MAJOR IMPROVEMENTS IN WEATHER FORECASTING

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Will the Minister of EARTH SCIENCES be pleased to state:

(a)   whether major improvements have been achieved in weather forecast accuracy, early warning dissemination system and climate services during the last three years and if so, the details thereof;

(b)   the manner in which the said interventions have provided measurable socio-economic benefits to farmers, fishermen, vulnerable communities and common people in the affected areas;

(c)   the progress made so far in expanding the Doppler weather radar coverage, urban climate platforms and heat action plans in collaboration with States; and

(d)   the details of roadmap formulated to strengthen last-mile access to weather and climate advisories?

ANSWER
THE MINISTER OF STATE (INDEPENDENT CHARGE) FOR
MINISTRY OF SCIENCE AND TECHNOLOGY
AND EARTH SCIENCES
(DR. JITENDRA SINGH)

(a)   Yes. There has been significant improvements in the early warning systems, including improvements in the accuracy of forecasting of various extreme weather events like cyclones, heat waves, heavy rainfall, and thunderstorms in recent years. The details are given below.

Improvements in Cyclone Forecasts: The annual average track forecast errors in 2025 were 80 km, 120 km, and 204 km, respectively, at 24, 48, and 72 hrs, compared with the past five-year average errors of 72, 111, and 154 km based on data from 2020-2024. The annual average landfall forecast errors for 2025 have been 76 km, 82 km, and 121 km for 24, 48, and 72 hrs lead periods, respectively, against the past five years' average errors of 16 km, 39 km, and 70 km during 2020-2024. The annual average absolute error (AE) in intensity forecast has been 3.1 knots, 2.7 knots, and 3.9 knots, respectively, for 24, 48, and 72 hrs lead periods, against the past five-year average of 5.9, 8.3, and 9.8 knots during 2020-2024.

Monsoonal rainfall and heavy rainfall warnings: The India Meteorological Department (IMD) has been following a seamless forecasting strategy for monsoonal rainfall. As per this strategy, it issues forecasts and warnings on different time scales and for different spatial scales. Nowcasting- up to six hours for all types of severe weather at all districts and around 1200 stations. Short to medium range (up to 7 days) forecasts for rainfall over cities, blocks, districts, and meteorological subdivisions. Extended range (up to 4 weeks) forecasts for 36 meteorological subdivisions. Monthly and seasonal long-range forecasts for rainfall for the whole country and for a homogenous region.

The latest assessment of the accuracy of its seasonal long range for Southwest Monsoon in the current year 2025 shows it was highly accurate and the forecast, issued in April 2025, for the southwest monsoon (June-September) rainfall over the country as a whole was 105% of long period average (LPA) while the actual season rainfall for the country as a whole was 108 % of LPA and it was within range of the forecast issued. The spatial probability forecasts were also largely accurate across most regions of the country. Similarly, the monthly rainfall forecasts closely matched the observed values and remained within the forecast limits.The latest assessment of Heavy rainfall Forecast Performance shows in 2025, the heavy rainfall forecast demonstrated high skill, with Probability of Detection of 0.85, indicating it was in overall accuracy.

IMD has adopted a new strategy for monthly and seasonal forecasting since 2021 based on the Multi-Model Ensemble (MME) approach. The strategy utilizes coupled global climate models (CGCMs from various global climate prediction and research centers, including IMD's Monsoon Mission Climate Forecasting System (MMCFS). The performance of IMD's seasonal forecasting system has shown improvement following the adoption of the MME-based approach. The verification details of IMD's seasonal forecasts for All India Summer Monsoon Rainfall for the period 2021 to 2025 are given below:

Year	ALL India Monsoon Rainfall (LPA)		
	Actual (%)	Forecast (%)	Remark
2021	99	101	Accurate
2022	106.5	103	Accurate
2023	95	96	Accurate
2024	108	106	Accurate
2025	108	106	Accurate
***Model error ± 4% of LPA			

Heat waves: For the summer of 2025, the Probability of Detection of heat wave forecasts/warnings for the season (March–June), is 98% for a 1-day advance, indicating excellent detection capability. Forecast skill decreases with increasing lead time, with the 3-day-ahead forecast skill at 75% and the 5-day forecast skill at 46% in 2025, compared to 68% and 50%, respectively, in 2022.

Thunderstorms: The 3-hourly thunderstorm (TS) nowcast (March–June), skill showed significant improvement for 2025 storm season, with the Probability of Detection as 0.92 in 2025, which was 0.83 in 2022. For 24-hour thunderstorm forecasts, the Probability of Detection was 0.89 in 2025.

(b) The interventions undertaken by the India Meteorological Department have significantly contributed to measurable socio-economic benefits for farmers, fishermen, vulnerable communities, and the general public, particularly in disaster-prone and climate-sensitive areas. The manner in which these benefits have accrued are as follows:

Improved Agricultural Planning and Productivity: District-level and block-level weather forecasts, agrometeorological advisories, and seasonal outlooks enable farmers to make informed decisions regarding sowing, irrigation, fertilizer application, harvesting, and crop protection. This has resulted in reduced crop losses, optimized input costs, and improved yields.

Reduction in Loss of Life and Property: Early warnings related to cyclones, heavy rainfall, heat waves, cold waves, thunderstorms, and lightning have enabled timely evacuation, preparedness measures, and contingency planning. This has substantially minimized casualties and damage to livelihoods.

Enhanced Safety for Fishermen: Timely marine weather forecasts, cyclone alerts, and ocean state warnings help fishermen avoid venturing into the sea during adverse conditions. This has reduced incidents of loss of life, damage to fishing vessels, and economic hardship.

Support to Disaster Management Authorities: Impact-based forecasting and real-time monitoring support State and district administrations in planning relief and response operations. Early action reduces recovery costs and safeguards vulnerable communities.

Heatwave and Cold Wave Action Plans: Forecast-based advisories have enabled local administrations to implement heat action plans, adjust working hours, and ensure access to drinking water and shelters, thereby protecting outdoor workers, the elderly, and economically weaker sections.

Climate Services for Long-term Resilience and Anticipatory Action against Climate Risk: Climate data services and seasonal forecasts assist policymakers in water resource management, crop insurance planning, reservoir operations, and infrastructure preparedness, contributing to long-term socio-economic resilience.

The measurable benefits are reflected in reduced disaster-related mortality, lower crop losses, improved marine safety, and enhanced preparedness at community and administrative levels. Continuous modernization of forecasting systems and expansion of dissemination channels through mobile applications, SMS alerts, and coordination with State agencies further strengthen outreach to affected populations.

(c)-(d) Currently, there are a total of 48 DWRs installed and operational in India. This has helped IMD improve monitoring and forecasting of severe events such as cloudbursts, thunderstorms, lightning, heat waves, and cyclones. The India Meteorological Department, in collaboration with various research centers across the country, has undertaken several initiatives to enhance monitoring and early warning systems across the country, including urban climate platforms. These efforts have significantly contributed to minimizing the loss of life and property during extreme weather events, including heat waves. These include:

- Heat Action Plans (HAPs) in 23 States that are prone to heatwave conditions were jointly implemented by the National Disaster Management Authority (NDMA) in collaboration with the State Governments.
- Issuing seasonal and monthly outlooks, followed by extended-range forecasts of temperature and heatwave conditions. The early warning and forecast information are also disseminated through various social media platforms for timely public outreach.
- District-wise heatwave vulnerability Atlas over India to help State Government authorities and disaster management agencies in planning.
- The hot weather hazard analysis map of India incorporates daily data on temperature, wind patterns, and humidity levels.
- A series of National and State-level heatwave preparedness meetings are conducted much before the start of the summer season, with regular review meetings from time to time during the season.

IMD has also brought out a web-based "Climate Hazard & Vulnerability Atlas of India" prepared for the thirteen most hazardous meteorological events, which cause extensive damage and economic, human, and animal losses. The same can be accessed at https://imdpune.gov.in/hazardatlas/abouthazard.html. This atlas will help State Government authorities and disaster management agencies identify the hotspots, including vulnerable urban and rural areas, and plan and take appropriate action to tackle extreme weather events. This product is helpful in building Climate change-resilient infrastructure.

IMD has been using all the latest available communication systems for improving outreach. Early warning dissemination has been strengthened through official IMD websites, API based direct to the users, Common Alerting Protocol (CAP), WhatsApp groups, mobile applications, web portals, SMS alerts, and closer coordination with disaster management authorities. Social Media Platforms such as YouTube, Facebook, X, and Instagram have been widely used by IMD. Also, IMD uses the following Apps:

- MAUSAM App for weather forecasting and warnings
- MEGHDOOT App for agro met services
- DAMINI App (developed by IITM) for lightning warning
- UMANG App (developed by Meity) for Weather forecasting and warnings

To ensure localised relevance and last-mile connectivity of weather updates in remote and vulnerable regions, IMD, in collaboration with the Ministry of Panchayati Raj (MoPR), has recently launched Panchayat-level weather forecasts covering nearly all Gram Panchayats in India. These forecasts are accessible through digital platforms such as e-Gramswaraj (https://egramswaraj.gov.in), Meri Panchayat app, e-Manchitra of MoPR, and Mausamgram of IMD, MoES (https://mausamgram.imd.gov.in). The main aims and objectives of Gram Panchayat Level Weather Forecasting (GPLWF) are to provide weather forecasts up to Gram Panchayat Levels, covering critical parameters such as temperature, rainfall, humidity, wind, and cloud conditions-essential data that farmers need for informed decision-making regarding sowing, harvesting, and irrigation. The platform is making weather forecast information accessible anytime and anywhere at the panchayat level across the country. This weather information reaches a larger number of people through Pashu Sakhis and Krishi Sakhis under the Ministries of Agriculture and Farmers Welfare and Rural Development.

To further advance weather and climate services in India, IMD conducts multiple state-level stakeholder consultation workshops with various state government departments. These engagements include users from agriculture, water resources, energy, disaster management, transport, aviation, media, health, urban planning, and local communities. The discussions help identify practical gaps, emerging needs, and opportunities to improve the usability, accessibility, and reach of weather and climate services across the country.

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