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## RESEARCH ARTICLE

### CLIMATE CHANGE IN HIMACHAL PRADESH AND IT'S CONSEQUENCES

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#### ARTICLE INFO

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#### ABSTRACT

Climate change is nothing new for post industrialization world. Every developed nation has contributed more in carbon emission than the developing nations. This development has achieved at the cost of destruction of millions of hectares of forest land, uncontrolled urbanization and destruction of local ecosystems. International conferences on climate change have not been so fruitful when it comes to curb carbon emission. The various studies and surveys reveal that the Himalayan region has witnessd the worst effect of climate change after the polar regions.

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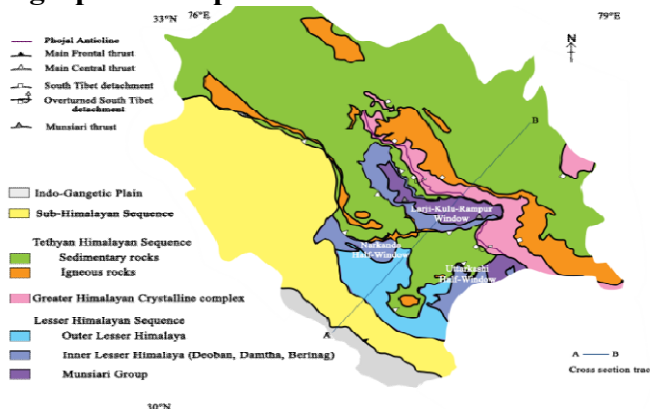
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## INTRODUCTION

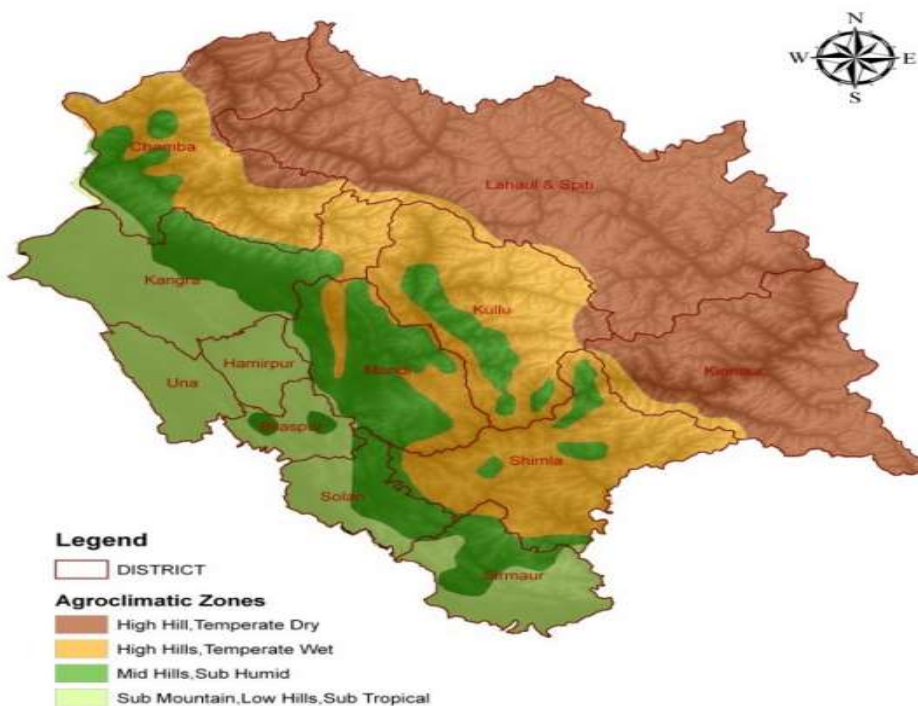
Climate change and it's control has become one of the biggest issue in modern civilization. Almost every nation on planet earth has been suffering from the various environmental issues since the beginning of industrial revolution. These climatic changes are disturbing ecological balance or ecosystems.

**CLIMATIC CHANGES:** We have been experiencing this change in climate since 2008 in the hilly areas of Himachal Pradesh, a province in Republic of India. In India, the month of March is the advent of summer season after undergoing five months of intense winters. But since 2008, the winter season has been extending up to the end of April month. Moreover, the peak time of winters is beginning in the month of December in Himalayan or mid Himalayan regions, which is quite unusual. This climatic trend is now shifting to the months of February and March. This change is writing the new script of major ecological, geological and socioeconomic status of India and the hill state of Himachal Pradesh.

### Himachal Pradesh Geographical Map

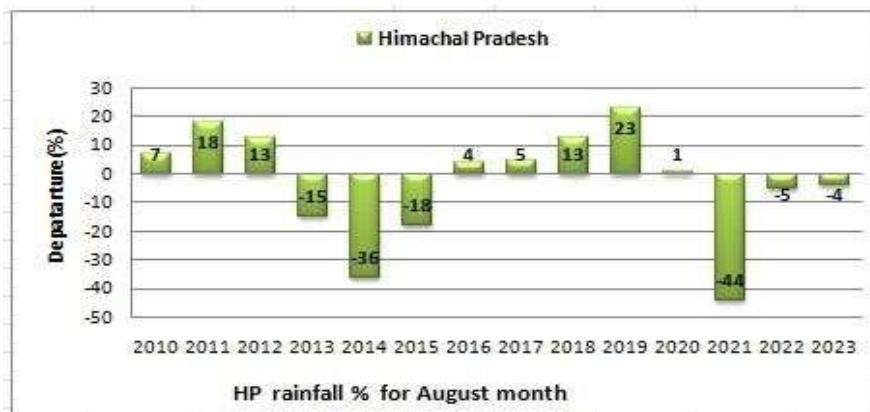


### Himachal Pradesh Climatic Zones

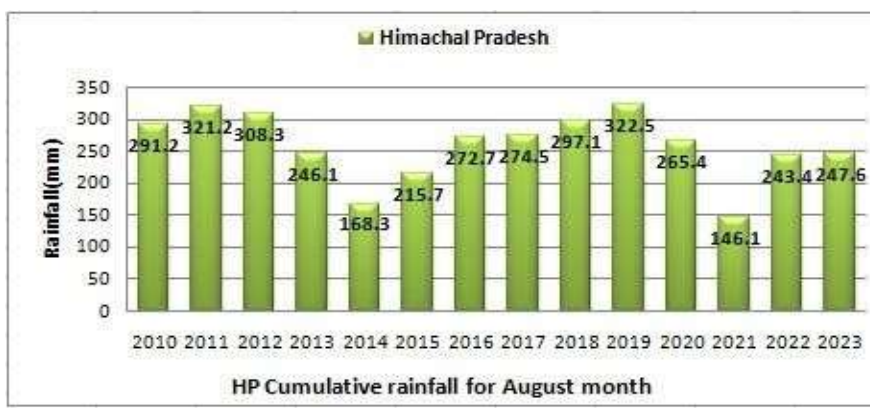


Data showing the change in climatic conditions and precipitation: Precipitation analysis of HP State for the August month (Period 2010 to 2023)

#### Percentage departure from normal

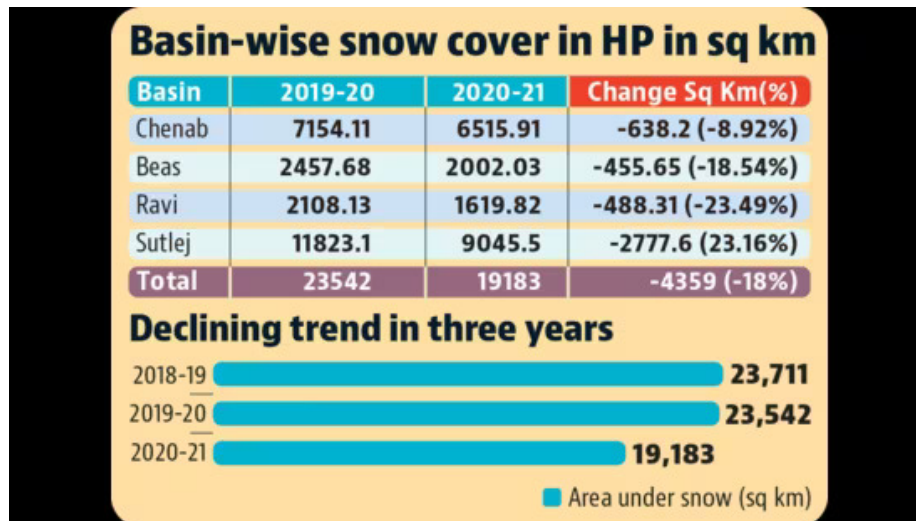


#### Actual Rainfall



## Rainfall (mm)

According to the above chart, for the month of August, the year 2019 received maximum rainfall of 322.5 mm with 23% departure whereas in 2021 August month has received the lowest rainfall with 146.1mm rainfall with(-44%) departure during the period 2010-2023. Along with rising temperature and change in rainfall pattern we have been witnessing the decline in area under glacier, which could be an alarming situation for the state of Himachal Pradesh.



## CONSEQUENCES

**Rising in average temperature:** Located at an elevation of 2197.07 meters (7208.23 feet) above sea level, Himachal Pradesh has a Temperate highland tropical climate with dry winters climate. The city's yearly temperature is 18.4°C (65.12°F) and it is -7.57% lower than India's averages. Himachal Pradesh typically receives about 105.62 millimeters (4.16 inches) of precipitation and has 146.27 rainy days (40.07% of the time) annually. The annual maximum temperature averaged over the state during the year 2022 was warmer than average with anomaly of 1.00C (5th warmest since 1901) while annual minimum highlights the Himachal Pradesh State averaged annual mean land surface air temperature (17.6 0C) during 2022 was 1.20C warmer than its Long Period Average (LPA) for the period 1981-2010 thus making it the 2nd warmest year on record for the state since 1901. The annual maximum temperature averaged over the state during the year 2022 was of 1.00C above its LPA (5th warmest since 1901), while annual minimum temperature was warmer by 1.30C (1st warmest since 1901). Out of 12 districts of the state, 1 received excess rainfall (20% to 59% of its 1971-2020 period LPA) and 9 districts received normal rainfall (-19% to +19% of its LPA) and 2 districts received deficient rainfall (-59 % to -20% of its LPA)temperature was warmer than average by 1.30C (1st warmest since 1901). The mean temperature for the state was 1.20C warmer than the average (2nd warmest year on record since 1901).

The Spatial pattern of Annual Maximum, Minimum and Mean Temperature anomalies over Himachal Pradesh during 2022 given in Fig 2.The temperature anomalies were between 1 – 2 0C over most parts of the state. However, the western districts of Himachal Pradesh were relatively less warm in respect of maximum temperature with anomaly between 0.5 to 1 degree celcius. The time series of variation of annual maximum, minimum and mean land surface air temperature anomalies averaged over the State for the period 1901-2022 is given in Fig 3. A significant increasing trend of 1.50 0C/100 years is observed in the State averaged annual mean temperature during 1901- 2022. It was more significant in respect of maximum temperature (+2.180C/100 years) and relatively less significant (+0.82 0C/100 years) in respect of minimum temperature. The five warmest years on record in order for Himachal Pradesh are 2016(anomaly+1.361°C), 2022(+1.16°C), 2017(+0.98°C), 2010(+0.9°C) and 2021(+0.78°C).

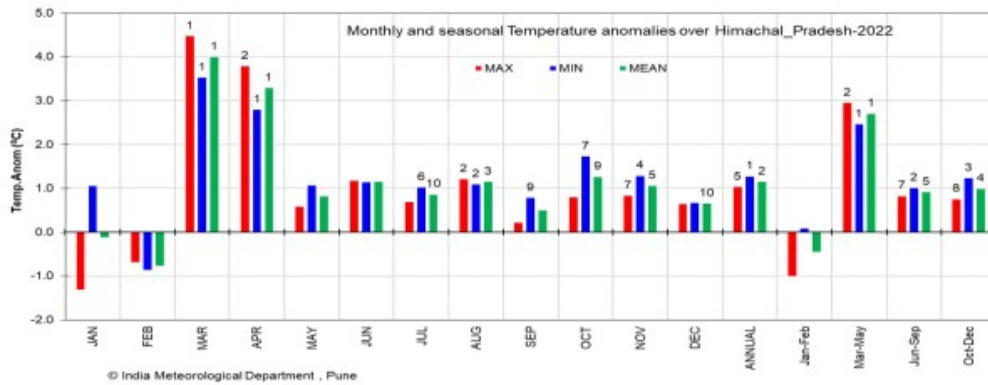


Fig. 1: Monthly and Seasonal Maximum, Minimum and Mean Temperature anomalies averaged over Himachal Pradesh during 2022. The anomalies were computed from the LPA base period of 1981-2010. The numbers above/below the bar indicate top 10 warmest/coolest ranking since 1901.

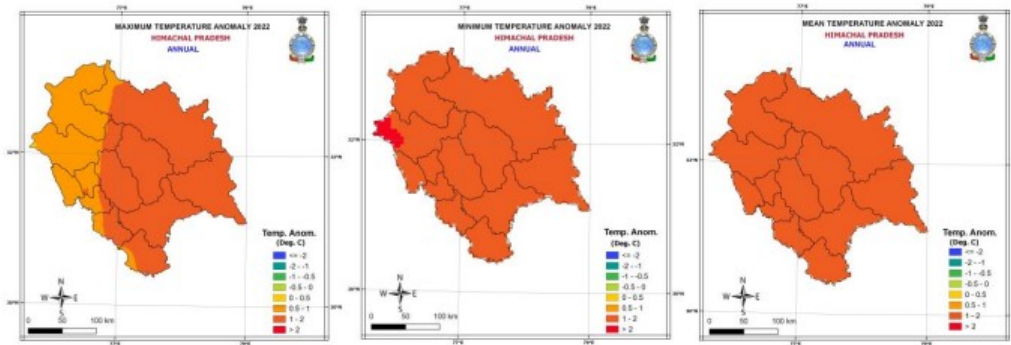


Fig. 2: Spatial pattern of Annual Maximum, Minimum, and Mean Temperature anomalies over Himachal Pradesh during 2022. The anomalies were computed from LPA for the base period of 1981-2010.

**Availability of less water for river drainage system:-** According to the Meteorological Department, the state has received only 59 milliliters of water in the last season, which is 69 percent less than usual. In addition, as the state’s population has grown over the past ten years, there has been a rise in demand for water, particularly in urban areas, and people are now depending more on piped water delivery systems than on the conventional sources like springs and bawris.

The patterns of rainfall have also changed. Water sources are drying up fast in some places, particularly in the Shivalik Hills where the soil has a very low water-holding capacity. Many communities in different constituencies go without water for weeks on end. Even in normal times, areas like Dalhousie and Banikhet experience water shortages, but in recent years, drought-like situations have already become a reality and are only expected to worsen in the years to come.

Month	Normal rainfall (mm)	Actual-2011	Actual-2012	Actual-2013	Actual-2014	Actual-2015	Actual-2016
January	41.74	33 (1)	58.75 (7)	42.45 (3)	60.4 (2)	77.8 (5)	8.6 (2)
February	63.62	132.5 (7)	15 (3)	79.8 (6)	104.8 (5)	77.5 (5)	17.2 (2)
March	48.44	40.5 (2)	-Nil-	50.7 (3)	76.1 (6)	154.2 (5)	64.4 (50)
April	42.93	38.75 (1)	64.75 (4)	7.5 (3)	34.4 (2)	47.5 (3)	20.6 (1)
May	32.16	33.25 (2)	-Nil-	13.27 (2)	69.8 (4)	22.8 (3)	73.6 (6)
June	145.88	133.25 (7)	26.25 (3)	228.68 (12)	104.5 (20)	140.8 (8)	99.1 (8)
July	302.65	221.75 (5)	169 (7)	207.8 (13)	428.0 (14)	281.0 (9)	338.6 (11)
August	420.13	317.5 (10)	319.9 (13)	745 (13)	260.6 (12)	371.3 (8)	516.5 (11)
September	136.30	102.5 (5)	229.2 (8)	102.5 (4)	63.0 (7)	73.6 (5)	76.4 (5)
October	29.03	-Nil-	-Nil-	28 (1)	-Nil-	5.2 (1)	-Nil-
November	5.41	-Nil-	5.4 (1)	22 (1)	2.0 (1)	11.0 (1)	-Nil-
December	26.41	-Nil-	47.7 (2)	32.3 (3)	61 (1)	21.6 (1)	-Nil-
Total	1294.7	1053.45	935.05	1560	1264.6	1284.3	1215

\*(mm) = millimeter, ( ) = Number of rainy days in a month

**Reducing areas under glaciers:** The area under snow cover in Himachal Pradesh in 2019-20 was 23,542 sq km, which dropped to 19,183 sq km in 2020-21. The study revealed that the area under snow cover in 2019-20 was 23,542 sq km, which dropped to 19,183 sq km in 2020-21, a decline of 3,404 sq km or 18.52%. Usually, in the winter season, about one-third of the geographical area of the state, which amounts to about 18,556 sq km, remains under thick snow cover. Most of the major rivers like Chenab, Beas, Parvati, Baspa, Spiti, Ravi, Sutlej and their perennial tributaries originating from the Himalayas depend upon the seasonal snow cover for their discharge dependability. The report added that the snow cover in the Chenab basin fell from 7,154 sq km in 2019-'20 to 6,516 sq km in 2020-21, a reduction of 638 sq km or 8.92%. The Beas basin shows a decrease of about 19% with its average snow cover area having decreased from 2,458 sq km to 2,002 sq km, a loss of 456 sq km. The Ravi basin saw an overall reduction of 23% in the total area under snow cover. The snow cover in the Sutlej Basin, which covers 45% area of Himachal and is the longest river in the state, shrunk the most by 23.49% or 2,777 sq km. It was 11,823 sq km in 2019-20 and 9,046 sq km this year. Another study published in 2019 said that the Sutlej River basin glaciers are melting fast and may shrink significantly by as soon as 2050. The research estimates that the melting would cause 33% of the glaciers to disappear by 2050 and 81% by the end of the century.

### **Formation of several new lakes, danger to lower Valleys**

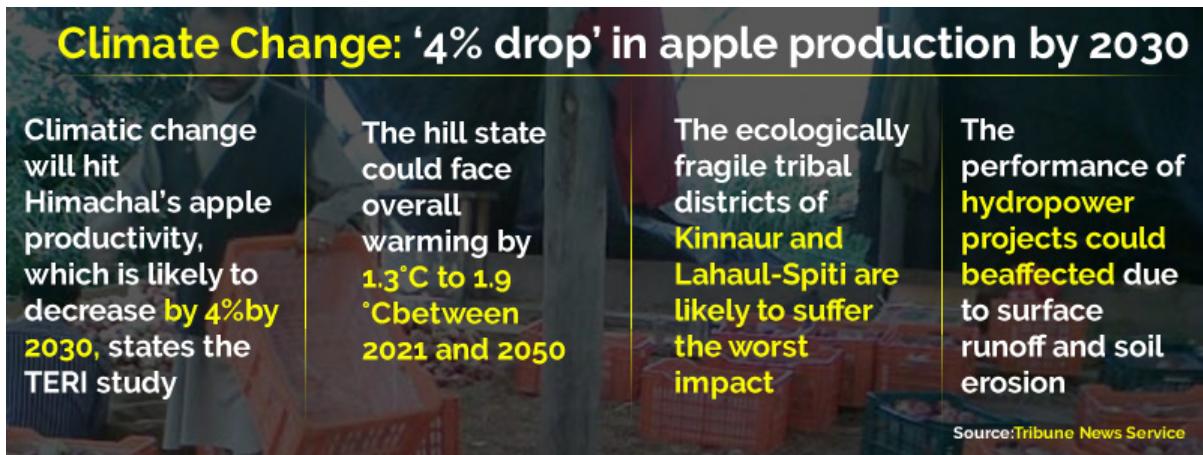
#### **Rapid increase in lakes over last 5 years**

Himachal Pradesh Council of Science and Technology monitors lake formation in river basins through remote sensing and satellite data. Studies have revealed that rapidly melting glaciers have led to the formation of numerous lakes in the basins of perennial Himalayan rivers, including Sutlej, Chenab, Beas and Ravi and their tributaries, over the last five years and that the number of lakes has been increasing at an alarming rate. Data collected between 2015 and 2018 shows that there was a 36% drop in lakes in the Beas basin. However, there has been a 32% increase in lakes in the Chenab basin, 94% increase in the Ravi basin and 97% increase in the Sutlej basin.

Sutlej has most glacial lakes. An analysis of images captured between 2015 to 2018 revealed that the Sutlej basin has 769 lakes, of which 663 are below five hectares, 57 lakes have an aerial range between five to 10 hectare and 49 lakes extend over 10 hectares. An additional 127 lakes have sprung up in the basin since 2017, indicating an overall increase of around 16% lakes in the basin. In the Chenab basin (Chandra, Bhaga, Miyar), 254 lakes were delineated, of which 64 were in the Chandra sub-basin, 84 in the Bhaga sub-basin and 106 in the Miyar sub-basin. The Chenab basin had 192 lakes in 2015. However, the count had increased to 254 in 2018. Notably, only 55 lakes had been reported in the Chenab basin in 2001.

**Change in crop pattern and production (cash crops):** This study assessed the climate vulnerability of the agriculture, horticulture, and livestock sectors at the block scale in the Kullu district of Himachal Pradesh. This region exhibits the most conspicuous manifestations of climate change. The study sites were selected to represent different elevation zones. A total of 108 indicators for the sectors were chosen to assess climate vulnerability as a methodological framework suitable for a mountain perspective.

The net climate vulnerability in the agriculture sector was lowest in blocks that had greater accessibility to the road network, were nearer to markets, had high literacy and more institutions, and were shifting to enterprises other than agriculture. The net vulnerability index (VI) for horticulture revealed that vulnerability was reduced by a shift toward off-season vegetable cultivation, productive soils for crops, and the establishment of new orchards. The net VI of the livestock sector was lower if there were fewer diseases and pests and they were quickly managed, if there was good access to veterinary facilities, if slopes were less steep, and if improved grassland was available. The composite net VI of all blocks in different sectors of this farming system revealed that the Naggar block, followed by Kullu and Nirmand, was the least vulnerable.



**Climate Change: '4% drop' in apple production by 2030**

Climatic change will hit Himachal's apple productivity, which is likely to decrease <b>by 4% by 2030</b> , states the TERI study	The hill state could face overall warming by <b>1.3°C to 1.9 °C</b> between <b>2021 and 2050</b>	The ecologically fragile tribal districts of <b>Kinnaur and Lahaul-Spiti</b> are likely to suffer <b>the worst impact</b>	The performance of <b>hydropower projects</b> could be affected due to surface runoff and soil erosion
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Source: Tribune News Service

## CONCLUSION

As the world's expanding population burns large quantities of fossil fuels and simultaneously cuts down large expanses of forests worldwide, the concentrations of CO<sub>2</sub> and other greenhouse gases are building up in the atmosphere. There is mounting evidence that this shift in Earth's atmosphere will lead to global changes and potentially major climatic disruptions. Human and ecological systems are already vulnerable to a range of environmental pressures, including climate extremes and variability. Global warming is likely to amplify the effects of other pressures and to disrupt our lives in numerous ways. Significant impacts on our health, the vitality of forests and other natural areas, the distribution of freshwater supplies, and the productivity of agriculture are among the probable consequences of climate change. On a business as usual path, the world is headed to concentrations far higher than have been observed during the time of human civilization and to levels not seen on the planet for millions of years--and all in one century, a geologic "blink of an eye." The faster the rate of change in climate, the less time there will be for both ecological and socio-economic systems to adapt and the greater the potential for "surprises" or unanticipated events. Given the long time lags between cause and effect and between effect and remedy, a prudent course of action is to slow the rate of change. Investing now to protect Earth's climate will enable our children and grandchildren to live in a world that is not dramatically altered by an enhanced greenhouse effect. And the impact of climate change would be more disastrous for the Himalayan regions as we have been witnessing for more than a decade.

## REFERENCES

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