1. Changing Weather Patterns - Geography

India is witnessing increasing weather extremes such as unseasonal rainfall, heatwaves, and humidity due to climate phenomena like Western Disturbances, El Niño, and La Niña significantly influencing monsoon, agriculture, and public health.

1.Background

India's climate system traditionally exhibited predictable seasonal patterns with monsoons arriving between June-September, winter months bringing cold temperatures particularly in northern regions, and summer months experiencing moderate heat before monsoon onset. However, recent decades have witnessed increasing climate unpredictability with unseasonal rainfall disrupting agricultural cycles, prolonged heatwaves affecting public health and infrastructure, extreme humidity making temperature perception worse than actual readings, and erratic weather patterns causing agricultural losses and water stress. These changes result from complex interactions between global climate phenomena including El Niño Southern Oscillation affecting Pacific Ocean temperatures and atmospheric pressure, Western Disturbances bringing winter precipitation to northern India, and anthropogenic climate change amplifying natural variability making extreme events more frequent and intense. Understanding heat waves requires distinguishing between actual air temperature measured by thermometers (dry bulb temperature) and perceived temperature accounting for humidity and wind effects (apparent temperature or "feels like" temperature).

The India Meteorological Department declares heatwaves when temperatures exceed 40°C in plains, 37°C in coastal areas, and 30°C in hills. Heat index combines relative humidity with actual temperature determining how hot the human body feels, while wind chill index measures cold perception when wind removes the thin warm air layer naturally produced by bodies for insulation. Wet bulb temperature, measuring the lowest temperature achievable through evaporation, is particularly critical for human survivability because bodies cool through sweating and evaporation—high humidity reduces evaporation efficiency making it difficult for bodies to cool themselves, potentially leading to heat stress, heat exhaustion, and fatal heat stroke when wet bulb temperatures exceed survivable thresholds around 35°C for extended periods.

2.Understanding Heat Waves

Definition and Criteria

1. A heatwave is a period of unusually high temperatures departing from normal, varying region-to-region depending on historical temperature observations.
2. IMD declares heatwaves when temperatures exceed 40°C in plains, 37°C in coastal areas, and 30°C in hills.

Temperature Measurement Concepts

"Feels Like" Temperature/Apparent Temperature - Accounts for wind and humidity conditions determining what outdoor air temperature feels like relative to body temperature.
Heat Index - Measures how hot the human body feels when combining relative humidity with actual temperature.
Wind Chill Index - Combines temperature and wind speed measuring how cold it feels on exposed skin as wind removes the thin warm air layer bodies naturally produce for insulation.

Wet Bulb vs Dry Bulb Temperature

Wet Bulb Temperature - Measures the lowest temperature achievable through evaporation, reflecting combined effects of heat and humidity. Human bodies cool through sweating and evaporation; high humidity reduces evaporation efficiency, making it difficult for bodies to cool themselves.
Dry Bulb Temperature - Refers to actual air temperature measured using standard thermometers without accounting for atmospheric moisture.

3.Western Disturbances

Formation and Movement

1. Western Disturbances are extra-tropical weather systems originating outside India, moving west to east, bringing rain, snowfall, and storms to northern Indian subcontinent, especially during winter and early spring.
2. They originate over the Mediterranean region, Black Sea, or Caspian Sea when cold polar air interacts with warmer, moist air creating low-pressure systems.
3. These systems are carried eastward by westerly winds in the upper atmosphere, particularly the subtropical westerly jet stream.

Regions Affected

1. Jammu & Kashmir, Himachal Pradesh, Uttarakhand, Punjab, Haryana, Delhi, Rajasthan, and Western Uttar Pradesh receive precipitation from Western Disturbances.

Significance

1. 30% of annual precipitation over North West India (J&K, Ladakh, Himachal Pradesh, Uttarakhand) is received during winter, mostly associated with Western Disturbances.
2. Precipitation influences Himalayan climate, glaciers, snow-water storage, flora, fauna, agricultural crops, and human inhabitants.
3. Winter rainfall from Western Disturbances is vital for rabi crops, especially wheat, mustard, and barley, improving soil moisture, crop yield, and food security.

4.ENSO (El Niño–Southern Oscillation)

Understanding ENSO

1. ENSO is a periodic fluctuation in sea surface temperatures and atmospheric pressure in the equatorial Pacific Ocean with two opposite phases - El Niño and La Niña.
2. ENSO influences Indian Monsoon, cyclone patterns, droughts, floods, and global temperature variability.

El Niño

1. El Niño is the warming of seawater in the central-east Equatorial Pacific occurring every few years.
2. During El Niño, surface temperatures in the equatorial Pacific rise, and trade winds (east-west winds blowing near the Equator) weaken.
3. Impact on India - El Niño years bring warmer temperatures and less rainfall, causing droughts in some regions affecting agriculture, water resources, and ecosystems. The El Niño phenomenon led to 1.4% decrease in food grain production for 2023-24 crop year.

La Niña

1. La Niña is the opposite of El Niño, witnessing cooler than average sea surface temperatures in the equatorial Pacific region.
2. Trade winds are stronger than usual, pushing warmer water towards Asia.
3. Impact - Leads to drier conditions in Southern U.S. and heavy rainfall in Canada, associated with heavy floods in Australia. La Niña brings cooler sea surface temperatures, leading to increased rainfall in certain parts of India.

5.Way Forward

Strengthen Climate Forecasting

1. India must strengthen climate forecasting and early warning systems using advanced meteorological models, satellite technology, and data analytics enabling timely alerts to vulnerable populations, farmers, and emergency services, while improving prediction accuracy for extreme weather events reducing response times and minimizing casualties.

Climate-Resilient Agriculture

1. Promote climate-resilient agriculture through drought-resistant crop varieties, improved irrigation efficiency, crop diversification away from water-intensive crops in vulnerable regions, and agronomic practices like conservation agriculture, while strengthening water conservation measures including rainwater harvesting, drip irrigation, and aquifer recharge protecting agricultural livelihoods from climate variability.

Urban Planning and Heat Mitigation

1. Urban planning should include green infrastructure such as urban forests, green roofs, and parks reducing urban heat island effects, while implementing heat mitigation strategies including cool roofs, shaded public spaces, and heat action plans protecting urban populations particularly vulnerable groups like outdoor workers, elderly, and children from extreme heat events.

Public Awareness Enhancement

1. Enhance public awareness regarding heat stress symptoms, prevention measures, and disaster preparedness through targeted communication campaigns, school education programs, and community engagement, while strengthening healthcare systems to handle climate-related health emergencies ensuring prompt treatment for heat-related illnesses and vector-borne diseases.

Research and Monitoring

1. Invest in climate research understanding regional climate patterns, attribution of extreme events to climate change, and development of adaptation strategies, while establishing comprehensive monitoring networks tracking temperature, humidity, rainfall, and other meteorological parameters enabling evidence-based policymaking and adaptive management.

Conclusion

India faces increasing weather extremes including unseasonal rainfall, heatwaves, and extreme humidity driven by Western Disturbances, El Niño, and La Niña phenomena. Western Disturbances originating over Mediterranean/Black/Caspian Seas provide 30% of North-West India's winter precipitation vital for rabi crops. El Niño causes warming, reduced rainfall, and droughts (1.4% food grain production decrease 2023-24), while La Niña brings cooler temperatures and increased rainfall. Heat waves are declared when temperatures exceed 40°C (plains), 37°C (coastal), 30°C (hills). Understanding includes wet bulb temperature (evaporative cooling capacity critical for human survival), heat index (perceived temperature with humidity), and wind chill (cold perception). Solutions require strengthened climate forecasting, climate-resilient agriculture, urban heat mitigation, and enhanced public awareness.

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