow lands	1.31	1.09	2.97
Net sown area	16.89	15.85	6.77
Area sown more than once as % of Net sown area	43.95	66.86	39.24

Source: Statistical Handbook, District Dehradun for various years from 1983 to 2013, Office of Economics and Statistical Office, Dehradun, Government of Uttarakhand

CROPPING PATTERN

The agricultural activities of Chakrata, as in case of other hill areas, are generally dictated by the local physical conditions. The majority of agricultural land is located on slopes in un-irrigated rain fed areas with small patches situated along river channels. Based on availability of moisture, people practice two crop seasons: the Kharif and the Rabi. The Kharif season starts in June/July with onset of monsoons whereas the duration of Rabi season is November-April. On an average more than 70% of the total cropped area is devoted to growing food grains. Wheat occupies largest share (36%) among all the crops followed by maize (31%), paddy (14%), mandua (12%), pulses (19%), oilseeds (6%) and potato (4%) (Table 2). Paddy and potato are normally grown along water channels and are mostly irrigated whereas a very small portion of wheat crop gets irrigation while all other crops gets water through rains only. Pulses, oilseeds, barley etc are grown in up-slope land parcels. In addition to potato, peas, cabbage, green chilies, onions etc. are other important vegetables grown in study area. On the whole the total area under vegetables was reported to be 3181 hectares in 2014-15.

Table 2: Area under Major Crops (in hectares) 2011-12

Name of the crop	Area covered by the crop (in hectares)	% of net sown area	% of irrigated area of the crop
Paddy	1640	14.16	87.01
Wheat	4201	36.28	10.09
Maize	3591	31.01	-
Mandua	1356	11.71	-
Barley	636	5.49	00.01
Pulses	2165	18.69	00.37
Potato	484	4.18	96.90
Oilseeds	764	6.59	00.02
Total cereals	12932	70.00(% of gross cropped area)	15.00
Total food grains	13486	73.00	18.53

Source: Statistical Handbook, District Dehradun for various years from 1983 to 2013, Office of Economics and Statistical Officer, Dehradun, Government of Uttarakhand

It will be worthwhile to mention that a significant change has taken place in crop types grown in the study area. The data of four time periods as presented in the table 3 below show that area under paddy has decreased from 2102 hectares to 1640 hectares between 1982-83 and 2011-2012. Similarly the wheat area has also decreased from 7245 hectares to 4201 hectares, area under barley has decreased from 2165 hectares to 636 hectares and that of maize, it has decreased from 5865 hectares to 3591 hectares between 1982-83 and 2011-12. . Similarly the wheat area has also decreased from 7245 hectares to 4201 hectares, area under barley has decreased from 2165 hectares to 636 hectares and that of maize, it has decreased from 5865 hectares to 3591 hectares between 1982-83 and 2011-12. The area under mandua (finger millet) and jhangora (foxtail millet) for which data are available for only two time periods, also show drastic decrease. On the other hand, the area under oilseeds and pulses has increased whereas it has shown fluctuation for potato. It is to be noted that the decrease or increase in area has a constant trend except few exception. The trends amply show that the farmers are replacing traditional cereal crops by oilseeds and pulses which bring better economic returns.

Table 3 - Area under Main Crops in Different Periods (in hectares)

Name of crop	1982-83	1991-92	1999-2000	2011-2012
Paddy	2102	1961	2101	1640
Wheat	7245	6668	5512	4201
Barley	2165	2300	1138	424
Maize	5856	4757	4382	3591
Mandua	N.A.	N.A.	2209	1356
Jhangora	N.A.	N.A.	785	367
Oilseeds	121	363	988	764
Pulses	640	495	954	2165
Potao	899	1116	1178	484

Source: Statistical Handbook, District Dehradun for various years from 1983 to 2013, Office of Economics and Statistical Officer, Dehradun, Government of Uttarakhand

RESEARCH FINDINGS

Some of the research findings are as follows

- ❖ The maximum and minimum temperature analysis of study area showed that the minimum temperature is increasing at annual, kharif and rabi season time scale.
- ❖ The rate of increase of minimum temperature during rabi is much higher than Kharif. The maximum temperature showed increasing trends in annual kharif and rabi time scale but very sharp rise was observed from the year 2000 onwards.
- ❖ Significant negative rainfall trends were observed in Chakrata region.
- ❖ The data on land use show that the agriculture area has been declining while agricultural waste land is increasing. There is no significant change in other land use categories.
- ❖ The trends amply show that the farmers are replacing traditional cereal crops by oilseeds and pulses which bring better economic returns.

CONCLUSIONS

It has been reported that the climate change is generally associated with increasing greenhouse gases and human induced aerosols and the imbalance between them may lead to uncertainly even in year-to-year monsoon behavior over India. From the study, it is clear that the impacts of changes in temperature and rainfall are being taken care by the farmers by changing crops. From the agriculture point of view, effect of extreme weather events on crops are to be documented on regional scale so that it will be handy to planners to mitigate their ill effect. Also there is need to guide farmers on projected impacts of climate change and sensitize them on probable mitigation and adaptation option to minimize the risk in agricultural sector.

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