IMPACT OF CLIMATE CHANGE ON SPRING SEASON IN THE NORTH-WESTERN HIMALAYAS: A STUDY OF KASHMIR VALLEY, INDIA (1901-2000)

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ABSTRACT

The global climate change is a serious challenge confronting humankind. Contemporary research insights reveal a general rise in mean surface temperature at global, regional and local levels. Studies carried out in Indian context also testify the prevalence of a warming trend. The valley of Kashmir lying in the lap of North Western Himalayas, with a delicate and fragile ecosystem is greatly influenced by these climatic fluctuations. The present study attempts to find out the impact of climate change on the variability of precipitation and temperature in the spring season of Kashmir Valley from 1901-2000. Spring is ecologically an important season in the Kashmir Valley. Being the flowering as well as the sowing season in the region, it has got tremendous ecological and socio-economic significance as it influences the production of agriculture and horticulture in the region. The study reveals that spring season has experienced an increase of 1.0 ^{o}C in mean maximum temperature and 0.5 ^{o}C in the mean minimum temperature which has the potential to trigger the early melting of glaciers in the region. The analysis of precipitation data reveals that spring rainfall has significantly increased, registering an increase of 50 mm, which translates in to an increase of 20 % from 1901-2000. On one hand Increased spring temperature has pre-poned flowering phenology of important horticulture crops like apple and almond in the Kashmir valley, on the other hand increased precipitation accompanied by prolonged wet and cloudy spells has badly affected the pollination of various fruit crops and reduced their production. The abnormal increase in the temperature of winter and spring seasons in the valley has serious economic and ecological repercussions, including effects on flowering pheonology, scarcity of water, dwindling agricultural productivity and changes in cropping and disease patterns in the study area.

Key words: Fragile Ecosystem, Warming Trend, Precipitation Regime, Glacial Recession, Flowering phenology, Cropping Pattern.

I. INTRODUCTION

Mountains occupy approximately 20% of the land area of the globe and are present across the continents and are usually characterized by sensitive-ecosystems, facing extreme weather events. These are the regions of conflicting interests between economic development and environmental conservation (Beniston et al,). At the same time, mountains contain ecosystems that are quite sensitive and highly vulnerable to natural risks, disasters, and ecosystem changes, be it through the occurrence of rapid mass movements, such as landslides, or via slow land degradation due to human activities, with all the attendant socioeconomic consequences (Ives, 1992). The Himalayas also referred as the abode of snow is also called as the third pole. It contains the third largest body of snow on earth after the Antarctic and Arctic regions. Almost 9% area of the Himalaya is covered with glaciers, with 30-40% additional area being covered with snow. (Navdanya, 2009).

The Himalayan region; teaming with specie richness holds tremendous ecological significance as it contains two out of the three biodiversity hot spots of India. Climate change concerns in the Himalayas are multidimensional-encompassing floods, droughts, landslides human health, biodiversity, agriculture livelihood, and food security (Xu et al., 2009). Various studies have confirmed that temperature data in the Himalayas overwhelmingly shows a warming trend, albeit at different rates in different periods depending on the regions and seasons. In another study carried out on western Indian Himalayas by Dash et al. (2007) a 0.9 °C rise was observed over 102 years (1901-2003) . Studies carried out by Shrestha et al. (1999) indicate that the Nepalese Himalaya also saw a warming trend in the last century between 0.4 and 0.9 °C/decade in the mean maximum temperature across different ecological belts. Tse-ring et al., (2010) in their study noticed that, in Bhutan, average temperature registered an increase of 0.5 °C in the non-monsoon season from 1985-2002.

In another study, Bhutiyani et. al. (2010) observed a statistically significant declining trend (at 5% significance level) in monsoon and average precipitation in the northwest Indian Himalayas during 1866-2006. Kashmir valley which lies in the North-Western Himalayas also exhibit the impact of global environmental changes as has been reported by a number of studies. In a study carried out by Guhathakurta and Rajeevan (2008) a significant declining trend in winter rainfall was observed in Jammu & Kashmir and Uttarakhand during 1901-2003.

II. STUDY AREA

The Valley of Kashmir is nestled in the north-western folds of Himalayas. The mountain ranges rise to height of about 5550 m in the north-east and dip down to a height of 2770 m in South. The valley of Kashmir stretches between (32°.22'/ to 34° 43'/) north latitude to 73° 52'/-75° 42'/ east longitudes (Hussain, 1987). The physical limits of the beautiful valley of Kashmir coincide with the drainage basin of Jhelum River. Kashmir is a Meso-geographical region with an area of 15948 square kilometers. Its south and south west border is formed by Pir Panjal range whereas the great Himalayan and north Kashmir ranges make its North and North-Eastern boundary, thus cutting it off from the frost bitten plateau of Ladakh. The altitude of the valley varies between 1500 to 1880 m above sea level.

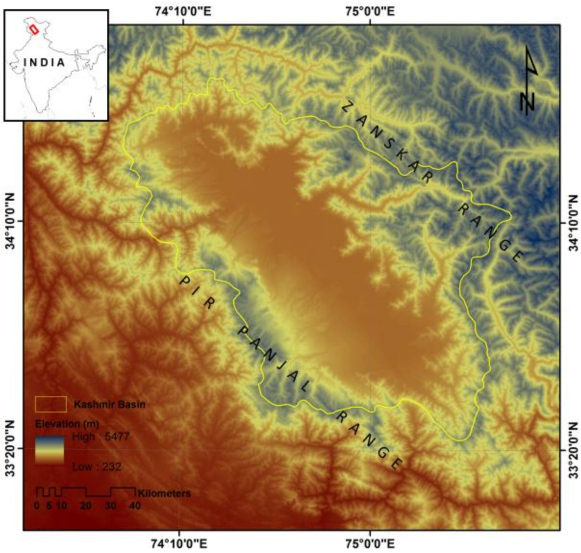

Figure 1: The Study area (Kashmir Valley)

III.DATA BASE AND METHODOLOGY

The present study is based on the secondary sources of data pertaining to various climatic variables (precipitation and temperature). Meteorological data from the authentic sources like Indian Meteorological Research Centre Pune, and National Data centre Pune and Regional Meteorological Centre, Srinagar J&K has been used. Trend analysis and Mann Kendall Test have been used to draw inferences and conclusions.

IV. RESULTS AND DISCUSSION

Kashmir valley has got a Sub-Mediterranean type of climate with relatively dry summers and wet winter. Summers are moderate and winters are long and cold. On account of altitude there is lot of variation within the Kashmir valley between valley floor and hilly areas. Almost absence of Monsoon is another peculiar feature of the climate of Kashmir Valley.

Srinagar is located in the central Kashmir in the vicinity of Zabarwan Hills, having an altitude of 1580-1590 m ASL. It is the only station in the Valley with available climatic record from 1901. Keeping in view altitudinal and locational aspects of Srinagar Meteorological Station it has been taken as the representative of the entire Valley of Kashmir. Time series analysis reveals that, there has been a decent increasing trend at Srinagar in the mean maximum temperature during the 20th century. It has registered an increase of 0.6^{o}C from 1901-2000. The annual mean minimum temperature has also registered a robust increasing trend, with an overall increase of 0.8 ^{o}C during the same period.

Having a look at the climatic scenario of Kashmir Valley in the 20th century it becomes clear that like most of the other Himalayan Hill Stations, the Valley has witnessed a significant warming trend in the mean maximum and mean minimum temperature. However contrary to the rest of the Western and Central Himalayan region where precipitation has registered a significant decline, the Valley of Kashmir has witnessed a marginal

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increasing trend in precipitation during the study period.

Mann Kendall Test and Linear Regression confirm the prevalence of an increasing trend in mean maximum temperature with a confidence level of 95%. Students T Test confirms that the increasing trend in mean maximum temperature is not significant. Mann Kendall Test and Linear Regression also confirm the prevalence of an increasing trend in mean minimum temperature with a confidence level of 99%. Students T Test also confirms the increasing trend in mean maximum temperature significant at 95% confidence level. In case of precipitation Mann Kendall Test confirm that no significant trend is witnessed which is evident from table number (1.0)

Table 1.0: Mann Kendall Test Statistics of Srinagar Station

Variable	Test	Test stat.	a=0.1	a=0.05	a=0.01	Results
Mean max. Temp.	Mann-Kendall	1.969	1.645	1.96	2.576	S(0.05)
	Student's T	-0.28	1.663	1.987	2.632	NS
Mean min. Temp.	Mann-Kendall	4.131	1.645	1.96	2.576	S(0.01)
	Student's T	-2.63	1.663	1.987	2.632	S (0.05)
Rainfall	Mann-Kendall	1.325	1.645	1.96	2.576	NS

Source: Compiled from Meteorological Data (1901-2000)

From the seasonal analysis of the data it becomes clear that despite an overall increase in mean maximum temperature, its implications vary across the seasons in Kashmir Valley. Winter and spring seasons are the worst affected by the warming trend with an approximate increase of around 1°C during 20th century. Autumn season has also registered an increase of 0.5°C in the mean maximum temperature. On the other hand summer season has experienced a decline of 0.1°C in the mean maximum temperature. The mean minimum temperature of the spring season has also registered an increase of 0.5 °C. The results of Trend Analysis of mean maximum and mean minimum temperature at Srinagar Kashmir are presented in the form of Scatter diagrams from figure number 2 to 5.

Figure: 2 Annual Mean Maximum Temperature at Srinagar (1901-2000)

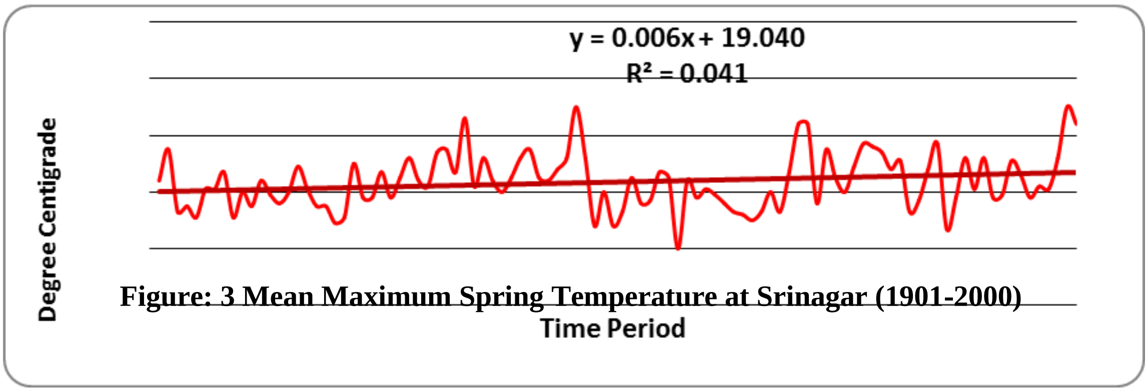

Figure: 3 Mean Maximum Spring Temperature at Srinagar (1901-2000)

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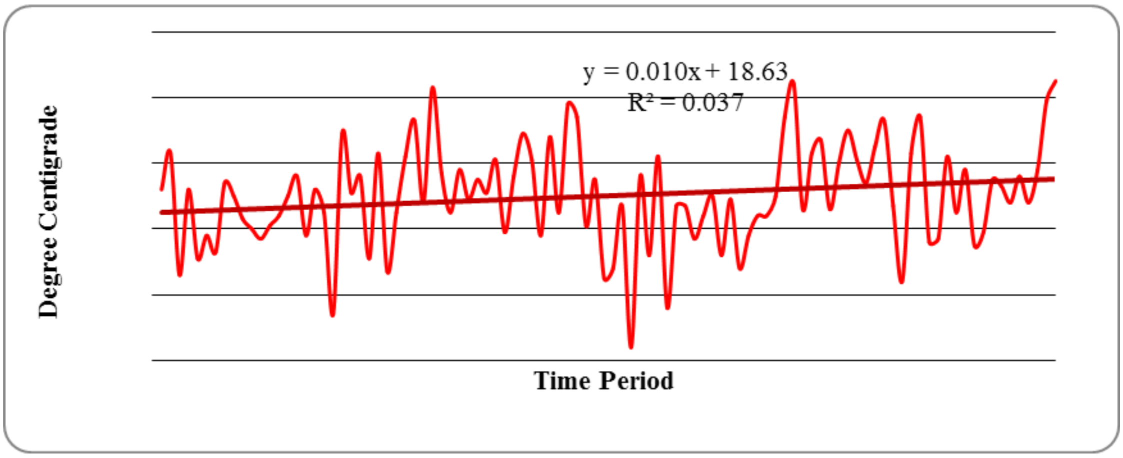


Figure: 4 Annual Mean Minimum Temperature at Srinagar (1901-2000)

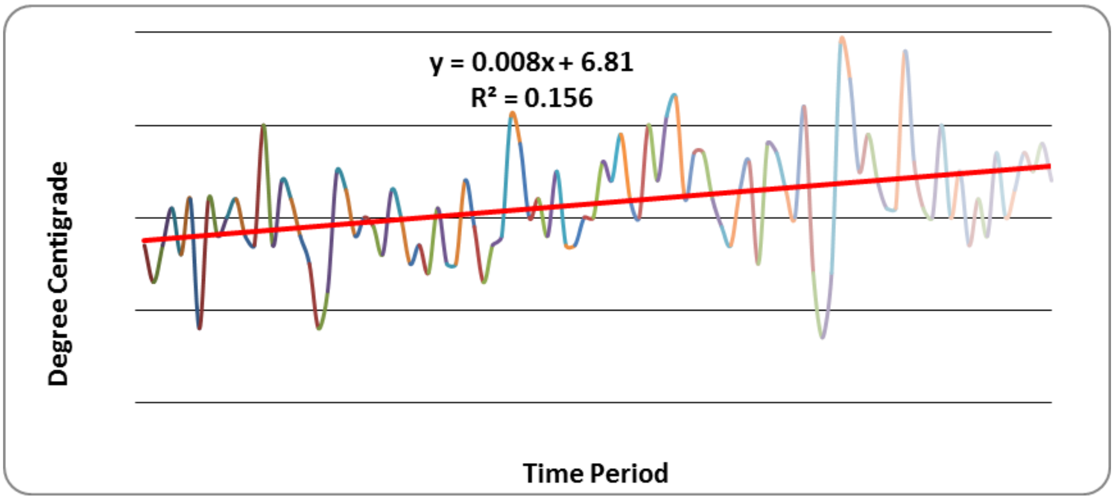
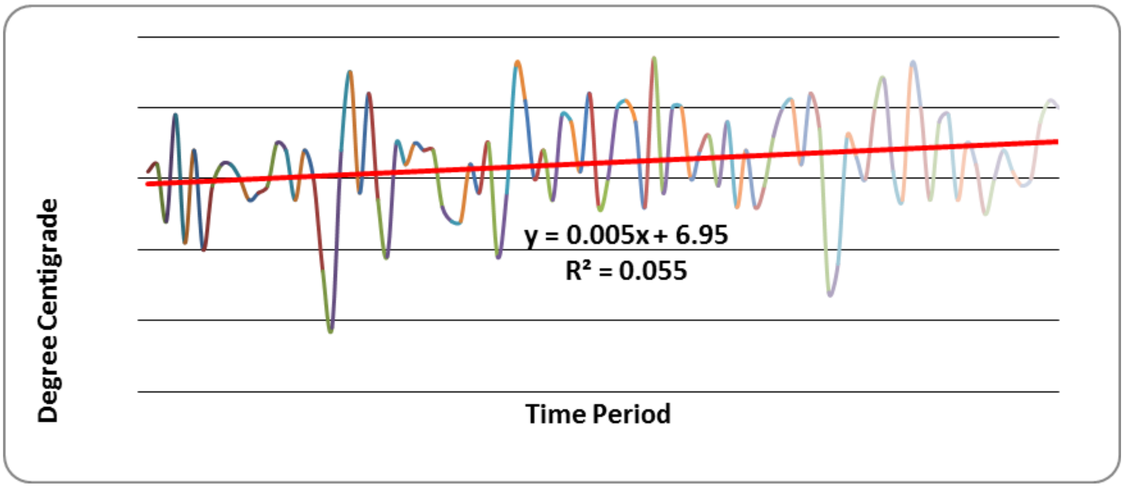


Figure: 5 Mean Minimum Spring Temperatures at Srinagar (1901-2000)



Unlike other hill stations in the Himalayas, precipitation in Kashmir Valley has shown a modest increasing trend in the 20th century. There is an increase of 68 mm of annual rainfall which translates into an increase of 10 % in this part of the western Himalayas. This is despite the fact that various research reports indicate that most of the Sub-Himalayan and central Himalayan regions have registered a significant decline in precipitation during the 20th century. On the basis of 100 year precipitation data mean annual rainfall at Srinagar stands at 670 mm.

However, the impact of increase in annual precipitation in Kashmir Valley varies across the seasons. Winter, the ecologically most important season has registered a decline of 13 mm in precipitation which translates into a decrease of about 8% during the 20th century. During the same period rainfall has increased by 50 mm in spring season which translates into an increase of 13%. Another important observation regarding the precipitation during the 20th century is the reduction in the number of rainy days despite increase in annual precipitation.

Trend Analysis indicates that there is reduction of (4) rainy days on annual basis from 1901-2000. Winter season alone has witnessed a decline of (3) rainy days during the last century. Spring is the rainiest season with a total of 257 mm followed by winter with 172 mm. March is the rainiest month with 101 mm followed by April and February with 90 mm and 70 mm respectively. November is the driest month 20 mm followed by September and October with 32 mm and 34 mm respectively. The trend analysis of precipitation at Srinagar, Kashmir is presented in the form of scatter diagrams from figure (6 to 7).

Figure: 6 Annual Precipitations at Srinagar (1901-2000)

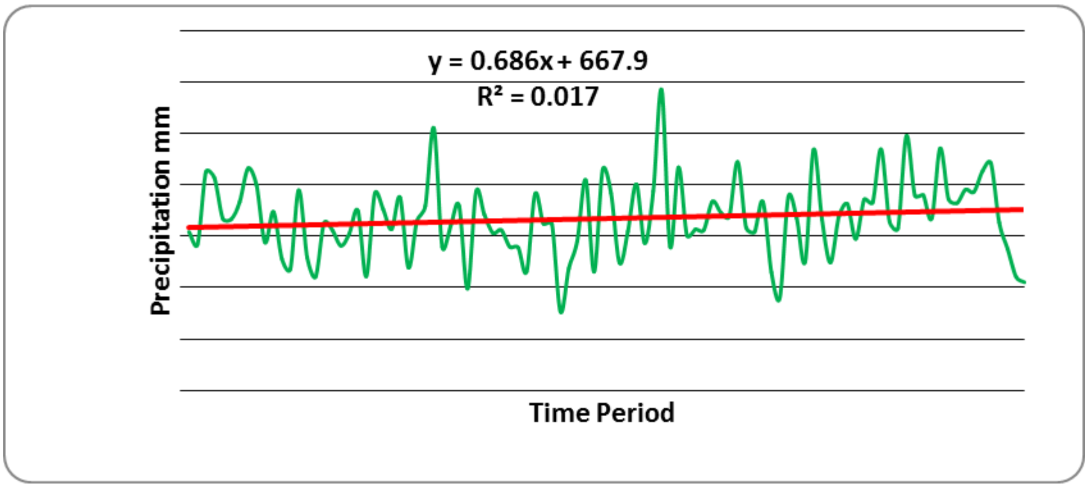


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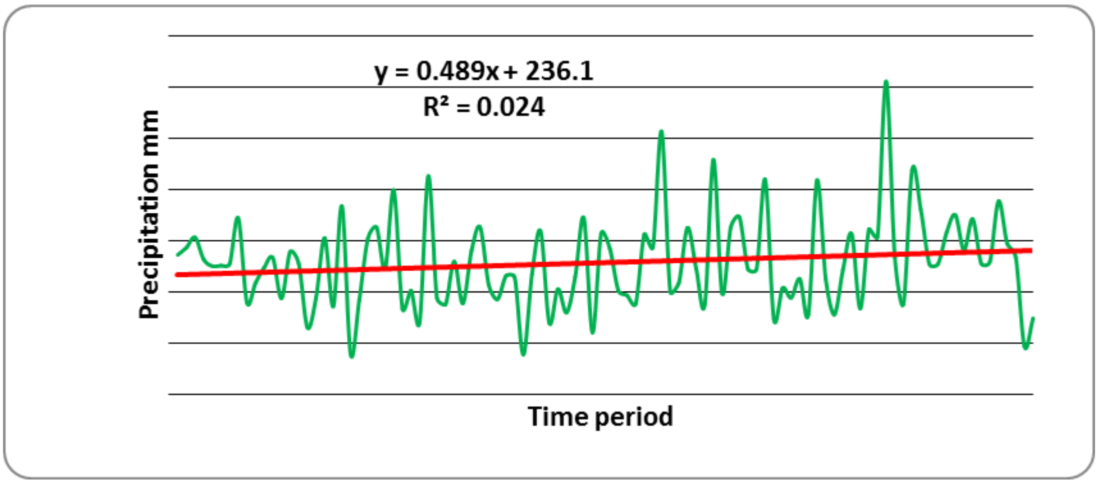
Figure: 7 Spring Precipitation at Srinagar (1901-2000)



V. CONCLUSION

In the present study it has been observed that winter precipitation has reduced with the passage of time and spring precipitation has increased significantly during the 20th century. It seems that winter precipitation is progressively getting postponed to spring in the valley of Kashmir. Furthermore winter as well as spring temperature is rising steeply. It has given rise to a peculiar scenario in which flowering pheonology of important fruit crops like almonds, apples and apricots is often getting pre-poned by 15-20 days. Moreover owing to increased spring precipitation accompanied by prolonged wet and cloudy spells pollination in orchards is badly affected which impacts the overall productivity of horticulture in the Kashmir Valley due to which farmers are resorting to assisted pollination by keeping the branches of pollinating apple cultivars in small buckets in their orchards.

Furthermore increased winter temperature reduces the required number of chilling hours which is necessary for bud break in various fruit crops. Keeping in view the fact that approximately 2/3 of the population in the valley of Kashmir Valley is dependent on agriculture and horticulture. The adverse effects of climate change especially in the spring season in which fruit setting of temperate fruits takes places is threatening the livelihood patterns in this region of north-western Himalayas. Increased spring temperature also induces early melting of glaciers in the region and aggravates the water scarcity thereby impacting irrigation facilities for agriculture in late summer when it is needed the most. Therefore to combat the adverse effects of climate change, proper water harvesting techniques need to be adopted, pollination needs to be improved and introduction of new cultivars which are resistant to the environmental stresses should be promoted to safeguard the productivity of agriculture for ensuring the livelihood patterns in North Western Himalayan region.

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