Warmer Winters 2024: Himalayas will bear maximum brunt of Climate Change

India's tryst with warmer winters continued for the second consecutive year. Rain and snow have been evading the country ever since the beginning of the season. February did bring in some respite but it does not seem to be enough to cover up the deficit.

The cumulative countrywide rainfall from January 1 to February 29 is a large deficit by 33%. The actual rainfall recorded during the winter season was 26.8 mm against the normal average of 39.8 mm.

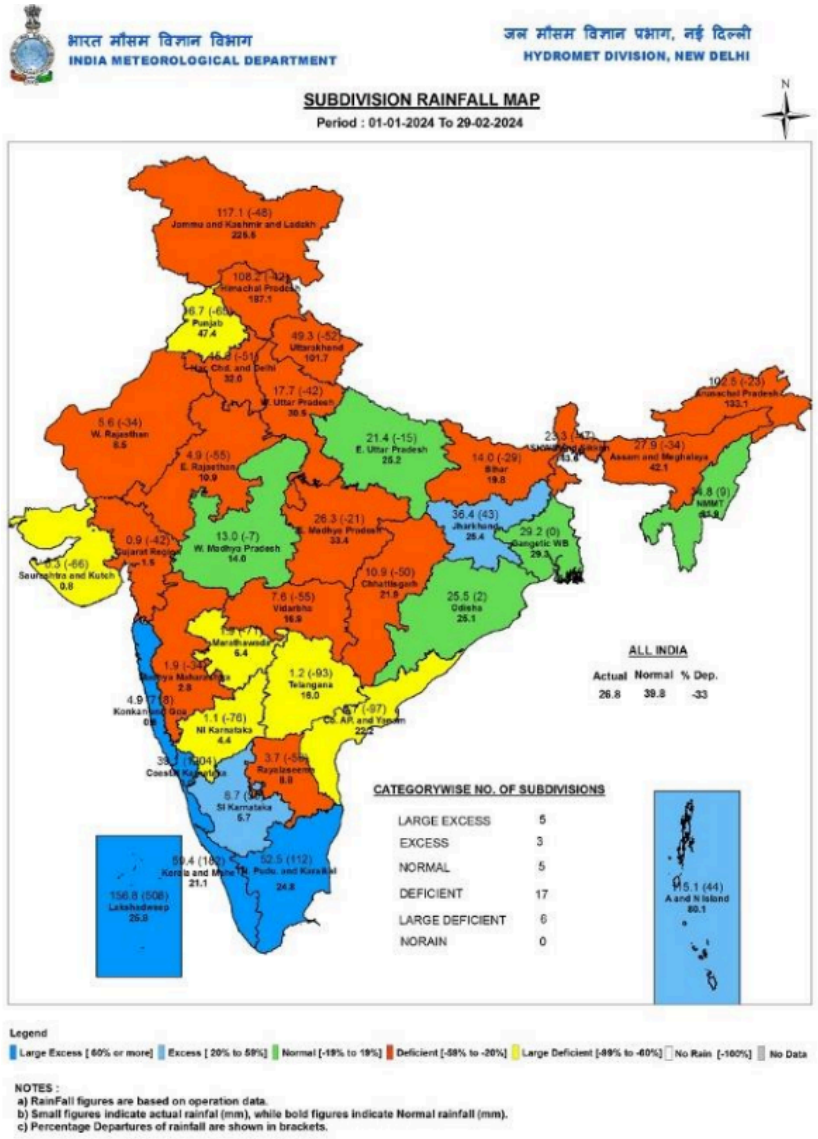


Image Courtesy: India Meteorological Department

According to meteorologists, increasing global warming has been altering the weather patterns, leading to anomalies in the temperatures and rainfall patterns. The prime weather system, Western

Disturbances, continued to dodge Western Himalayas as they mostly travelled in the upper latitude.

Western Disturbance (WD) is known to drive the weather activities and bring winters to Northwest India and adjoining areas of Central India. Both the intensity as well as frequency of Western Disturbances have been on the lower side this winter season.

December: December started on a warmer note, with no rain and snowfall, winter chill kept evading the entire north western plains as well as the hilly states. The month recorded 6.6 mm of rain against the normal average of 18.9 mm, resulting in a deficit of 65%.

January: The month saw four WDs, out of these, only one WD (28-31 Jan) caused rain or snowfall over Western Himalayas and adjoining plains areas. However, the remaining three WDs were feeble and did not affect the region significantly. Northwest India recorded a mere 3.1 mm of rainfall against the normal 33.8 mm for the core winter month of January. This resulted in a rain deficit of 91%, which is the second lowest since 1901.

February: February had begun on a brighter note, with increased passage of WDs, bringing rain and snow across the hilly regions as well as the plains of Northwest India. In total, the month saw eight WDs, out of which six were active, which helped to improve rainfall deficiency for the country from 58% on January 31 to 33% on February 29. Despite the widespread precipitation, both the maximum and minimum temperatures have settled above normal average.

Changing Weather Trends: The Rise in Minimum Temperatures

Global warming continues to push mercury to new levels. Initially it was maximum temperatures that registered the rise, but now minimum temperatures are also following the same route. The diurnal temperature variation, which is the difference between daily maximum and minimum temperatures, has decreased. February witnessed the second highest minimum temperature in the month since 1901, while January recorded the fourth highest minimum temperature since the IMD started keeping records.

	February				**January**			
	Actual Min	**Normal Min**	**Anomaly**	**Rank**	**Actual Min**	**Normal Min**	**Anomaly**	**Rank**
Country	14.61	13.82	0.79	2	14.66	13.69	0.97	4
Northwest India	8.54	8.94	-0.41		5.52	5.61	-0.10	
Central India	16.62	14.99	1.63	1	15.0	13.56	1.43	2

East & Northeast India	13.21	12.66	0.54		10.25	9.96	0.29	
Peninsular India	21.17	19.74	1.43	1	22.18	20.59	1.59	2

Please note all figures in ℃ / Image Credit: IMD

The Role of El Niño

The oceanic phenomenon of El Niño is known for its truant nature that develops in the Pacific Ocean on average every two to seven years, and typically lasts up to nine to 12 months. An El Niño condition occurs when surface water in the equatorial Pacific becomes warmer than average.

El Nino is invariably linked with below normal Monsoon, warmer winters and foggy days. Similar weather conditions were witnessed in the season so far.

"Though there is no rule book but if you have El Niño conditions, warm air increases near the tropical region and it pushes the cold air towards the north. Hence, it limits the passage of western disturbances in the Indian region. Due to large-scale features like the El Niño, minimum temperatures were higher-than-normal, making it a warm winter season in the country," **said Mrutyunjay Mohapatra, Director General, India Meteorological Department (IMD).**

Another aspect that has contributed to the warming is the constant rise in ocean heating. According to a research by IMD, sea surface temperatures (SSTs) of the Arabian Sea and the Bay of Bengal are rising and there is strong positive correlation between land surface temperatures and sea surface temperatures suggesting significant contribution of warmer sea waters which may have important climatic implications over neighbouring regions. SSTs in the tropical latitudes have increased and as a response to this increase in ocean water temperature, tropical land surface temperatures as well as tropical tropospheric temperatures have also trended upward.

Erratic Western Disturbances (WD) ruled the season

WDs are primarily disturbances originating in the west and travelling in the upper atmosphere in the subtropical westerly jet and arriving in the Indian sub-continent during the wintertime. Their frequency peaks during December to February, with an average number of 4-5 per month.

The interplay of WDs with the topography of the western Himalayas determines the spatial and vertical distribution of precipitation. Hence, it becomes very important to read the role of climate change and its impact on WDs. According to scientists, WDs are getting lighter due to more convection and heat coming in due to increasing global warming.

"Based on the data from 1990 onwards, there is a trend that frequency of WDs are showing a decreasing trend for December to February months. The same is reflected in rainfall precipitation

trends. Subtropical high is also shifting towards the north because of global warming, due to which WDs are also shifting north, hence affecting precipitation over Northwest India, which will also decrease. The sub tropics is the region which has high pressure belts where WDs develop and if this shifts north, the frequency, intensity and movement of the WDs will also be affected," **said Dr Mohapatra.**

He further added, *"North Atlantic Oscillation Index was in a negative phase during the winters. When in the negative phase, it results in less frequent and less intense Western Disturbance over the northwestern region. Thus, even though there were five active WDs, they were not able to give any precipitation over Northwest India."*

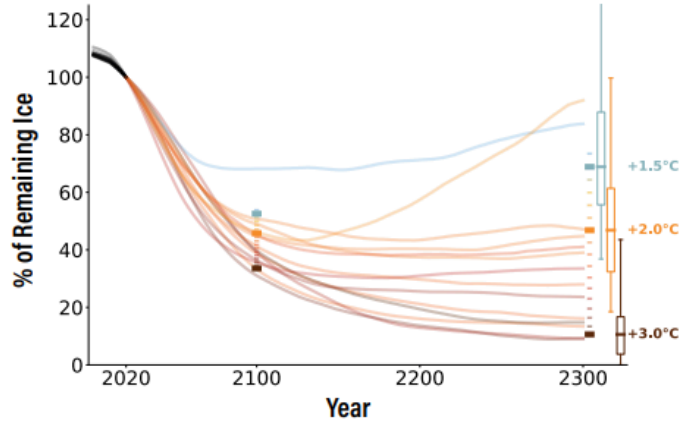
Southern proposition of Northern Atlantic Oscillation (NAO) pushes the subtropical westerly jet further south, increasing the likelihood of a greater number of WDs. If reverse happens, there would be a smaller number of WDs. In the warming scenario, there will be a more stable atmosphere and global teleconnection, which will lead to weakening of WDs.

"Heatwave in the Arctic region due to global warming have become quite frequent now. Hence, it is a major cause of concern as it directly impacts the circulations affecting the Asia region. Warming in the Arctic region pushes air upwards leading to the formation of a low-pressure area, which attracts circulations in the subpolar region. This has been the case last season and this season as well. The intensifying Arctic heatwave pulled up the weather systems including Western Disturbances northwards, making them travel in higher latitudes and thus, it did not affect the weather over India," **said Mahesh Palawat, Vice President – Meteorology and Climate Change, Skymet Weather.**

Increase in glacial lakes: Potential disaster threat to the Himalayas

Climate change and associated glacier recession have led to the formation of new glacial lakes and the expansion of existing ones across the Himalayas. Many pose a potential glacial lake outburst flood (GLOF) threat to downstream communities and infrastructure.

FIGURE 3-6. **Glaciers of High Mountain Asia**



Colors Show Global Temperature Change in 2100, Without Overshoot, by Tenths of a Degree 1.4°–3.0°C

High Mountain Asia includes the highest mountains of the world, in the Hindu Kush Himalaya. Even these extremely high altitude glaciers, which provide seasonal water to at least 2 billion people, will lose most of their ice by 3°C; 1.5°C preserves much more.

CREDIT: SCHUSTER ET AL. (2023)

According to a recent report on the Himalayas by the University of Zurich, glacial lakes are highly dynamic water reservoirs that respond to climate change by expanding in number, size, and volume. This is particularly evident across the mountains of Asia, including in the Hindu Kush Karakoram Himalayas (HKH), Tien Shan, and Tibet. As a result of climate change, and consequent accelerated glacier recession, the number (area) of glacial lakes in HKH increased from 4549 lakes (398.9 km2) in 1990 to 4950 lakes (455.3 km2) in 2015. Several large-scale and regional assessment studies confirm the growth of glacial lakes and their hazardous potentials across Asia.

Jammu and Kashmir (JK) has the highest combined exposure to potential GLOFs with a total number of 556 lakes that include very high and high danger lakes. This was followed by Arunachal Pradesh (AP) with 388 lakes, and Sikkim (SK) with 219 lakes. Sector-wise, J&K faces the greatest GLOF threat to roads and population, whereas the threat to cropland and hydropower is greatest in Arunachal Pradesh and Sikkim, respectively.

However, the highest-priority lakes, where urgent monitoring and local site investigations are recommended include 13 lakes in Sikkim, 5 in Himachal Pradesh, 4 in Jammu & Kashmir, 2 in Uttarakhand, and 1 in Arunachal Pradesh, are of highest priority for local investigation and potential risk reduction measures. These results are of vital importance to policymakers, disaster management authorities, and the scientific community.

State-wise distribution of high-risk glacial lakes

States	No. of high-risk lakes
Jammu and Kashmir	18
Himachal Pradesh	8
Uttarakhand	4
Sikkim	25
Arunachal Pradesh	1
Total	56

Source: Swiss Development Cooperation (SDC)

Particularly in Jammu and Kashmir, exposure increases from remote areas in the northeast toward the southwest, where lakes can threaten densely populated areas in and around Srinagar valley. Current GLOFs also potentially affect the foothill areas of non-Indian Himalayan Region (IHR) states, for example, northern West Bengal. The high exposure level to GLOFs in Jammu & Kashmir, Arunachal Pradesh, and Sikkim result from intense agricultural activities, a dense road network, and a relatively high population density located high in the inner Himalayan valleys, all of which are within reach of GLOF trajectories.

According to the State of the Cryosphere Report 2023, if 2°C warming is reached, projections show that nearly all tropical glaciers (north Andes, Africa) and most mid-latitude glaciers outside the Himalayas and polar regions will disappear, some as early as 2050. Even the Himalayas are projected to lose around 50% of today's ice at 2°C.

Once 3°C has passed, even most large polar glaciers, and the very high-altitude glaciers in the Himalayas and southern Andes, are unlikely to survive. A low emissions scenario could limit glacier loss to 30% in the Hindu Kush Himalaya.

Water scarcity and increased risk of avalanches

As glaciers melt, risks of catastrophic events – landslides, sudden ice shears, and in some cases glacial lake outburst floods – will rise. This will affect entire communities and those further downstream as a source of water for drinking and/or irrigation, with some contributing only a few percent over the course of a year, but of greater importance during dry seasons, heat waves and droughts.

Winter snowpack at 2°C generally will decrease, but also will become more volatile; with some years of hardly any snow, and others with record-breaking amounts that threaten infrastructure

and lives. Indeed, most glacier-covered regions outside high latitude polar regions and the Himalayas have already passed this period of “peak water”.

Avalanche Risk: The warming observed in recent decades has been accompanied by increased snow avalanche frequency in the Western Indian Himalayas. Powder snow avalanches tend to occur after intense snow precipitation during cold winter conditions, whereas wet and dense flows often coincide with warm spells, typically toward the end of the winter and early spring. As a consequence, changing climatic conditions may modify avalanche activity. Land cover changes, such as afforestation and deforestation, are also likely to play a role. According to the weather models, snow avalanche probabilities are highest if warmer temperatures persist during these months.

Extensive adaptation therefore needs to begin immediately to prepare for this future, even as mitigation to preserve glaciers as much as possible is also prioritised.

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