GOVERNMENT OF INDIA
MINISTRY OF EARTH SCIENCES
RAJYA SABHA
UNSTARRED QUESTION NO. 515
ANSWERED ON 04/12/2025

OPERATIONAL FORECASTING AND MONITORING MECHANISMS

515. DR. SUMER SINGH SOLANKI:
SHRI MITHLESH KUMAR:
SHRI NARESH BANSAL:
SHRI MOKARIYA RAMBHAI:
SHRI KESRIDEVSINH JHALA:
SHRI BABUBHAI JESANGBHAI DESAI:
SMT. MAYA NAROLIYA:
SHRI CHUNNILAL GARASIYA:
SHRI BABURAM NISHAD:

Will the Minister of **EARTH SCIENCES** be pleased to state:

(a) the details of methodology and tools currently used by IMD to provide seasonal prediction of monsoon rainfall;
(b) how accurate was IMD's operational forecasting for 2025 SW Monsoon season rainfall;
(c) the details of performance of IMD's operational seasonal forecasting since multi model ensemble forecasting was implemented;
(d) the steps taken by IMD or the Ministry in improving the monitoring and forecasting of the weather and climate hazard; and
(e) the details of weather and climate services provided by IMD for south Asian countries?

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

(a) Currently, the India Meteorological Department (IMD) is using both the statistical forecasting system and the newly developed Multi-Model Ensemble (MME) forecasting system for issuing monthly and seasonal operational forecasts for the southwest monsoon rainfall over the country. The MME forecasting system is based on the coupled global climate models (CGCMs) from various global climate prediction centers, including IMD's Monsoon Mission Climate Forecasting System (MMCFS) model. These systems provide probabilistic forecasts of rainfall and temperature at various spatial and temporal scales, including all-India, regional, and sub-divisional levels.

(b) IMD's operational qualitative forecast for the 2025 Southwest Monsoon season rainfall (June to September) over the country as a whole issued during both the first stage (issued on 15th April) and second stage forecast (issued on 27th May), was above normal (i.e., 105 to 110% of LPA of the Long Period Average (LPA)). Quantitatively, the IMD forecast for the 2025 south-west monsoon season rainfall issued during the first and second stage forecasts were 105% of LPA with a model error of ±4% and 106% of the LPA with a model error of ±4% respectively. The realised 2025 seasonal monsoon rainfall over the country as a whole was 108% of its LPA. Thus, the realised seasonal rainfall for 2025 was within the forecast limits, and both the first and second stage forecasts were accurate. Further details on the verification of monthly and region-wise forecasts are given in Annexure-1, which clearly demonstrates that these forecasts were accurate for the 2025 season.

(c) Due to the implementation of the Multi-Model Ensemble-based forecasting strategy in 2021, the accuracy of monsoon predictions has shown marked improvement. During the period 2021–2024, the average absolute error in the operational forecast was 2.28% of the LPA, while the average absolute error during the preceding four years (2017–2020) was significantly higher, at 7.5% of the LPA. Overall, the All-India south-west monsoon rainfall forecasts (June–September) during 2021–2024 were notably more accurate. A summary of various forecasts issued during the monsoon season, along with their verification over the last 5 years since 2021, is provided in Annexure-2.

(d) Various steps have been taken by the Government for improving the monitoring & forecasting of the weather and climate hazards. There has been a significant improvement in the satellite, RADAR-based monitoring system, surface and other observational networks, and forecasting capability over the past decade.

- The number of rainfall monitoring stations increased from 3980 in 2015 to 6727 in 2025.
- Satellite and RADAR-based monitoring has increased manifold. Currently, 6 Channels in INSAT 3-D are providing 30-minute gap cloud pictures and water vapour, wind-related products at a very high resolution of up to 1 km. In 2014, a total of 15 DWRs were operational across India, while in 2024-2025, a total of 45 DWRs are functional at real time- a 3-times increase has been noted.
- IMD currently is equipped with a Decision Support System (DSS) based real time multi-hazard impact based early warning system (EWS) which integrates all types of real time and historical data, NWP products, etc to effectively Monitor, detect and provide timely forecasts and impact based warnings with suggested actions upto districts and city/station levels against all types of extreme weather events such as heavy rainfall events, floods, droughts etc. IMD has Met Centres (MCs) in each State and also special centers like Cyclone Warning Centers and Flood Meteorological Offices available for each impacted states, which provides services during cyclones and heavy rainfall Seasons round the clock, respectively.
- Besides a seamless forecast system with implementation of new model products, which has helped improvement of real-time ERF and Monthly and seasonal forecasts as discussed in **(a)**, Heavy rainfall warning is currently issued up to 7 days in advance as compared to 5 days in advance during 2014. Nowcasting is currently issued for each district and location/city, in contrast to a few cities and districts in 2014. Also, Impact Based Forecast (IBF) and risk-based warning up to district levels have been introduced since 2019.

- Earlier, till 2014, it was issued at the sub-division level. From 2022, it is issued at the sub-division, District, and station levels, and is updated twice a day.
- Quantitative Precipitation Forecast (QPF): Validity of QPF was for 2 days and outlook for the subsequent 3 days in 2014. Presently, Validity is for the next 7 days.
- The Ministry had launched an ambitious and well-resourced research programme on a Mission mode, called the Monsoon Mission. The first phase of the mission was implemented during 2012-2017, and the second phase (2017-25) is underway. Through this mission, India has also augmented its capability of a High-Performance Computing (HPC) system for supporting meteorological services, which is close to 22 petaflops capacity now, and it is the backbone of the monsoon research and operational services in the country. India has the fourth-best computing facilities in the world for weather and climate services.

(e) IMD is one of the founder members of the World Meteorological Organisation (WMO) and supports various countries through exchange of observations, model guidance, weather & climate forecast, knowledge sharing, and capacity building initiatives. Various weather and climate services provided by IMD to South Asian Countries including Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, and Sri Lanka are given below: IMD acts as one among the five Regional Specialised Meteorological Centres (RSMC) established as part of the WMO Tropical Cyclone Programme (TCP) for promoting and coordinating the planning and implementation of measures to mitigate tropical cyclone disasters in respective region. As RSMC, IMD provides daily guidance for cyclonic disturbances over the North Indian Ocean, weekly extended range outlook and 3 hourly bulletins during cyclones. It acts among 6 Tropical Cyclone Advisory Centre (TCAC) globally to provide cyclone advisories to Asia Pacific countries and Middle East countries for civil aviation as per International Civil Aviation Organisation guidelines.

IMD is also leading WMO's Severe Weather Forecasting Project (SWFP) – South Asia. It provides daily severe weather guidance on heavy rainfall, strong wind, storm surge, high waves, and cyclonic disturbances to 9 member countries, including Thailand, Myanmar, Bangladesh, Nepal, Bhutan, India, Sri Lanka, Maldives, and Pakistan, through a dedicated webpage and email. It also provides training to Forecasters of member countries. IMD is also leading WMO's Advisory Group on Severe Weather Forecasting. It also acts as South Asia Flash Flood Guidance WMO's Regional Centre for Flash Flood Guidance at sub catchment scale over the South Asian region (Nepal, Bhutan, Bangladesh, Sri Lanka & India) with focus on hilly regions, steep terrains and urban centres. It provides guidance on impact-based flood warning, urban flood warning, riverine/channel routing, etc. IMD, Pune office currently has been acting as one of the 7 WMO's Regional Climate Centres and is involved in providing Long Range Forecast (LRF), climate monitoring, data services, and training to support regional and national climate services. India acts as the RCC for the Third Pole region.

Annexure-1

Monthly and Homogenous-wise Forecasts of Southwest Monsoon 2025:

The monthly monsoon rainfall for the country as a whole was predicted to be >108% of Long Period Average (LPA) for June, >106 % of LPA for July, 94 to 106 % of LPA for August, and >109 % of LPA for September. The realised monthly rainfall over the country as a whole was 109% of LPA in June, 105% in both July and August, and 115% of LPA in September. Hence, the monthly rainfall forecasts were accurate for the southwest monsoon of 2025.

The southwest monsoon seasonal (June to September 2025) rainfall was forecasted to be above-normal over Central India and South Peninsular India (>106% of LPA), above normal over Northwest India (>108% of LPA), and below normal over Northeast India (<94% of LPA). The southwest monsoon seasonal rainfall over the monsoon core zone, consisting of most of the rainfed agriculture areas in the country, was most likely to be above Normal (>106% of LPA). The observed rainfall over Northwest India, Central India, Northeast India, South Peninsula, and Monsoon Core Zone were 27%, 15%, -20%, 10% and 22% of the LPA, respectively. The seasonal forecast issued for homogeneous regions during the season was within the range of the forecast, except for Northwest India.

Annexure-2

YEAR	All India Monsoon Rainfall (LPA)		
	Actual (%)	**Forecast (%)**	**Remark**
2021	100	101	Accurate
2022	106	103	Accurate
2023	95	96	Accurate
2024	108	106	Accurate
2025	108	106	Accurate
***Model error ± 4% of LPA			

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