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VARIATION OF PRECIPITATION AND TEMPERATURE FOR DACHIGAM AND TEILBAL CATCHMENTS

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Abstract: The study was an attempt to analyze the variation of precipitation in the Dachigam and Teilbal catchments of Srinagar. The precipitation and temperature data were obtained from the metrological station of SKUAST-K, Shalimar. Trend lines were established with the help of the moving averages of 5 years; which revealed that with the increasing temperature, precipitation decreased. The trend is in accordance with the global climatic and hydrological findings. The study concluded that there was an adverse effect of the climate change on the given catchments.

Keywords: climate change; temperature; precipitation; catchments; trend

Introduction:

The long term change in the statistical distribution of weather patterns over periods of time that range from decades to millions of years is termed as climate change. Climate change may be limited to a specific region or occur globally. Recently, in the context of environmental policy, climate change usually refers to changes in modern climate. It may be qualified as anthropogenic climate change, more generally known as global warming or anthropogenic global warming i.e. due to human interference in the natural balance. The rise of carbon dioxide and other greenhouse gases has led to changes in hydrological cycle such as increasing atmospheric water vapour content, increasing evaporation, changing precipitation patterns intensity and extremes; reduced snow cover; and changes in soil moisture and runoff (Huntington, 2006). The frequency of heavy precipitation events has increased over most areas. There have been significant decreases in water storage in mountain glaciers and northern hemisphere snow cover. Shifts in the amplitude and timing of runoff in glaciers and snowmelt fed rivers and ice related phenomena in the rivers and lakes have been observed. Due to continuous increase in the temperatures, glaciers and ice caps are projected to lose mass due to summer melting. A simulation study on glaciers has predicted a volume loss of 60% of these glaciers by 2050 (Schneeberger et al. 2003). IPCC (Technical paper 4, 2018) has concluded that the dry area has more than doubled since 1970.

Kashmir has witnessed a changing climate over the decades on the same lines as the whole world. The precipitation over the years has decreased and the temperatures increased. Also the rainfall distribution in the seasons has drastically changed. The state is rich in fresh water resources making it vulnerable to climate change as there are abundant evidences that fresh water resources have potential to be strongly impacted by the climate change with wide ranging consequences for humans. The study was taken as a small initiative on this front. The major catchments of world famous Dal Lake, Dachigam and Teilbal were taken up for the study and the impact assessment due to temperature on the catchments was done. To investigate the impact of climate change data of about 20 years was collected and analyzed.

Previous Studies:

A thorough research on the previous works undertaken related to the present study was done. This was an essential part of the project work, as it laid the foundation for the selection of the most appropriate approach by which the stated objectives could be achieved. The literature compiled includes those regarding the climate change due to global warming and the reciprocal effects on the hydrological balances of the water reservoirs and their catchments. Thiaml and Singh (2001) revealed that the temperature analysis indicated that the climate changed from around the mid-1960s throughout the Casamance River basin. The temperature increase would increase evaporation and exacerbate salinity in the basin. New (2002) predicted the increases in CO_2 to raise global and regional temperatures, and produce changes in other climate variables that drive the terrestrial hydrological cycle, most notably precipitation and potential evaporation. Archer (2003) mentioned that summer runoff on the high altitude glacier-fed catchments is positively correlated with summer temperatures. He suggested a 17% increase in summer runoff for Shyok for 1°C temperature rise. However, runoff and temperature are negatively correlated on middle altitude snow-fed catchments.

Pratap, et al. (2003) evaluated depletion of snow covered area (SCA) using mean air temperature. Because depletion of snow is cumulative effect of climatic conditions in an around snow cover area, the cumulative mean temperature (CMT) at a nearby station should represent depletion of SCA. The study was carried out on Satluj basin (22,305 km^2) located in the western Himalayan region. It was found that the depletion of SCA is exponentially correlated with CTM (R^2>0.98). An increase in temperature by 20C enhanced the melting area of snow over the melt season by 5.1%. Choi (2004) reviewed the recent studies addressing the hydrological impacts, especially on stream flow, of climatic change and/or urbanization. Xu, et al. (2004) investigated the plausible association between climate change and the variability of water resources in the Tarim River basin, west China. The long-term trend of the hydrological time series including temperature, precipitation, and streamflow were detected using both parametric and nonparametric techniques.

Jhajharia, et al. (2005) studied climate variation over Agartala and Tripura using monthly data for last 48 years from 1953-2000. The linear trends in various meteorological parameters were obtained using five-years moving average method. The results of this study suggest falling trends in the rainfall, wind speed and sunshine duration. The rising trend was also observed for relative humidity, mean temperature and pan evapo-transpiration. Kim (2005) examined the effects of increased atmospheric CO_2 on the frequency of extreme hydrologic events in the Western United States (WUS) for the 10-yr period of 2040-2049 using dynamically downscaled regional climate change signals. Kumar et al. (2005) deduced that with rapid growing population and improving living standards, the pressure on our water resources is increasing and per capita availability of water resources is reducing day by day. Due to spatial and temporal variability in precipitation, the country faces the problem of flood and drought syndrome. Singh et al. (2006) studied a glaciarized Himalayan basin. The results indicated that for the study basin, runoff increased linearly with increase in temperature and rainfall. For the temperature rise of 2^0C, the increase in summer stream flow was computed to be about 28 %. Changes in rainfall by 10% resulted in corresponding changes in stream flow by 3.5%. Dar et al. (2007) assessed the impact of land use change on stream flow in the famous Dal Lake catchment, in J&K, India. A grid based water quality and quantity assessment model was used to assess the stream flow within the Dal Lake catchment. The model developed allows land use planners to interactively simulate and assess the environmental effects of various land use changes.

Study Area:

The catchment of Dal Lake was taken as the study area which is located in the state of J&K. The state of Jammu & Kashmir is situated in the north western Himalayan region lying between 270 17' to 370 N latitude and 74018' to 80023' E longitude. The Kashmir valley comprises the temperate zone of the state and covers a total of 1.6 Mha. The region is endowed with abundant precipitation, intense solar radiation and favorable temperature and above all fresh water lakes, wetlands, and tarns. Both Dachigam and Teilbal comprise of an area of 234.17 sq. km. The study area is located among high mountains of the mighty western Himalayas. The variation in altitude is vast, ranging from 5500 feet to 14000 feet above mean sea level.

Dachigam is the largest catchment and drains via the Dachigam Nallah and the Telbal Nallah, the latter being the main stream flowing into Dal Lake and is the main carrier of silt load into the Lake. The valley catchment begins above the vegetation line in the Himalayan foothills at an elevation of 4500 m and has very steep sides, characteristic of the region. The Nallah is a steep, fast flowing boulder bed stream. At the outlet of the catchment the Dachigam Nallah flow is diverted to the irrigation canals in Telbal, the Harwan Reservoir (irrigation water storage) and the water treatment plant at Harwan. The balance continues to flow down the Nallah, which is then called the Telbal Nallah. At times of flood when the Nallah is carrying a large silt load the reservoir is by-passed.

Telbal catchment discharges into the Dal Lake via the Telbal and a number of other small streams. The catchment begins in the foothills which being south facing has been denuded by burning off and over-grazing. From the base of the steep hills to the Lake the gently sloping ground is extensively used for paddy fields which are dissected by a system of irrigation canals.

Data:

The data required for the catchment areas was obtained from Agronomy Division of SKUAST-Kashmir, Shalimar Campus. The other data required of the physical features of the catchment was taken from LAWDA and Soil Conservation Department, Magarmalbagh.

The catchment area has dramatic climatic diversity. The mean annual temperature is about 13.15^{o}C. Average maximum and minimum temperatures are 19.7^{o}C and 7.6^{o}C respectively. The month of July was observed to be hottest with mean monthly temperature of 23.38^{o}C and January was the coldest month with mean monthly temperature of 2.14^{o}C.

March and April have the highest precipitation in these catchments. Mean annual rainfall was computed as 784.4 mm. The precipitation in the form of snowfall is also common in the months of December to February.

Table 1: Temperature Data and Annual Precipitation for the Catchment

Year	Mean Annual Temperature (^{o}C)	Annual Precipitation (mm)
1990	13.84664	13.84664
1991	12.08208	12.08208
1992	12.4743	12.4743

1993	12.78144	12.78144
1994	13.04577	13.04577
1995	12.31222	12.31222
1996	12.41649	12.41649
1997	12.44153	12.44153
1998	13.09498	13.09498
1999	13.81557	13.81557
2000	13.78304	13.78304
2001	13.97486	13.97486
2002	13.37055	13.37055
2003	13.03089	13.03089
2004	13.59383	13.59383
2005	12.80018	12.80018
2006	13.61672	13.61672
2007	13.62471	13.62471
2008	13.31292	13.31292
2009	13.26458	13.26458
2010	13.45922	13.45922

Discussion:

The data for the temperature and precipitation in the catchment from 1990-2010 is given in Table1. The data was analysed using 5-year moving averages. The trend test was done on the set of organized data to assess the variation of precipitation with the temperature in the given region.

Table 2: Temperature Data for the Catchment

Year	**Mean Annual Temperature (^oC)**	**Annual Precipitation (mm)**	**Moving Average (5 year) for mean Annual temperature**	**Moving Average (5 year) for mean Annual precipitation**
1990	13.84664	13.84664	-	-
1991	12.08208	12.08208	-	-
1992	12.4743	12.4743	12.84605	946.34
1993	12.78144	12.78144	12.53916	979.16
1994	13.04577	13.04577	12.60604	1052.88
1995	12.31222	12.31222	12.59949	984.92
1996	12.41649	12.41649	12.6622	940.86
1997	12.44153	12.44153	12.81616	815.06
1998	13.09498	13.09498	13.11032	680.54
1999	13.81557	13.81557	13.422	561.54
2000	13.78304	13.78304	13.6078	542.64
2001	13.97486	13.97486	13.59498	574.64
2002	13.37055	13.37055	13.55063	622.48
2003	13.03089	13.03089	13.35406	701.3
2004	13.59383	13.59383	13.28243	806.76
2005	12.80018	12.80018	13.33327	797.7
2006	13.61672	13.61672	13.38967	769.16
2007	13.62471	13.62471	13.32382	754.8
2008	13.31292	13.31292	13.45563	738.88
2009	13.26458	13.26458	-	-
2010	13.45922	13.45922	-	-

The analysis of temperature data was done by plotting it against time for 1990-2010. The rising trend was observed in the mean annual air temperature over the catchment at the rate of 0.058^{o}C per year. An annual mean global warming of 0.4 to 0.8^{o}C has been reported since the late nineteenth century (IPCC, 1998). Pant and Kumar (1997) reported the rise in the seasonal and the annual surface temperature over India at the rate of 0.57^{o}C per century using the data for 1881-1997. Similarly, precipitation was plotted against time. A falling trend was observed in the rainfall at the rate of 16.78 mm per year. The decreasing trend in the rainfall was in line with the findings of the IPCC report, as per which at the regional scale both increases and decreases are projected (IPCC, 2001). A decreasing trend of about 2% per year in the precipitation was observed over the past 20 years over the given catchment.

Conclusion:

The study is an indication of the global warming effects on the critical catchments. The major catchment area of Dal Lake comprising of Dachigam and Teilbal were chosen as the area of study. Data was obtained from LAWDA, Soil Conservation Department and SKUAST-Kashmir. A rising rate was observed in the temperature of the catchment at the rate of 0.058oC and a falling trend in the precipitation at the rate of 2% was observed. The trends were compared with the IPCC reports and were found in accordance with these. The study is an indication of the worst outcomes of the changing climates.

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