ISSN 2349-6193
Impact Factor (PIF): 2.243

IJESMR

International Journal OF Engineering Sciences & Management Research

IMPACT OF CLIMATE CHANGE ON PRECIPITATION PATTERN IN KINNAUR DISTRICT, HIMACHAL PRADESH, INDIA.

Vinay Kumar Pandey* & Ajai Mishra
[1]GIPL, Orbit Plaza, New Prabhadevi road, Prabhadevi, Mumbai-400025, Maharastra, India.
[2] Department of Geology, University of Lucknow, Lucknow-226007, U.P., India
*e-mail: vinay78pandey@gmail.com

Keywords: Climate Change, Precipitation, Wet & dry period, Hydro-meteorological disasters, Flash flood/flood.

ABSTRACT

Climate change is a major challenge facing our planet today and pattern of global warming will be more pronounced at high altitude zones, especially those in the tropics and subtropics upto 3 to 5 times faster warming than the rest of world. Continuing climate change is predicted to lead to major changes in the precipitation pattern that affecting the river flows, groundwater recharge, natural hazards, and the ecosystem, as well as to people and their livelihoods. Most part of Kinnaur comes under cold desert with high mountainous area, ranging in altitude from 2,320 to 6,816 meters (7,612 to 22,362 ft), covered with snow. Any variation in precipitation would affect the climate of Kinnaur. Change in precipitation pattern in Himalayan has considerable impact on environment and ecosystem. The river and adjoin grassland and forest ecosystems would be severally affected by the change in the precipitation pattern. It also increase the chances of hydro-meteorological disaster flash flood, Avalanche, flood, Glacier lake outburst flood (GLOF), changing vegetation pattern, shifting of snowline etc. For know the impact of climate change on precipitation pattern, we studied 100 year precipitation (year 1914 – 2013) data of Kinnaur and concluded that there is series of wet and dry period for 25 year & studied of average precipitation for 50 years indicated that average precipitation has been increases since year 1964. Above data also indicated that next 20-25 years will be wet period for Kinnaur and chances of hydro-meteorological disaster will be increased.

INTRODUCTION

Climate change is a major challenge facing our planet toady and some of the best evidence such as melting glaciers comes from mountain areas. Continuing climate change is predicted to lead to major changes in the strength and timing of the Asian monsoon, inner Asian high pressure systems, and winter westerlies – the main systems affecting the climate of the Himalayan region. The impacts on river flows, groundwater recharge, natural hazards, and the ecosystem, as well as on people and their livelihoods, could be dramatic, although not the same in terms of rate, intensity, or direction in all parts of the region[1] . A substantial portion of the annual precipitation falls as snow, particularly at high altitudes (above 3000m) feeding the Himalayan glaciers. The high Himalayan and inner Asian ranges have the most highly glaciated areas outside the polar regions[2] -[3].

Rising global temperature may have triggered large scale changes in the energy exchange processes (radiative forcings), affecting the atmospheric circulation and the global precipitation patterns[4] -[6]. Effects will not be limited to changes in precipitation. Global warming reduces snow cover, melts away glaciers, and degrades permafrost[7] .

There are evidences to indicate that Himalayas are warming at the higher rate than the global average rate[8] -[9] and its impact are studied by many scientist[3],[10] -[24]. Warming will be significant in arid regions of Asia and the Himalayan highlands, including the Tibetan Plateau[25] -[26]. The Indian Institute of Tropical Meteorology, Pune has reported a decrease in precipitation over 68 per cent of India's area over the last century[21]. The precipitation received in an area is an important factor in determining the amount of water available to meet various demands, such as agricultural, industrial, domestic water supply and for hydroelectric power generation. Global climate changes may influence long-term precipitation patterns impacting the availability of water, along with the danger of increasing occurrences of droughts and floods. The southwest (SW) monsoon, which brings about 80% of the total precipitation over the country, is critical for the availability of freshwater for drinking and irrigation. Changes in climate over the Indian region, particularly the SW monsoon, would have a significant impact on agricultural production, water resources management and overall economy of the country.

The state of Himachal Pradesh has experienced a variation in precipitation pattern and large number of incidences of flood since 1971. Though the state has also faced severe flood disaster in 1975 and 1988 but the last decade (1997-

ISSN 2349-6193
Impact Factor (PIF): 2.243

IJESMR

International Journal OF Engineering Sciences & Management Research

2005) has proved one of the worst decades as both the magnitude and frequency of floods has gone up[27]. In view of the above, a number of studies have attempted to investigate the trend of climatic variables for the country. These studies have looked at the trends on the country scale, regional scales and at the individual stations. This article gives an exhaustive coverage of the precipitation variation in Kinnaur district from last 100 years from 1914 to 2013, its future trend in Kinnaur district, Himachal Pradesh.

METHEDOLOGY

Change in precipitation pattern in Himalayan has considerable impact on environment and ecosystem. The river and adjoin grassland and forest ecosystems would be severally affected by the change in the precipitation pattern. It also increase the chances of hydro-meteorological disaster flash flood, Avalanche, flood, Glacier lake outburst flood (GLOF), changing vegetation pattern, shifting of snowline etc. To know the impact of climate change on precipitation variation in Kinnaur district in last 100 years from 1914 to 2013, we collected precipitation data from Indian Water Portal, India Meteorological department and Himachal Pradesh Statistical book 2010-2011. After that calculated average precipitation variation for each five year, twenty five years, fifty years and one hundred years.

STUDY AREA

Kinnaur is located between 77°45' and 70° 00'35" East longitude and 31°05'50" to 32° 05'15" north latitude and bounded by Tibet and Uttaranchal on the east, Shimla district in south-west, Kullu and Lahaul-Spiti district in the north-west, about 235 km from the state capital, Shimla. District headquarter is located at Reckong Peo. The district is divided into three administrative sub-division- Pooh, Kalpa and Nichar. It has five Tehsils namely Pooh, Moorang, Kalpa, Sangla and Nichar and one Sub-Tehsil i.e. Hangrang[28], [29].

Kinnaur situated in Trans Himalayan Zone of Himalayas having high mountain ranges, altitude from 1600 m to 6816 m; considered to be a sedimentary wedge between colliding plate margins of Indian and Asian plates and having deep narrow valleys/gorges of River Satluj and its numerous tributaries, having their origin in the glaciated ridge. Kinnaur has three high mountains ranges, namely, Zanskar, Himalayas and Dhauldhar that enclose valleys of Sutlej, Spiti, Baspa and their tributaries. In the regional overview, the Kinnaur district occupies a position as harbinger between the Kumaon and Punjab Himalaya with Satluj river forming the divide[30]. The rock types, vary from highly metamorphosed schists and gneisses to shale and sandstone ranging in age from Middle Pre-Cambrain to Cretaceous. Rocks exposed in Upper Satluj Valley belong to Vaikrita and Haimantha Groups ranging in age from Middle - Late Proterozoic to Lower-Middle Cambrian.

The district Kinnaur is upstream to the dividing line between climatic zones I and III of northern India. Zone I, the Tropical Monsoon climate, extends from the Indian Ocean, north as far as Wangtoo, with its effects altered by elevation and topography. The tropical monsoon climate involves an annual rainfall in excess of 1000 mm, occurring mostly in the months of June to October. Climatic Zone III, the Arid Mountain Climate, is affecting the Tibetan and western China Plateau, is characteristically cold and dry in winter, and hot and dry in summer. This is strongly modified by the topography of the region.

Winters are severe with heavy snowfall causing Glaciers and Avalanches. Summers are mild with the rainy season in most of the Kapla and Nichar Sub-Divisions of the district. Pooh Sub-Division of this district forms part of 'Indian Cold Desert' and receives scanty rainfall as it falls in rain-shadow zone of the Himalaya. Satluj is the main river of Kinnaur district.

The unique Geo-tectonic, Geological, Geomorphologic and Climatic conditions of the district take it vulnerable/susceptible to various kinds of natural hazards/disasters which have been compounded by increasing human interventions with the nature. Probability of Cloudburst, flood/flash flood and landslide in Kinnaur district is very high.

RESULT AND DISCUSSION

Precipitation in the North Western Himalaya occurs under the influence of westerly disturbances during the months from October to May and due to the southwest monsoon from July to September. Different parts of the region experience varied climatic conditions. The extreme eastern part with little vegetative cover near Tibet experiences a cold dry climate with limited precipitation, both in the form of rain and snow. The western part is endowed with comparatively moist weather with moderate precipitation (snow and rain), evergreen to semi-evergreen forest cover

ISSN 2349-6193
Impact Factor (PIF): 2.243

IJESMR

International Journal OF Engineering Sciences & Management Research

with many rivers and valleys. Depending upon the altitude, different ranges in the North Western Himalaya receive different amounts of snowfall ranging from about 100 to >1600 cm. Most part of Kinnaur comes under cold desert with high mountainous area, ranging in altitude from 2,320 to 6,816 meters (7,612 to 22,362 ft), covered with snow. Any variation in precipitation would affect the climate of Kinnaur. Available studies suggest, an increase in the frequency of high intensity rainfall from last few years [32]- [33]. In many areas, a greater proportion of total precipitation appears to be falling as rain than before. As a result, snowmelt begins earlier and winter is shorter; this affects river regimes, natural hazards, water supplies, and people's livelihoods and infrastructure, particularly in basins such as the Tarim, which is dependent upon glacial melt in summer.

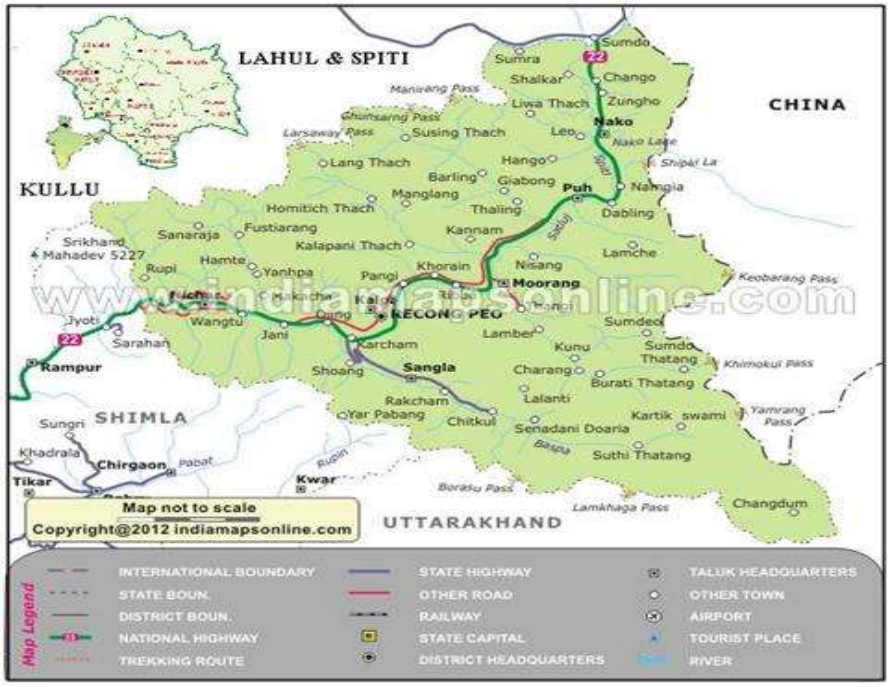

Fig 1.: Political map of Kinnaur district[31].

According to Rabindranath[24] (2008), the rainfall is projected to increase during June to Sept. This may lead to increased occurrence of floods and flow in to rivers and dams and have significant impact on food production, water and forests.

To knowing the precipitation pattern in Kinnaur district, we have arrange precipitation data year wise and calculated average precipitation for 5 years, 25 years, 50 years and for last 100 years, given in table 1 and shown in figure 2:

Table 1: Average Precipitation from year 1914 to 2013, Kinnaur district, H.P. [34]- [36]

Time (5 year interval)	5 year mean Precipitation (in mm)	25 year mean Precipitation (in mm)	50 year mean Precipitation (in mm)	100 year mean Precipitation (in mm)
1914- 1918	1086.76	1011.87	976.23	978.96
1919-1923	955.65			
1924-1928	991.49			
1929- 1933	963.91			
1934-1938	1061.52			
1939-1943	858.45	940.59		
1944- 1948	944.25			
1949-1953	986.35			
1954-1958	1013.47			
1959- 1963	900.45			

ISSN 2349-6193
Impact Factor (PIF): 2.243

IJESMR

International Journal OF Engineering Sciences & Management Research

1964-1968	809.66	1006.96	981.69	
1969-1973	1006.48			
1974- 1978	1186.07			
1979-1983	950.85			
1984-1988	1081.70			
1989- 1993	822.93	956.42		
1994-1998	1001.58			
1999-2003	741.6			
2004- 2008	1455.78			
2009-2013	760.22			

Table number 1 shows that average yearly precipitation for the year 1914 to 2013 is 978.96 mm and for 25 years interval average precipitation are 1011.87 mm for year 1914 to 1938 , 940.59 mm for year 1939 to 1963, 1006.96 mm for year 1964 to 1988 and 956.42 mm for year 1989 to 2013. It shows wet period (high precipitation from 100 years average) for year 1914-1938 & year 1964- 1988 and dry period (Less precipitation from 100 years average) for year 1939-1963 & year 1989-2013. The average precipitation for 50 years, first 50 years (year 1914 to 1963) showing 976.23 mm and second 50 years (year 1964 -2013) 981.69 mm precipitation and indicates that average precipitation has been increased in second 50 years.

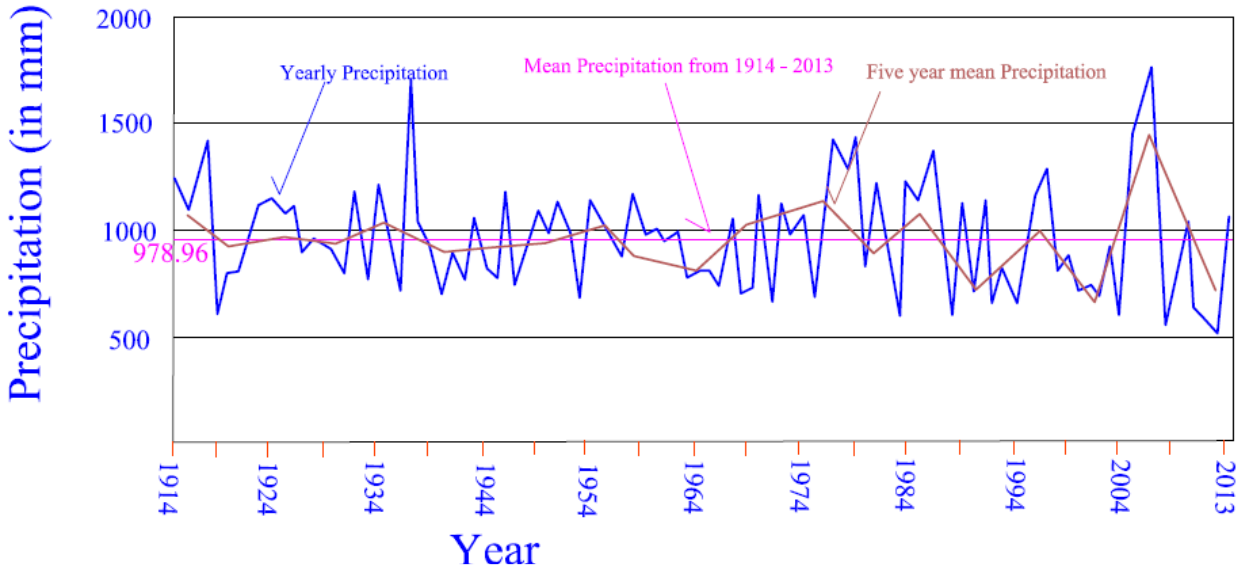

Fig 2: Year wise graphical presentation of precipitation data from year 1914 to 2013.

Impact of Precipitate pattern on Environment

The earlier studies by Pant and Kumar[37] (1997) using the data series of Parthasarathy et. Al. [38] (1994) also found the similar results of 30 alternate sequence of dry and wet period for Indian precipitation patter.

Following the above result, precipitation pattern showing that further 20 -25 years would be wet period in Kinnaur district, which increase the water flow in river and its tributries. Nominal change in precipitation pattern will give high impact on environment and society due to weak geological & topographical condition; will increase chances of hydro-meoteorological disaster such as flash flood, Cloudburst, flood, landslide, avalanche, hailstorn, extrem snowfall.

High precipitation pattern increased the water availabilty in water bodies and would be benificial for hydro-electric project. There will be positive impact on vegetation. Local pepole will also be get benefites through tourism, agriculture and infrastructure activities related to water.

CONCLUSION

From the above study, it concluded that precipitation following the 25 year cycle of wet and dry period. From year 1914 to 1938, high precipitation after that from year 1940 to 1963, dry period again from year 1964 to 1988 wet period

ISSN 2349-6193
Impact Factor (PIF): 2.243

IJESMR

International Journal OF Engineering Sciences & Management Research

and from year 1989 to 2013 dry period. So it may be next 20-25 year will be wet period (high precipitation) and from the average precipitation for 50 years, year 1964 to 2013 shows high precipitation compared to year 1914 to 1963. This result also indicates increasing in precipitation. May be climate change is behind the increase in precipitation in this area.

Due to increase in precipitation, socio-economic impact would be beneficial due to development of water related activities and tourism. There may be increase in hydro-meteorological disasters events and affect society in form of economical loss as well as casualties. So we have to prepared take preparatory measures.

REFERNCES

[1] Eriksson, Mats; Jianchu, Xu; Shrestha, A. B,; Vaidya, R.A.; Nepal, Santosh; Sandstrom, Kals. The Changing Himalayas- Impact of climate change on water resources and livelihoods in the Greater Himalayas. Perspectives on water and climate change adaptation. ICIMOD, 2009, pp 1-22.

[2] Owen, L. A., Finkel, R. C., & Caffee, M. W. A note on the extent of glaciation throughout the Himalaya during the global last glacial maximum Quaternary Science Reviews 21, 2002, pp147–157.

[3] Dyurgerov, MB. and Meier MF. Glaciers and the Changing Earth System: A 2004 Snapshot. Institute of Arctic and Alpine Research, Occasional paper, 2005, 58.

[4] Fallot JM, Barry RG, Hoogstrate D. Variation of mean cold season temperature, precipitation and Snow depths during the last 100 years in the former depths during the last 100 years in the former Soviet Union (FSU). Hydrological Science Journal 42, 1997, 301–327.

[5] Zhai P, Sun A, Ren F, Xiaonin L, Gao B, Zhang Q. Changes in climate extreme in China. Climate Change 42, 1999, 203–218.

[6] Beniston M. Climatic change in mountainous regions: a review of possible impacts. . Climate Change, 59. 2003, 5–31.

[7] Bavay M, Lehning M, Jonas T, and Löwe. Simulations of future snow cover and discharge in Alpine headwater catchments. Hydrological Processes 23(1), 2009, pp. 95-108.

[8] IPCC: Climate Change. The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, 2007a.

[9] Du, M. Y., Kawashima, S., Yonemura, S., Zhang, X. Z., & Chen, S. B. Mutual influence between human activities and climate change in the tibetan plateau during recent years. Global and Planetary, 41, 2004, 241–249.

[10] Holeman, J.N. Sediment Yield of Major Rivers of the World: Rivers and Lakes of Xizang (Tibet). Science Press, Bejjing, 1984.

[11] Singh, J.S. & S.P. Singh. Forests of Himalaya. Gyanoday Prakashan , Nainital, India, 1992.

[12] Ageta, Y. & T. Kadota. Predictions of changes of glacier mass balance in the Nepal 36 K. Higuchi Himalaya and Tibetan Plateau: a case study of air temperature increase for three glaciers. Annal. Of Glaciology, 16, 1992, 89-94.

[13] Zobel, D.B. & S.P Singh.Forests of Himalaya: their contribution to ecological generalizations. Bioscience 47, 1997, 735-745.

[14] Yamada, T. Monitoring of glacier lake and its outburst floods in Nepal Himalaya. Japanese Society of Snow and Ice, Monograph No. 1, 1998, Tokyo.

[15] Fujita, K.; Kadota, T.; Rana, B.; Kayastha, RB. & Ageta, Y. Shrinkage of Glacier AX010 in Shorong region, Nepal Himalayas in the 1990s. Bull. Glaciology Reserach18, 2001, 51–54.

[16] Singh, P., & Bengtsson, L. Hydrological sensitivity of a large Himalayan basin to climate change. Hydrological Processes, 18, 2004, 2363–2385.

ISSN 2349-6193
Impact Factor (PIF): 2.243

IJESMR

International Journal OF Engineering Sciences & Management Research

[17] Beniston M. The risks associated with climatic change in mountain regions. In: Huber U., Bugmann H. and Reasoner M. (eds) Global change and mountain regions: an overview of current knowledge. Springer, Dordrecht, 2005, pp 511-520.

[18] Hewitt, K. The Karakoram anomaly? Glacier expansion and the 'elevation effects' Karakoram Himalaya. Mountain Research and Development, 25(4), 2005, pp 332–340.

[19] Phillips M. Avalanche defense strategies and monitoring of two sites in mountain permafrost terrain. Pontresina, eastern Swiss Alps. Natural Hazards, 39, 2006, 353-379.

[20] Singh S.P. Climate change an overview. Fifteenth national symposium on environment (NSE-15). Mitigation of pollutants for Clean environment BARC Macmillan India Ltd. Mumbai, 2007, pp 24-29.

[21] Kumar, R., A. K. Shai, K. Krishna Kumar, S. K. Patwardhan, P. K. Mishra, J. V. Rewadhar, K. Kamal & G. B. Pant. High resolution climate change scenario for India for the 21st century. Current Science 90, 2006, pp 334-345.

[22] Kumar, V., Singh, P., & Singh, V. Snow and glacier melt contribution in the Beas River at Pandoh Dam, Himachal Pradesh, India. Hydrology Sciences- Journal Des Sciences Hydrologiques. 52(2), 2007.

[23] Kumar, K., S. Joshi & V. Joshi. Climate variability, vulnerability, and coping mechanism in Alaknanda catchment, Central Himalaya, India. AMBIO 37, 2008, pp 286-291.

[24] Rabindranath, NH. Climate Change & Himachal Pradesh: Impacts, Adaptation & Mitigation. Shimla, Himachal Pradesh, India, 2008.

[25] Gao, X. J., Li, D. L., Zhao, Z. C., & Giorgi, F. Climate change due to greenhouse effects in Qinghai-Xizang Plateau and along the Qianghai- Tibet Railway. Plateau Meteoro, 22(5), 2003, pp 458–463.

[26] Yao, T., Li, Z., Thompson, L. G., Mosley-Thompson, E., Wang, Y.Tian, L., Wang, N., and Duan, K. 18O records from Tibetan ice cores reveal differences in climatic changes. Ann. Glaciol. 43, 2006, pp 1–7.

[27] Sharma D.D. Flood and Flash Flood in Himachal Pradesh: A Geographical Analysis. NIDM -National Institute of Disaster Management, Govt Of India, New Delhi, 2006.

[28] Department of Economics & Statistics (DoES), Govt of Himachal Pradesh. Baseline Survey on Assessment of Existing knowledge level, Awareness & Preventive Practices of Disaster Management in Himachal Pradesh, Shimla., 2012, pp 3-6.

[29] Department of Economics & Statistics, Govt of Himachal Pradesh. Statistical outline of Himachal Pradesh 2012-13, Shimla,

[30] Bassi U.K. Final Report on the Geology of the Kinnaur district, Himachal Pradesh (Compilation). Unpubl. GSU Report, 1988.

[31] Location and River map of Himachal Pradesh. http://www.mapsofindia.com/maps/ himachalpradesh/rivers. , 2013.

[32] Chalise, S. R., & Khanal, N. R. An introduction to climate, hydrology and landslide hazards in the hindu kush-himalayan region. Landslide Hazard Mitigation in the Hindu Kush-Himalayas, Kathmandu. ICIMOD, 2001, pp 51–62.

[33] ICIMOD. Flash Flood Hotspot Mapping in Hindu Kush-Himalayan Region ICIMOD. International Journal of Climatology 20, 2007, pp 1729-1742.

[34]Kinnaur Precipitation data from year 1914-2002; Indian water Portal. http://indiawaterportal.org/met_data/

[35] Kinnaur Precipitation data from year 2003-2010. Himachal Pradesh Statistical book 2010-2011.

ISSN 2349-6193
Impact Factor (PIF): 2.243

IJESMR

International Journal OF Engineering Sciences & Management Research

[36] Kinnaur Precipitation data From Year 2011-2013--- http://www.imd.gov.in/section/hydro /distrainfall/webrain/hp/kinnaur.txt

[37] Pant, G.B. & Rupa Kumar, K. Climates of South Asia. John Wiley & Sons, Chichester, 1997, 320.

[38] Parthasarathy, B., Munot A and Kothawale D.R. All India monthly and seasonal rainfall series 1887-1993. Theoretical and Applied Climatology, 49, 1994, 217-224.

	Dr Vinay Kumar Pandey, Doctorate in Geology, has more than ten year experience in Engineering Geology, Environmental Geology and Exploration works. He has published 9 papers in national and international journals & one book on Climate Change and Hydrometerological disaster.
	Dr Ajai Mishra is Professor in the Department of Geology, University of Lucknow, India. His specialization is on the Geo-morphology, Glaciology, Remote Sensing and Environment Geology. He has published about 40 research papers in national and international Journals & twelve Ph.D. thesis awarded under his supervision & one book.