MINISTRY OF EARTH SCIENCES
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A REPORT
ON SOUTH WEST MONSOON
2024
OVER NORTH WEST INDIA

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HIGHLIGHTS

Southwest Monsoon 2024 over Northwest India

- The Southwest Monsoon 2024 over Northwest India was **normal**, with the region receiving **107% of its Long Period Average (LPA)** rainfall based on 1961–2010 data, representing a seasonal departure of +7% from LPA.
- The monthly rainfall distribution showed significant intra-seasonal variation — **June (67% of LPA)** and **July (86% of LPA)** recorded below-normal rainfall, whereas **August (130% of LPA)** and **September (129% of LPA)** experienced markedly above-normal rainfall, indicating a strong recovery during the latter half of the season.
- Of the **nine meteorological subdivisions** of Northwest India, West Rajasthan recorded **large excess rainfall** (>+60%), East Rajasthan received **excess rainfall** (+20% to +59%), five subdivisions—Himachal Pradesh, Uttarakhand**,** Haryana, Chandigarh & Delhi, and Uttar Pradesh—received **normal rainfall** (–19% to +19%), while Jammu & Kashmir and Ladakh, and Punjab experienced **deficient rainfall** (–20% to –59%).
- Among the **six States** and four Union Territories in the region, Rajasthan and Delhi experienced excess rainfall; Ladakh**,** Himachal Pradesh**,** Uttarakhand, Haryana**,** Chandigarh, and Uttar Pradesh received normal rainfall; whereas Punjab and Jammu & Kashmir remained **deficient** during the monsoon season.
- The **onset of the Southwest Monsoon** occurred over **Kerala on 30th May 2024**, and the monsoon **advanced into Northwest India by 25th June**, covering the **entire region by 2nd July**, which was **about six days earlier than its normal date of 8th July**.
- The **withdrawal of the Southwest Monsoon** began from **West Rajasthan and Kachchh on 23rd September 2024**, marking a slightly delayed onset of withdrawal. The process progressed steadily across the region, and the monsoon completely withdrew from **Northwest India by 11th October 2024**.
- The **withdrawal from the entire country** was completed by **15th October 2024**, indicating a **delay of about four days** compared to the climatological normal.

1. INTRODUCTION

The North West (NW) India is one of the major agrarian regions of the country and plays a vital role in India's food grain production. The region comprises nine meteorological subdivisions — Jammu & Kashmir, Ladakh, Gilgit-Baltistan & Muzaffarabad, Himachal Pradesh, Punjab, Haryana, Chandigarh & Delhi, West Rajasthan, East Rajasthan, West Uttar Pradesh, and East Uttar Pradesh. The South-West Monsoon (SWM) season is the principal rainy season for this region, contributing the majority of its annual precipitation. Owing to its unique geographical location, complex orography, and dynamic interaction with the monsoon circulation, the region exhibits high spatial and temporal rainfall variability, making it vulnerable to weather-induced disasters such as droughts and floods. Climatologically, the Long Period Average (LPA) rainfall for the season (June–September) over NW India is **58.76 cm** based on data from 1971–2020, and the **normal onset date of the monsoon over the region is 20 June**.

2. ONSET AND ADVANCE OF SOUTHWEST MONSOON 2024

The Southwest Monsoon 2024 set in over some parts of the South Bay of Bengal, most parts of the Andaman & Nicobar Islands, and the Andaman Sea on **19 May 2024**, marking the commencement of the monsoon advance over the Indian region. The monsoon subsequently advanced steadily and set in over Kerala on 30 May 2024, two days earlier than its normal onset date of 1 June. Thereafter, the monsoon progressed northward in a systematic manner, **reaching parts of Rajasthan by 25 June 2024**, with the Northern Limit of Monsoon (NLM) passing through 23°N/60°E, 23°N/65°E, Mundra, Mehsana, Udaipur, Shivpuri, Siddhi, Chaibasa, Haldia, Pakur, Sahibganj, and Raxaul.

By 27 June 2024, the monsoon advanced into most parts of Uttarakhand, Himachal Pradesh, Jammu-Kashmir-Ladakh-Gilgit-Baltistan-Muzaffarabad, some parts of Punjab, and additional areas of Rajasthan, West Uttar Pradesh, and East Uttar Pradesh. On 28 June, it further covered entire Delhi, remaining parts of East Rajasthan, some more parts of Haryana, and extensive areas of Uttar Pradesh and Uttarakhand. The NLM on that day extended through 26°N/65°E, Jaisalmer, Churu, Bhiwani, Delhi, Aligarh, Hardoi, Moradabad, Una, Pathankot, Jammu, and 33°N/74°E.

The southwest monsoon advanced further into additional parts of West Rajasthan and Haryana, remaining parts of Uttar Pradesh, and some more parts of Punjab, Himachal Pradesh, and Jammu by 30 June 2024, with the NLM passing through 26°N/65°E, Jaisalmer, Churu, Hissar, Karnal, Jalandhar, Tarn Taran, and 31.5°N/74.5°E. The subsequent phase on 1 July 2024 saw its extension into remaining parts of Rajasthan, Haryana, Punjab, and entire Chandigarh, with the NLM passing through 26°N/65°E, Jaisalmer, Sirsa, Kurukshetra, Rajpura, Ludhiana, and 31.2°N/74.5°E.

Finally, **on 2 July 2024**, the southwest monsoon covered the remaining parts of Rajasthan, Haryana, and Punjab, thereby covering the entire country six days ahead of the normal date of 8 July. The overall advance of the monsoon during 2024 was thus characterized by a smooth and accelerated progression across the Indian subcontinent. The isochrones of monsoon advance depicting this progression are presented in Figures 1 and 2.

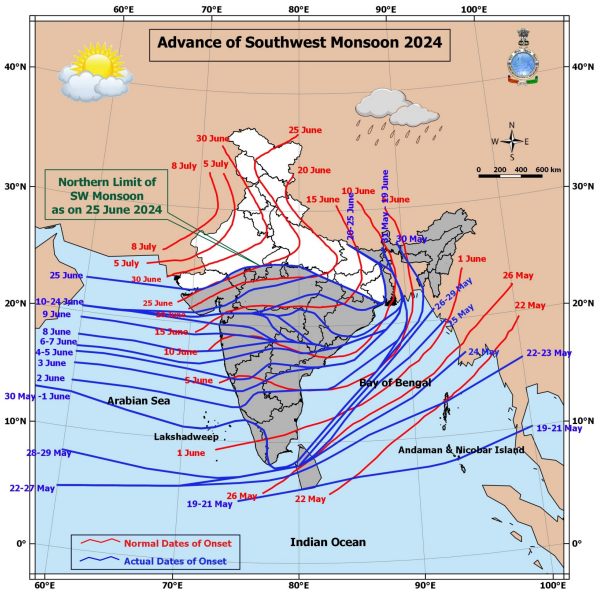

Fig.1: Progress of SW Monsoon on 25th June

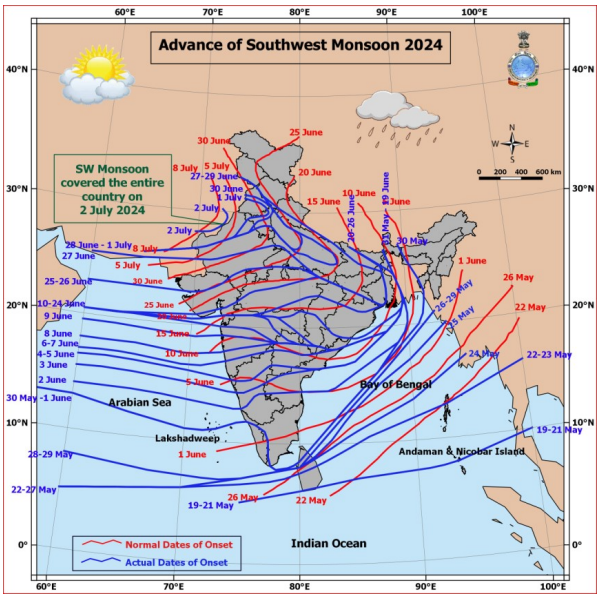

Fig.2: Progress of SW Monsoon on 2nd July

3. CHIEF SYNOPTIC FEATURES

3.1 Depressions and Low Pressure

During the southwest monsoon season 2024, a total of thirteen low-pressure systems formed over the Indian region, of which one intensified into a cyclonic storm. The synoptic activity during the season comprised one cyclonic storm, three deep depressions, two depressions, two well-marked low-pressure areas, and five low-pressure areas, making a total of thirteen systems. The cumulative influence of these systems maintained active to vigorous monsoon conditions across central and northern India, including the Northwest region.

In June, only one low-pressure system developed over the Bay of Bengal, and the delayed monsoon onset over several parts of the Indo-Gangetic plains contributed to rainfall deficiency during the month. In July, three low-pressure systems formed (15–17, 18–23, and 26–28 July), including one that intensified into a depression during 19–20 July. These systems enhanced rainfall activity over central and eastern India, with subsequent moisture advection bringing beneficial rains to parts of Northwest India.

August was the most active month of the season, with six low-pressure systems forming — two low-pressure areas (including one over land during 3–5 August and another over the Arabian Sea during 22–24 August), one well-marked low-pressure area over the Bay of Bengal (25–28

August), one depression (29 August–2 September), one deep depression (2–5 August), and a cyclonic storm "Asna" over the Bay of Bengal (16 August–2 September). The enhanced synoptic activity during this month led to vigorous monsoon conditions and widespread rainfall across the core monsoon zone and adjoining northern parts, contributing substantially to the seasonal rainfall over Northwest India.

In September, three low-pressure systems formed, including two deep depressions and one low-pressure area. The first deep depression originated over the west-central and adjoining northwest Bay of Bengal (8–10 September) and moved inland across northeast Madhya Pradesh. The second deep depression developed over the northeast Bay of Bengal and adjoining Bangladesh (12–19 September) and tracked westward across central India. Another low-pressure area formed over the west-central Bay of Bengal on 25 September and moved inland before dissipating. The westward movement of these systems along the monsoon trough contributed to excess rainfall over large parts of central and north India, including the northwest region, during September.

During July and August 2024, the monsoon trough generally remained south of its normal position, and no prolonged break-monsoon conditions were observed. Consequently, the core monsoon zone received above-normal rainfall. However, the absence of active western disturbances through most of the season, except in September, resulted in relatively subdued rainfall activity over the western Himalayan region.

Overall, the synoptic-scale activity during the season was near normal, with 52 low-pressure system days against the climatologically normal of 57 days. The collective influence of these systems ensured active to vigorous monsoon conditions over large parts of the country and contributed to the above-normal rainfall over Northwest India.

The month-wise frequency of these systems is summarized in Table 1, and the tracks of the cyclonic storm and deep depressions are shown in Figure 3.

Table 1: Number of Low pressureSystem (LPS) including Low (L), Well Marked Low (WML), Depression (D), Deep Depression (DD), Cyclonic Storm (CS) in monsoon season 2024

Systems / Month	CS	Deep Depression	Depression	Well-marked low-pressure area	Low-pressure area	Total systems
June	0	0	0	0	1	1
July	0	0	1	1	1	3
August	1	1	1	1	2	6
Sept.	0	2	0	0	1	3

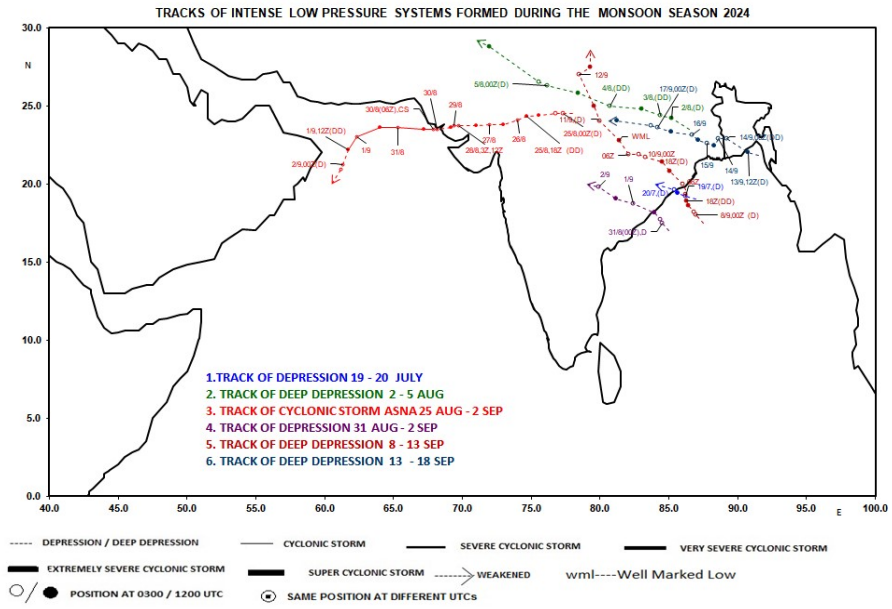

Fig. 3. Tracks of the Cyclonic Storms and Depressions formed during Monsoon 2024

3.2 Western Disturbances

During the 2024 southwest monsoon season, the activity of western disturbances (WDs) over north and northwest India showed notable variability.

In June 2024, only three WDs were observed across north India (during 5–10, 19–25, and 26–28 June) against the normal of 4–5 systems. The absence of any significant WD activity between 10 and 19 June contributed to a prolonged dry spell and intense heat wave conditions over northwest and adjoining central India. However, one notable WD during late June interacted with the advancing monsoon trough, resulting in heavy rainfall over parts of northwest India, including Delhi, which recorded 44% excess rainfall for the month. The cold and arid region of Ladakh also experienced an exceptional 385% above-normal rainfall, highlighting the significant influence of this interaction.

During the peak monsoon months of July and August 2024, the monsoon trough remained south of its normal position on most days, and no break monsoon condition developed during this period. Consequently, the core monsoon zone received above-normal rainfall, while the western Himalayan region remained comparatively less affected due to the absence of active WDs.

In September 2024, five WDs traversed the extreme northern parts of India on 1–7, 8–13, 13–19, 16–18, and 28–29 September. Among these, three significant systems (8–13, 13–19, and 16–18 September) interacted with monsoonal low-pressure systems, enhancing rainfall activity over the northern plains and Himalayan states—particularly Jammu & Kashmir, Himachal Pradesh, and Uttarakhand. These interactions led to localized heavy rainfall, landslides, flash floods, and waterlogging in several vulnerable areas. The combined influence of these WDs and

monsoon systems extended the active monsoon phase over northern India and caused above-normal rainfall in several pockets.

Overall, apart from September, no strong WD activity was observed during the monsoon season. This limited interaction of WDs, especially during July and August, was one of the key factors behind below-normal rainfall over some parts of the western Himalayan region, despite favorable monsoon conditions elsewhere.

4. RAINFALL DISTRIBUTION

4.1 Distribution of cumulative rainfall over North West INDIA

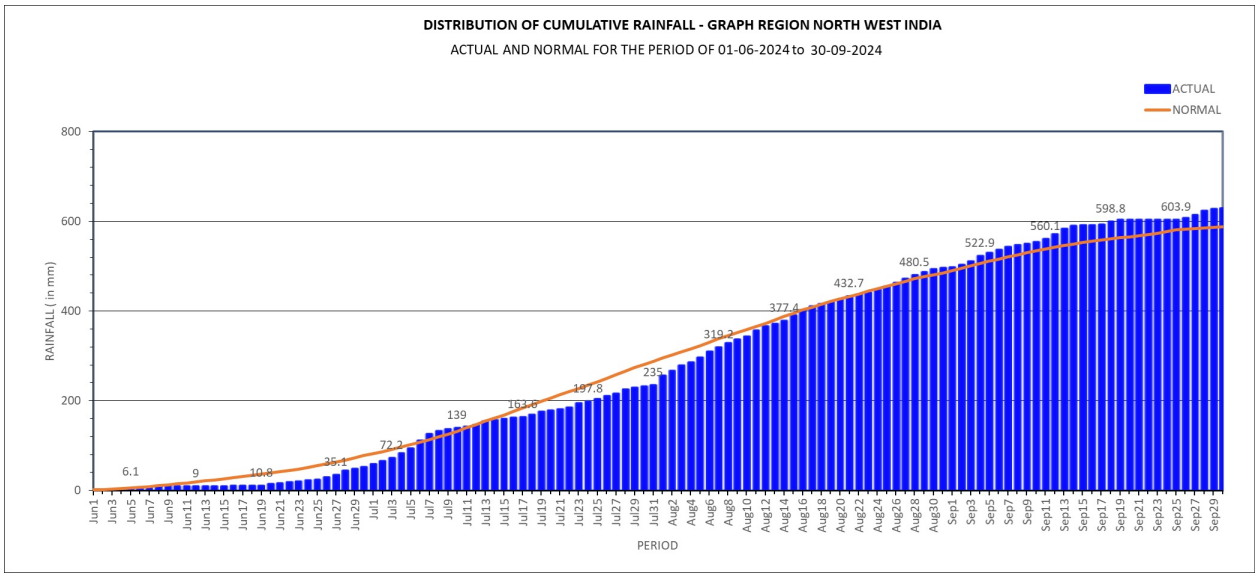

Fig. 4. Distribution of cumulative rainfall during Monsoon Season 2024

The cumulative rainfall distribution during the southwest monsoon 2024 over northwest India (Fig. 4) shows distinct temporal and spatial variability across the region. The monsoon onset was timely but the progress remained uneven during June due to weak low-pressure activity and absence of active western disturbances, resulting in below-normal rainfall during the first fortnight of the season. Rainfall activity improved markedly during late June and July, when monsoon currents strengthened and a series of active phases contributed to widespread rains over the plains of Punjab, Haryana, Delhi, and west Uttar Pradesh. The cumulative rainfall curve shows a steady rise through July and early August, indicating sustained wet conditions associated with the southward position of the monsoon trough. From mid-August onwards, rainfall activity became subdued for short periods, though occasional revival phases maintained near-normal cumulative values. A sharp increase in the cumulative rainfall during September is evident in response to successive interactions between western disturbances and monsoonal low-pressure systems, which caused enhanced precipitation particularly over the western Himalayan region and adjoining plains. Overall, the cumulative rainfall trend for the season

remained close to or slightly above the long-period average for most sub-divisions of northwest India, reflecting a generally normal to above-normal monsoon performance in 2024.

4.2 Seasonal rainfall variation over North West India

The southwest monsoon seasonal rainfall (June–September 2024) over northwest India as a whole was 107% of its Long Period Average (LPA), indicating a normal monsoon performance for the region. Quantitatively, the region received **62.86 cm** of rainfall against the LPA of **58.76 cm** (based on the 1971–2020 period).

Month-wise analysis reveals significant intra-seasonal variability. The month of June 2024 experienced deficient rainfall, with the region receiving 52.1 mm against its LPA of 78.1 mm (67% of LPA, i.e., 33% below normal). The delayed advance of the monsoon and weak synoptic activity contributed to prolonged dry spells and heatwave conditions during the first half of the month.

In July 2024, rainfall improved but remained within the *normal* category, with 179.4 mm received against an LPA of 209.7 mm (86% of LPA, i.e., 14% below normal). Although low-pressure systems were active over central and eastern India, their limited westward extension restricted rainfall activity over the northwest plains.

The month of August 2024 was the wettest of the season, with above-normal rainfall conditions. The region received 256.2 mm against an LPA of 197.1 mm (130% of LPA, i.e., 30% above normal). This was attributed to the formation of multiple low-pressure systems over the Bay of Bengal and their west-northwestward movement, along with the persistent southward position of the monsoon trough, which favored sustained rainfall activity across the plains and foothills.

In September 2024, the region also received above-normal rainfall, amounting to 132.7 mm against an LPA of 102.7 mm (129% of LPA, i.e., 29% above normal). The interaction between active western disturbances and monsoonal low-pressure systems during the month significantly enhanced precipitation, particularly over the western Himalayan states and adjoining plains.

Overall, the cumulative rainfall during the monsoon season (June–September 2024) amounted to **628.6 mm** against a normal of **587.6 mm**, showing a **7% positive departure** from the long-period average, thus categorizing the season as *normal* for northwest India.

The Month-to-Month Rainfall Variation is summarized in Table 2.

Table 2. Month-to-Month Rainfall Variation over Northwest India during Southwest Monsoon 2024

Season/Month	Rainfall received in 2024	Long Period Average (LPA) Rainfall	% Departure	% of LPA	CAT.
June	52.1 mm	78.1 mm	-33%	67%	D
July	179.4 mm	209.7 mm	-14%	86%	N
August	256.2 mm	197.1 mm	30%	130%	E
September	132.7 mm	102.7 mm	29%	129%	E
Monsoon Season	628.6 mm	587.6 mm	7%	107%	

4.3 Subdivision-wise distribution

The subdivision-wise rainfall distribution over Northwest India during the Southwest Monsoon season (01 June–30 September 2024) shows that the region as a whole received 628.6 mm of rainfall against the normal of 587.6 mm, registering a 7% above-normal rainfall, thereby categorizing the season as normal. Spatially, rainfall distribution exhibited significant variability across the nine meteorological subdivisions of the region. Large excess rainfall was observed over West Rajasthan (71% above normal), while East Rajasthan (47%) also recorded excess rainfall. Uttarakhand (10%), Haryana, Chandigarh & Delhi (-3%), West Uttar Pradesh (11%), East Uttar Pradesh (-7%), and Himachal Pradesh (-19%) experienced normal rainfall. However, Punjab (-28%) and Jammu & Kashmir including Ladakh (-26%) received deficient rainfall. The contrasting rainfall pattern highlights the complex interaction of monsoonal systems, topography, and synoptic features influencing the seasonal precipitation across the Northwest region, where western Himalayan subdivisions remained comparatively drier while the plains and arid zones of Rajasthan experienced substantially above-normal rainfall.

The subdivision-wise distribution of rainfall is summarized in Table 3 and depicted graphically in Figure 5.

Table 3 Subdivision-wise distribution of rainfall

Period: 01-06-2024 to 30-09-2024					
S NO	REGION/MET. SUBDIVISION	ACTUAL (mm)	NORMAL (mm)	% DEP.	CAT.
1	JAMMU & KASHMIR AND	**408.5**	**549.1**	**-26%**	**D**

	LADAKH				
2	HIMACHAL PRADESH	**594.7**	**734.4**	**-19%**	**N**
3	UTTARAKHAND	**1273.4**	**1162.7**	**10%**	**N**
4	PUNJAB	**314.8**	**439.8**	**-28%**	**D**
5	HAR. CHD & DELHI	**417.1**	**430.7**	**-3%**	**N**
6	WEST UTTAR PRADESH	**743.1**	**672.0**	**11%**	**N**
7	EAST UTTAR PRADESH	**746.2**	**799.2**	**-7%**	**N**
8	WEST RAJASTHAN	**486.0**	**283.6**	**71%**	**LE**
9	EAST RAJASTHAN	**920.0**	**626.6**	**47%**	**E**
	REGION : NORTH WEST INDIA	**628.6**	**587.6**	**7%**	**N**

Fig.5 Subdivision-wise distribution of rainfall

4.3.1 Sub-Divisional Monthly rainfall variation

The Sub-Divisional Monthly Rainfall Variation over Northwest India during the southwest monsoon season 2024 (June–September) exhibited considerable intra-seasonal fluctuations, reflecting the evolving monsoon dynamics and synoptic activity across the region.

In **June 2024**, most meteorological subdivisions experienced deficient rainfall, primarily due to delayed monsoon onset and prolonged dry spells associated with the absence of active low-pressure systems and western disturbances. Severe deficits were recorded over Himachal Pradesh (-54%), Uttarakhand (-49%), Punjab (-46%), Haryana, Chandigarh & Delhi (-43%), and East Uttar Pradesh (-50%). Jammu & Kashmir and Ladakh (-38%) and West Rajasthan (-23%) also remained deficient, while East Rajasthan (1%) and West Uttar Pradesh (-5%) received near-normal rainfall, marginally cushioning the regional shortfall. As a result, the North West India region as a whole recorded 33% below-normal rainfall in June.

During **July 2024**, rainfall activity improved marginally but remained below normal in most subdivisions. Uttarakhand (15%), West Uttar Pradesh (-6%), East Uttar Pradesh (-10%), West Rajasthan (0%), and East Rajasthan (1%) recorded normal rainfall, while the remaining subdivisions — particularly Jammu & Kashmir and Ladakh (-42%), Himachal Pradesh (-29%), Punjab (-45%), and Haryana, Chandigarh & Delhi (-41%) — experienced deficient rainfall. Overall, Northwest India received 14% below-normal rainfall during July, continuing the seasonal lag in precipitation recovery.

In **August 2024**, the monsoon intensified significantly, supported by multiple low-pressure systems and a favorable monsoon trough position. Nearly all subdivisions, except minor normal variations, recorded normal to large excess rainfall. East Rajasthan (82%) and West Rajasthan (197%) witnessed large excess rainfall, while Haryana**,** Chandigarh & Delhi (29%) also received excess rainfall. Other subdivisions such as Punjab (5%), Uttarakhand (9%), Himachal Pradesh (-5%), and East Uttar Pradesh (2%) reported normal rainfall. This active phase marked the most productive monsoon month for the region, with Northwest India as a whole recording 30% above-normal rainfall.

In **September 2024**, rainfall remained active and well-distributed, mainly due to the interaction between monsoonal low-pressure systems and western disturbances. West Uttar Pradesh (105%), East Rajasthan (109%), West Rajasthan (58%), Uttarakhand (55%), and Haryana, Chandigarh & Delhi (38%) recorded excess to large excess rainfall, while Himachal Pradesh (3%) and East Uttar Pradesh (14%) received normal rainfall. However, Punjab (-46%) and Jammu & Kashmir and Ladakh (-48%) remained deficient. Overall, the region as a whole received 29% above-normal rainfall in September.

The cumulative trend indicates that while the early part of the monsoon (June–July) was marked by widespread deficiency, the latter half (August–September) experienced strong recovery and surplus rainfall, ensuring a **normal monsoon performance for Northwest India** by the end of the season**.** The subdivisional monthly distribution of rainfall is summarized in Table 6 and depicted graphically in Figure 6-9.

Table-6 Sub-Divisional Monthly rainfall variation

	June					July			
Sub Division	Actual (mm)	Normal (mm)	% Dep.	Cat.		Actual (mm)	Normal (mm)	% Dep.	Cat.
JAMMU & KASHMIR AND LADAKH	47.1	75.9	-38%	D		111.9	192.6	-42%	D
HIMACHAL PRADESH	46.5	101.1	-54%	D		180.6	255.9	-29%	D
UTTARAKHAND	89.5	176.8	-49%	D		481.9	417.8	15%	N
PUNJAB	29.4	54.5	-46%	D		89.4	161.4	-45%	D
HAR. CHD & DELHI	31.3	55.3	-43%	D		89.5	150.5	-41%	D
WEST UTTAR PRADESH	74.5	78.6	-5%	N		225.7	240.3	-6%	N
EAST UTTAR PRADESH	54.0	108.3	-50%	D		248.0	276.9	-10%	N
WEST RAJASTHAN	30.5	39.4	-23%	D		107.4	107.8	0%	N
EAST RAJASTHAN	75.1	74.7	1%	N		231.1	228.6	1%	N
REGION : NORTH WEST INDIA	**52.1**	**78.1**	**-33%**			**179.4**	**209.7**	**-14%**	
	August					**September**			
Sub Division	Actual (mm)	Normal (mm)	% Dep.	Cat.		Actual (mm)	Normal (mm)	% Dep.	Cat.
JAMMU & KASHMIR AND LADAKH	161.9	184.9	-12%	N		50.1	95.7	-48%	D
HIMACHAL PRADESH	243.6	256.8	-5%	N		124.1	120.6	3%	N
UTTARAKHAND	419.4	385.7	9%	N		282.5	182.4	55%	E
PUNJAB	153.7	146.2	5%	N		42.2	77.7	-46%	D
HAR. CHD & DELHI	190.0	147.7	29%	E		106.3	77.2	38%	E
WEST UTTAR PRADESH	186.9	228.3	-18%	N		256.0	124.8	105%	LE
EAST UTTAR PRADESH	246.4	240.6	2%	N		197.7	173.4	14%	N
WEST RAJASTHAN	283.3	95.5	197%	LE		64.8	40.9	58%	E
EAST RAJASTHAN	421.5	231.5	82%	LE		192.2	91.8	109%	LE
REGION : NORTH WEST INDIA	**256.2**	**197.1**	**30%**			**132.7**	**102.7**	**29%**	

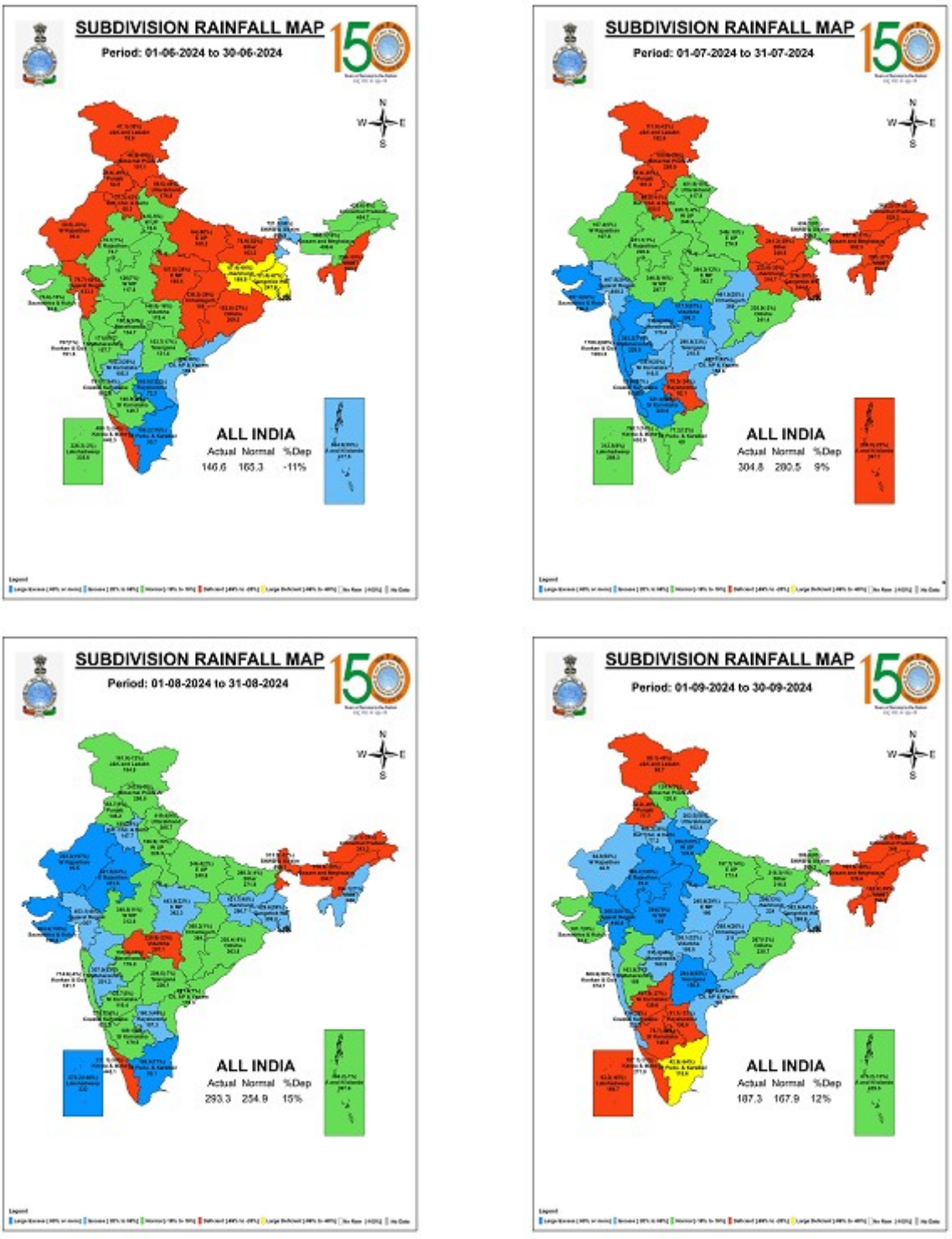

Fig.6-9 Subdivision-wise Monthly distribution of rainfall

4.4 State-wise Distribution of Rainfall over Northwest India (01 June – 30 September 2024)

During the monsoon season 2024, the cumulative rainfall distribution over various States and Union Territories of Northwest India exhibited significant spatial variability. As seen from Table 4, Rajasthan received 678.4 mm of rainfall against a normal of 435.6 mm, recording a 56% excess, while Delhi (UT) also experienced 21% excess rainfall. Uttarakhand registered 10% above normal rainfall, indicating good monsoon activity over the state. On the other hand, Jammu & Kashmir (UT) and Punjab experienced deficient rainfall with -26% and -28% departures from normal, respectively. Himachal Pradesh, Chandigarh (UT), and Haryana received rainfall close to normal, with departures ranging between -4% and -19%. The Ladakh (UT) region recorded 26.0 mm rainfall against a normal of 22.3 mm, indicating near-normal conditions. Overall, the rainfall pattern across Northwest India during the 2024 monsoon season was **normal**, with **pockets of excess rainfall over the plains and deficiency over the northern hill states**.

The state-wise distribution of rainfall is summarized in Table 7 and depicted graphically in Figure 10.

Table 7 State-wise distribution of rainfall

Period: 01-06-2024 to 30-09-2024					
S. NO.	STATE /UNION TERRITORIES	ACTUAL (mm)	NORMAL (mm)	% DEP.	CAT.
1	LADAKH (UT)	**26.0**	**22.3**	**17%**	**N**
2	JAMMU & KASHMIR (UT)	**408.5**	**549.1**	**-26%**	**D**
3	HIMACHAL PRADESH	**594.7**	**734.4**	**-19%**	**N**
4	UTTARAKHAND	**1273.4**	**1162.7**	**10%**	**N**
5	PUNJAB	**314.8**	**439.8**	**-28%**	**D**
6	CHANDIGARH (UT)	**710.8**	**844.9**	**-16%**	**N**
7	HARYANA	**408.7**	**426.0**	**-4%**	**N**
8	DELHI (UT)	**658.3**	**544.3**	**21%**	**E**
9	UTTAR PRADESH	**1273.4**	**1162.7**	**10%**	**N**
10	RAJASTHAN	**678.4**	**435.6**	**56%**	**E**

Fig.10 State-wise distribution of rainfall
(Period : 01-06-2024 to 30-09-2024)

4.4.1 State-wise Monthly Rainfall variation over Northwest India

The monthly state-wise rainfall variation over Northwest India during the southwest monsoon season 2024 (June–September) reveals marked temporal and spatial variability across different months.

In **June 2024**, most parts of Northwest India experienced **deficient** rainfall, largely due to the delayed monsoon onset and absence of active synoptic systems. Severe deficits were recorded in Chandigarh (-92%), Himachal Pradesh (-54%), Uttarakhand (-49%), Punjab (-46%), and Haryana (-46%), while Delhi (44%) and Ladakh (385%) registered excess to large excess rainfall due to localized pre-monsoon and early monsoon activity. The remaining states, including Jammu & Kashmir (-38%), Uttar Pradesh (-35%), and Rajasthan (-9%), received below-normal to near-normal rainfall during the month.

In **July 2024**, rainfall improved over some parts of the region but remained deficient over several subdivisions. Persistent shortfalls continued in Jammu & Kashmir (-42%), Himachal Pradesh (-29%), Punjab (-45%), Chandigarh (-35%), Haryana (-41%), and Delhi (-27%). However, Uttarakhand (15%), Uttar Pradesh (-9%), and Rajasthan (1%) experienced normal rainfall, indicating partial revival of monsoon activity following the late June dry spell.

August 2024 was the **wettest month of the season**, characterized by widespread and intense monsoon activity. Nearly all states in Northwest India recorded normal to large excess rainfall, supported by multiple low-pressure systems and a southward-positioned monsoon trough. Rajasthan (121%), Delhi (61%), Ladakh (87%), Haryana (27%), and Chandigarh (23%) witnessed excess to large excess rainfall, while Uttarakhand (9%), Himachal Pradesh (-5%), Punjab (5%), and Uttar Pradesh (-6%) received normal rainfall. The enhanced monsoon vigor during this month significantly compensated for earlier rainfall deficits.

In **September 2024**, rainfall remained active to excess in most parts of the region, mainly due to the interaction between monsoonal lows and western disturbances. Rajasthan (91%), Uttarakhand (55%), Uttar Pradesh (45%), Haryana (39%), Chandigarh (29%), and Delhi (20%) recorded excess to large excess rainfall, while Himachal Pradesh (3%) received normal rainfall. However, Punjab (-46%), Jammu & Kashmir (-48%), and Ladakh (-65%) experienced deficient rainfall.

Overall, the rainfall progression across the season depicts a transition from widespread deficiency in June and July to active and surplus conditions in August and September, reflecting the dominance of favorable synoptic activity and enhanced monsoon dynamics during the latter half of the season.

The state-wise monthly distribution of rainfall is summarized in Table 8 and depicted graphically in Figure 11-14.

Table-8 State-wise Monthly rainfall variation

	June					July			
State	Actual (mm)	Normal (mm)	% Dep.	Cat.		Actual (mm)	Normal (mm)	% Dep.	Cat.
LADAKH (UT)	**14.1**	**2.9**	**385%**	**LE**		**1.0**	**9.0**	**-89%**	**LD**
JAMMU & KASHMIR (UT)	**47.1**	**75.9**	**-38%**	**D**		**111.9**	**192.6**	**-42%**	**D**
HIMACHAL PRADESH	**46.5**	**101.1**	**-54%**	**D**		**180.6**	**255.9**	**-29%**	**D**
UTTARAKHAND	**89.5**	**176.8**	**-49%**	**D**		**481.9**	**417.8**	**15%**	**N**
PUNJAB	**29.4**	**54.5**	**-46%**	**D**		**89.4**	**161.4**	**-45%**	**D**
CHANDIGARH (UT)	**11.9**	**155.5**	**-92%**	**LD**		**178.2**	**273.2**	**-35%**	**D**
HARYANA	**29.3**	**54.7**	**-46%**	**D**		**87.8**	**149.1**	**-41%**	**D**
DELHI (UT)	**95.6**	**66.5**	**44%**	**E**		**134.6**	**185.1**	**-27%**	**D**
UTTAR PRADESH	**62.5**	**95.9**	**-35%**	**D**		**238.8**	**261.7**	**-9%**	**N**
RAJASTHAN	**50.3**	**55.0**	**-9%**	**N**		**162.2**	**161.4**	**1%**	**N**
	August					**September**			
State	Actual (mm)	Normal (mm)	% Dep.	Cat.		Actual (mm)	Normal (mm)	% Dep.	Cat.
LADAKH (UT)	**9.0**	**4.8**	**87%**	**LE**		**1.9**	**5.6**	**-65%**	**LD**
JAMMU & KASHMIR (UT)	**161.9**	**184.9**	**-12%**	**N**		**50.1**	**95.7**	**-48%**	**D**
HIMACHAL PRADESH	**243.6**	**256.8**	**-5%**	**N**		**124.1**	**120.6**	**3%**	**N**
UTTARAKHAND	**419.4**	**385.7**	**9%**	**N**		**282.5**	**182.4**	**55%**	**E**
PUNJAB	**153.7**	**146.2**	**5%**	**N**		**42.2**	**77.7**	**-46%**	**D**
CHANDIGARH (UT)	**351.6**	**284.8**	**23%**	**E**		**169.2**	**131.4**	**29%**	**E**
HARYANA	**186.0**	**146.1**	**27%**	**E**		**105.5**	**76.1**	**39%**	**E**
DELHI (UT)	**302.1**	**187.6**	**61%**	**LE**		**126.0**	**105.1**	**20%**	**E**
UTTAR PRADESH	**221.9**	**235.5**	**-6%**	**N**		**221.7**	**153.1**	**45%**	**E**
RAJASTHAN	**344.6**	**155.7**	**121%**	**LE**		**121.3**	**63.5**	**91%**	**LE**

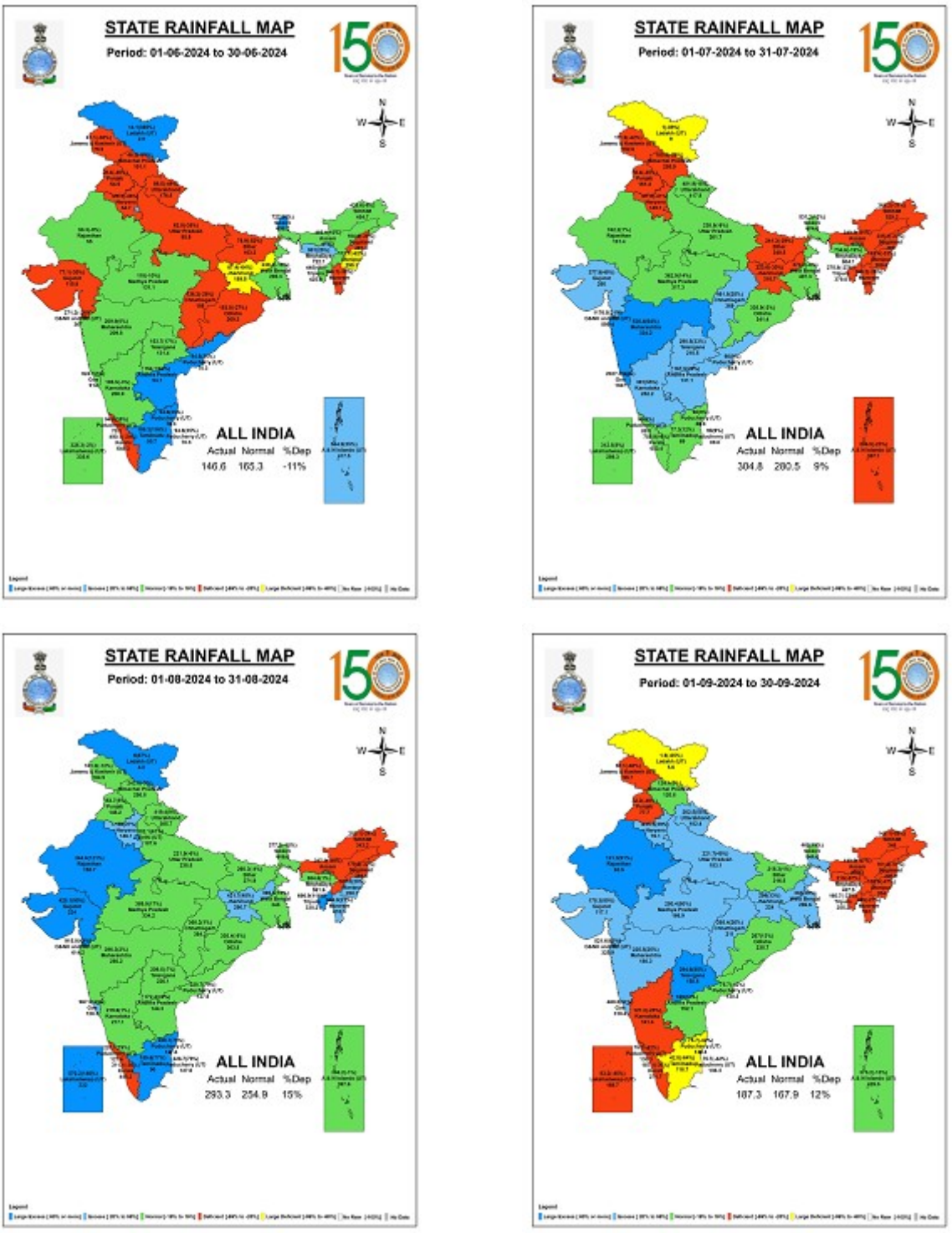

Fig.11-14 State-wise Monthly distribution of rainfall

4.5 District-wise seasonal rainfall distribution

The North West Region consists of nine meteorological sub-divisions comprising a total of 209 districts — 22 in Jammu & Kashmir and Ladakh, 12 in Himachal Pradesh, 13 in Uttarakhand, 22 in Punjab, 32 in Haryana, Chandigarh & Delhi (Haryana–22, Chandigarh–1, Delhi–9), 33 in West Uttar Pradesh, 42 in East Uttar Pradesh, 10 in West Rajasthan, and 23 in East Rajasthan. Out of these 209 districts, Large Excess rainfall was observed in 25 districts, Excess in 32 districts, Normal in 82 districts, Deficit in 63 districts, and Large Deficit in 5 districts during the southwest monsoon season of June to September 2024. Bageshwar district in Uttarakhand recorded the highest rainfall departure of +223% of its long-period average (LPA), while Shopian district in Jammu & Kashmir experienced the lowest departure of –80% of LPA. Data for one district was not available.

Spatially, Large Excess and Excess rainfall conditions were predominant over many districts of Rajasthan (both East and West divisions), parts of Haryana, and the National Capital Territory of Delhi, as well as in isolated pockets of Uttarakhand and West Uttar Pradesh, where monsoon activity remained vigorous during August and September. In contrast, Deficit to Large Deficit rainfall conditions prevailed over the hilly regions of Jammu & Kashmir, Himachal Pradesh, and northern Punjab, where the monsoon was comparatively weak. Most districts of East Uttar Pradesh and Haryana received Normal to Near Normal rainfall, indicating a more even rainfall distribution. Overall, the district-wise rainfall pattern revealed considerable spatial variability across the region, with significant surpluses over the plains of Rajasthan, Haryana, and Delhi, and shortfalls over the northern hill states of Northwest India.

Table 9 represents the district rainfall distribution as percentage departures from normal over the nine meteorological subdivisions of the North West region during the period Jun-Sep 2024 and Fig.15, the district-wise seasonal rainfall over the various states and UTs over the NW region.

Table 9: District-wise distribution of rainfall

SUB DIVISION	STATE	CATEGORY	DISTRICTS WITH % DEPARTURE OF RAINFALL
JAMMU & KASHMIR AND LADAKH	JAMMU & KASHMIR (UT)	NORMAL	BARAMULA (1%), JAMMU (0%), PULWAMA (-13%), RAJOURI (-18%), SAMBA (13%), UDHAMPUR (-19%)
		DEFICIT	ANANTNAG (-54%), BADGAM (-50%), BANDIPORE (-57%), DODA (-39%), GANDERBAL (-39%), KATHUA (-31%), KUPWARA (-26%), RAMBAN (-40%), REASI (-48%), SRINAGAR (-30%)
		LARGE DEFICIT	KULGAM (-62%), POONCH (-76%), SHOPIAN (-80%)

	LADAKH (UT)	NORMAL	KARGIL (8%), LEH AND LADAKH (18%)
HIMACHAL PRADESH	HIMACHAL PRADESH	NORMAL	BILASPUR (2%), KANGRA (-3%), MANDI (-2%), SHIMLA (14%), SIRMAUR (-2%),
		DEFICIT	CHAMBA (-35%), HAMIRPUR (-28%), KINNAUR (-22%), KULLU (-20%), SOLAN (-21%), UNA (-32%)
		LARGE DEFICIT	LAHUL&SPITI (-72%)
UTTARAKHAND	UTTARAKHAND	LARGE EXCESS	BAGESHWAR (223%), CHAMOLI (74%)
		EXCESS	DEHRADUN (21%)
		NORMAL	ALMORA (13%), CHAMPAWAT (6%), TEHRI GARWAL (5%), HARIDWAR (-15%), NANITAL (-15%), PITHORAGARH (-7%), RUDRAPRAYAG (-4%) UDHAM SINGH NAGAR (9%), UTTARKASHI (-5%)
		DEFICIT	PAURI GARHWAL (-39%)
PUNJAB	PUNJAB	EXCESS	TARN TARAN (48%)
		NORMAL	AMRITSAR (--19%), FARIDKOT (-1%) PATHANKOT (8%), PATIALA (-15%)
		DEFICIT	BARNALA (-35%), BATHINDA (-59%), FATEHGARH SAHIB (-25%), FAZILKA (-32%), FIROZPUR (-44%), GURDASPUR (-21%), HOSHIARPUR (-56%), JALANDHAR (-42%), KAPURTHALA (-28%), LUDHIANA (-27%), MANSA (-34%), MOGA (-45%), MUKTSAR (-28%), RUPNAGAR (-28%), SANGRUR (-25%) SAS NAGAR (-46%), SBS NAGAR (-44%),
HARYANA, CHANDIGARH & DELHI	HARYANA	LARGE EXCESS	NUH (70%),
		EXCESS	GURGAON (53%), JHAJJAR (27%), MAHENDRAGARH (43%),
		NORMAL	BHIWANI (-11%), CHARKHI DADRI (13%), FARIDABAD (-2%), FATEHABAD (-4%), KURUKSHETRA (7%), PALWAL (10%), PANIPAT (-10%), REWARI (13%), SIRSA (5%), SONIPAT (-7%)
		DEFICIT	AMBALA (-22%), HISAR (-22%), JIND (-26%), KAITHAL (-23%), KARNAL (-38%), PANCHKULA (-31%), ROHTAK (-22%), YAMUNANAGAR (-31%)
	CHANDIGARH (UT)	NORMAL	CHANDIGARH (-16%)

	DELHI (UT)	LARGE EXCESS	NORTH DELHI (75%), NORTH WEST DELHI (62%)
		EXCESS	EAST DELHI (25%), NEW DELHI (32%), SOUTH WEST DELHI (25%),
		NORMAL	SOUTH DELHI (8%), NORTH EAST DELHI (-14%)
		DEFICIT	CENTRAL DELHI (-31%), WEST DELHI (-20%),
WEST UTTAR PRADESH	UTTAR PRADESH	LARGE EXCESS	AURAIYA (111%), ETAH (108%), FIROZABAD (75%), HATHRAS (64%)
		EXCESS	AGRA (59%), BADAUN (32%), BAREILLY (22%), HAMIRPUR (40%), JALAUN (33%), KASGANJ (55%), LALITPUR (32%), MORADABAD (25%)
		NORMAL	ALIGARH (-17%), BAGHPAT (-6%), BIJNOR (-5%), BULANDSAHAR(15%), ETAWAH (12%), JHANSI (-4%), MAHOBA (-4%), MAINPURI (13%), MATHURA (0%), MEERUT (-8%), MUZAFARNAGAR (-6%) RAMPUR (8%), SAMBHAL (18%), SHAHJAHANPUR (-18%)
		DEFICIT	AMROHA (-33%), GHAZIABAD (-27%), HAPUR (-30%), PILHIBHIT (-44%), SHARANPUR (-34%)
		LARGE DEFICIT	GAUTAMBUDH NAGAR (-73%) SHAMLI (-73%)
EAST UTTAR PRADESH	UTTAR PRADESH	EXCESS	BALRAMPUR (57%), BASTI (54%), CHITRAKOOT (24%), KANNAUJ (34%), MAHARAJGANJ (28%), SONBHADRA (-18%)
		NORMAL	AMBEDKARNAGAR (5%), AYODHYA (-8%), AZAMGARH (-8%), BAHRAICH (18%), BALLIA (-16%), BANDA (14%), BARABANKI (2%), FARRUKHABAD (--11%), GAZIPUR (-4%), GONDA (-5%), GORAKHPUR (-5%), HARDOI (-10%), KANPUR CITY (-16%), KAUSHAMBI (-15%), KHERI (3%), LUCKNOW (2%), PRATAPGARH (14%), SANTKABIRNAGAR (7%), SHRAWASTI NAGAR (-12%), SIDDHARTHNAGAR (5%), SITAPUR (16%), VARANASI (-5%)

		DEFICIT	AMETHI (-48%), BHADOHI (-40%), CHANDAULI (-48%), DEORIA (-43%), FATEHPUR (-51%), JAUNPUR (-51%), KANPUR DEHAT (-25%), KUSHINAGAR (-50%), MAU (-42%), MIRZAPUR (-34%), PRAYAGRAJ (-20%), RAIBEARELI (-37%), SULTANPUR (-35%), UNNAO (-38%)
WEST RAJASTHAN	RAJASTHAN	LARGE EXCESS	BARMER (65%), BIKANER (71%), CHURU (61%), JAISELMER (148%), JODHPUR (73%), NAGAUR (78%),
		EXCESS	SRI GANGANAGAR (53%), PALI (59%) HANUMANGARH (29%)
		NORMAL	JALOR (13%),
EAST RAJASTHAN	RAJASTHAN	LARGE EXCESS	AJMER (79%), ALWAR (73%), BHARATPUR (70%), BUNDI (63%), DAUSA (137%), DHOLPUR (107%), JAIPUR (88%), KARAULI (109%), SWAIMADHOPUR (94%), TONK (97%)
		EXCESS	BARAN (30%), BHILWARA (41%), JHUNJHUNUN (35%), KOTA (23%), PRATAPGARH (20%), RAJSMAND (46%), SIKAR (54%)
		NORMAL	DUNGARPUR (10%), BANSWARA (18%), CHITTAURGARH (12%), JHALAWAR (-3%), UDAIPUR (13%), SIROHI (6%),

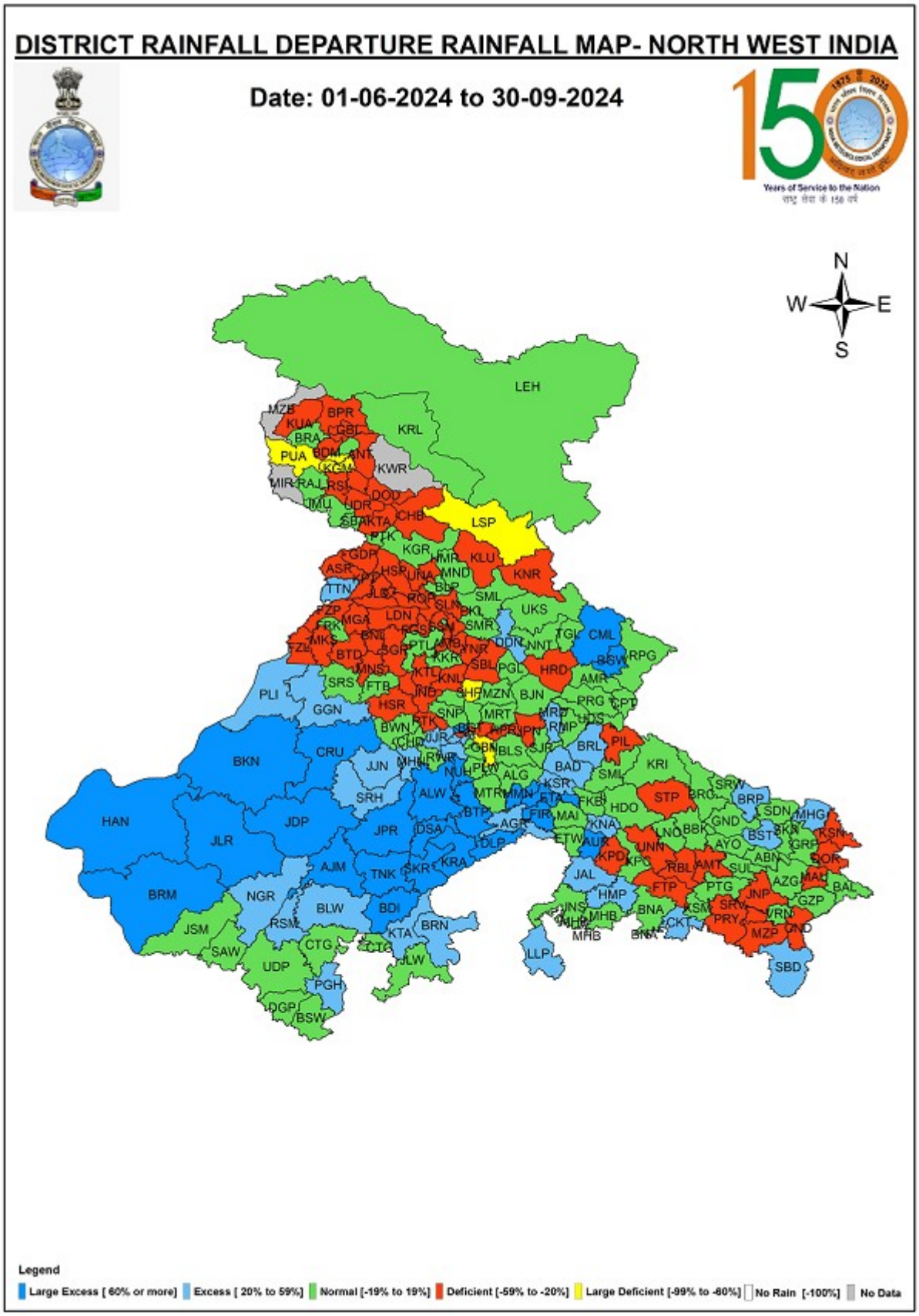

Fig.15 District rainfall departure

4.5.1 District -wise Monthly rainfall variation

In **June 2024**, out of 209 districts in Northwest India, 14 districts recorded large excess rainfall, 19 districts experienced excess rainfall, 30 districts received normal rainfall, 80 districts reported deficit rainfall, and 65 districts recorded large deficit rainfall, while 1 district had no data. At the district level, Leh (Ladakh) registered the highest positive departure of +515% of the Long Period Average (LPA), whereas West Delhi (Delhi) recorded the lowest departure of –99% of the LPA. In terms of actual rainfall, New Delhi (Delhi) district received the highest monthly rainfall of 184.0 mm, while West Delhi (Delhi) district received the lowest rainfall of 1.0 mm during June 2024.

In **July 2024**, among the 209 districts, 8 districts recorded large excess rainfall, 27 districts had excess rainfall, 54 districts received normal rainfall, 85 districts experienced deficit rainfall, and 34 districts recorded large deficit rainfall, with 1 district having no data. Bageshwar district (Uttarakhand) recorded the highest positive departure of +263% of LPA, while Shopian district (Jammu & Kashmir) registered the lowest departure of –96% of LPA. In terms of actual rainfall, Bageshwar district received the highest monthly rainfall of 184.0 mm, whereas Leh (Ladakh) received the lowest of 1.3 mm in July 2024.

In **August 2024**, 44 districts recorded large excess rainfall, 47 districts experienced excess rainfall, 62 districts received normal rainfall, 48 districts reported deficit rainfall, and 8 districts recorded large deficit rainfall. Jaisalmer district (West Rajasthan) recorded the highest positive departure of +377% of LPA, while Pilibhit district (West Uttar Pradesh) experienced the lowest departure of –86% of LPA. The highest actual rainfall was observed in Bageshwar district (Uttarakhand) with 882.8 mm, whereas Kargil (Ladakh UT) received the lowest rainfall of 3.4 mm during August 2024.

In **September 2024**, 69 districts recorded large excess rainfall, 47 districts had excess rainfall, 28 districts received normal rainfall, 44 districts reported deficit rainfall, and 20 districts recorded large deficit rainfall, while 1 district had no data. Hathras district (West Uttar Pradesh) registered the highest positive departure of +394% of LPA, whereas Central Delhi district recorded the lowest departure of –93% of LPA. In terms of actual rainfall, Bageshwar district (Uttarakhand) received the highest monthly rainfall of 522.5 mm, while Leh (Ladakh) recorded the lowest rainfall of 2.5 mm during September 2024.

Figures 16–19 illustrate the month-wise district-level rainfall variation during the period June–September 2024.

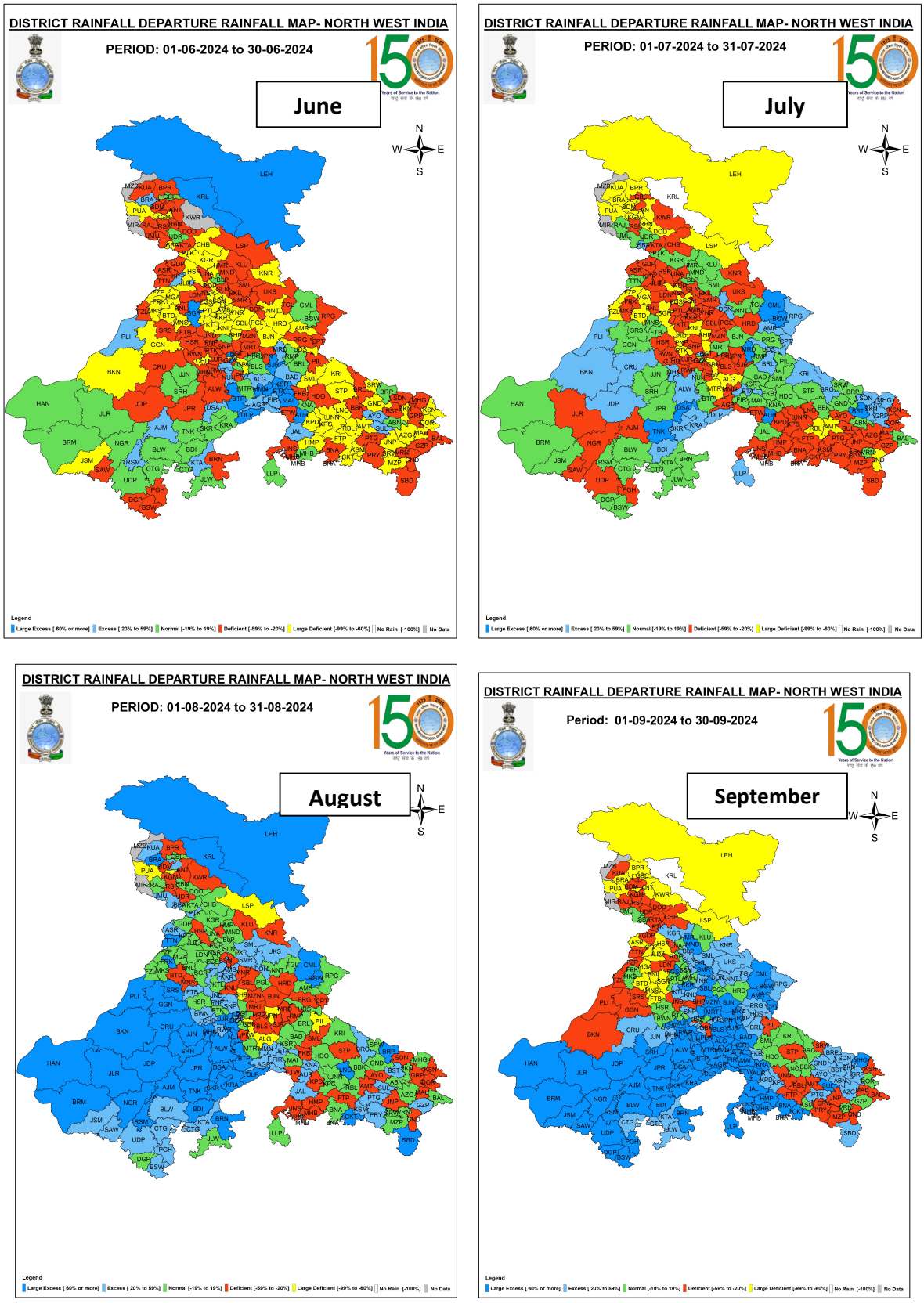

Fig. 16-19 District wise Monthly rainfall variation

5. EXTREME WEATHER EVENTS DURING SOUTH WEST MONSOON 2024

5.1 Heavy Rainfall events

Table 10 presents the number of days of heavy, very heavy, and extremely heavy rainfall occurrences over the various meteorological sub-divisions of Northwest India during the southwest monsoon season (June–September 2024). The data show considerable spatial and temporal variation in the intensity and frequency of rainfall events across the region.

During the season, isolated **heavy rainfall events (≥ 64.5 mm/day)** occurred on 17 days over Jammu & Kashmir, 26 days over Himachal Pradesh, 35 days over Uttarakhand, 23 days over Punjab, 27 days over Haryana–Chandigarh–Delhi, 33 days over West Uttar Pradesh, 35 days over East Uttar Pradesh, 24 days over West Rajasthan, and 39 days over East Rajasthan.

Very heavy rainfall events (≥ 115.6 mm/day) were reported on 5 days in Jammu & Kashmir, 12 days in Himachal Pradesh, 23 days in Uttarakhand, 8 days in Punjab, 8 days in Haryana–Chandigarh–Delhi, 11 days in West Uttar Pradesh, 18 days in East Uttar Pradesh, 9 days in West Rajasthan, and 27 days in East Rajasthan.

Extremely heavy rainfall events (≥ 204.5 mm/day) were less frequent but noteworthy, recorded on 1 day in Jammu & Kashmir, 3 days in Himachal Pradesh, 7 days in Uttarakhand, 2 days in Haryana–Chandigarh–Delhi, 6 days each in West and East Uttar Pradesh, 2 days in West Rajasthan, and 7 days in East Rajasthan.

Among all the sub-divisions, Uttarakhand and East Uttar Pradesh experienced 35 days each with heavy rainfall activity, while East Rajasthan recorded the maximum with 39 days, including the highest frequencies of very heavy and extremely heavy events. In contrast, Jammu & Kashmir witnessed the least number of such days. The temporal distribution indicates that July and August were the most active months for heavy to extremely heavy rainfall over most sub-divisions of Northwest India, corresponding to the core monsoon period.

Table 10 represents the number of days of heavy rainfall occurrences over subdivisions of North West India during June-September 2024.

Table-10:
Number of days of heavy rainfall occurrences over various subdivisions in the Northwest region during June-September 2024

No. of days of heavy rainfall occurrences															
Sub Div	JUN			JUL			AUG			SEP			JUN-SEP		
	H	VH	EH	H	VH	EH	H	VH	EH	H	VH	EH	H	VH	EH
J&K	0	0	1	8	0	0	7	5	0	2	0	0	17	5	1
HP	0	1	0	8	4	2	10	6	1	8	3	0	26	12	3
UK	4	2	0	14	11	3	11	8	1	6	2	3	35	23	7
PUNJAB	2	0	0	7	3	0	11	4	0	3	1	0	23	8	0
HAR,CHD &DEL	0	1	1	10	1	0	10	5	0	7	1	1	27	8	2
WEST UP	3	2	0	10	6	3	11	1	1	9	2	2	33	11	6
EAST UP	6	2	0	10	5	3	11	9	0	7	2	3	35	18	6
WEST RAJ	4	0	0	8	1	0	7	7	2	5	1	0	24	9	2
EAST RAJ	2	2	0	19	9	0	8	12	5	10	4	2	39	27	7

Legend: H: Heavy rain (≥ 7 cm (64.5 mm)/day);VH: Very Heavy rain (≥ 12 cm (115.6 mm) /day);EH: Extremely Heavy rain (≥ 21cm (204.5 mm) /day).

5.2 Thunderstorm events

During the southwest monsoon season of 2024 (June to September), the frequency of thunderstorm events over northwest India showed significant spatial and temporal variations. Jammu & Kashmir and Ladakh recorded the highest number of thunderstorm occurrences, with 89 days, followed closely by Himachal Pradesh with 86 days. Haryana, Chandigarh, and Delhi together reported 80 thunderstorm days, while Uttarakhand and East Rajasthan experienced 64 and 67 days, respectively. Among the plains, Punjab and West Rajasthan recorded 59 and 60 thunderstorm days, whereas East Uttar Pradesh and West Uttar Pradesh reported 72 and 53 days, respectively. The activity was generally higher during June and July, coinciding with the active phases of the monsoon, and gradually decreased toward September. Overall, the distribution of thunderstorm occurrences reflects the influence of orographic effects in the hilly regions and convective activity across the plains of northwest India.

Table 11 represents thunderstorm events over subdivisions of North West India during June-September 2024.

Table-11
Thunderstorm events during South West Monsoon 2024

STATE	JUNE	JULY	AUGUST	SEPTEMBER	TOTAL
J&K AND LADAKH	27	27	20	15	89
HP	20	24	23	19	86
UK	13	13	21	17	64
PUNJAB	10	20	18	11	59
HAR,CHD &DEL	14	24	25	17	80
WEST UP	18	4	19	12	53
EAST UP	16	4	30	22	72
WEST RAJ	18	10	21	11	60
EAST RAJ	21	12	20	14	67

6. WITHDRAWAL OF SOUTHWEST MONSOON

The withdrawal of the southwest monsoon in 2024 began slightly later than normal, commencing from West Rajasthan and Kachchh on 23rd September, against its usual date of 17th September. This delay was attributed to the persistence of moist conditions and the late establishment of anti-cyclonic circulation in the lower troposphere. Following its onset, the withdrawal advanced gradually eastward and southward, accompanied by a noticeable reduction in rainfall activity, the prevalence of dry weather, and the appearance of clear skies across the region. By early October, the monsoon had retreated from Punjab, Haryana, Delhi, western Uttar Pradesh, and Madhya Pradesh, signifying the cessation of monsoon conditions over most parts of northwest India.

The continued weakening of monsoon troughs and the dominance of dry northerly and northwesterly winds facilitated the steady withdrawal. The southwest monsoon completely withdrew from northwest India by 11th October, 2024, and from the entire country by 15th October, about four days later than the normal date. Subsequently, the withdrawal progressed further south, covering Gujarat, Maharashtra, and central India by mid-October, and finally the southern peninsula—including Karnataka, Kerala, and Tamil Nadu—by 23rd October, 2024. This marked the end of the southwest monsoon season and the gradual transition toward the northeast monsoon phase over southern India. The withdrawal phase was characterized by a decline in humidity, cooler night temperatures, and the commencement of post-monsoon agricultural activities across large parts of the country. The isochrones depicting the withdrawal of the southwest monsoon 2024 are shown in Figures 20 and 21.

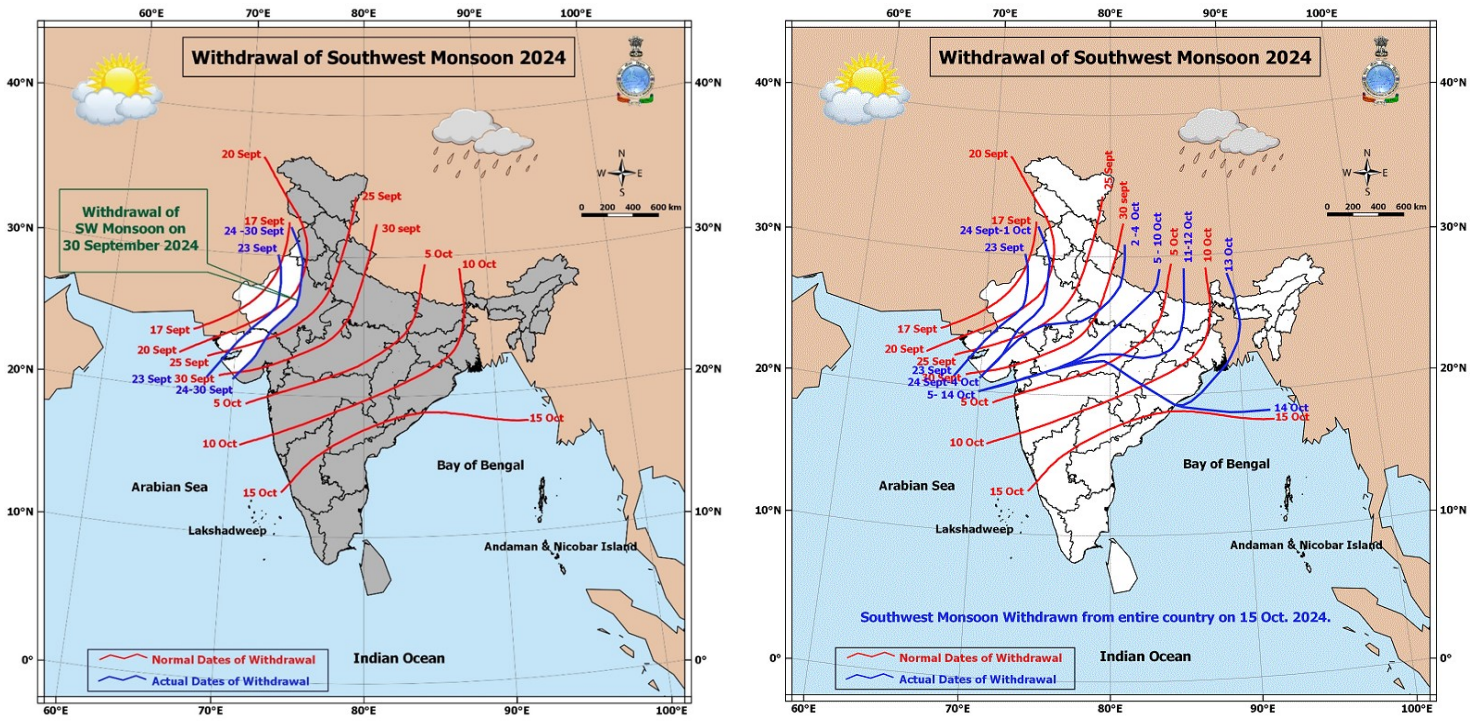

Fig. 20-21 Isochrones of withdrawal of SW Monsoon 2024

7. VERIFICATION OF LONG-RANGE FORECAST ISSUED FOR SW MONSOON 2024

The long-range forecast (LRF) performance for the southwest monsoon 2024 was highly satisfactory, demonstrating a close agreement between the predicted and realized rainfall both at the national and regional scales. The forecast for monsoon onset over Kerala proved accurate, marking the nineteenth successful prediction since 2005 (barring 2015). The forecasted onset date was 31st May (±4 days), and the monsoon actually set in on 30th May, well within the model's error margin.

For the country as a whole, the first-stage forecast issued in April 2024 projected seasonal rainfall at 106% of the Long Period Average (LPA) with a model error of ±5%, which was reaffirmed in the updated May forecast (106% ±4%). The actual rainfall during June–September 2024 was 108% of LPA, confirming the forecast's accuracy. Over Northwest India, the forecast issued on 27th May 2024 indicated "normal" rainfall (92–108% of LPA), and the realized seasonal rainfall stood at 107% of LPA, aligning well with the prediction.

Month-wise analysis also showed reasonably good forecast verification. In June, rainfall over Northwest India was **deficient (-33% PDN)** against a forecast of below-normal to normal conditions, while July witnessed **near-normal rainfall (-14% PDN)**, consistent with the forecast of normal to above-normal rainfall. August and September showed **above-normal rainfall (30% and 29% PDN respectively)**, matching the forecast outlook for wetter-than-average conditions. At the all-India scale, rainfall remained **normal to above-normal**

throughout the monsoon months, demonstrating the overall reliability and skill of the long-range forecast system for the 2024 southwest monsoon season.

Table 12 represents the Performance of monthly Rainfall Forecast during Monsoon 2024.

Table 12:
Performance of monthly Rainfall Forecast during Monsoon 2024

Month	Area	Forecast	Realised
June 2024	All India	Normal rainfall (92-108% of LPA) is most likely over the country as a whole during June, 2024	91% of LPA
	North West India	Below Normal to Normal rainfall is most likely.	Deficit (-33%PDN)
July 2024	All India	Above Normal (>106 % of LPA) is most likely over the country as a whole during July, 2024	109% of LPA
	North West India	Normal to above normal rainfall is most likely over most parts of region except some parts of northwest, where below normal rainfall is likely.	Normal (-14%PDN)
August 2024	All India	Normal ((94 to 106 % of LPA) is most likely over the country as a whole during August, 2024	115% of LPA
	North West India	Above-Normal rainfall is likely over North West region .	Above Normal (30% PDN)
September 2024	All India	Above Normal (>109 % of LPA) is most likely over the country as a whole during September, 2024	112% of LPA
	North West India	Above-Normal rainfall is likely over most parts of region..	Above Normal (29% PDN)

9. CONCLUSION

The Southwest Monsoon 2024 over Northwest India was characterized by an overall normal seasonal performance, with well-distributed rainfall across most subdivisions and timely intraseasonal variations. Despite a weak onset phase in June leading to initial deficits, the subsequent months, particularly August and September, witnessed active monsoon conditions that compensated for the early shortfall. The season's cumulative rainfall over Northwest India stood at 107% of the Long Period Average (LPA), classifying it as a normal monsoon. Several active synoptic systems, including low-pressure areas and monsoon depressions, significantly influenced rainfall distribution and intensity across the region. Frequent thunderstorm and heavy rainfall events, especially over Uttarakhand, East Rajasthan, and East Uttar Pradesh, highlighted the dynamic nature of the season. The withdrawal of the monsoon commenced

slightly later than normal but progressed steadily, completing over the entire country by 15th October 2024. The long-range forecasts issued by IMD for both the onset and seasonal rainfall were well-validated by actual observations, demonstrating the robustness of the forecasting system. Overall, the 2024 monsoon season over Northwest India was meteorologically significant, with balanced rainfall distribution supporting agricultural and hydrological activities, marking it as a normal and well-predicted season.