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भारत मौसम विज्ञान विभाग
INDIA METEOROLOGICAL DEPARTMENT (IMD)
Salient Features of the 2024 Southwest Monsoon Season

HIGHLIGHTS

- Rainfall over the country as a whole during the 2024 southwest monsoon season (June- September) was 108% of its long period average (LPA). Thus the seasonal rainfall was above normal ($>104\%$ of LPA) as per the IMD forecast.
- Seasonal rainfalls over Northwest India, Central India, South Peninsula and Northeast (NE) India were 107%, 119%, 114% and 86% of respective LPA.
- The southwest monsoon seasonal (June to September) rainfall over the monsoon core zone, which consists of most of the rain fed agriculture regions in the country received 122% of LPA.
- Out of the total 36 meteorological subdivisions, 2 subdivisions received large excess rainfall (9% of the total area of the country), 10 subdivisions constituting 26% of the total area received excess, 21 subdivisions received normal rainfall (54% of the total area) and 3 subdivisions (Arunachal Pradesh, Punjab, J & K and Ladak) constituting 11% of the total area) received deficient season rainfall.
- Monthly rainfall over the country as a whole was 89% of LPA in June, 109% of LPA in July, 115% of LPA in August, and 112% of LPA in September.
- Southwest monsoon current advanced over the south Andaman Sea and Nicobar Islands in time (19 May 2024, nearly two days before the normal date). It set in over Kerala on 30th May 2024 against the normal date of 1st June and covered the entire country on 2nd July 2024 against its normal date of 8th July. Monsoon withdrawal commenced from west Rajasthan on 23rd September (delay of 6 days).
- The forecast for monsoon onset over Kerala for this year was correct, which is the nineteenth consecutive correct forecast for this event except year 2015 since the commencement of this forecast in 2005. The Forecast date of monsoon onset over Kerala was 31st May with a model error of ± 4 days and monsoonset in over Kerala on 30th May.
- The forecast for the rainfall over the country as whole during the season as a whole was correct as the realized rainfall is 108% of LPA against the forecast of $106\% \pm 4\%$.

1. Onset and Advance of 2024 Southwest Monsoon

The Southwest Monsoon made its advance on May 19, 2024, over parts of the Maldives, Comorin area, south Bay of Bengal, Nicobar Islands, and the South Andaman Sea, aided by strengthened westerly and south-westerly winds (up to 20 knots) in the lower troposphere. Increased cloud cover (Outgoing Longwave Radiation (OLR) below 200 W/m²), along with widespread rainfall over the Nicobar Islands, marked the progress of the monsoon. The Northern Limit of Monsoon (NLM) on May 19 passed through Lat. 5°N/Long. 75°E to Lat. 10°N/Long. 100°E. The NLM remained stationary on May 20 and 21 before advancing further on May 22 into some more parts of the south Arabian Sea, Maldives, and Andaman & Nicobar Islands. By May 24, the southwest monsoon advanced into more parts of the Maldives, south Bay of Bengal, and east-central Bay of Bengal, further advancing into southwest Bay of Bengal by May 25. It continued its progression into the central and northeast Bay of Bengal on May 26 and reached parts of the south Arabian Sea and Maldives by May 28.

On May 30, the monsoon advanced into the Lakshadweep area, most parts of Kerala, Mahe, and south Tamil Nadu, with further progress over northeast India, including Nagaland, Manipur, Mizoram, Arunachal Pradesh, and parts of Tripura, Meghalaya, and Assam. Thus the monsoon onset over Kerala occurred on May 30, two days earlier than the normal date. By May 31, it covered parts of the northeast Bay of Bengal, Sub-Himalayan West Bengal, Sikkim, and Assam. The progress of the southwest monsoon over its Bay of Bengal branch was more rapid than the Arabian Sea, partly due to the formation and movement of the Severe Cyclonic storm, Remal, over the region.

The monsoon continued advancing in early June, covering parts of central and northwest Bay of Bengal, coastal Andhra Pradesh, Telangana, Goa, and Karnataka. By June 8, it reached southern Maharashtra, Telangana, and Odisha. Between June 8 and 12, it extended further into the north Arabian Sea and Maharashtra, including Mumbai, before a brief halt in its progress from June 12 to 19. On June 20, the monsoon resumed its advancement, reaching Vidarbha, Chhattisgarh, Odisha, Sub-Himalayan West Bengal, and parts of Bihar. It spread into Madhya Pradesh, Jharkhand, and Gujarat by June 23. By June 27, the monsoon had reached the northern Arabian Sea, Gujarat, Rajasthan, and parts of Jammu & Kashmir, Himachal Pradesh, and Punjab. The Southwest Monsoon entirely covered India by July 2, 2024, six days earlier than its normal date of July 8,

bringing widespread rainfall across the country. The onset dates of Monsoon 2024 are shown in **Fig.1**. The withdrawal of the Southwest Monsoon 2024 commenced on September 23, delayed by 6 days from its normal date of September 17, following a reduction in rainfall and the formation of an anti-cyclonic circulation in the lower troposphere. The withdrawal dates of the 2024 Southwest Monsoon are illustrated in **Fig.2**.

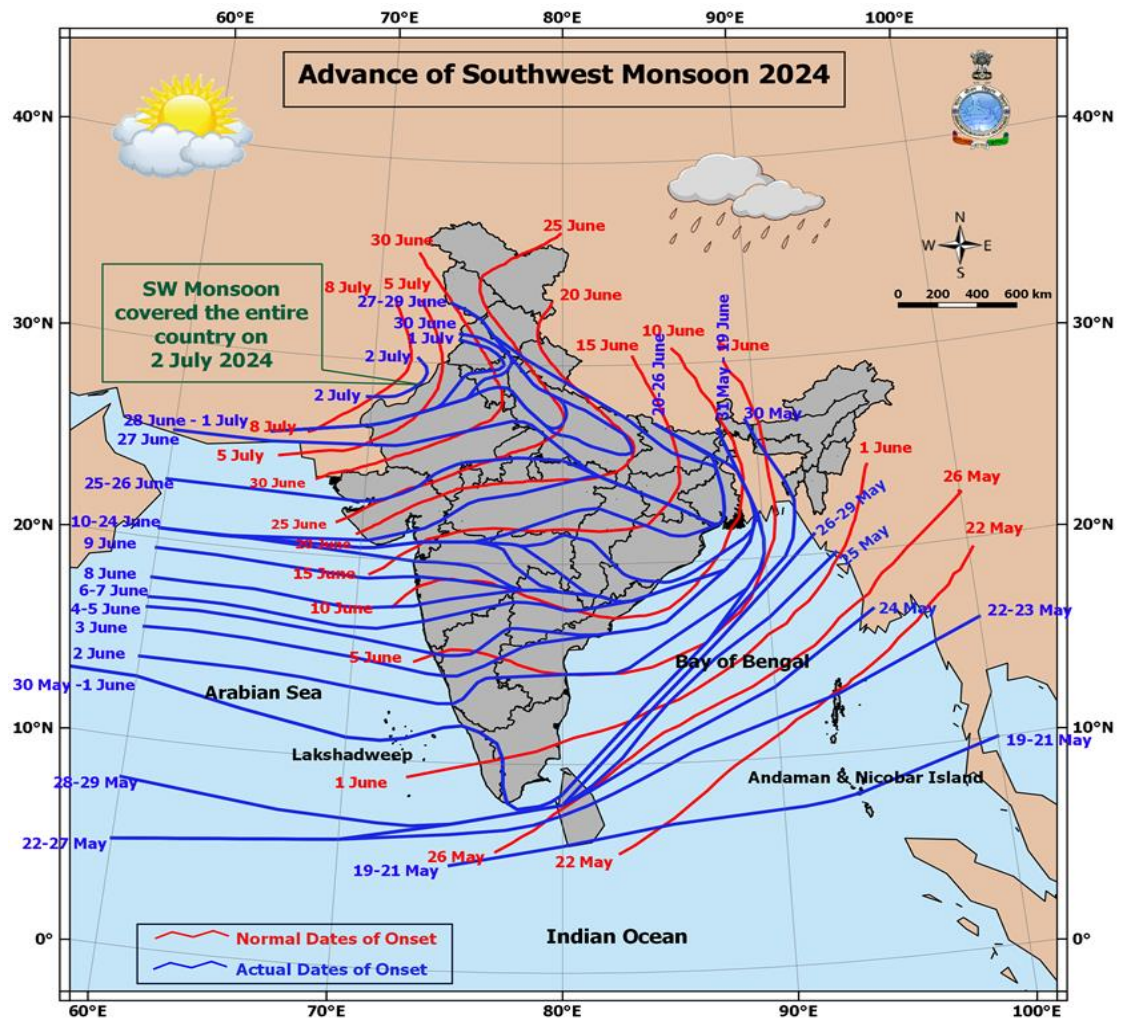


Fig.1: Isochrones of advance of the Southwest monsoon during 2024

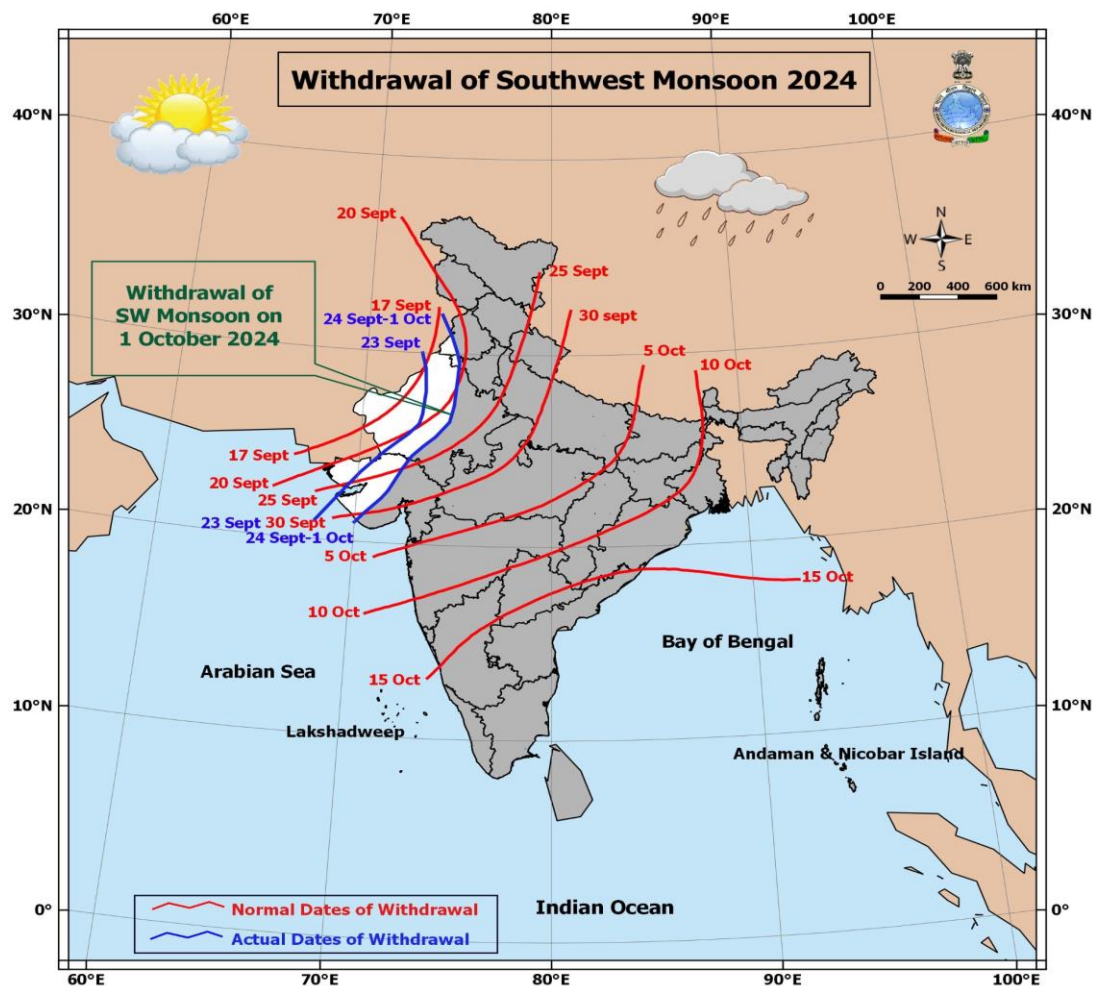


Fig.2: Isochrones of withdrawal of southwest monsoon – 2024 as on 1st October 2024.

2. Rainfall Distribution

The realized 2024 southwest monsoon season (June to September) rainfall over the country as a whole and four broad geographical regions are given in the table below along with respective long period average (LPA) values. The rainfall during the 4 monsoon months and the second half of the monsoon season (August + September) over the country as a whole are also given in the Table 1.

As seen in the Table-1 above, the 2024 seasonal rainfall over the country as a whole was above normal (>104% of LPA). Regional wise, the 2024 season rainfall was above normal over three of the four geographical regions of the country (central India (>106% of LPA), Northwest India (>108% of LPA) and South Peninsula (>106% of LPA) and was below normal over East & Northeast India (<94% of LPA). The rainfall over the monsoon core zone also was above normal (>106% of LPA)

| Table 1. Season (June to September) rainfall | | | |
|---------------------------------------------------------------------------------------------------------------|--------------------------------------|---------------------------------|----------------------------|
| Region | Long Period Average (LPA)(mm) | Actual Rainfall for 2024 | |
| | | Rainfall (mm) | Rainfall (% of LPA) |
| All India | 868.6 | 934.8 | 108 |
| Northwest India | 587.6 | 628.6 | 107 |
| Central India | 978.0 | 1168.5 | 119 |
| East & Northeast India | 1367.3 | 1178.7 | 86 |
| South Peninsula | 716.2 | 815.4 | 114 |
| Monsoon Core Zone | 832.2 | 1017.1 | 122 |
| <i>Monthly & second half of the monsoon season rainfall over the country as a whole(All India)</i> | | | |
| Month | LPA (mm) | Actual Rainfall for 2024 | |
| | | Rainfall (mm) | Rainfall (% of LPA) |
| June | 165.4 | 147.2 | 89 |
| July | 280.5 | 305.8 | 109 |
| August | 254.9 | 293.9 | 115 |
| September | 167.9 | 187.3 | 112 |
| August + September | 422.8 | 481.2 | 114 |

Month wise, the rainfall over the country as a whole was below normal in June (<92% of LPA) and above normal in all other 3 months; July (> 106 of LPA), August (> 106 of LPA) and September (112% of LPA). The rainfall during the second half of the seasonal over the country as whole was also above normal (> 106 of LPA),

Fig. 3 shows the subdivision wise season (June to September) rainfall.

Out of the total 36 meteorological subdivisions, 2 subdivisions received large excess (9% of total area), 10 subdivisions constituting 26% of the total area of the country received excess, 21 subdivisions received normal rainfall (54% of the total area) and 3 subdivisions (11% of the total area) received deficient season rainfall. The 3 Meteorological subdivisions which got deficient rainfall are Arunachal Pradesh, Punjab, J & K and Ladak.

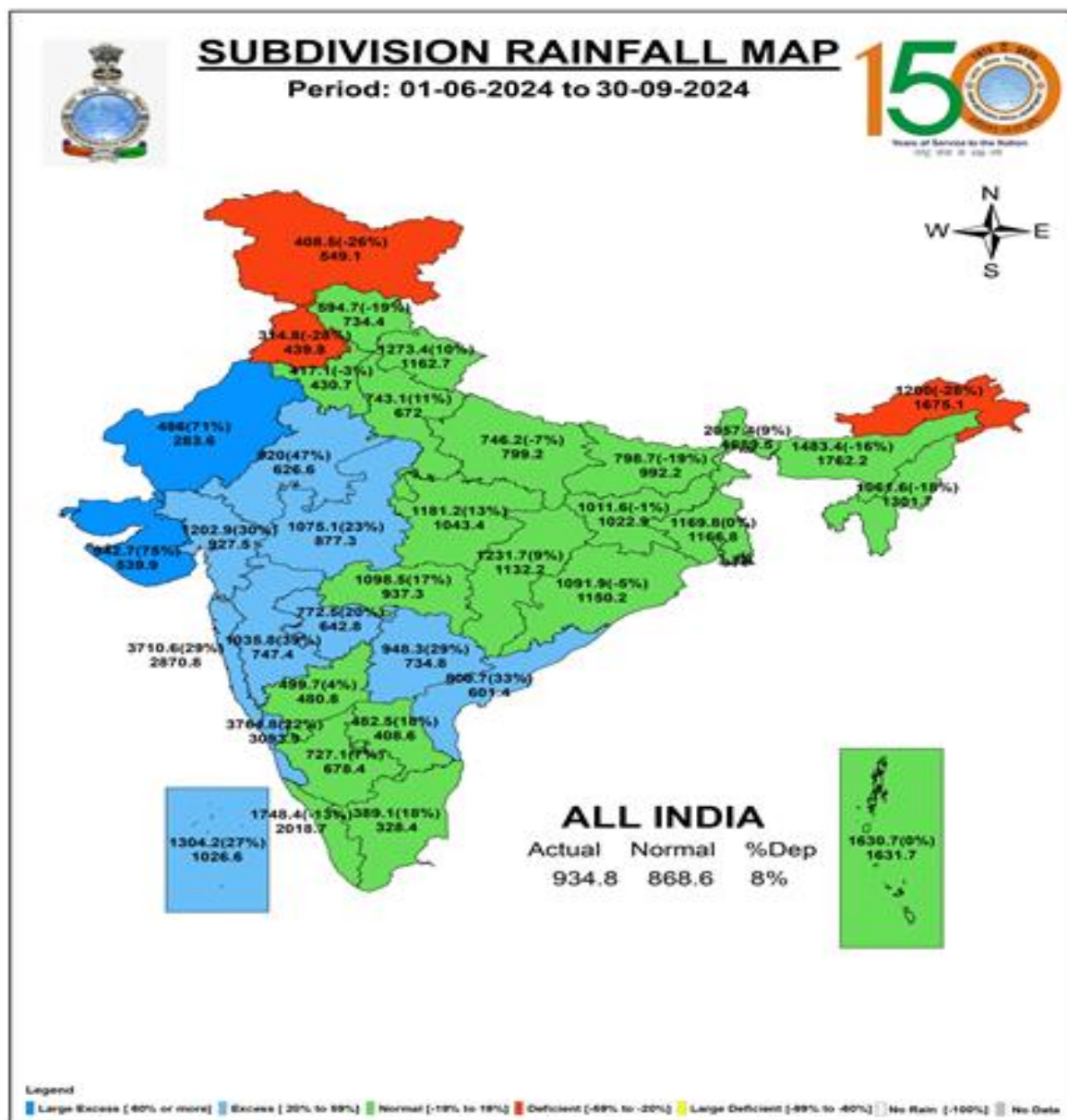


Fig. 3: Sub-division wise rainfall distribution over India during southwest monsoon season (June to September) – 2024.

Fig. 4 shows the subdivision-wise monthly rainfall. In June, 2 subdivisions received large excess rainfall, 4 subdivisions received excess rainfall, 14 subdivisions received normal rainfall, 14 subdivisions received deficient rainfall and 2 subdivisions received large deficient rainfall. The most notable feature of the rainfall distribution in June was the large spatial variability over the South Peninsula, with excess rainfall in 5 subdivisions, normal rainfall in 4 subdivisions, and deficient rainfall in 1 subdivision out of the 10 subdivisions. Region-wise, South Peninsula (114% of LPA) above normal and three regions (67% of

LPA for Northwest India ,87% of LPA for Northeast India, 86% of LPA for Central India) have received below normal rainfall.

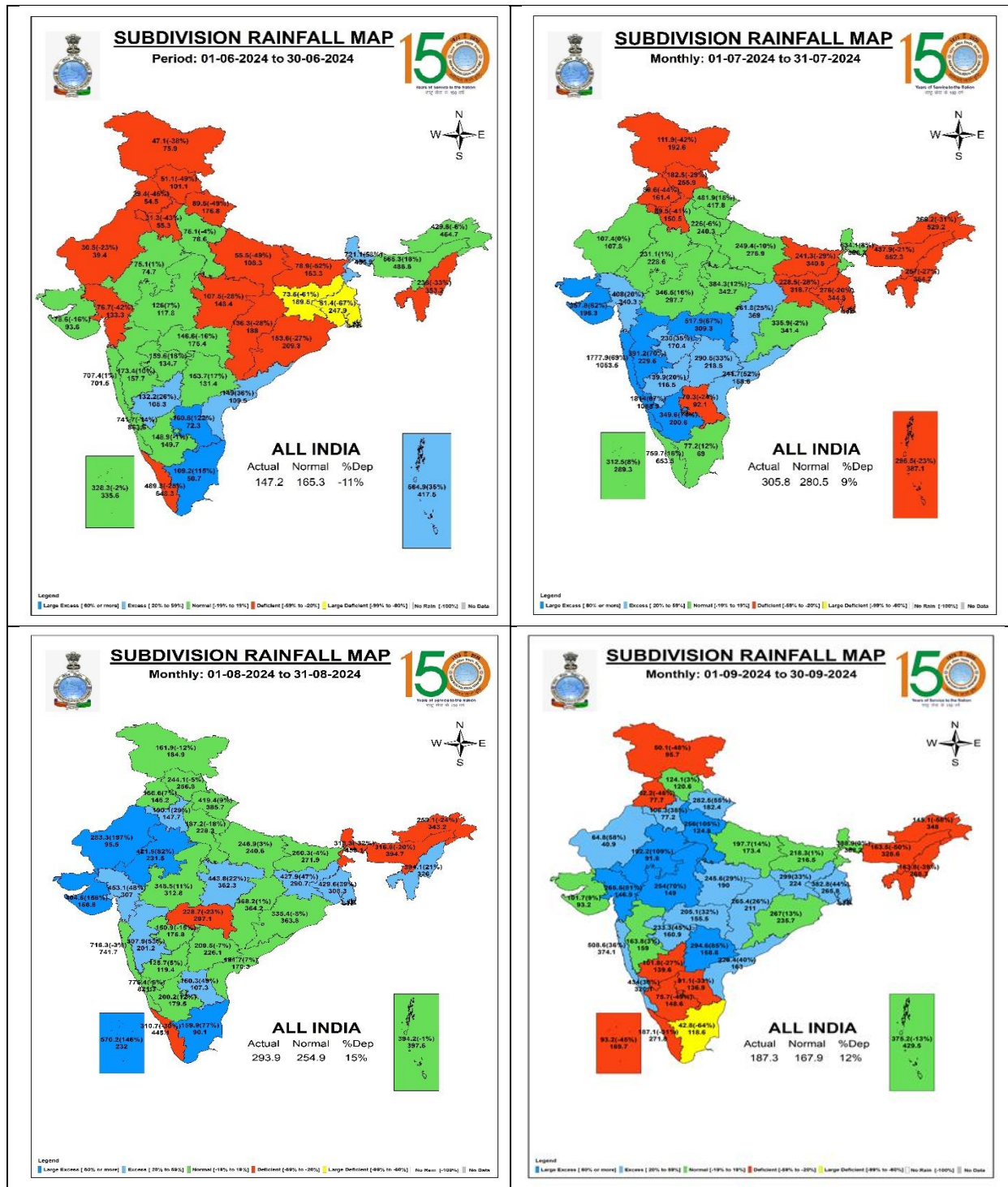


Fig. 4: Sub-division wise monthly rainfall distribution over India during southwest monsoon season – 2024

In July, 06 subdivisions received large excess rainfall, 6 subdivisions received excess rainfall, 12 subdivisions received normal rainfall, 12 subdivisions received deficient rainfall. The most notable feature of the rainfall distribution in July was the large spatial variability over Central India, with excess rainfall in 7 subdivisions and normal rainfall in 3 subdivisions out of a total of 10 subdivisions. In contrast, in East and Northeast India, 6 out of 7 subdivisions experienced deficient rainfall, while 1 had normal rainfall. Region wise, South peninsula (137% of LPA) Central India (133% of LPA) received above normal rainfall whereas Northwest India (86% of LPA) and North & North East India (77% of LPA) received below normal rainfall.

In August, 05 subdivisions received large excess rainfall, 8 subdivisions received excess rainfall, 18 subdivisions received normal rainfall, 5 subdivisions received deficient rainfall. Most noticeable feature of rainfall distribution during August was the large excess rainfall over Saurashtra & Kutch, East & West Rajasthan and Lakshadweep. Region wise, Northwest India (130% of LPA) and Central India (116% of LPA) received excess rainfall whereas East & Northeast India (102% of LPA) and South Peninsula (107% of LPA) received normal rainfall.

In September, 05 subdivisions have received large excess rainfall, 12 subdivisions received excess rainfall, 8 subdivisions received normal rainfall, 10 subdivisions received deficient rainfall and 1 subdivision received large deficient rainfall. Most noticeable feature of rainfall distribution during September was the large excess rainfall over west Uttar Pradesh, West Madhya Pradesh, Gujarat Region and Telangana where as large deficient rainfall over Tamil., Puducherry & Karaikal. Region wise, Northwest India (129% of LPA) and Central India (132% of LPA) experienced excess rainfall whereas East & Northeast India (102% of LPA) received deficient rainfall and South Peninsula (97% of LPA) received normal rainfall.

Fig. 5 depicts the monthly variation of rainfall for All India and four homogeneous regions during 2024 southwest monsoon season and **Fig. 6** depicts the weekly and cumulative weekly rainfall anomaly expressed as percentage departure from the LPA.

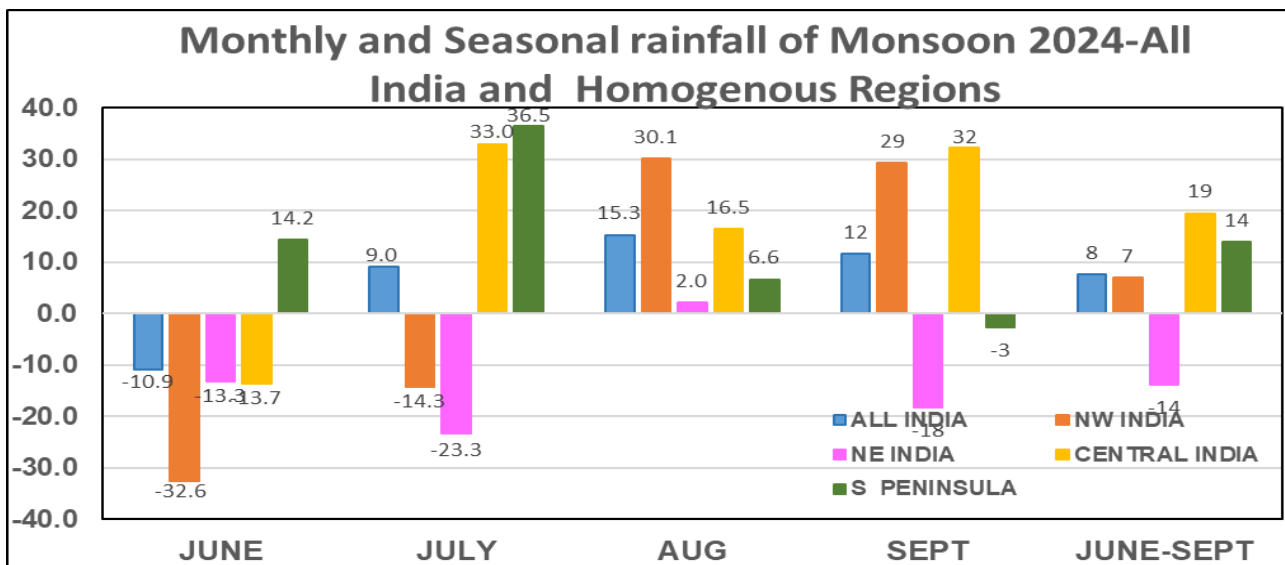


Fig. 5. Monthly and seasonal monsoon rainfall of 2024 over Broad homogenous region and Country as a whole in % departure.

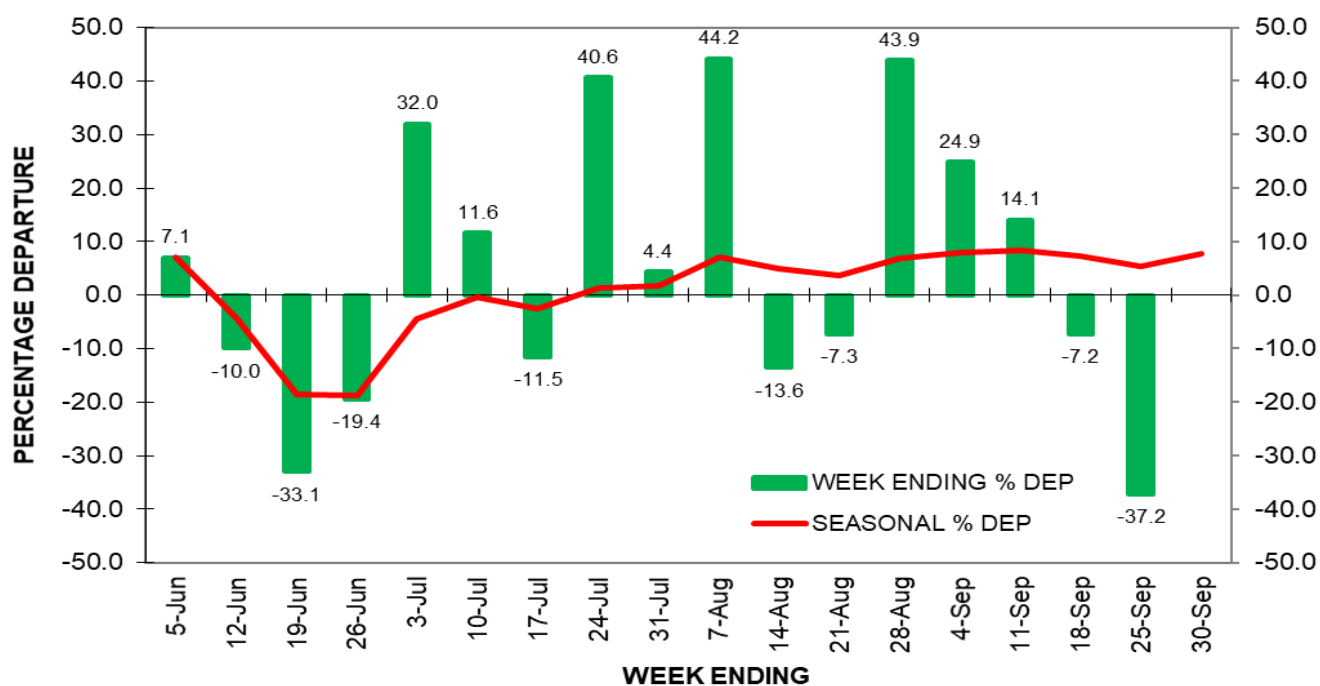


Fig. 6. Week by week progress and cumulative rainfall (% departure from normal) over Country as a whole.

The all India weekly rainfall anomalies during 8 of the 17 weeks of the monsoon season were negative. Out of the 9 positive rainfall anomaly weeks, 1 week was in June, 4 weeks was in July and two weeks each in August and September. Except for the first week of June, all the remaining weeks in the month received negative rainfall. The highest negative weekly rainfall anomaly was recorded during the week ending 19th June and week ending 25th September ((-33% and -37% of LPA resp.). The highest positive rainfall anomalies were recorded during the week ending on 24th July (40% of LPA), 7th August (44% of LPA), followed by the week ending on 28th August (44% of LPA). The increase in the weekly rainfall during the season was mainly associated with the low pressure systems which moved along the monsoon trough.

3. Other Features of the Southwest Monsoon Season

During the season, six Monsoon depressions formed and one intensified into Cyclonic Storm. The tracks of the Cyclonic Storm and Deep Depression are shown in **Fig. 7**. The information of number of low-pressure systems formed during the season is shown in Table-2. In June, only one low-pressure System developed over the Bay of Bengal and Monsoon onset was delayed over many subdivisions over Indo Gangetic plains, causing large rainfall deficiency over the region. A total of three low-pressure systems (LPS) were formed during July (15 -17, 18-23 and 26-28 Jul). Out of these, one system intensified into Depression (19 to 20 Jul). The low-pressure systems formed during the monsoon season contributed heavy and very heavy rainfall over many parts of the country.

In August, six low-pressure systems formed (2 low pressure areas (one over land during 3- 5 August, one over Arabian Sea during 22 - 24 August), 1 well marked low pressure area over Bay of Bengal during 25 - 28 August, 1 Depression over Bay of Bengal during 29 August – 2 September, one land Deep depression during 2 - 5 August and one cyclonic storm “ASNA” over Bay of Bengal during 16 August - 2 September). These low pressure systems helped to get good rainfall over many parts of the country.

In September, three low-pressure systems formed (one Deep Depression over West central and adjoining Northwest Bay of Bengal (8th- 10th Sept, 11-13 Sept 2024), which moved to Northeast Madhya Pradesh and weekend over the same areas as a well-marked Low pressure area on the evening of 10th Sept. It re-intensified into a

Depression on morning of 11th Sept over Northeast Madhya Pradesh and moved northwest Madhya Pradesh during 11-12 Sept and weakened into a well-marked low-pressure area over northwest Uttar Pradesh & neighborhood on 13th Sept; one Deep depression Northeast Bay of Bengal and adjoining Bangladesh during 12th Sept – 19th Sept, which moved across central India and weakened into a well-marked Low Pressure Area over northeast Madhya Pradesh and adjoining southwest Uttar Pradesh on 19 Sept; 1 low pressure area formed over West central Bay of Bengal & adjoining Northwest Bay off north Andhra - south Odisha coasts which moved over to south Chhattisgarh & neighborhood across Odisha on 25th September and became less marked thereafter). The country as a whole received excess rainfall during September mainly due to the west/north-westward movement of three low-pressure systems and their associated cyclonic circulations along the monsoon trough from the Northwest Bay of Bengal towards central India. Out of these two systems intensified into the deep depression.

During peak monsoon rainfall months of July and Aug 2024, monsoon trough was south of the normal position in most dates and there was no break monsoon as such developed/prevailed on any date during monsoon 2024. Hence, core zone of Monsoon region received above normal rainfall. Also, during the season no active WD impacted north India except in September month. This is the main reason for the below normal rainfall over some areas over the western Himalayan.

The number of heavy rainfall events during the last five years is given in Table 3. Month-wise locations of Very Heavy Rainfall (115.6 to 204.4 mm) and Extremely Heavy Rainfall (more than 204.4 mm) reported stations for June to Sept 2024 are given in **Fig. 8**. The extreme rainfall events were more realized over Konkan & Goa, coastal Karnataka, Uttaranchal, Himachal Pradesh, Gujarat, West Madhya Pradesh, Telangana, Bihar, Orissa and Gangetic West Bengal.

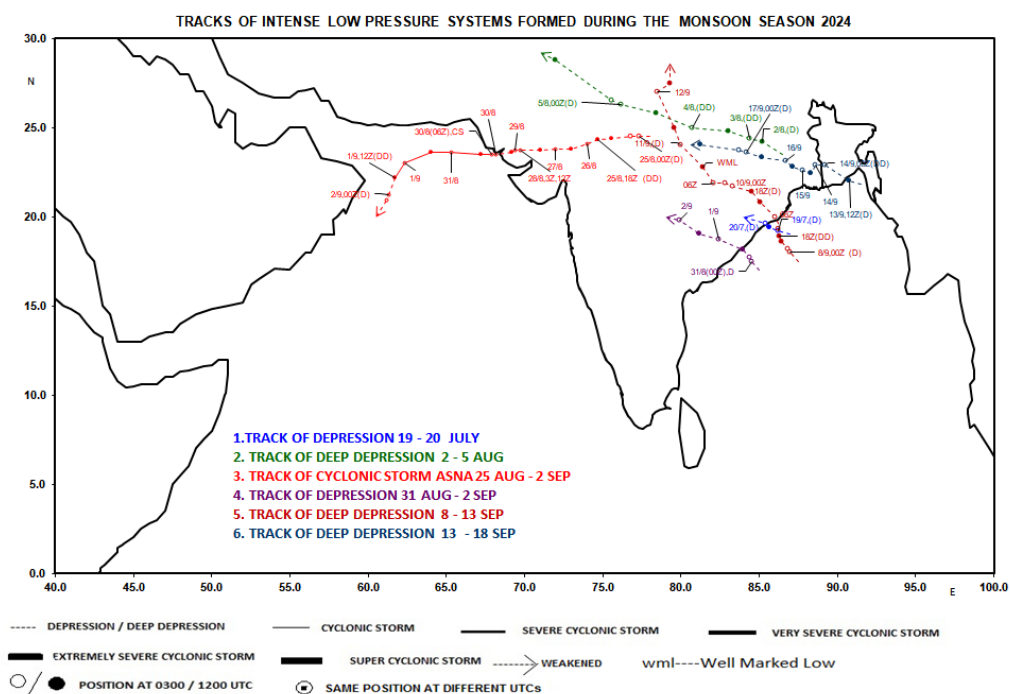


Fig. 7. Tracks of the Cyclonic Storms and Depressions formed during Monsoon 2024

Table 2: Number of Low-pressure System (LPS) including Low (L), Well Marked Low (WML), Depression (D), Deep Depression (DD), Cyclonic Storm (CS) and number of LPS days in monsoon 2024.

| Systems / Month | CS | DD | D | WML | L | Land Low | Total systems |
|-----------------|----|----|---|-----|---|----------|---------------|
| June | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| July | 0 | 0 | 1 | 1 | 1 | 0 | 3 |
| August | 1 | 1 | 1 | 1 | 2 | 0 | 6 |
| Sept. | 0 | 2 | 0 | 0 | 1 | 0 | 3 |

Table 3: The number of heavy rainfall events during the last five years

| Year | 2020 | | 2021 | | 2022 | | 2023 | | 2024 | |
|---------|-------------------------|--------|-------------------------|--------|-------------------------|--------|-------------------------|--------|-------------------------|--------|
| Month | >115.6 and <204.5 | >204.5 | >115.6 and <204.5 | >204.5 | >115.6 and <204.5 | >204.5 | >115.6 and <204.5 | >204.5 | >115.6 and <204.5 | >204.5 |
| Jun | 262 | 36 | 277 | 35 | 237 | 80 | 429 | 65 | 284 | 51 |
| Jul | 447 | 90 | 638 | 121 | 829 | 131 | 1113 | 205 | 1059 | 194 |
| Aug | 1008 | 165 | 272 | 28 | 577 | 63 | 402 | 66 | 762 | 132 |
| Sep | 308 | 61 | 449 | 89 | 231 | 22 | 377 | 85 | 527 | 96 |
| Monsoon | 1912 | 341 | 1636 | 273 | 1874 | 296 | 2321 | 421 | 2632 | 473 |

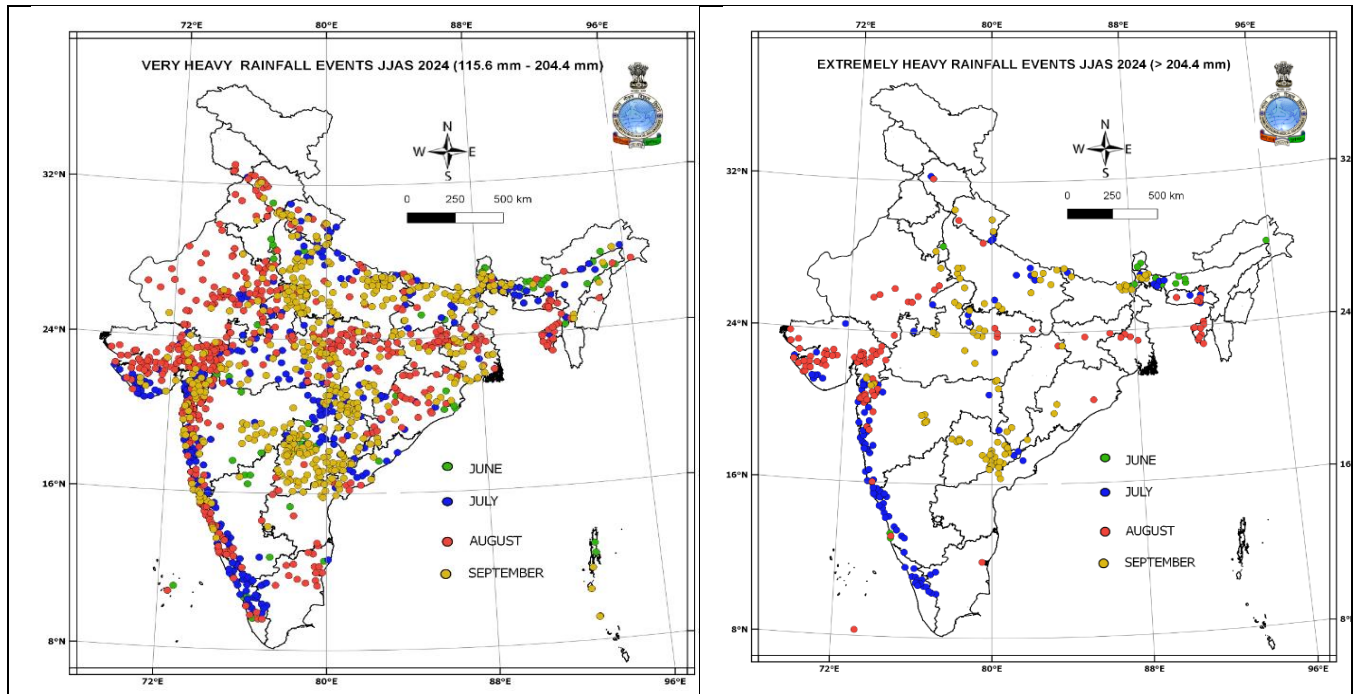


Fig 8. The location of Very Heavy Rainfall (115.6 to 204.4 mm) (left one) and Extremely Heavy Rainfall (more than 204.4 mm) (right one) stations during JJAS 2024.

4. Verification of Long-Range Forecast issued for SW Monsoon 2024:

The forecast for monsoon onset over Kerala for this year was correct, which is the nineteenth consecutive correct forecast for this event except the year 2015 since the commencement of this forecast in 2005. The Forecast date of onset of monsoon over Kerala was 31st May with a model error of ± 4 days and realized date of onset of monsoon over Kerala was 30th May.

The first stage forecast for the season (June-September) rainfall over the country as a whole issued in April was 106% of LPA with a model error of $\pm 5\%$ of LPA and the update forecast issued in the end of May 2024 was 106% of LPA with a model error of $\pm 4\%$ of LPA. The actual season rainfall for the country as a whole was 108 % of LPA. Thus the seasonal rainfall forecast for the country as a whole was correct.

Considering the four broad geographical regions of India, the forecasts issued on 27th, May indicated that the southwest monsoon seasonal (June to September 2024) rainfall is most likely to be above-normal over Central India and South Peninsular India ($>106\%$ of LPA), normal over Northwest India (92-108% of LPA) and below normal over Northeast India ($<94\%$ of LPA). The forecast for the southwest monsoon seasonal rainfall over the monsoon core zone consisting of most of the rainfed agriculture was also above Normal ($>106\%$ of LPA). The actual rainfall over Northwest India, Central India, Northeast India, South Peninsula and Monsoon Core Zone was recorded at 7%, 20%, -14%, 14% and 19% of the LPA, respectively. The monthly forecast issued during the season was within the range of the forecast. However, the June forecast was slightly underestimated. The forecast for the second half of the monsoon season (August –September) for the country as a whole also was within the forecast limits. Details of the verification of the forecast are shown in Tables 4(a) and 4(b).

This year, IMD had indicated the weakening of El Niño conditions prevailed over the equatorial Pacific Ocean and the possibility of developing a La Niña conditions during the second half of the monsoon season. IMD has also indicated that a positive Indian Ocean Dipole is likely to develop during the monsoon season. The El Niño conditions over the equatorial Pacific were weakened, and neutral ENSO conditions prevailed during the season. However, large-scale atmospheric circulation features were similar to La Niña condition over the equatorial Pacific even though the Sea surface anomaly did not cross the La Niña threshold value (-0.5 Degree). Neutral IOD conditions prevailed during southwest monsoon season.

The Tables 4(a) and 4(b) below gives the summary of the verification of the long-range forecasts issued for the 2024 Southwest monsoon.

Table 4(a): Performance of Long Range Forecast of Southwest Monsoon 2024

| Seasonal Forecast | | Observed |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 15 April 2024-1st Stage For Season as a whole | 27th May 2024-2nd stage - | |
| <p>El Niño condition is likely to weaken to neutral ENSO conditions during early part of the monsoon season and La Niña conditions are likely to develop during second half of monsoon season.</p> <p>Positive IOD conditions are likely to develop during the latter part of the southwest monsoon season.</p> <p>With Weakening of El-Nino, it was predicted that Quantitatively, ISMR likely to be above normal with 106% of LPA with a model error of $\pm 5\%$.</p> | <p>➤ Same ENSO forecast</p> <p>➤ Same IOD forecast</p> <p>➤ Same forecast was reiterated in 2nd Stage LRF issued on 27th May 2024, above normal with 106% with $\pm 4\%$.</p> | <p>➤ Neutral El Nino Southern Oscillation (ENSO) conditions developed in July and continued till Sept</p> <p>➤ IOD remained neutral till end of Aug</p> <p>➤ Rainfall is (107.8 % of LPA).</p> |
| 1 Aug -3rd Stage (For 2nd half of Monsoon 2024 (Aug- Sept)) | | |
| <p>➤ Currently, Neutral El Nino-Southern Oscillation (ENSO) conditions are prevailing in the equatorial Pacific region. La Nina is likely to develop in the second half of the monsoon season towards end of August</p> <p>➤ Neutral IOD conditions are prevailing and likely to continue remaining part of the monsoon season.</p> <p>➤ Rainfall is most likely to be above normal ($>106\%$ of LPA)</p> | | <p>➤ Neutral El Nino-Southern Oscillation (ENSO) conditions prevailed.</p> <p>➤ IOD remained neutral.</p> <p>➤ 1st half of the monsoon season 2024 got normal rainfall (102%). It was above normal during 2nd half the season (114% of the LPA).</p> |

Table 4(b): Performance of monthly Rainfall Forecast during Monsoon 2024

| Month | Forecast | Realized |
|----------------|---------------------------------------------------------------------------------------------------|-------------|
| June 2024 | Normal rainfall (92-108% of LPA) is most likely over the country as a whole during June, 2024 | 91% of LPA |
| July 2024 | Above Normal ($>106\%$ of LPA) is most likely over the country as a whole during July, 2024 | 109% of LPA |
| August 2024 | Normal ((94 to 106 % of LPA) is most likely over the country as a whole during August, 2024 | 115% of LPA |
| September 2024 | Above Normal ($>109\%$ of LPA) is most likely over the country as a whole during September, 2024 | 112% of LPA |