PARLIAMENT QUESTION: ACCURATE WEATHER FORECASTING

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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 the 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.

The early warnings by the IMD and the timely action taken by the Government (Central & State) have significantly reduced the loss of life due to cyclones in recent times. Recently, the India Meteorological Department (IMD), in coordination with other centres in the MoES, has developed an

end-to-end GIS-based Decision Support System (DSS), which has been working as the front end of the early warning systems for the timely detection and monitoring of all-weather hazards across the country.

Though the Government has not assessed the direct public benefit in recent years, but the significant improvement in the early warning systems, including the forecast accuracy of severe weather events, has led to a significant reduction in the death toll. For example, due to cyclones, around 7000 people lost their lives in the 1999 Odisha Super Cyclone, while it has been reduced to less than 100 over the entire region from the impact of tropical cyclones during recent years. Accurate forecast of 1 cyclone saves around 1100 crore rupees in terms of expenditure towards payment of ex-gratia to kins of dead, cost towards evacuation, and savings to various sectors, e.g., Power, Marine, Aviation, Railways, etc. Similarly, heat wave-related losses of lives have been reduced during recent years.

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.

The Government is continuously working to strengthen weather and climate forecasting systems in the country. New techniques and technologies have been implemented from time to time to improve weather and climate forecasting systems. Recently, a new Central Sector Scheme, "Mission Mausam", has been launched by MoES with the goal of making Bharat a "Weather-ready and Climate-smart" nation to mitigate the impact of climate change and extreme weather events and strengthen the resilience of communities. Some of the progress in the various components of the early warning system are given below:

- Strengthening of the observing system with the installation of additional AWS, ARG, and DWR, etc.
- Improvement of the data integration and development of GIS-based DSS.
- Improvement of NWP models and climate models, as well as a real-time seamless monitoring, forecasting, and early warning system.
- Shifting from conventional weather forecast and warning to sector-specific color-coded Impact-based forecast (IBF) and risk-based warning (RBW) up to district/sub-city levels with dynamical impact and risk matrix.
- Application of AI/ML.
- Customisation of bulletins and warnings.
- Substantial increase of computational power to integrate voluminous data and to run meso-scale, regional, and global models at a further higher resolution scale, with improvement of process understanding and model physics. Supercomputers (Arka and Arunika) are being used for this purpose.
- Panchayat Mausam Seva.
- A state-of-the-art dissemination system with the use of a mobile app, Common Alerting Protocol (CAP), WhatsApp groups, etc.

This information was submitted by Minister of State (Independent Charge) For Earth Sciences Dr. Jitendra Singh in Lok Sabha today.

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