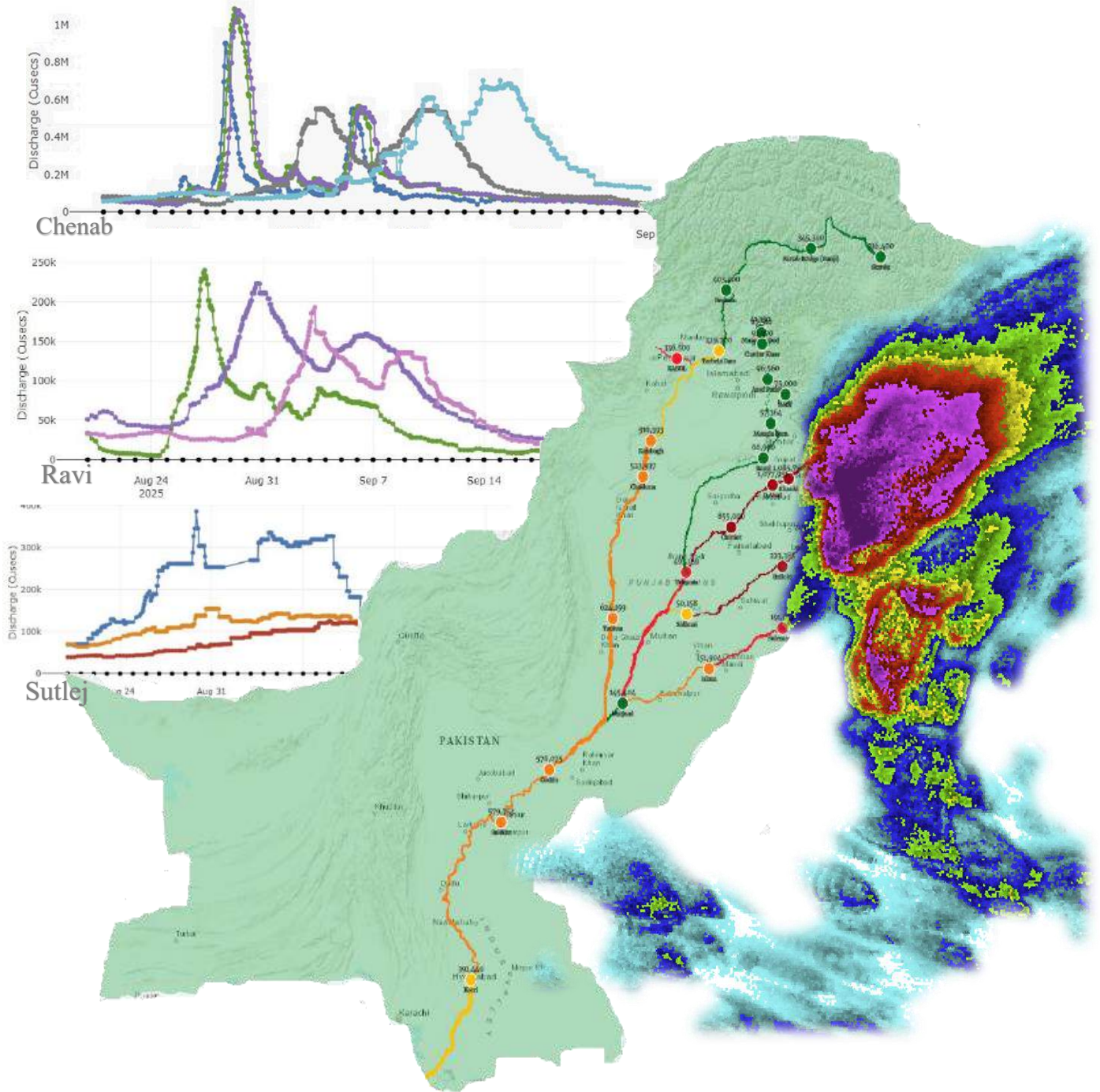




Hydro-Meteorological Flood Report-2025



فلڈ فور کاسٹنگ ڈویژن لاہور

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Mahr Sahibzad Khan, is the Director General of the Pakistan Meteorological Department (PMD), an esteemed position that underscores his expertise and leadership in meteorology and climate science. With a distinguished career spanning several decades, Khan has significantly contributed to the advancement of meteorological services in Pakistan. His work

focuses on improving weather forecasting, climate monitoring, and early warning systems to mitigate the impact of natural disasters. Under his guidance, the PMD has made notable strides in integrating modern technologies and methodologies, enhancing the accuracy and reliability of meteorological data. His commitment to scientific excellence and public service has earned him a respected reputation both nationally and internationally. His leadership continues to drive the PMD towards achieving its mission of providing timely and accurate weather information, thereby safeguarding lives and property.

Message from Director General:

The Flood Forecasting Division Lahore (FFD), since its establishment is serving the nation by issuing flood forecasts during each flood season (15th June to 15th October). The Flood Forecasting Division Lahore (FFD) is an active Unit of PMD. The FFD Lahore monitored the Flood Season 2025 carefully through its Hydro-Meteorological Bulletins, Warnings and then by keeping informed different government agencies, press and electronic media, in order to minimize the losses. The compilation of flood report after each flood season is a regular feature of FFD Lahore. This year Flood Season 2025 Monsoon Report is attached. This report is prepared under the supervision of Director General (DG) Met Services.



Dr. Zaheer Ahmad Babar serves as the Chief Meteorologist at Pakistan Meteorological Department (PMD), Flood Forecasting Division (FFD), Lahore, a pivotal position that places him at the heart of flood forecast in Pakistan. With a robust background in meteorology and hydrology, he brings extensive expertise to the FFD, where his

core responsibility involves analyzing and interpreting meteorological data to produce effective flood forecasts. These forecasts are essential for effective disaster preparedness and response.

Dr. Babar has played a key role in advancing the FFD's capabilities through the integration of modern forecasting tools and methods. His efforts ensure that timely warnings and critical information reach government bodies and the public, significantly helping to reduce the damaging effects of floods. Renowned for his dedication and precision, his contributions are indispensable in protecting communities and infrastructure from the devastation of flooding. Through his leadership and deep expertise, Dr. Zaheer Ahmad Babar continues to enhance Pakistan's resilience in the face of natural disasters.

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List of Acronyms

- AJK Azad Jammu & Kashmir
- BoB Bay of Bengal
- CDPC Climate Data Processing Centre
- DCO District Coordination Officer
- FFC Federal Flood Commission
- FFD Flood Forecasting Division
- GHQ General Head Quarter (Pak Army)
- GLOF Glacial Lake Outburst Flood
- IFAS Integrated Flood Analysis System
- IRSA Indus River System Authority
- KPK Khyber Pakhtunkhwa
- LPA Long Period Average
- MAF Million Acre Feet
- MCL Maximum Conservation Level
- NCAR National Centre for Atmospheric Research
- NCEP National Centre for Environmental Prediction
- NDMA National Disaster Management Authority
- PCIW Pakistan Commissioner for Indus Water
- PDMA Provincial Disaster Management Authority
- PID Provincial Irrigation Department
- PMD Pakistan Meteorological Department
- SDMA State Disaster Management Authority
- WAPDA Water And Power Development Authority
- XEN Executive Engineer

1 Executive summary of Flood Season-2025.

The 2025 monsoon season resulted in significant flooding across Pakistan, characterized by exceptional rainfall, accurate advance prediction, and complex cross-border hydrological factors.

The Pakistan Meteorological Department (PMD) successfully forecasted the 2025 flood events through both seasonal, medium and short-range forecasts, and timely advisories were shared with all relevant stakeholders. The Flood Forecasting Division (FFD) issued advance notifications, including formal briefings and bulletins, enabling preparedness and response actions.

Key Drivers & Characteristics:

- **Exceptional Rainfall:** The season delivered 172.8 mm of rain, a 23% surplus above the Long Period Average (LPA), with Punjab (+34%), Sindh (+26%), and Balochistan (+28%).
- **Predictive Success:** The Pakistan Meteorological Department (PMD) accurately forecast the high-risk season and specific flood events through seasonal and short-range warnings, enabling pre-emptive advisories to all relevant agencies.
- **Major Hydrological Events:** The season commenced early on 26 June 2025 (four days ahead of normal) and withdrew in the third week of September.
 - This season featured nine monsoon lows/depressions, with seven approaching Pakistan; four impacted central/northeastern areas, and three affected southern/southeastern regions.

Two successive weather systems in late August caused exceptionally high flood levels at Marala (Chenab), Jassar (Ravi), and Ganda Singh Wala (Sutlej). Prolonged peaks persisted across these rivers, 345 hours (on the Sutlej at Ganda Singh Wala), 15 hours (on the Ravi at Jassar) and 10 hours (on the Chenab at Marala).
 - Qadirabad Barrage registered the highest peak flow in its history, while Marala and Khanki observed their second-highest peaks.
 - The Indus River at Tarbela received approximately 20% above-normal inflows, reaching Medium Flood Level and attaining Maximum Conservation Level (MCL) on 21 August 2025.
 - Jhelum River at Mangla reached Very High Flood Level and attained MCL on 10 October 2025.

- **Aggravating Cross-Border Factors:** Flood severity was exacerbated by substantial, continuous water releases from upstream Indian dams (Thein, Pong, and Bhakra) at over 80% capacity. The suspension of the Indus Waters Treaty hindered quantitative data sharing, complicating precise forecasting.
- **Compound Disasters:** Heavy rainfall combined with higher-than-normal temperatures triggered glacial melt, contributing to flash floods and Glacial Lake Outburst Floods (GLOFs) in northern regions.

Operational Response:

The Flood Forecasting Division (FFD) Lahore effectively monitored conditions and coordinated critical reservoir management with NDMA, PDMA, WAPDA, PIDs, Tarbela and Mangla Dam management, and GHQ Engineering Directorate. Timely public warnings were also disseminated through multiple channels.

Conclusion:

The 2025 floods were a severe hydro-meteorological event driven by above-average monsoon dynamics, intensified by upstream water management and compound climatic effects. While forecasting and inter-agency coordination were effective, the event underscores critical challenges related to transboundary water data sharing and the increasing risks posed by extreme rainfall patterns.

2 Preface

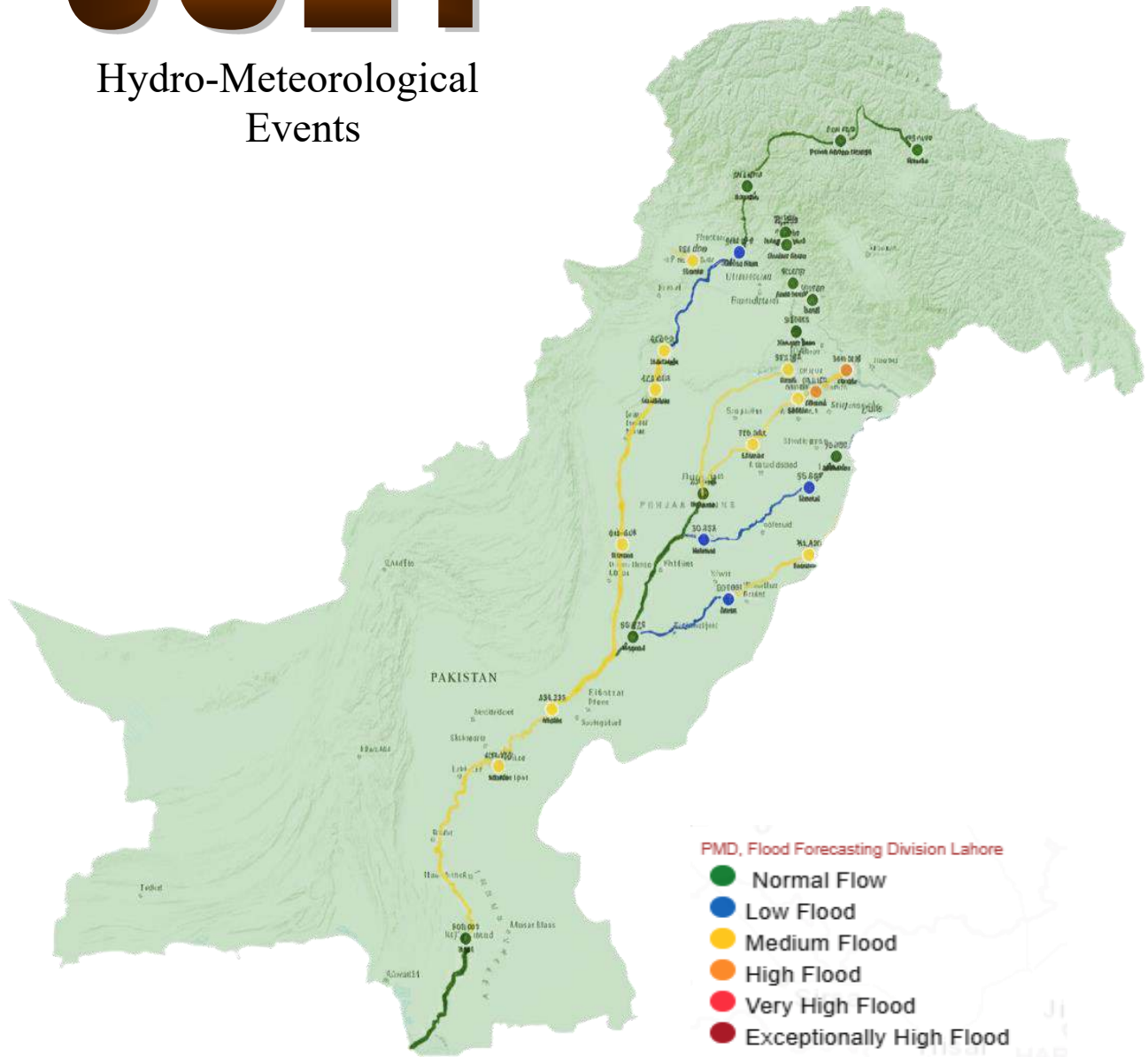
Monsoon rains are not only a cause for individual celebration but also a national one in Pakistan. However, they often turn into chaos when accompanied by flooding, power outages, damaged roads, infrastructure collapse, and even loss of life. With each passing year, the effects of climate change grow more pronounced, and its impacts ranging from extreme heatwaves to unpredictable rainfalls seem relentless. While we cannot control weather systems, we can at least take forecasts seriously rather than dismissing the predictions of meteorological agencies. Meteorology is an ever-evolving science, changing minute by minute. A slight shift in wind patterns can alter the direction and intensity of a weather system

Natural disasters are those caused by the forces of nature, and floods are one of the most destructive among them. Floods can be caused by a range of factors, including prolonged or intense rainfall, rapid snowmelt, and the failure of water control structures like dams or levees. In many countries, floods consistently rank as the leading cause of devastation. With the continuous rise in atmospheric temperatures, this disaster has become more frequent and severe over the years, a direct consequence of climate change over the past 2-3 decades. Floods inevitably wreak havoc on ecosystems, disrupting the habitats of plants and animals, and causing long-lasting damage to the environment. Many species lose their lives in the aftermath. Additionally, when an area's infrastructure and land are destroyed, the local economy suffers significantly, and the citizens bear the brunt. Commercial progress grinds to a halt as attention shifts to rebuilding shattered livelihoods.

Pakistan experiences unique meteorological conditions that contribute to its floods. Although the southeasterly monsoon is the dominant weather system in summer, westerly waves also affect the country's weather patterns. The intensification of monsoon systems and the northward shift of monsoon depressions are largely driven by these westerly waves. Floods in Pakistan are primarily caused by heavy monsoon rains between July and September.

JULY

Hydro-Meteorological Events



3 Significant Hydro-Meteorological events during the month of July-2025.

During July 2025, four distinct rainfall spells were reported across the country. High Flood in River Chenab & Exceptional High Flood level recorded in DG Khan Division Hill Torrents. Nationwide, rainfall was 23% above normal. Regions such as Azad Jammu & Kashmir 14%, Gilgit Baltistan 52%, Sindh -47%, Balochistan 33%, Khyber Pakhtunkhwa 05% and Punjab 57%. By the end of July, the Tarbela reservoir was at 88% of its capacity, and Mangla reservoir was at 59%. For the month of July, as per operational practices, a wet day is defined as a day receiving ≥ 2.5 mm of rainfall. A wet spell consists of at least 2–3 consecutive wet days, with more than 25% of site observations available for the period.

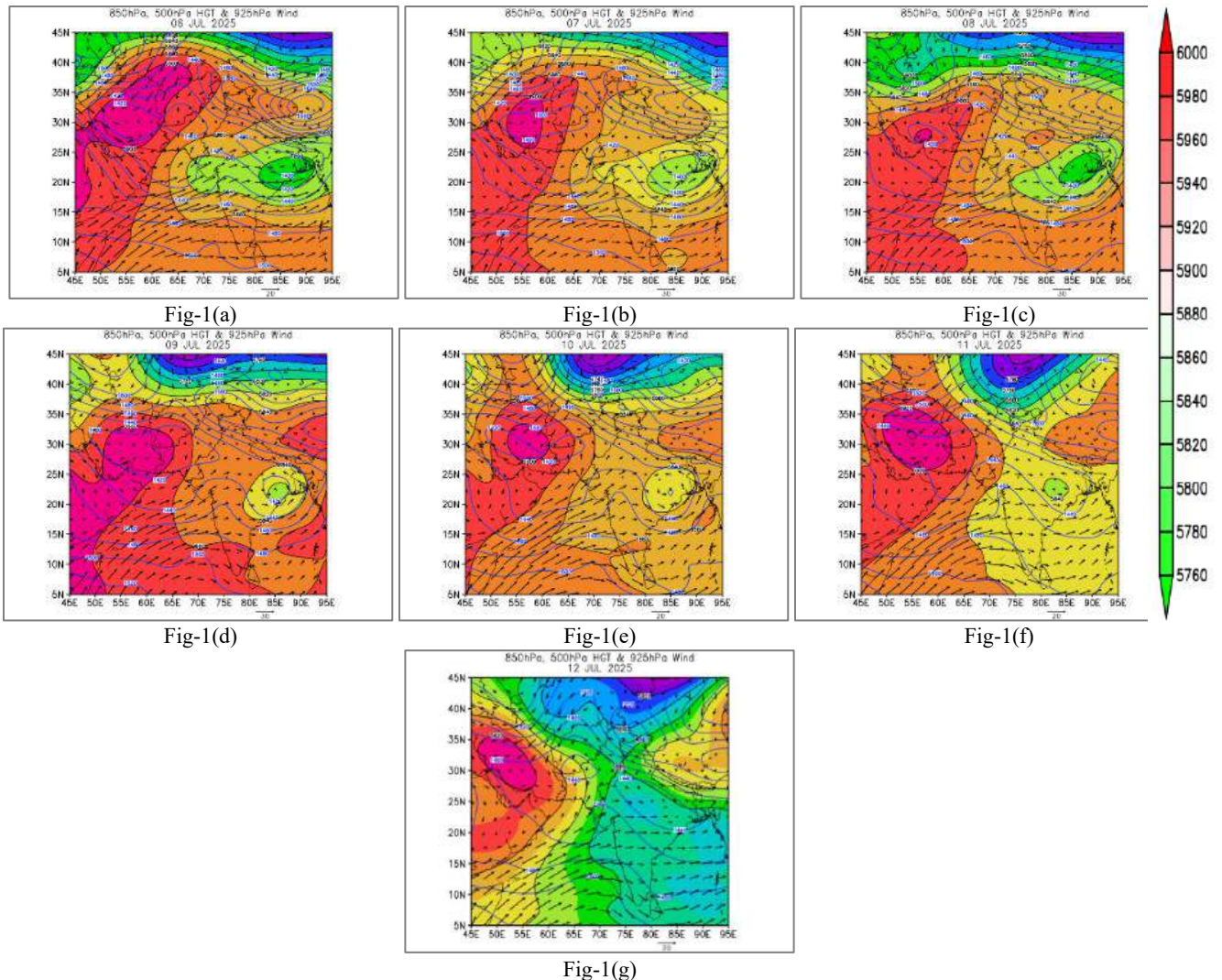
3.1 1st Wet Spell of July 2025 (06-12).

During 06–11 July 2025, the country experienced an active synoptic regime due to the interaction of westerly waves and monsoon circulation, supported by a persistent seasonal low over Balochistan. The presence of the subtropical jet stream to the north of the country, with its core exceeding speeds of 100 knots, along with wind speed divergence along the foothills of the Himalayas towards Pakistan, created favourable conditions for the system. A steep pressure gradient was also observed over the northern parts of Afghanistan during this period. Fig -1 illustrates the geopotential height patterns at 500 hPa and 850 hPa, along with the wind flow at 925 hPa during the spell. The presence of south westerly winds at 925 hPa ensured an adequate supply of moisture from the Arabian Sea and Bay of Bengal.

Westerly troughs affected northern parts of the country, particularly between 08–10 July, significantly enhancing atmospheric instability as shown in Fig-1. At the same time, moderate to strong monsoon currents from the Arabian Sea, with intermittent support from the Bay of Bengal, penetrated into northern and upper regions. A monsoon low over central West Bengal, later shifting towards Jharkhand (India), further strengthened the monsoon flow over the region.

The seasonal low over northwest Balochistan, at times well-marked with central pressure around 986 hPa, remained quasi-stationary with its trough extending north eastwards, contributing to sustained moisture convergence. By 11 July, both the monsoon currents and the seasonal low weakened, while the westerly trough shifted towards Kashmir and adjoining areas, indicating a gradual decrease in synoptic forcing.

During the spell, rainfall was recorded at 82% of meteorological observatories across the country, with the maximum value of 267 mm observed at Lahore. On 10 July, the maximum daily coverage was observed, when 52% of observation stations reported measurable precipitation, and the highest 24-hour rainfall of 115 mm was recorded at Lahore city. The prevailing synoptic and mesoscale conditions led to widespread heavy rainfall over Khyber Pakhtunkhwa, Punjab, and northeastern Balochistan. The spatial distribution of accumulated rainfall is presented in Fig-2, while the date-wise progression and movement of the associated weather system during the spell are illustrated in Fig-3.



Colour shades represent 500 hPa Geopotential Heights, Blue contour lines indicate 850 hPa Geopotential Heights and barbs show 925 hPa winds.

Fig-(1) 1st Spell of July-2025, 850 & 500 hPa Geopotential Height & 925 hPa winds map.

Lahore City received 267 mm rainfall during the spell. Other rainfall distribution during the spell over the country can also be seen from the Fig-2.

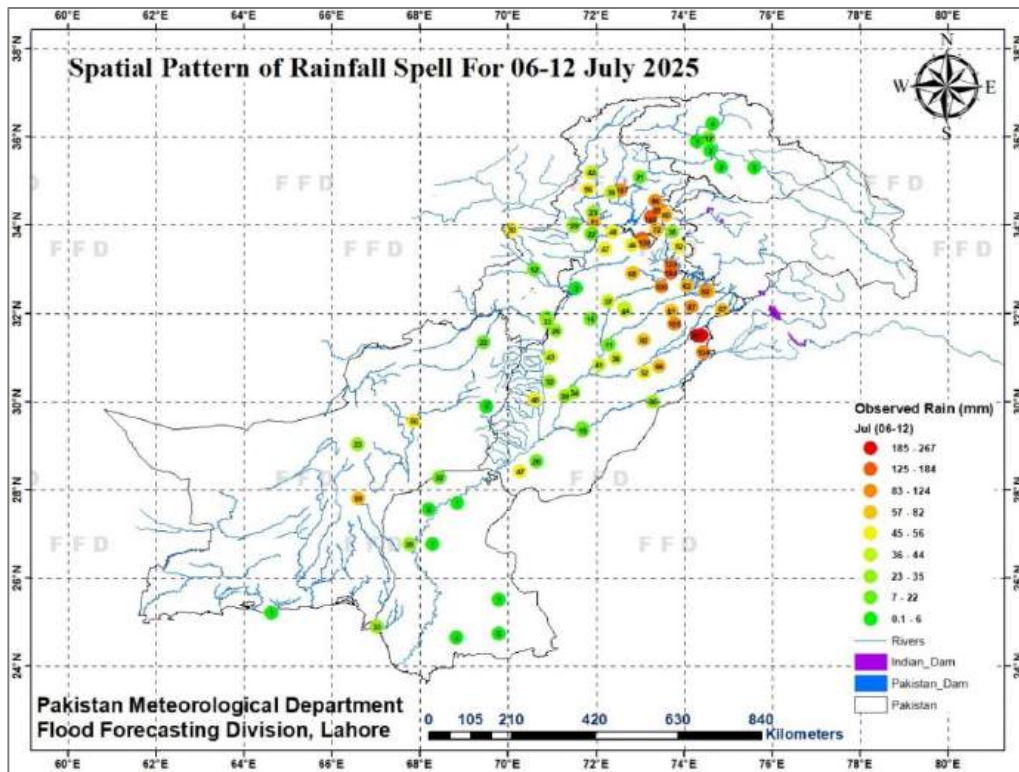


Fig-(2-a) 1st Spell of July-2025, PMD total rainfall

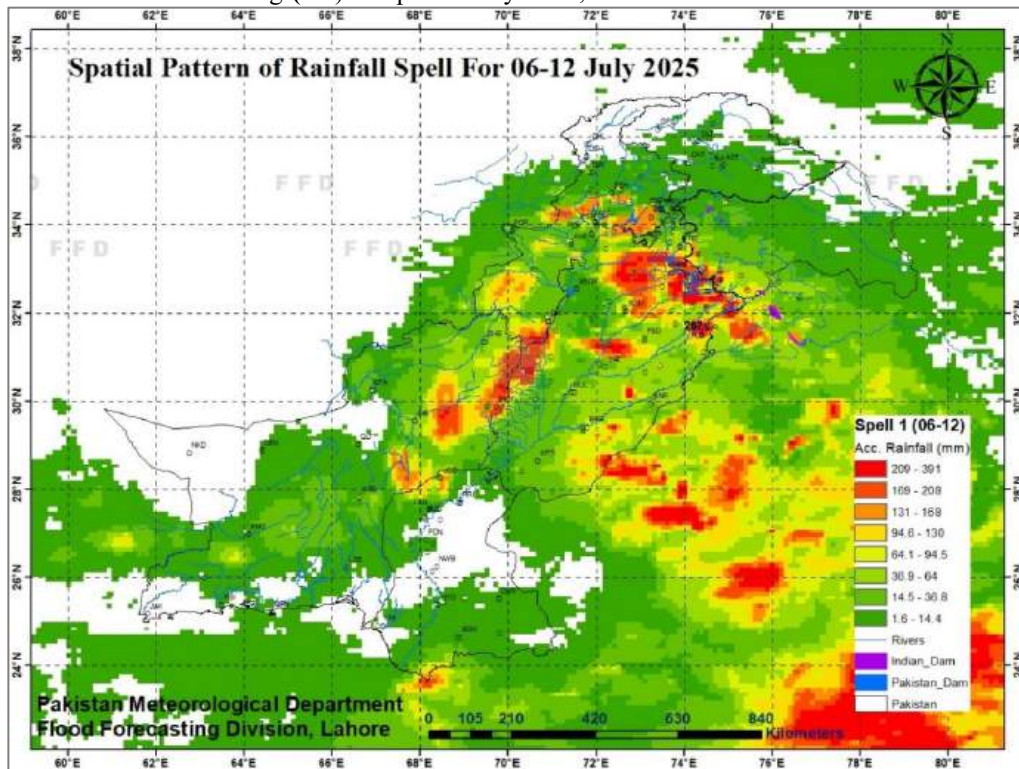
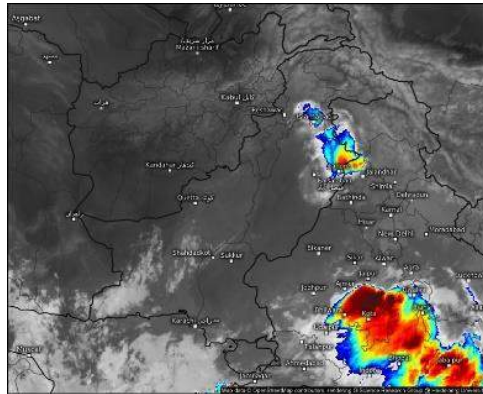


Fig-(2-b) 1st Spell of July-2025, PMD, Radar & Satellite total merged rainfall

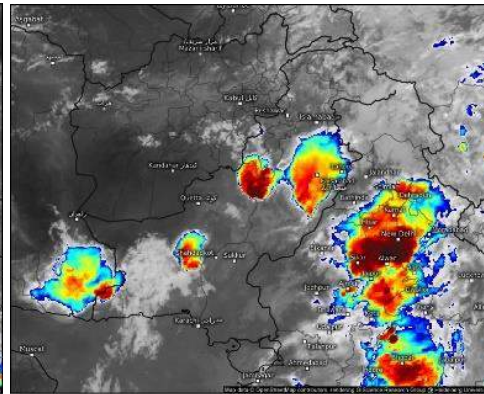
Fig-(2) 1st Spell of July-2025, Total Rainfall

Satellite cloud images during the spell are shown below in Fig-3.



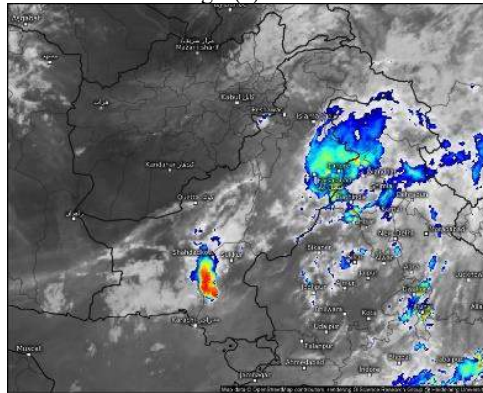
Satellite Cloud Tops Alert
Sat 07/05/2025, 08:00AM PKT

Fig-3(a)



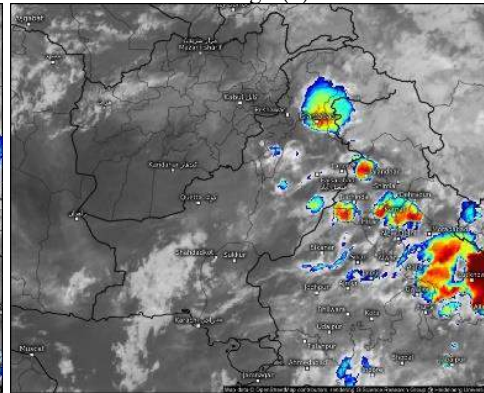
Satellite Cloud Tops Alert
Wed 07/09/2025, 08:00AM PKT

Fig-3(b)



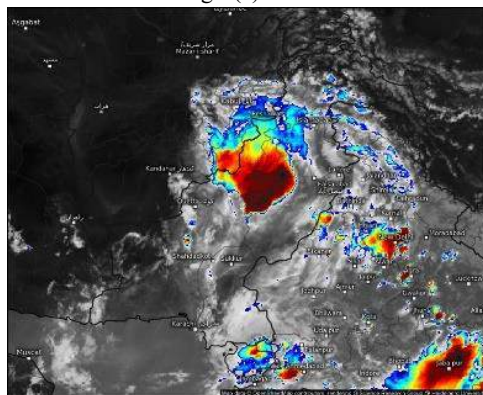
Satellite Cloud Tops Alert
Thu 07/10/2025, 08:00AM PKT

Fig-3(c)



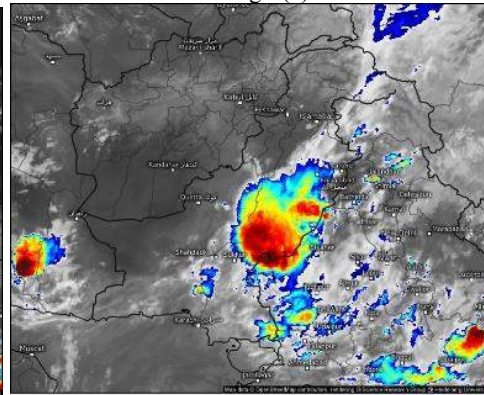
Satellite Cloud Tops Alert
Wed 07/16/2025, 08:00AM PKT

Fig-3(d)



Satellite Cloud Tops Alert
Wed 07/16/2025, 02:00PM PKT

Fig-3(e)



Satellite Cloud Tops Alert
Thu 07/17/2025, 11:00AM PKT

Fig-3(f)

Fig-(3) 1st Spell of July-2025, Satellite images

Due to the first wet spell, flows in major rivers increased significantly. The Indus River at Tarbela recorded a maximum flow of 332,000 cusecs, the Kabul River at Nowshera reached 59,900 cusecs, the Jhelum River at Mangla registered 65,000 cusecs, the Chenab River at Marala recorded 126,609 cusecs, the Ravi River at Jassar reached 8,098 cusecs, and the Sutlej River at Ganda Singh Wala recorded 8,853 cusecs, as shown in Figure 17.

In addition, the D.G. Khan hill torrent system remained active during the spell, with an exceptionally high flood peak observed at Sakhi Sarwar, while high flood peaks were also recorded in Pitok and Chachar nullahs, as presented in Table 1.

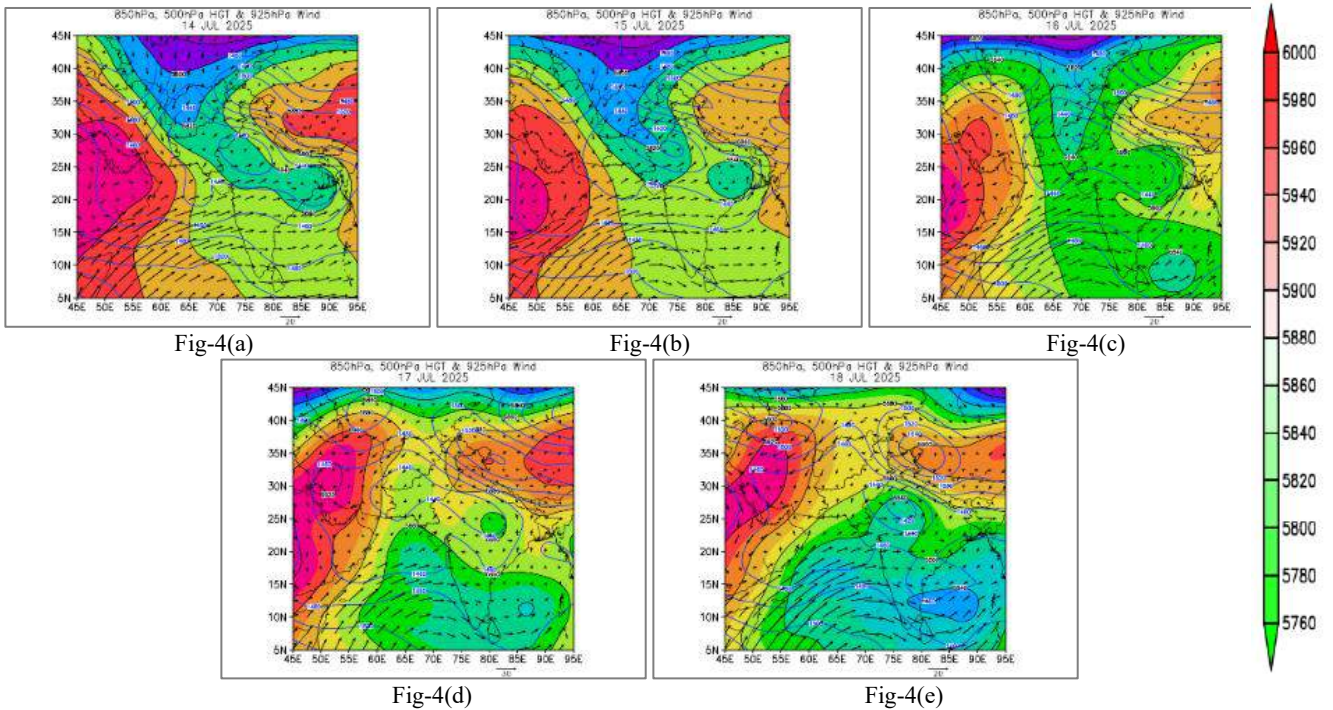
3.2 2nd Wet Spell of July 2025 (14-18).

The second wet spell of July 2025 persisted for five days (14–18 July) under the influence of an active monsoon system (track 3 of monsoon shown in Fig-41) in interacting with westerly waves, supported by a persistent seasonal low over Balochistan. Fig-4 shows the 500 and 850 hPa geopotential height patterns and 925 hPa moisture flow, indicating the presence of a westerly wave over parts of Pakistan and strong south-westerly moisture transport from the Arabian Sea.

During 14–16 July, a well-marked monsoon low from central India moved westward into the country, while moderate to strong monsoon currents from the Arabian Sea and Bay of Bengal penetrated central and upper regions, favouring enhanced rainfall. On 17 July, the monsoon low lies over Bahawalnagar, Faisalabad, and the westerly trough shifted over northern areas, while the seasonal low over north Balochistan maintained low-level convergence.

By 18 July, the monsoon low became insignificant and the westerly trough moved eastward. Concurrently, a low-pressure system over central India intensified into a depression, and monsoon inflow was temporarily cut off, indicating a weakening of synoptic support.

Overall, the period experienced active monsoon conditions during 14–17 July, followed by a noticeable decline in monsoon activity on 18 July. During the spell, rainfall was recorded at 77% of meteorological observatories across the country, with Okara receiving the highest total of 412 mm. On 16 July, the maximum daily coverage was observed, when 65% of observation stations reported measurable precipitation, and the highest 24-hour rainfall of 217 mm was recorded at Sheikhpura.



Colour shades represent 500 hPa Geopotential Heights, Blue contour lines indicate 850 hPa Geopotential Heights and barbs show 925 hPa winds.

Fig-(4) 2nd Spell of July-2025, 850 & 500 hPa Geopotential Height & 925 hPa winds map

Other rainfall distribution during the spell over the country can also be seen from the Fig-5.

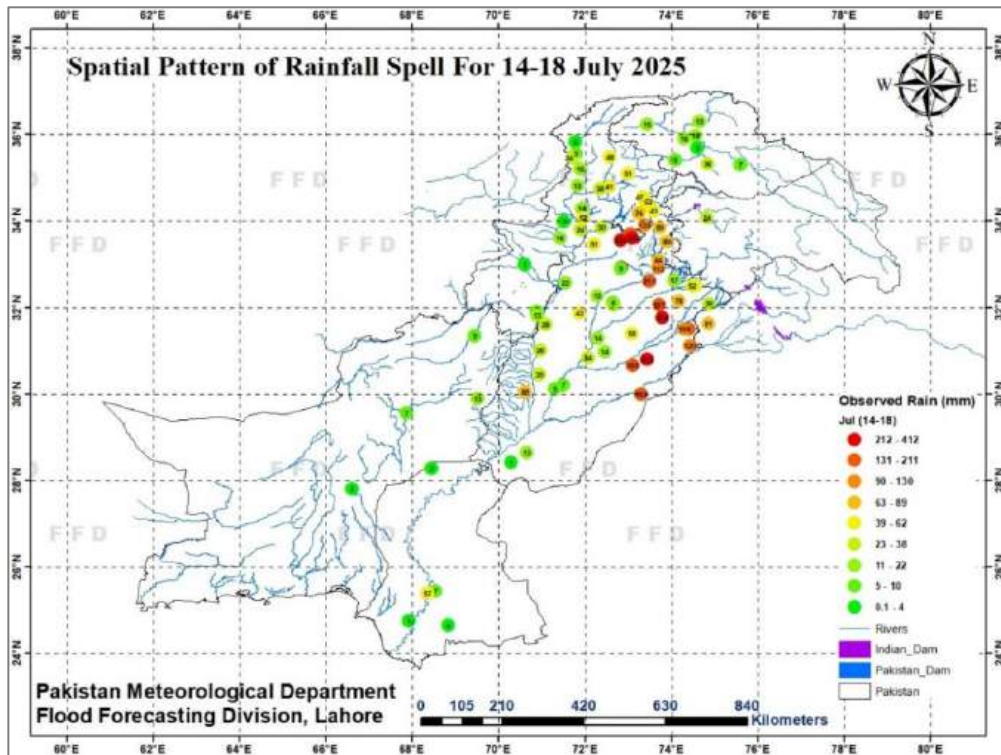


Fig-(5-a) 2nd Spell of July-2025, PMD total rainfall

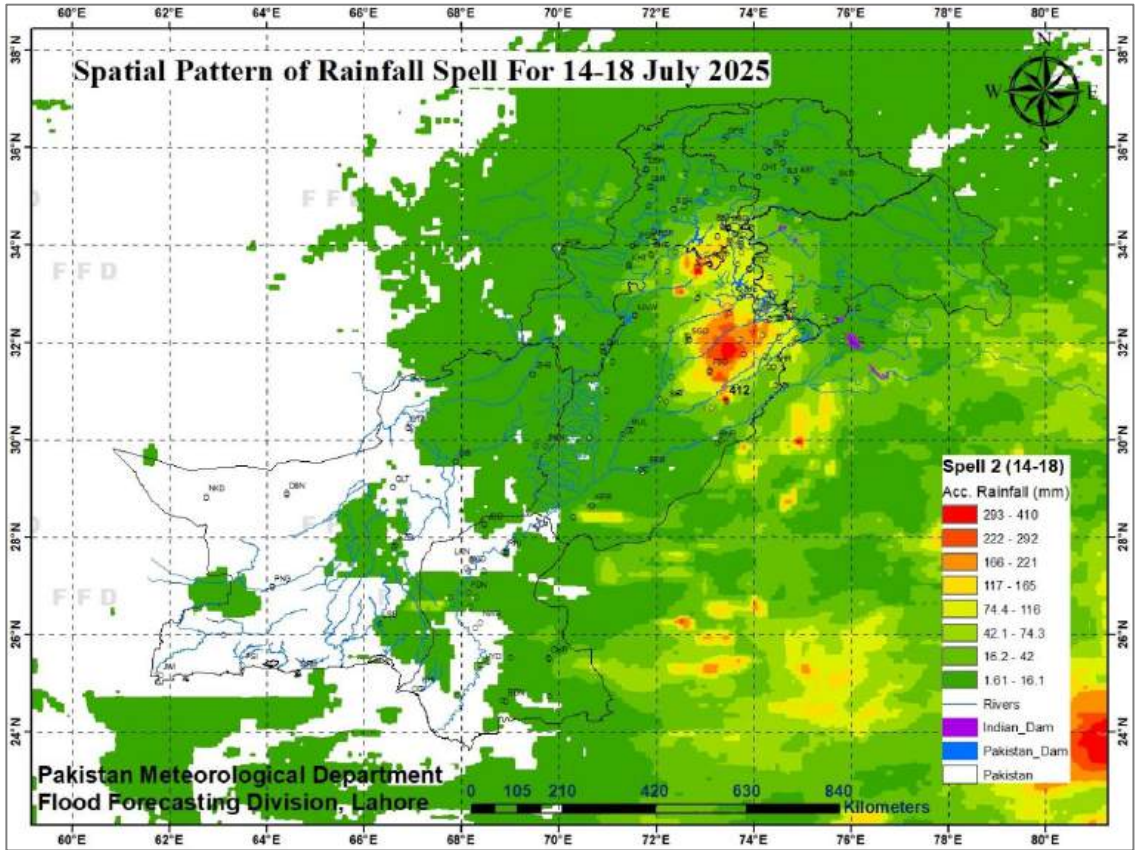


Fig-(5-b) 2nd Spell of July-2025, PMD, Radar & Satellite total merged rainfall
 Fig-(5) 2nd Spell of July-2025, Total Rainfall

Dense clouds observed by satellite during the spell are illustrated in Fig-6.

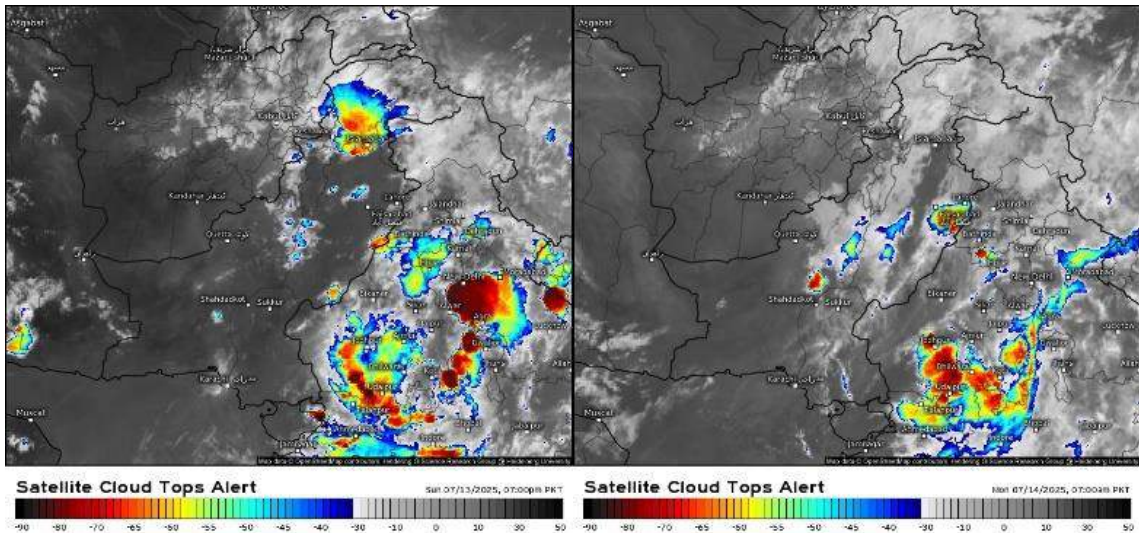


Fig-6(a)

Fig-6(b)

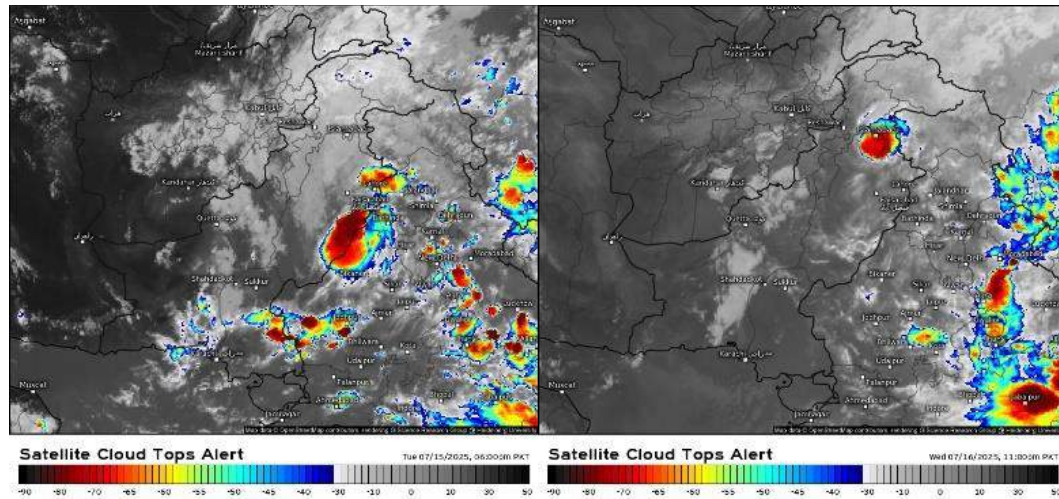


Fig-6(c)

Fig-6(d)

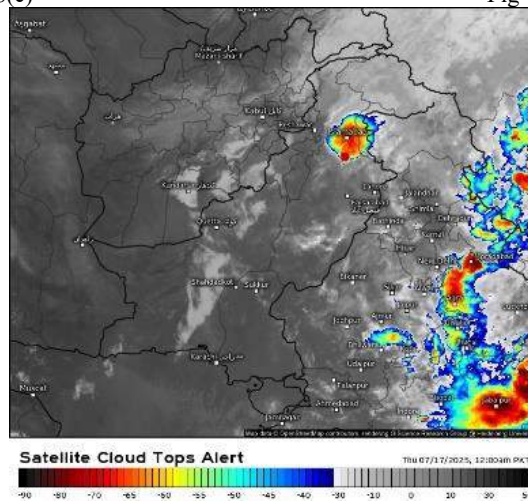


Fig-6(e)

Fig-(6) 2nd Spell of July-2025, Satellite images

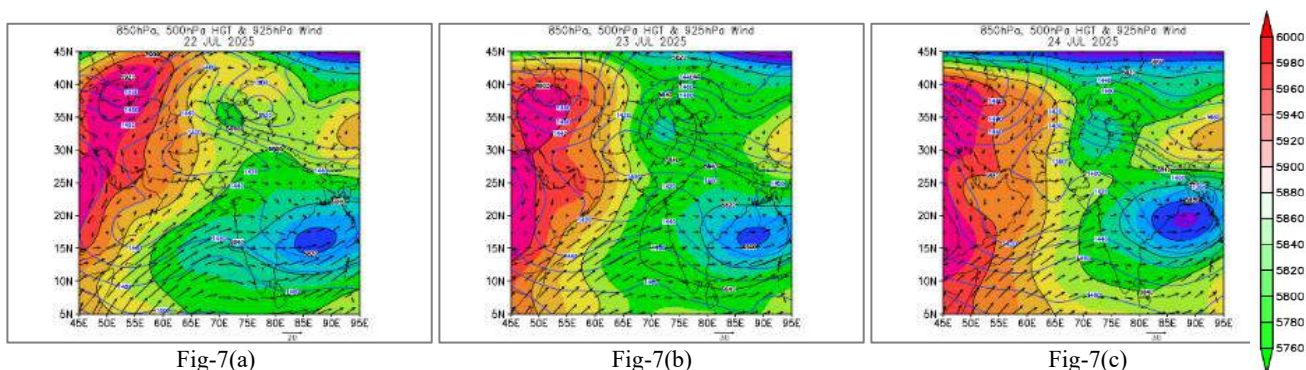
During the second wet spell, the impact on major river rim-station flows remained limited, as the associated weather systems predominantly affected areas below the rim stations. Consequently, no significant flood response was observed at the rim stations. However, Maximum Flood Peaks recorded during the period included 269,000 cusecs at Tarbela on the Indus River, 47,200 cusecs at Nowshera on the Kabul River, 77,000 cusecs at Mangla on the Jhelum River, 73,468 cusecs at Marala on the Chenab River, 2,888 cusecs at Jassar on the Ravi River, and 4,750 cusecs at Ganda Singh Wala on the Sutlej River, as illustrated in Figure 17. Due to the impact of a monsoon low affecting areas downstream of Mangla Dam, Chakwal observatory recorded 250 mm of rainfall during the spell. As a result, high flood peaks were observed in the associated nullahs (Bhuna and Kahan) of the Jhelum River, while a medium flood peak was recorded at Rasul Barrage as listed in Table-1.

3.3 3rd Wet Spell of July 2025 (22-25).

During the third wet spell (21–24 July 2025), the country experienced moderate monsoon activity influenced by transient westerly waves and a persistent seasonal low over northwestern Balochistan. Fig-7 represents 500 hPa and 850 hPa geopotential height patterns along with 925 hPa moist wind flow during the spell. It indicates that parts of Pakistan remained under the influence of the westerly wave. Southeasterly and south-westerly winds at 925 hPa were also present, ensuring a moderate supply of moisture from the Bay of Bengal and the Arabian Sea. A strong moisture influx from the Arabian Sea, particularly on 21 July, supported rainfall over the upper catchments, while a westerly trough intermittently affected northern parts of the country.

From 22 to 23 July, the westerly trough remained over northern regions as light to moderate monsoon currents continued to penetrate upper parts, with a gradual weakening trend. By 24 July, the westerly trough shifted towards Kashmir and adjoining areas and weakened, while a monsoon trough extended from the Bay of Bengal to South Punjab, confining monsoon activity mainly to the lower half of the country.

Overall, the third wet spell was characterized by short-lived synoptic support and moderate rainfall activity, followed by a decline in intensity towards the end of the period. During the spell, rainfall was recorded at 69% of meteorological observatories across the country, with Narowal receiving the highest cumulative rainfall of 157 mm. On 24 July, the maximum daily coverage was observed, when 57% of observation stations reported measurable precipitation, and the highest 24-hour rainfall of 125 mm was recorded at Attock.



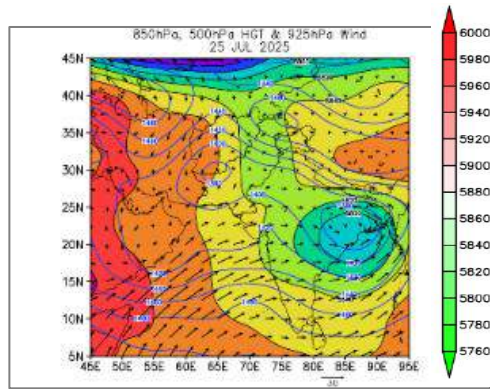


Fig-7(d)

Colour shades represent 500 hPa Geopotential Heights, Blue contour lines indicate 850 hPa Geopotential Heights and barbs show 925 hPa winds.

Fig-(7) 3rd Spell of July-2025, 850 & 500 hPa Geopotential Height & 925 hPa winds map

Narowal received 157 mm rainfall during the spell. Other rainfall distribution during the spell over the country can also be seen from the Fig-8.

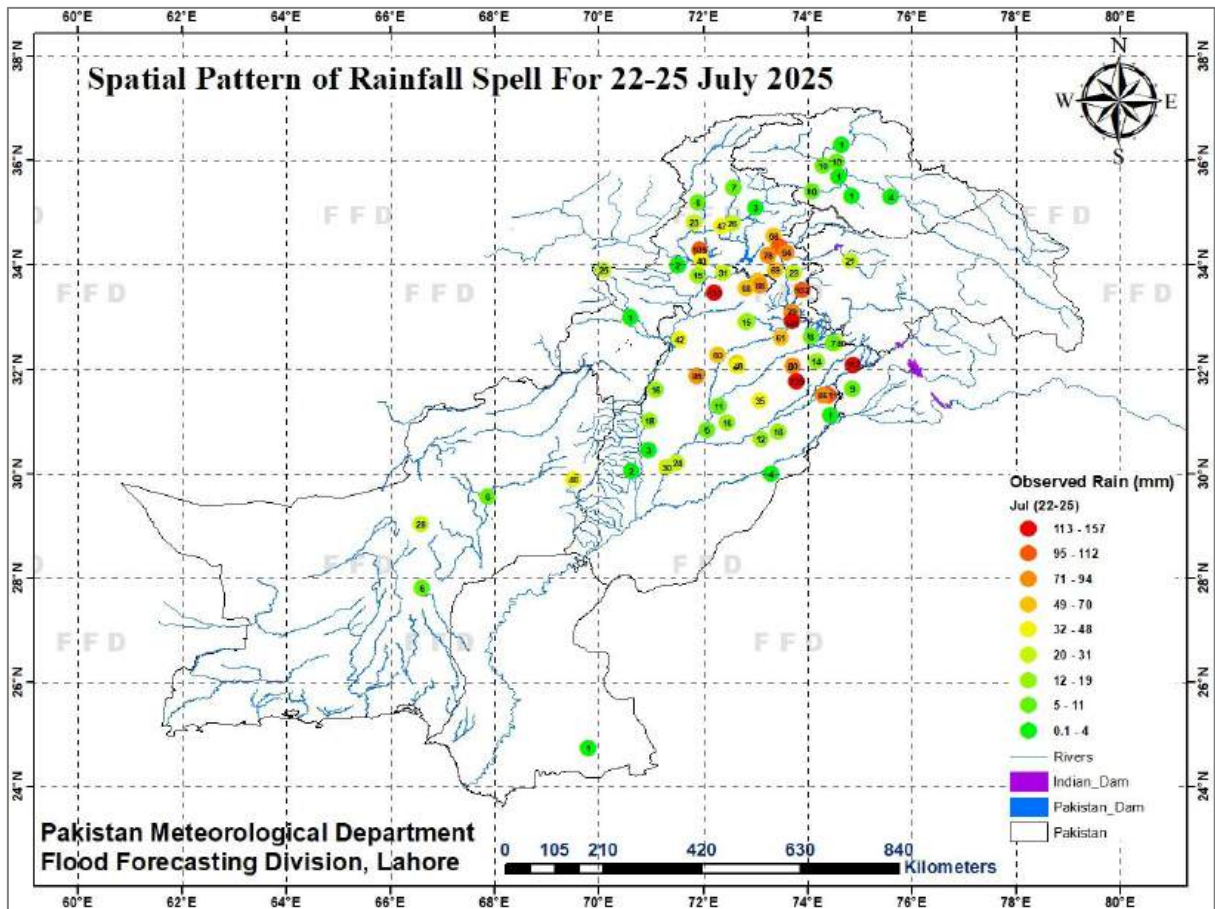


Fig-(8-a) 3rd Spell of July-2025, PMD total rainfall

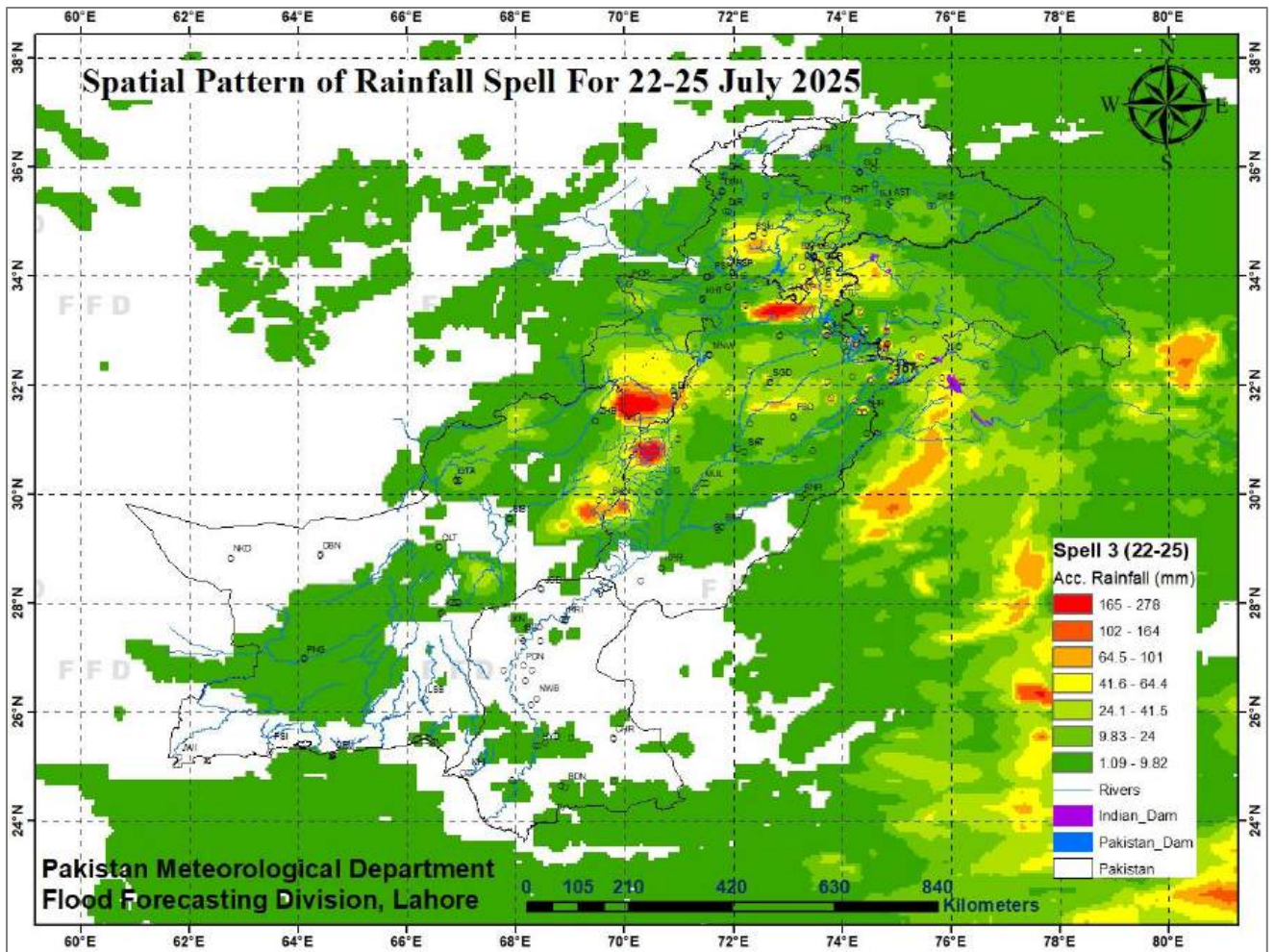


Fig-(8-b) 3rd Spell of July-2025, PMD, Radar & Satellite total merged rainfall

Fig-(8) 3rd Spell of July-2025, Total rainfall

Dense clouds observed by satellite during the spell is shown in the Fig-9.

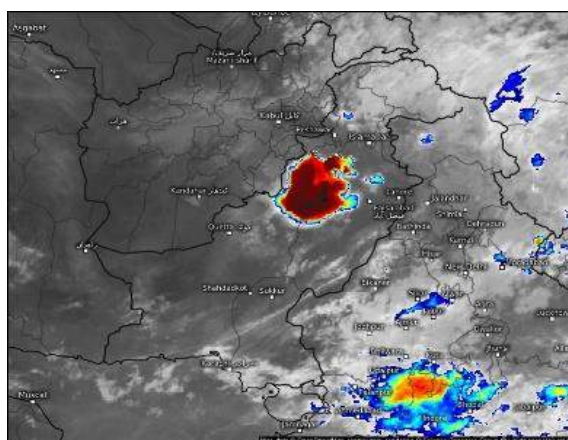


Fig-9(a)

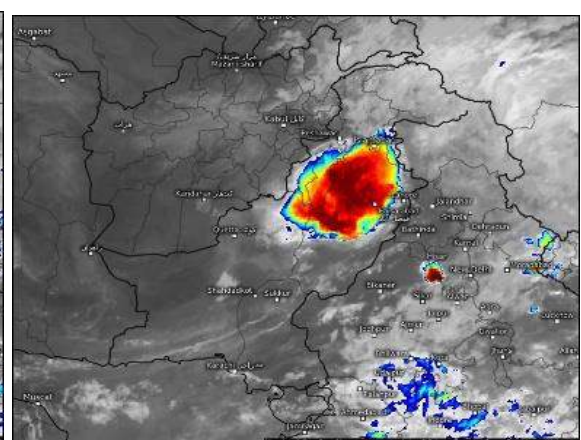


Fig-9(b)

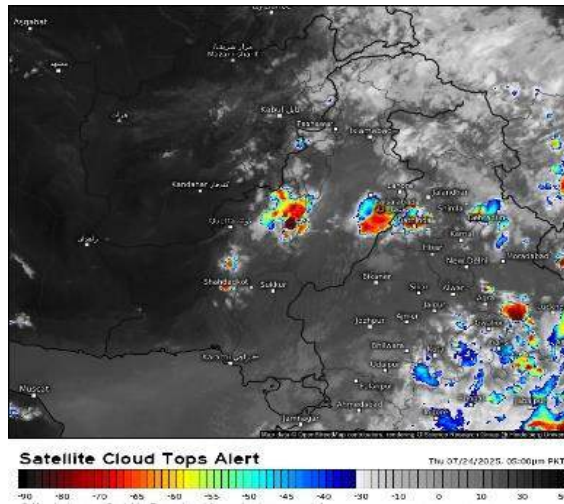


Fig-9(c)

Fig-(9) 3rd Spell of July-2025, Satellite images

The third wet spell impacting the upper catchments of all major rivers led to a significant increase in river flows. The Indus River at Tarbela recorded a maximum flow of 370,000 cusecs, with enhanced contributions from accelerated snowmelt over Gilgit-Baltistan and Khyber Pakhtunkhwa due to elevated temperatures (Annex-L & M). The Kabul River at Nowshera reached 50,700 cusecs, the Jhelum River at Mangla registered 80,000 cusecs, the Chenab River at Marala recorded 144,378 cusecs, the Ravi River at Jassar reached 12,571 cusecs, and the Sutlej River at Ganda Singh Wala recorded 12,074 cusecs, as shown in Fig-17.

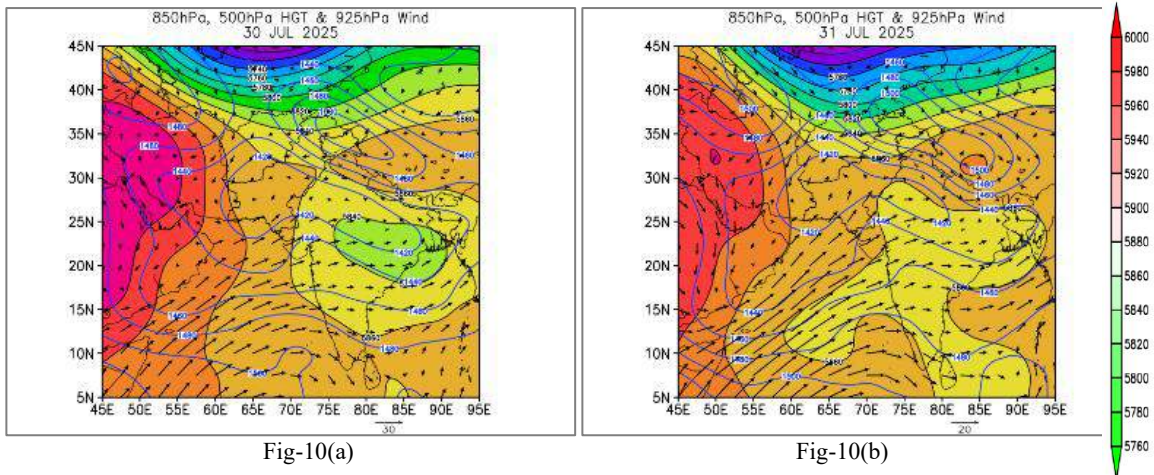
3.4 4th Spell of July 2025 (30-31).

The fourth wet spell of July 2025 remained active for two days, from 29–30 July 2025. During this period, the synoptic situation over the country was influenced by a monsoon low over northwest Madhya Pradesh, a persistent westerly trough, and an active seasonal low over Balochistan. Moderate monsoon currents from both the Arabian Sea and the Bay of Bengal penetrated the country, with a tendency to intensify.

The westerly trough, initially over northeast Afghanistan, shifted over northern parts of the country, while the monsoon low remained nearly stationary. The seasonal low over Balochistan persisted, maintaining low-level convergence and continued monsoon activity. Fig-10 illustrates the 500 hPa and 850 hPa geopotential height patterns along with 925 hPa moisture flux, indicating that parts of Pakistan remained under the influence of the westerly wave. Southeasterly winds at 925 hPa were present, providing a strong moisture supply from the Bay of Bengal, along with moderate moisture influx from the Arabian Sea.

During the spell, rainfall was observed at 53% of meteorological observatories nationwide, with Gujranwala recording the highest cumulative total of 86 mm. On 30 July, the maximum daily coverage

was observed, when 42% of observation stations reported measurable precipitation, and the highest 24-hour rainfall of 82 mm was recorded at Jhelum.



Colour shades represent 500 hPa Geopotential Heights, Blue contour lines indicate 850 hPa Geopotential Heights and barbs show 925 hPa winds.

Fig-(10) 4th Spell of July-2025, 850 & 500 hPa Geopotential Height & 925 hPa winds map

Gujranwala received 86 mm rainfall during the spell. Other rainfall distribution during the spell over the country can also be seen from the Fig-11.

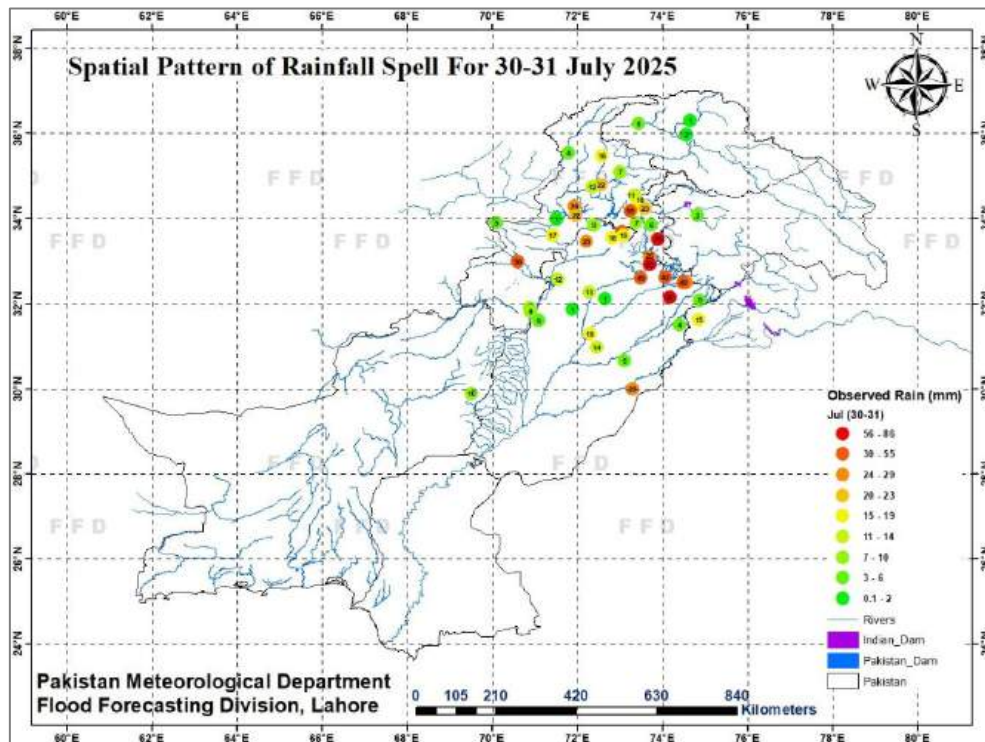


Fig-(11-a) 4th Spell of July-2025, PMD total rainfall

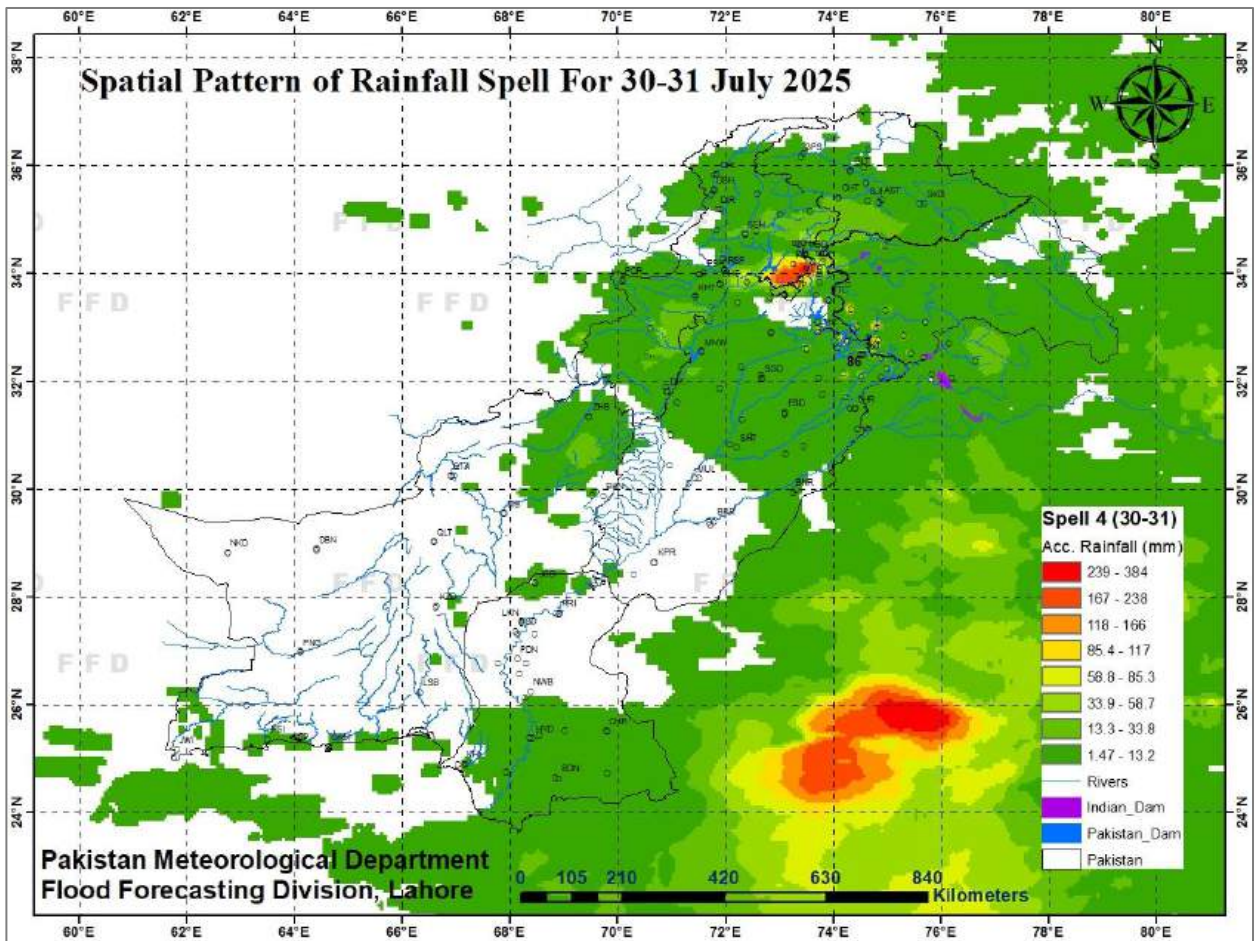


Fig-(11-b) 4th Spell of July-2025, PMD, Radar & Satellite total merged rainfall

Fig-(11) 4th Spell of July-2025, Satellite images

Dense clouds observed by satellite during the spell are shown in the Fig-12.

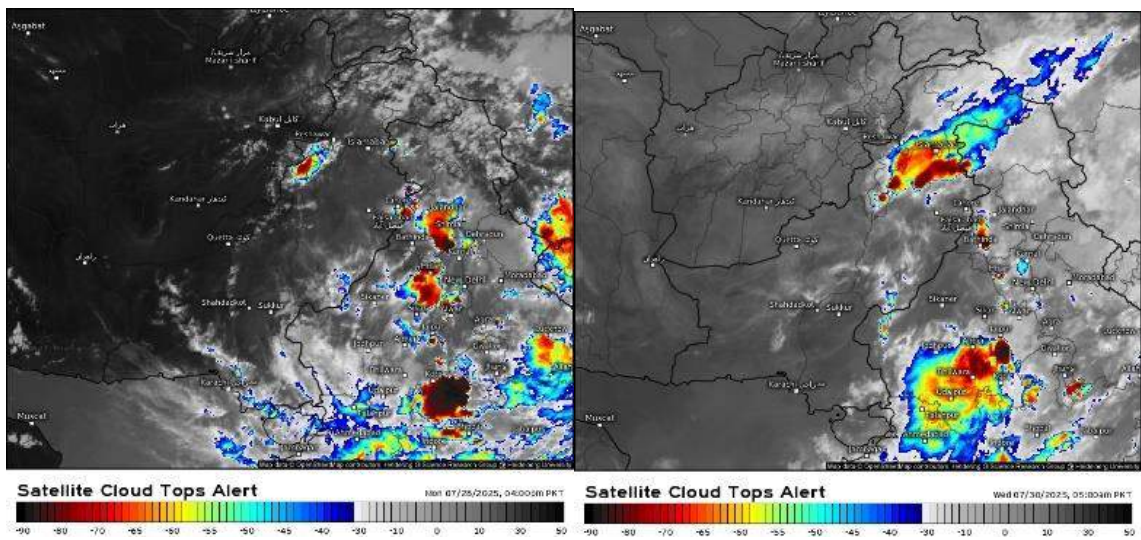


Fig-12(a)

Fig-12(b)

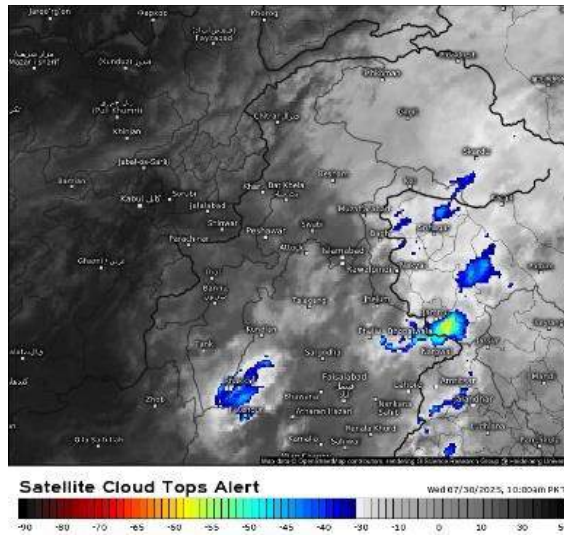


Fig-12(c)
Fig-(12) 4th Spell July-2025, Satellite images

Due to wet spell there is no significant impact of the major river flows.

3.5 Monthly maps of Total rainfall of July 2025.

The isohyetal map for July 2025 indicates that the maximum rainfall, exceeding 612 mm, was recorded around Islamabad, while Sheikhupura, Lahore Airport, Jhelum, and Chaklala Airbase received totals exceeding 500 mm during the month. Rainfall distribution across the rest of the country is illustrated in Fig-13. Overall, rainfall was recorded at 94% of meteorological observatories nationwide. However, on 28 July, 92% of observation stations reported no measurable precipitation, indicating a temporary lapse in rainfall activity across most parts of the country.

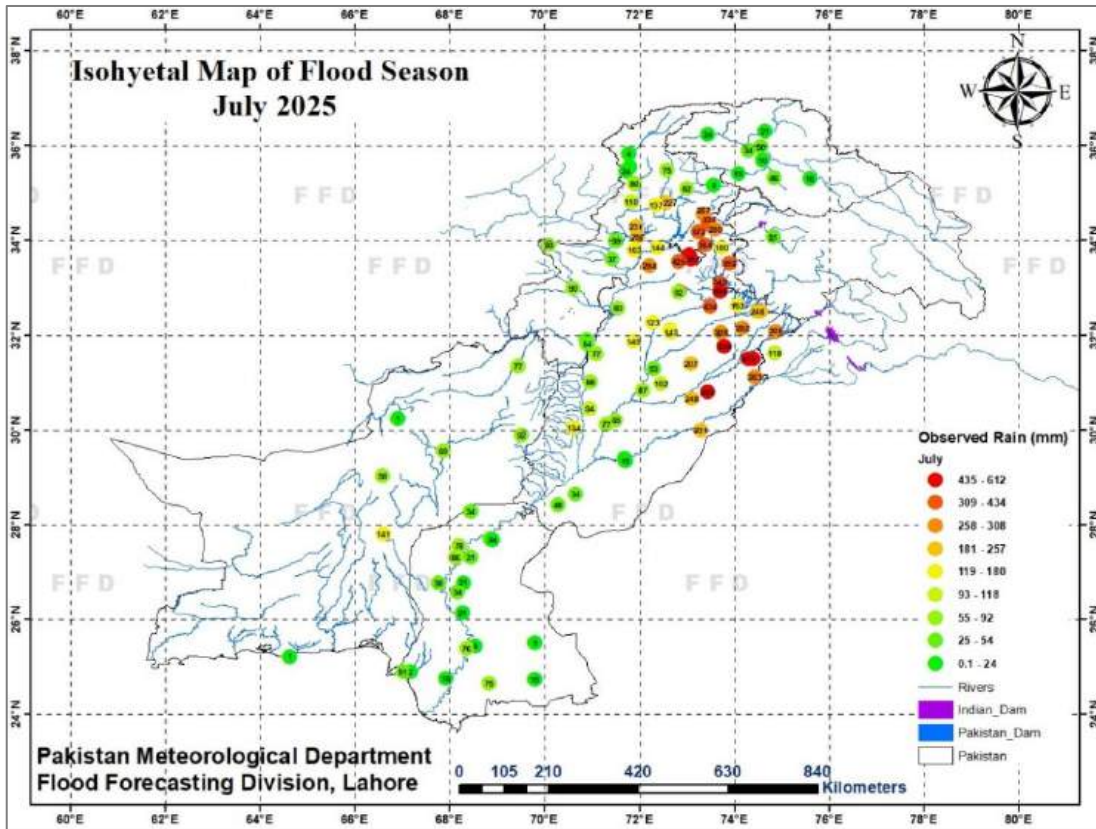


Fig-(13-a) July-2025, PMD total rainfall

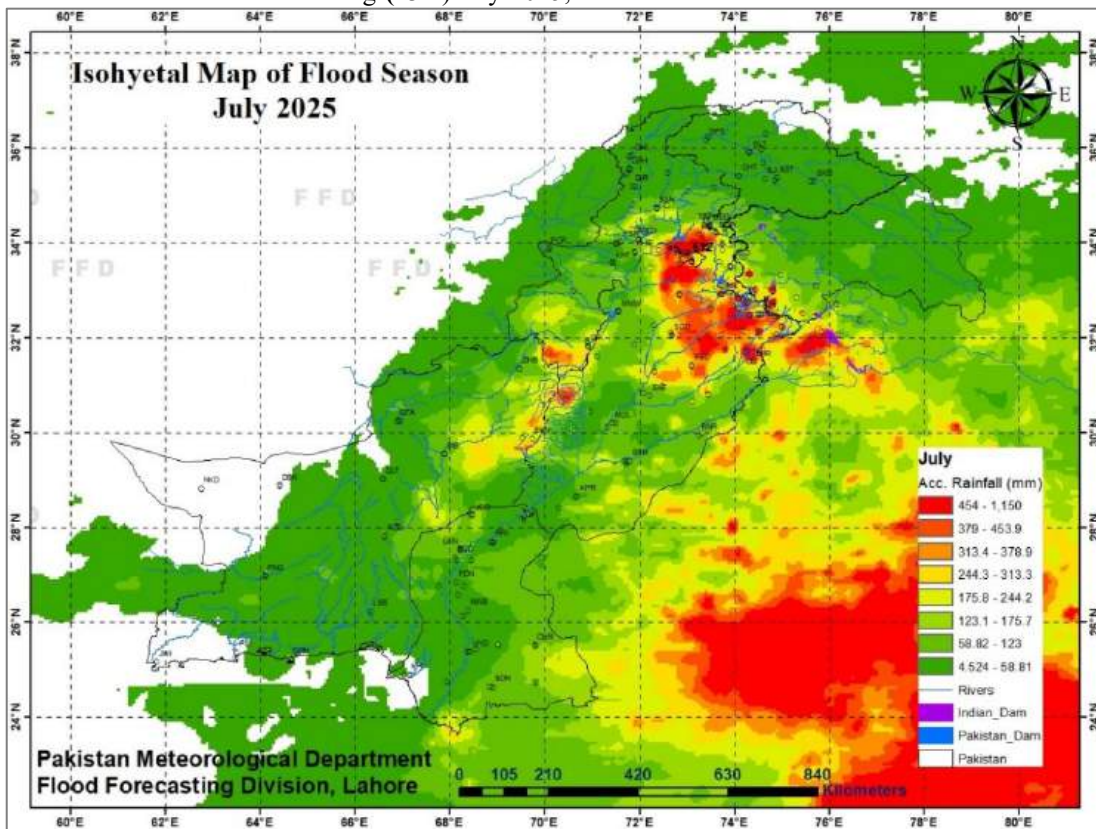


Fig-(13-b) July-2025, PMD, Radar & Satellite total merged rainfall

Fig-(13) July-2025, Total Rainfall

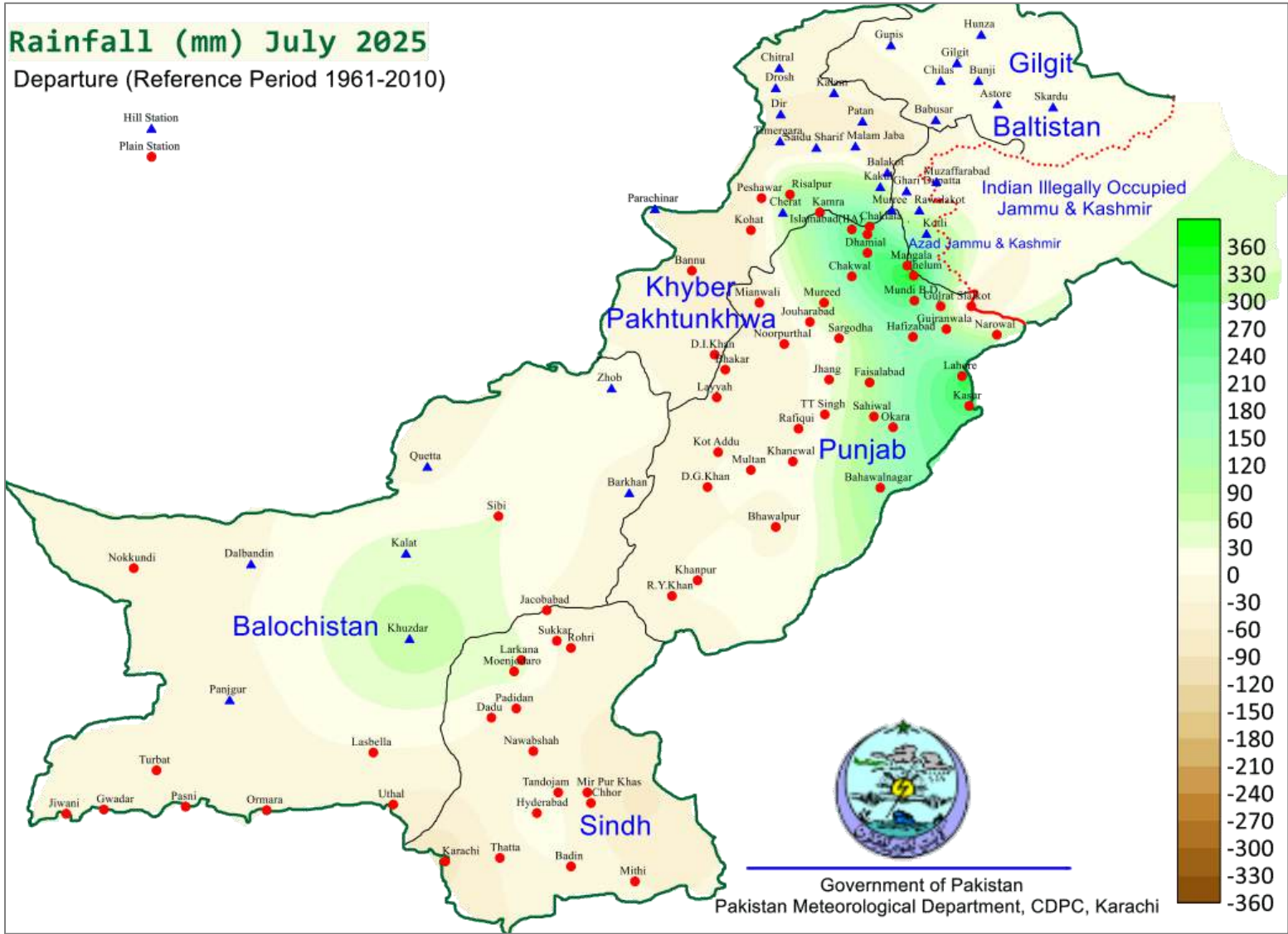


Fig-(14) July-2025, Monthly total rainfall Departure.

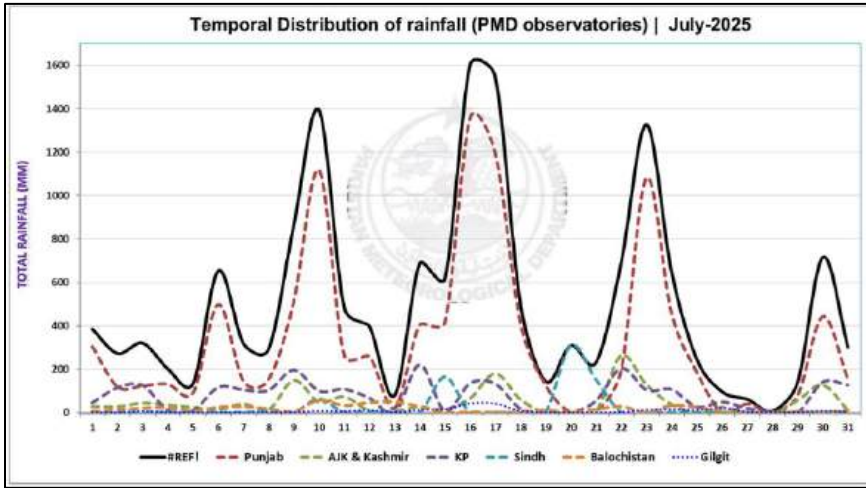


Fig-15(a)

	01 to 31 July, 2025 Rainfall		
	normal (mm)	actual (mm)	Dev (%)
Pakistan	63.3	77.7	22.8
Azad J&K	173.9	197.7	13.7
Balochistan	29.7	39.3	32.5
Gilgit-B	13.3	20.2	52.0
Khyber-PK	106.7	111.5	4.5
Punjab	104.0	163.5	57.3
Sindh	60.2	31.6	-47.5

Fig-15(b)

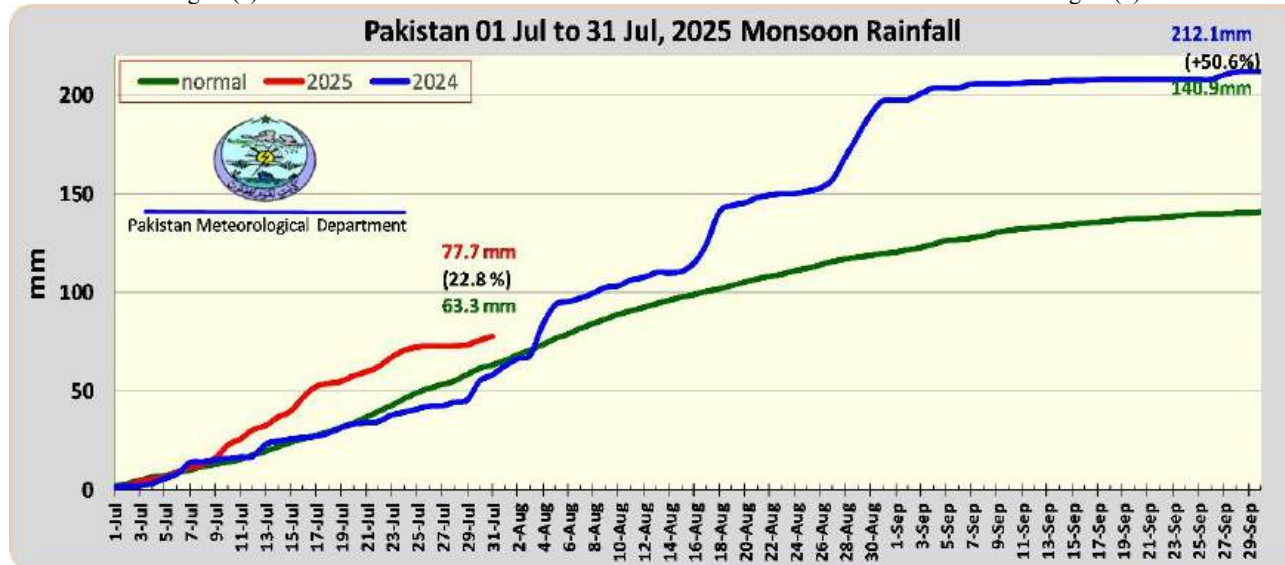


Fig-15(c)

Fig-(15) July-2025, Monthly Temporal distribution, AWR Comparison Rainfall

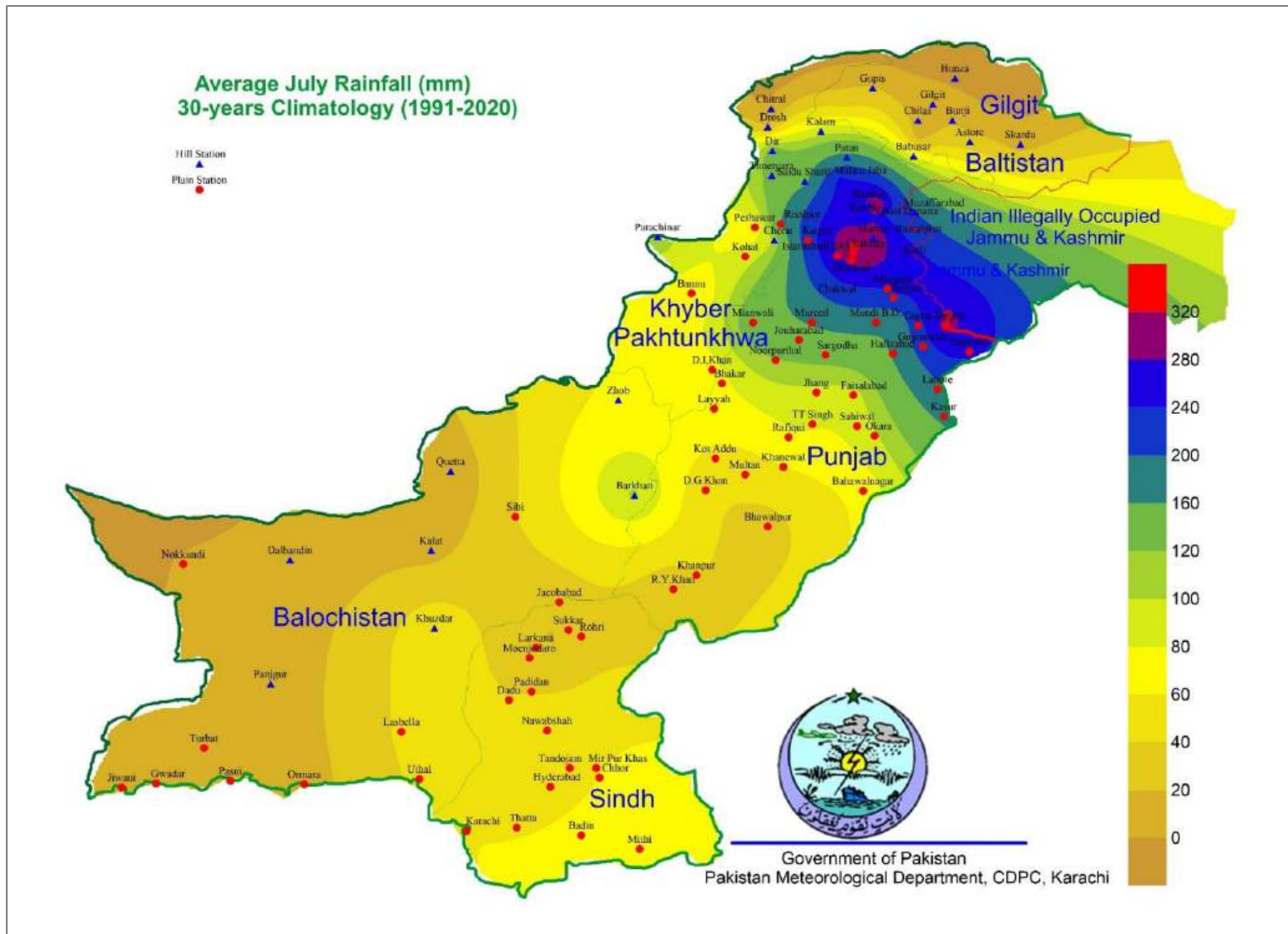


Fig-(16) July Climate normal of Rainfall

3.6 Maximum Flood Peaks recorded during the month of July-2025.

The first significant monsoon wet spell of July 2025 occurred during mid-July, driven by active monsoon currents from the Arabian Sea and Bay of Bengal, along with westerly wave troughs. Rainfall was concentrated over northern and northeastern Pakistan, particularly the upper catchments of the Jhelum, Chenab, and Ravi Rivers. Northern Punjab, Khyber Pakhtunkhwa, and Kashmir received moderate to heavy rainfall. Maximum cumulative rainfall was recorded in the upper catchments, supporting increased river flows. Flows at rim stations such as Tarbela, Mangla, and Marala remained mostly within normal to slightly above-normal levels. The Indus River at Tarbela showed a moderate increase due to elevated temperatures accelerating snow and glacier melt.

During July 2025, base flows at Tarbela remained above normal due to elevated temperatures in the upper Indus catchment, particularly at Chilas, which recorded a maximum of 48.5°C. The higher temperatures accelerated snow and glacier melt, contributing to above-normal base flows. During the month, Tarbela received 3.25 MAF more water than normal, resulting in a total water availability of 37.17 MAF by the end of July, which is 6.14 MAF above normal, as shown in Fig-47. In contrast, Mangla Dam received 0.86 MAF less than normal during July, with total water availability at the end of the month being 3.41 MAF below normal.

River	Site	Inflow	Flood Level	Date
Indus	Tarbela	370000	Low	23/07/2025
	Attock	384500	Medium	07/07/2025
	Kalabagh	453291	Medium	18/07/2025
	Chashma	447262	Medium	24/07/2025
	Taunsa	447936	Medium	26/07/2025
	Guddu	424331	Medium	29/07/2025
	Sukkur	379455	Medium	31/07/2025
	Kotri	191015	Normal	23/07/2025
Jhelum	Mangla	80000	Low	23/07/2025
	Rasul	136079	Medium	17/07/2025
Chenab	Marala	210900	High	30/07/2025
	Khanki	176315	Medium	31/07/2025
	Qadirabad	171580	Medium	31/07/2025
	Cheniot Bridge	104139	Low	24/07/2025
	Trimmu	77535	Normal	22/07/2025
	Punjad	60852	Normal	31/07/2025
	Jassar	30690	Normal	31/07/2025
Ravi	Ravi Syphon	19701	Normal	31/07/2025
	Shahdara	19496	Normal	31/07/2025
	Balloki	56305	Low	18/07/2025
	Sidhnai	38724	Low	22/07/2025
	GS Wala	12074	Normal	24/07/2025
Sutlej	Sulemanki	25832	Normal	15/07/2025
	Islam	18970	Normal	20/07/2025
	Mailsi Syphon	12557	Normal	22/07/2025
	Nowshera	59900	Normal	10/07/2025
Kabul	Nowshera	59900	Normal	10/07/2025
Nullahs	Bein-R	4897	Medium	29/07/2025
	Deg-R	3025	Normal	22/07/2025
	Ura-C	1912	Normal	31/07/2025
	Basantar-R	327	Normal	31/07/2025
	Palku-C	765	Normal	27/07/2025
DG Khan	Kaura	17570	Normal	06/07/2025
	Vehova	20850	Normal	06/07/2025
	Sanghar	41088	Normal	25/07/2025
	Sori Lund	29270	Normal	14/07/2025
	Vidore	75589	High	06/07/2025
	S.Sarwar	32570	Ex.High	06/07/2025
	Mithanwa	19175	Normal	14/07/2025
	Kaha	29340	Low	25/07/2025
Rajanpur	Chachar	48901	High	12/07/2025
	Pitok	11309	High	12/07/2025
	Sori Shumali	9605	Medium	31/07/2025
	Zangi	10739	High	12/07/2025
	Kala Bagga Khosra	17994	High	14/07/2025

Table 1: Maximum recorded Inflow/Peaks in July-2025

3.7 Rim Stations Hydrographs, July 2025

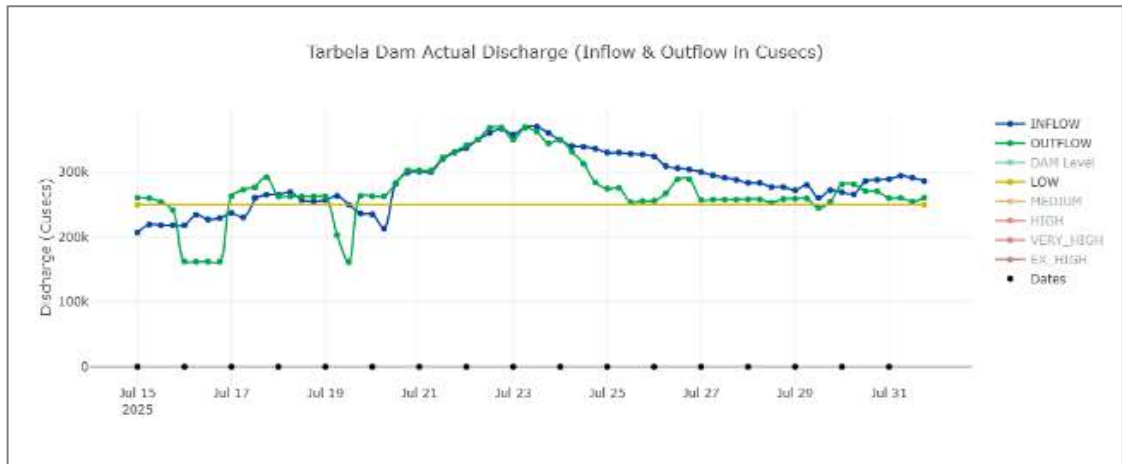


Fig-17(a)

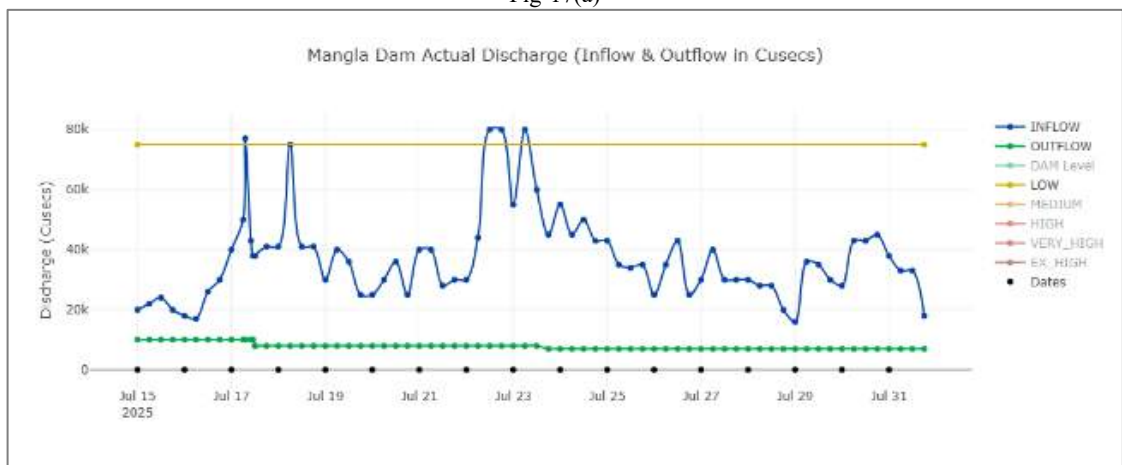


Fig-17(b)



Fig-17(c)

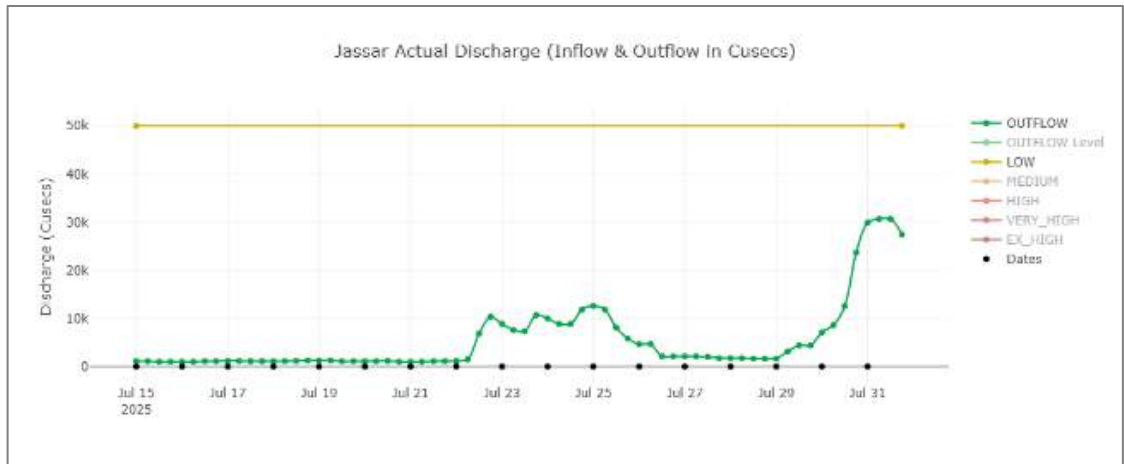


Fig-17(d)

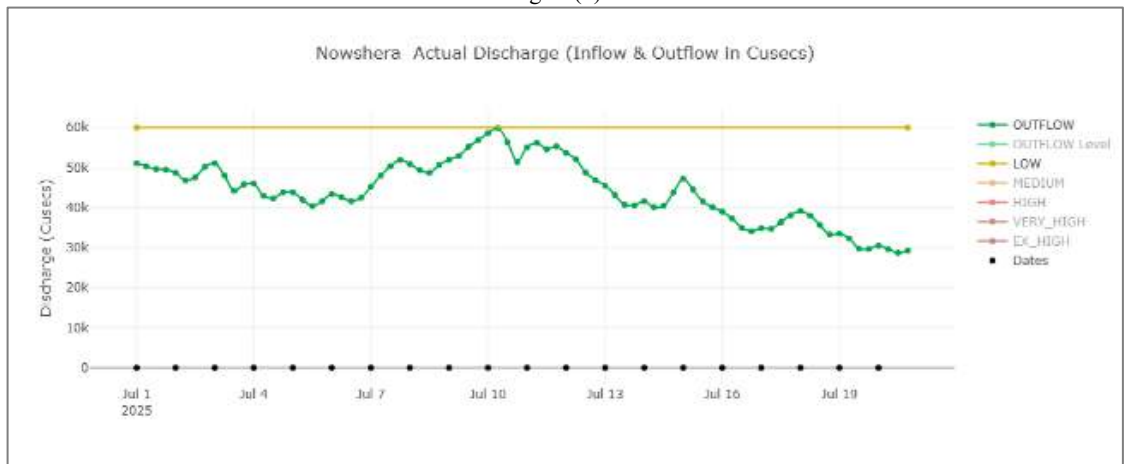


Fig-17(e)

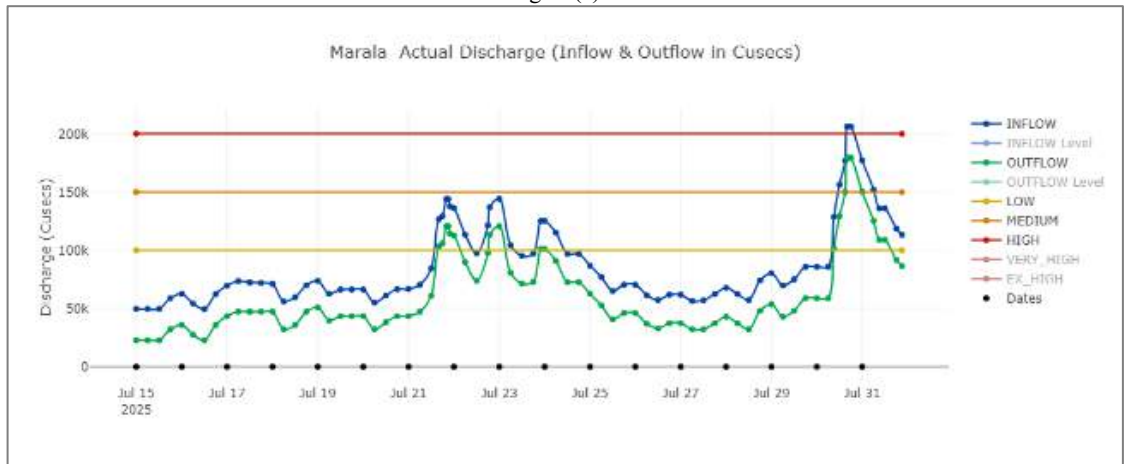


Fig-17(f)

Fig-(17) July-2025, Rim stations & Nowshera at Kabul Hydrograph

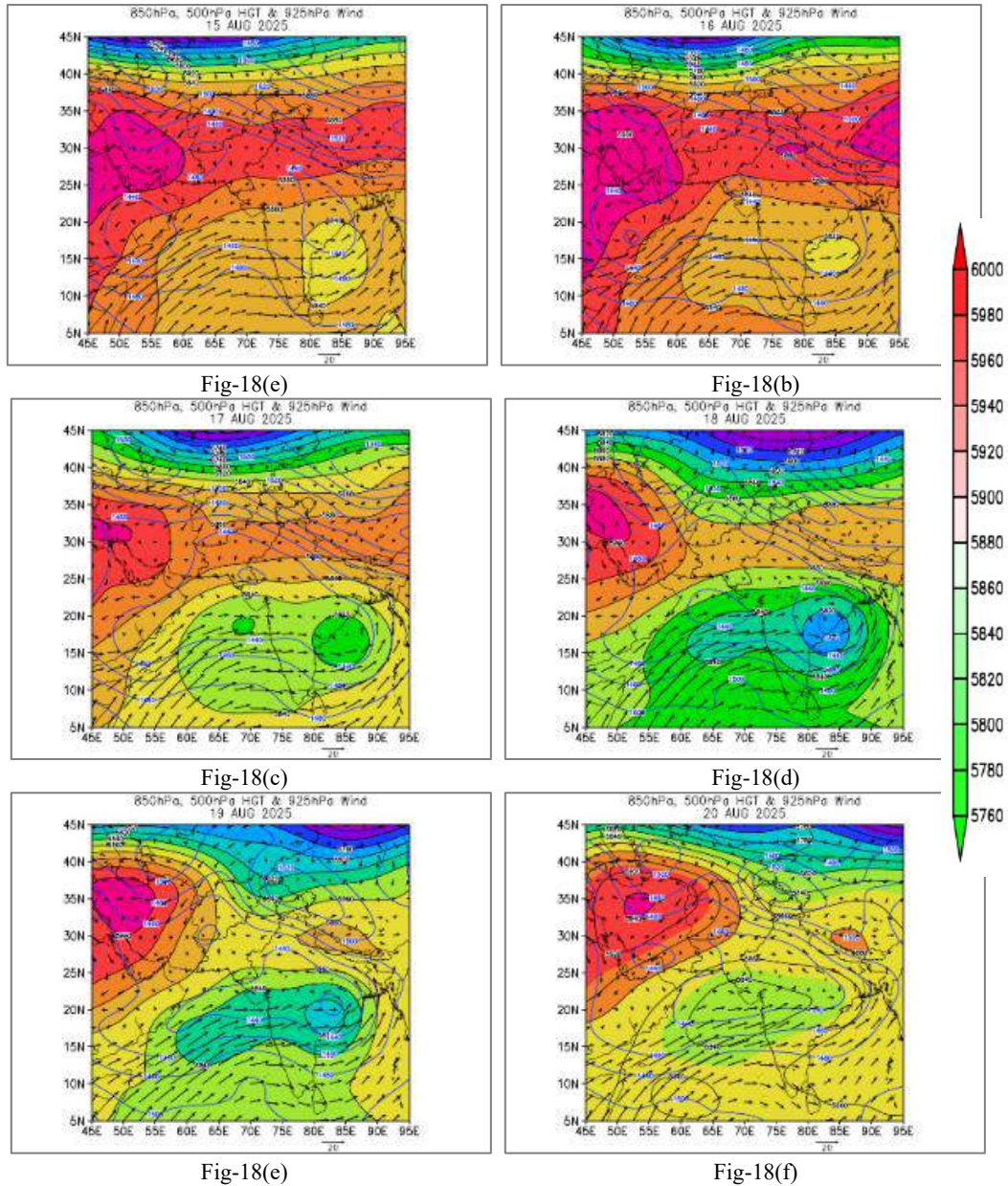
4 Significant Hydro-Meteorological events during the month of August 2025.

During August 2025, two distinct rainfall spells were reported across the country. Medium to High in River Indus, Very High in Jhelum, Exceptional High Flood level recorded in River Chenab, Ravi & Sutlej. Medium to High level Flood recorded in DG Khan Division Hill Torrents. Nationwide, rainfall was 11% above normal. Regions such as Azad Jammu & Kashmir 11%, Gilgit Baltistan 44%, Sindh 01%, Balochistan 24%, Khyber Pakhtunkhwa 07% and Punjab 11%. By the end of July, the Tarbela reservoir was at 100% of its capacity, and Mangla reservoir was at 82%. During the month of August, flood-generating systems 2nd Spell of August and 1st Spell of September are defined purely on the basis of RADAR and Satellite data, as flood-generating weather systems mostly lie in the transboundary region.

4.1 1st Wet Spell of August 2025 (15-20).

The first wet spell of August 2025, which remained active for six days, during the spell, the prevailing synoptic conditions over the country were governed by active monsoon circulation interacting intermittently with westerly waves, supported by a persistent seasonal low over north Balochistan. Fig-18 represents 500 hPa and 850 hPa geopotential height patterns along with 925 hPa wind flow during the spell. South westerly winds at 925 hPa were also present ensuring sufficient moisture supply from the Arabian Sea and Bay of Bengal. A monsoon low originating over south Odisha moved westward to Chhattisgarh and adjoining Maharashtra, later evolving into a low-pressure area and depression over southeast Odisha, sustaining moderate to strong moisture influx from the Bay of Bengal. At the same time, monsoon currents from the Arabian Sea periodically supplemented the moisture supply. Westerly troughs intermittently affected northern parts of the country, shifting eastward and weakening during the latter part of the period. By 20 August, the depression weakened over central Chhattisgarh, while an additional low-pressure area developed over west Gujarat and the adjoining Arabian Sea, indicating continued but fluctuating synoptic support.

Overall, the spell was marked by intermittent yet active monsoon conditions, with enhanced rainfall potential during periods of strong Bay of Bengal inflow.



Colour shades represent 500 hPa Geopotential Heights, Blue contour lines indicate 850 hPa Geopotential Heights and barbs show 925 hPa winds.

Fig-(18) 1st Spell of Aug-2025, 850 & 500 hPa Geopotential Height & 925 hPa winds map

During the spell, rainfall was observed at 91% of meteorological observatories nationwide, with Rawalakot recording the highest cumulative rainfall of 235 mm. On 19 August, the maximum daily coverage was observed, when 82% of observation stations reported measurable precipitation, and the highest 24-hour rainfall of 110 mm was recorded at Rawalakot. Other rainfall distribution during the spell over the country can also be seen from the Fig-19.

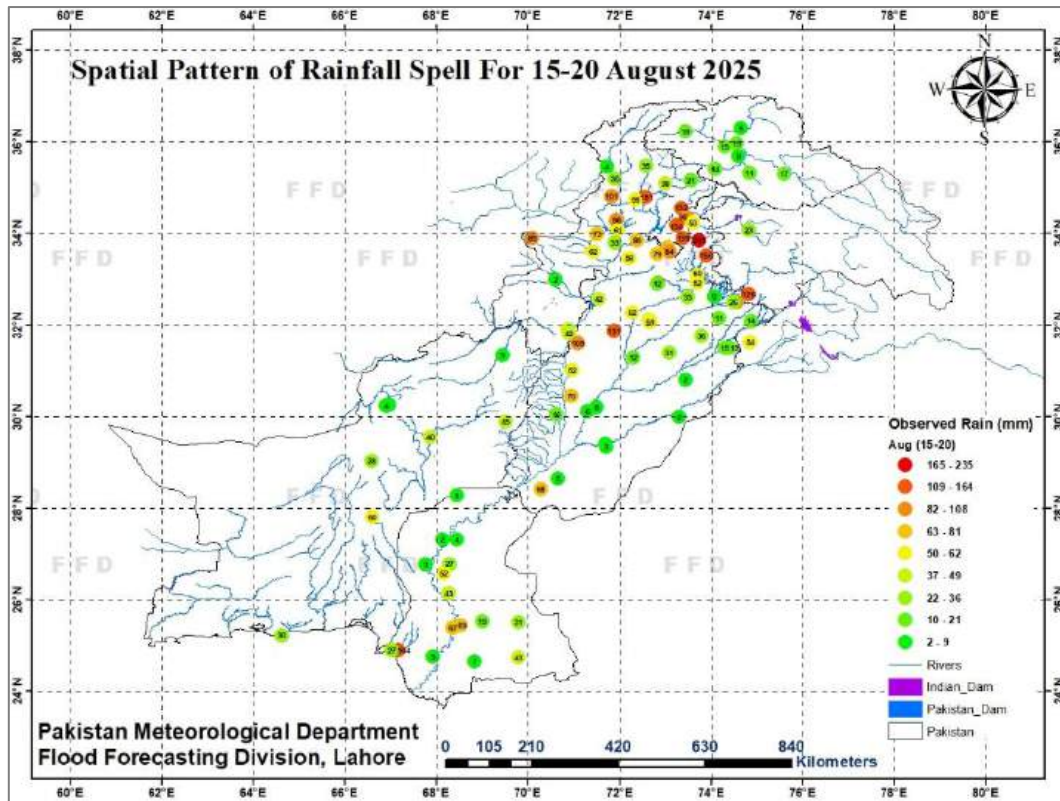


Fig-(19-a) 1st Spell of Aug-2025, PMD total rainfall

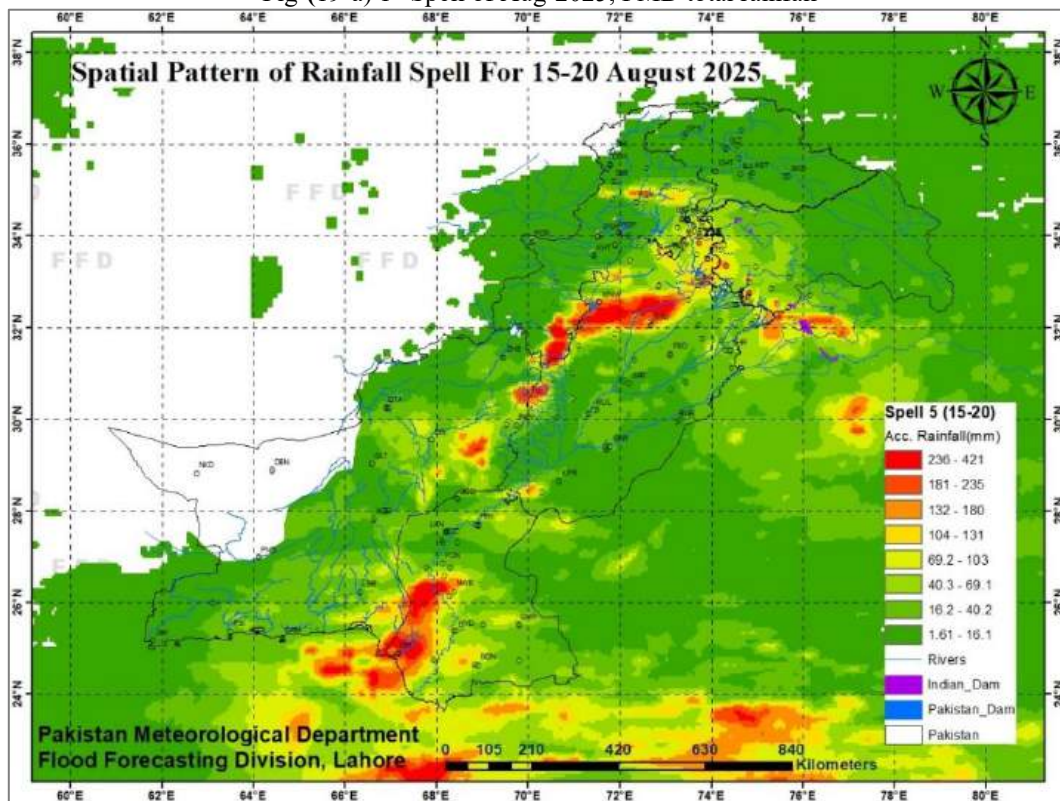


Fig-(19-b) 2nd Spell of Aug-2025, PMD, Radar & Satellite total merged rainfall

Fig-(19) 1st Spell of August-2025, Total Rainfall

Satellite images during the spell are shown below in Fig-20.

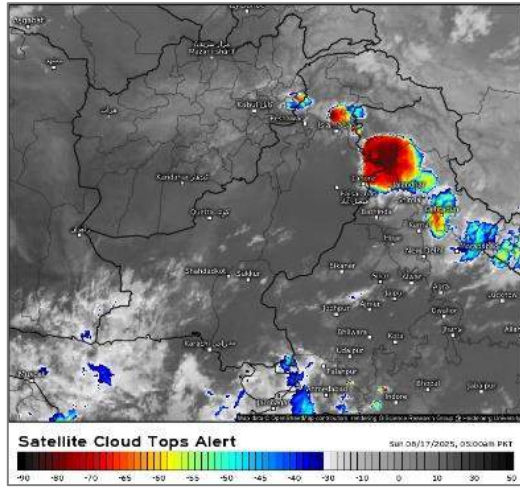


Fig-20(a)

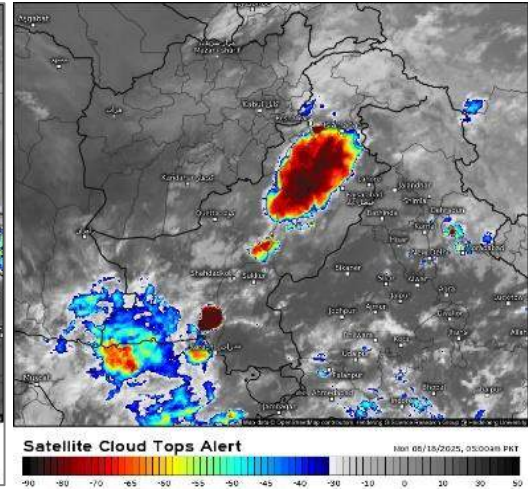


Fig-20(b)

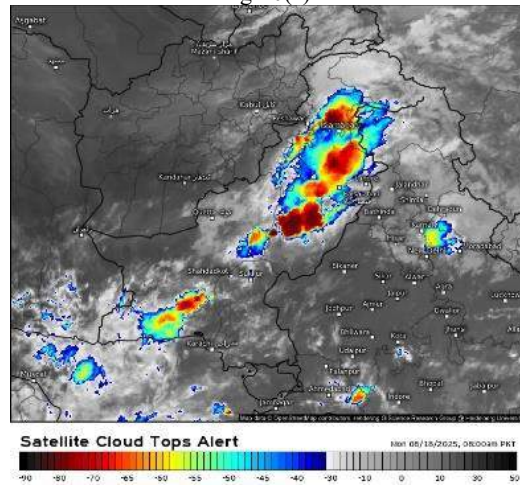


Fig-20(c)

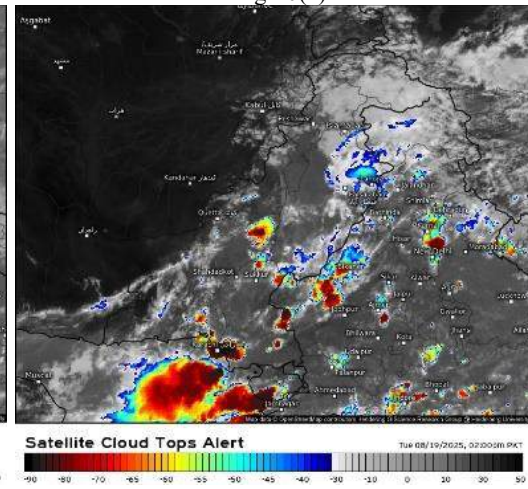


Fig-20(d)

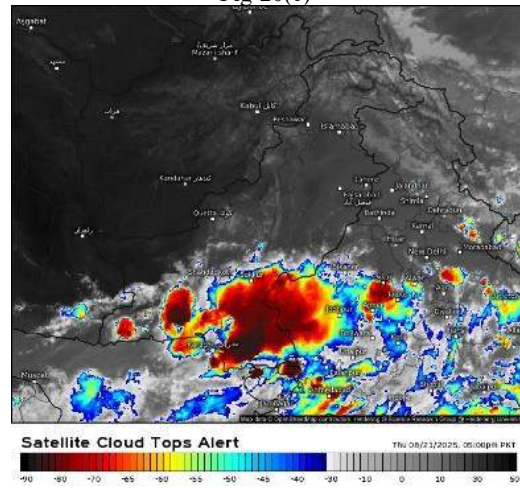


Fig-20(e)

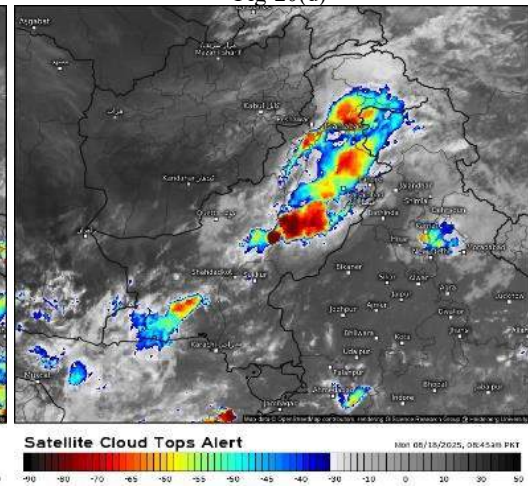


Fig-20(f)

Fig-(20) 1st Spell of Aug-2025, Satellite images

Ahead of the first wet spell of August, persistently high maximum temperatures (Annex-L) over Chilas, Bunji, and Gilgit led to enhanced snowmelt within the upper Indus catchment, resulting in elevated base flows at Tarbela from 12-15 August. With the onset of the first August wet spell, widespread rainfall over the upper catchments of major rivers further intensified river discharges. Consequently, the Indus River at Tarbela attained a peak flow of 460,000 cusecs, reflecting combined contributions from monsoon rainfall and accelerated snowmelt across Gilgit-Baltistan and Khyber Pakhtunkhwa. During the same period, Maximum Flood Peaks of 109,900 cusecs at Nowshera on the Kabul River, 260,000 cusecs at Mangla on the Jhelum River, 187,700 cusecs at Marala on the Chenab River, 61,176 cusecs at Jassar on the Ravi River, and 74,390 cusecs at Ganda Singh Wala on the Sutlej River were recorded, as illustrated in Fig-29. During this wet spell many places in KPK and Gilgit-Baltistan have flash flood especial Bunner, Shahangla, Bajur, Manshera and Swat.

4.2 2nd Wet Spell of August 2025 (24-27).

The second long wet spell of August 2025 remained active for four days and was driven by monsoon lows and depressions over eastern India, supported by persistent westerly waves and a seasonal low over north/northeast Balochistan. Rainfall activity commenced with a low-pressure area over northwest Bay of Bengal, which intensified into a depression over southeast Odisha on 19 August. The monsoon low pressure system (Track6 in Fig-41) subsequently moved northwestward across central India, drawing strong moisture from the Bay of Bengal and Arabian Sea, while intermittent westerly troughs influenced northern Pakistan and Kashmir.

During the spell, monsoon currents penetrated both upper and lower parts of the country, with the seasonal low over Balochistan maintaining low-level convergence, sustaining widespread rainfall. By 27 August, the system over south Punjab and Haryana had weakened. Fig-22 illustrates the 500 hPa and 850 hPa geopotential height patterns along with 925 hPa moist wind flow, showing that Pakistan remained under the influence of the westerly wave, with southeasterly winds supplying strong moisture from the Bay of Bengal and moderate inflow from the Arabian Sea. The complete track of the monsoon system, from the Bay of Bengal to upper catchments, along with its intensity, is depicted below.

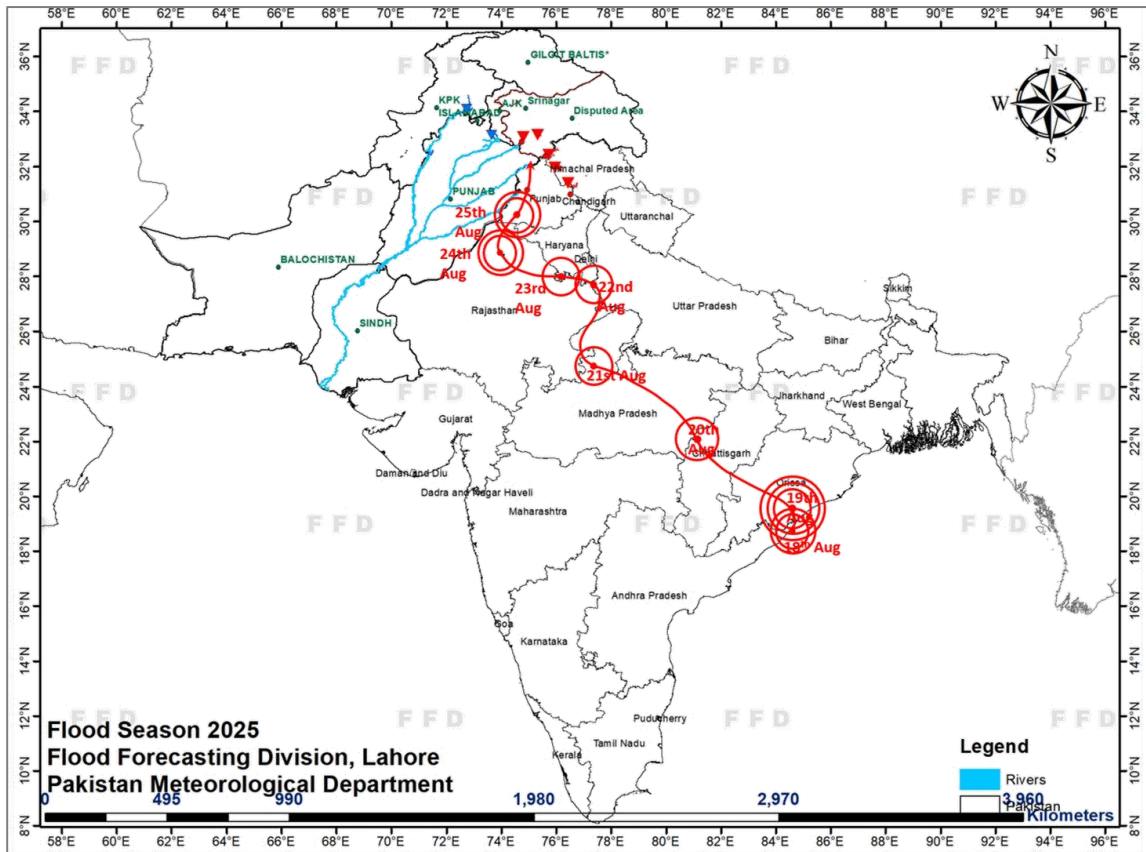


Fig-(21) Track of Monsoon Low which Generated the First Flood Wave

The spell produced active and sustained rainfall, particularly over eastern and northern river catchments, driven by the combined influence of monsoon lows, depressions, and westerly waves. The monsoon low-pressure system that developed on 18 August served as a primary moisture source, advecting significant atmospheric moisture inland toward the eastern river catchments. Continuous monitoring by the Flood Forecasting Division (FFD) from 20–24 August prompted repeated alerts, highlighting intensifying rainfall and projected increases in river discharge, indicating a high probability of significant hydro meteorological events.

On 25 August, the FFD issued warnings for Exceptionally High Flood for the Sutlej River and High to Very High Floods for the Ravi and Chenab Rivers, followed by an Exceptional High Flood warning for the Ravi and Chenab on 26 August, reflecting the heightened flood risk during this spell.

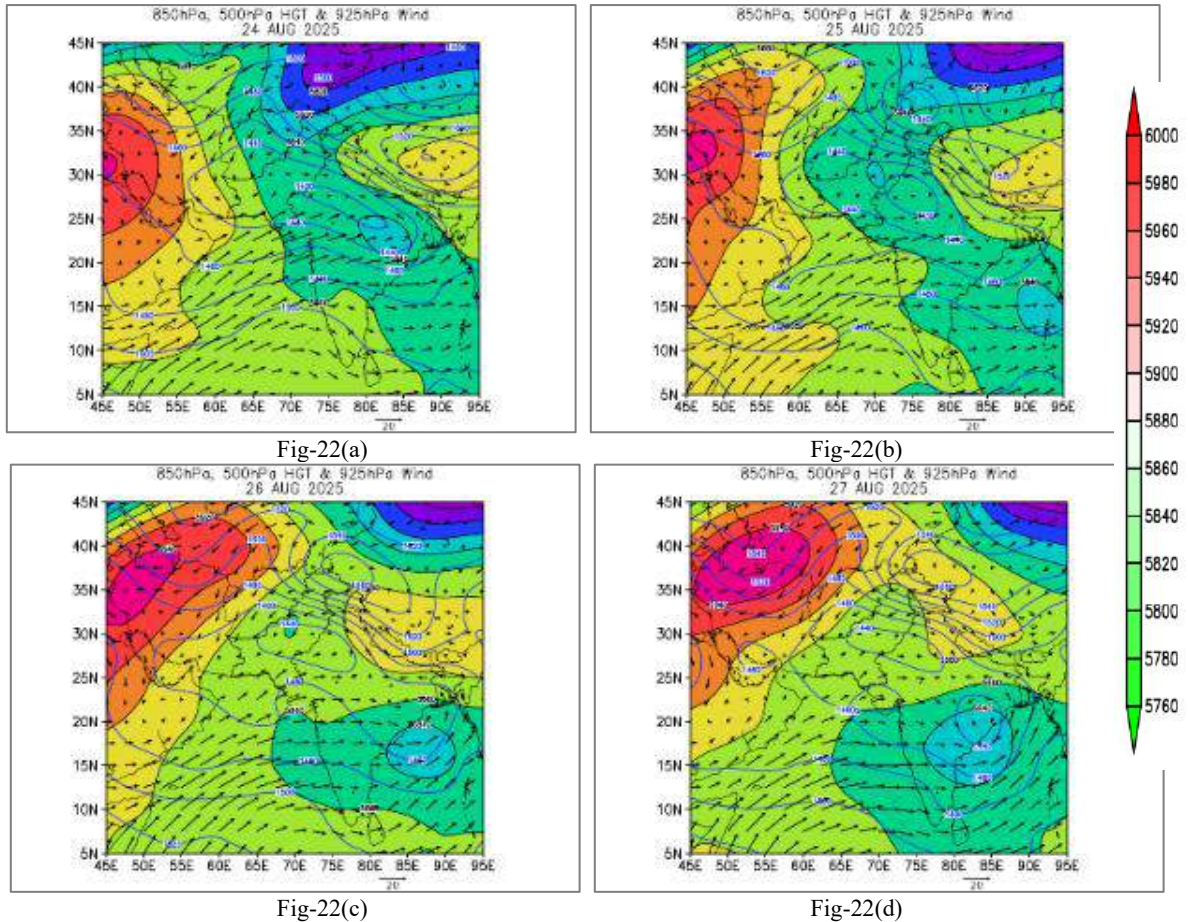


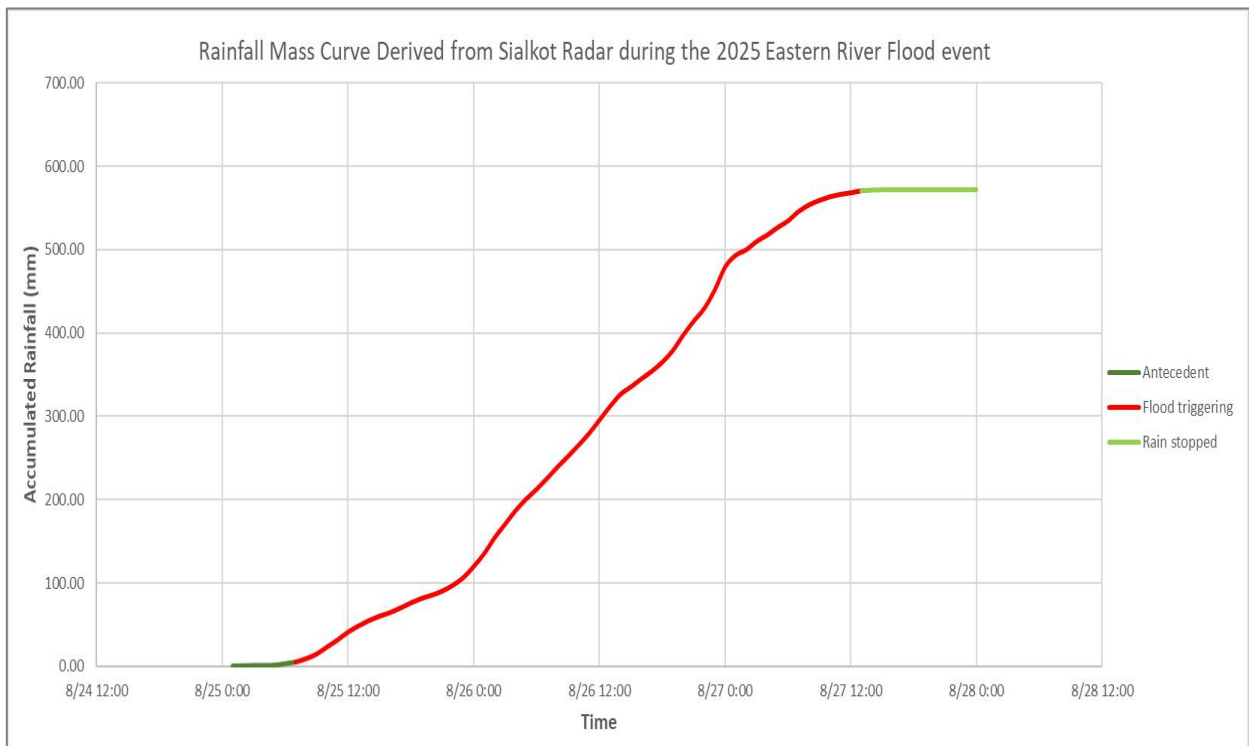
Fig-22(a) Fig-22(b) Fig-22(c) Fig-22(d)
 Colour shades represent 500 hPa Geopotential Heights, Blue contour lines indicate 850 hPa Geopotential Heights and barbs show 925 hPa winds.

Fig-(22) 2nd Spell of Aug-2025, 850 & 500 hPa Geopotential Height & 925 hPa winds map

During the spell, the majority of rainfall occurred over the catchments of the Chenab, Ravi, and Sutlej Rivers. As India had suspended routine information sharing under the Indus Waters Treaty, real-time hydrological data were not available. Consequently, information from the Indian side was received with delays and only in qualitative form through diplomatic channels, rather than through established technical mechanisms.

Under these circumstances, the Sialkot Weather Radar remained the primary source for monitoring rainfall over the eastern catchments and effectively captured the spatial and temporal distribution of precipitation. The rainfall mass curve derived from the Sialkot Radar is presented below.

According to the Sialkot Weather Radar, Monsoon system produce accumulated average rainfall 570 mm during 55 hours, the rainfall spell over the Beas catchment persisted for 54 hours, producing an average accumulated rainfall of 147 mm. The Ravi catchment experienced a 55-hour rainfall episode with an average accumulated rainfall of 200 mm. Meanwhile, the Chenab catchment underwent a 48-hour rainfall spell, generating an average accumulated rainfall of 321 mm. This intense and prolonged rainfall over the eastern river catchments resulted in the exceptionally high flood peak in the Chenab, Ravi, and Sutlej Rivers, as presented in Table 1. As the Indian reservoirs were already filled beyond 80% of their storage capacity, Maximum Flood Peaks were observed at Jassar on the Ravi River and Ganda Singh Wala on the Sutlej River, resulting from a combination of regulated releases from upstream dams and storm rainfall runoff. The flows in the Ravi and Sutlej Rivers were therefore influenced by controlled water releases from Indian dams, including Their (Ranjit Sagar), Pong, and Bhakra, in addition to local runoff contributions. Flood conditions further intensified downstream along the Chenab and Ravi Rivers due to additional inflows from tributary nullahs, thereby aggravating overall flood severity.



Radar-Based Rainfall Mass Curves for Eastern River Flood Events

As the system was centered over Occupied Kashmir and transboundary regions, rainfall was recorded at 66% of meteorological observatories nationwide, with Sialkot Cantt receiving the highest cumulative rainfall of 463 mm during the spell. On 27 August, the maximum daily coverage was observed, when 20% of observation stations reported measurable precipitation, and the highest 24-hour rainfall of 364 mm was recorded at Sialkot Cantt. This not only caused urban flooding in Sialkot but also further aggravated the flood situation in the associated nullahs of the Chenab and Ravi Rivers. The overall rainfall distribution across the country during the spell is illustrated in Fig-22.

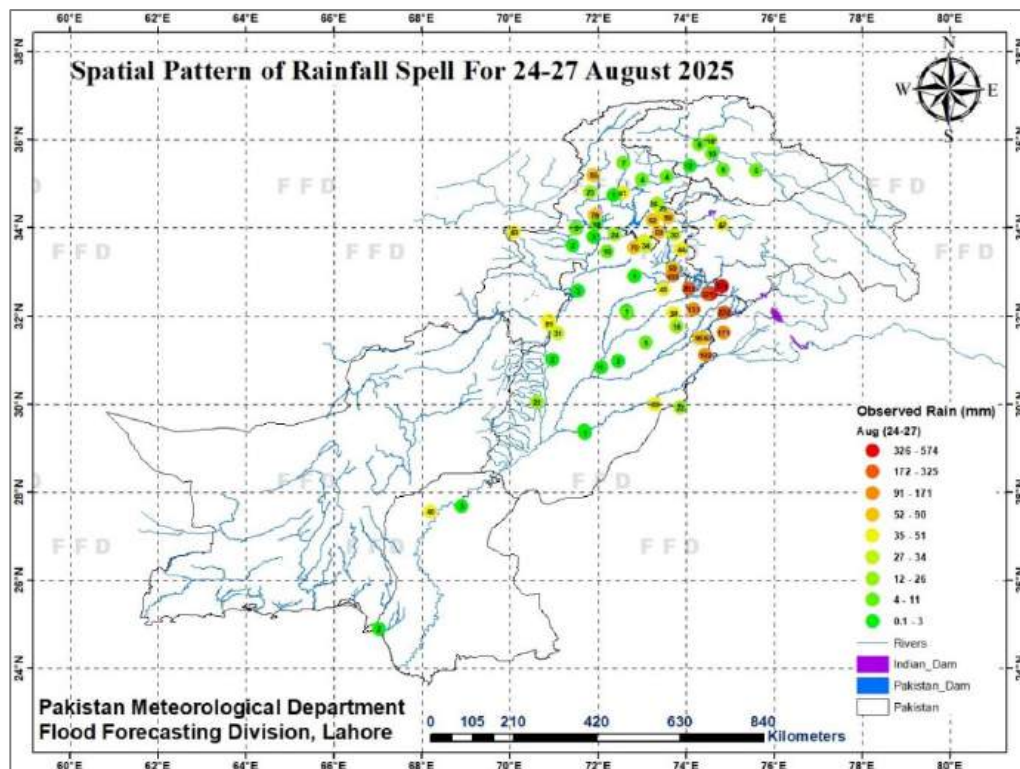


Fig-(23-a) 2nd Spell of Aug-2025, PMD total rainfall

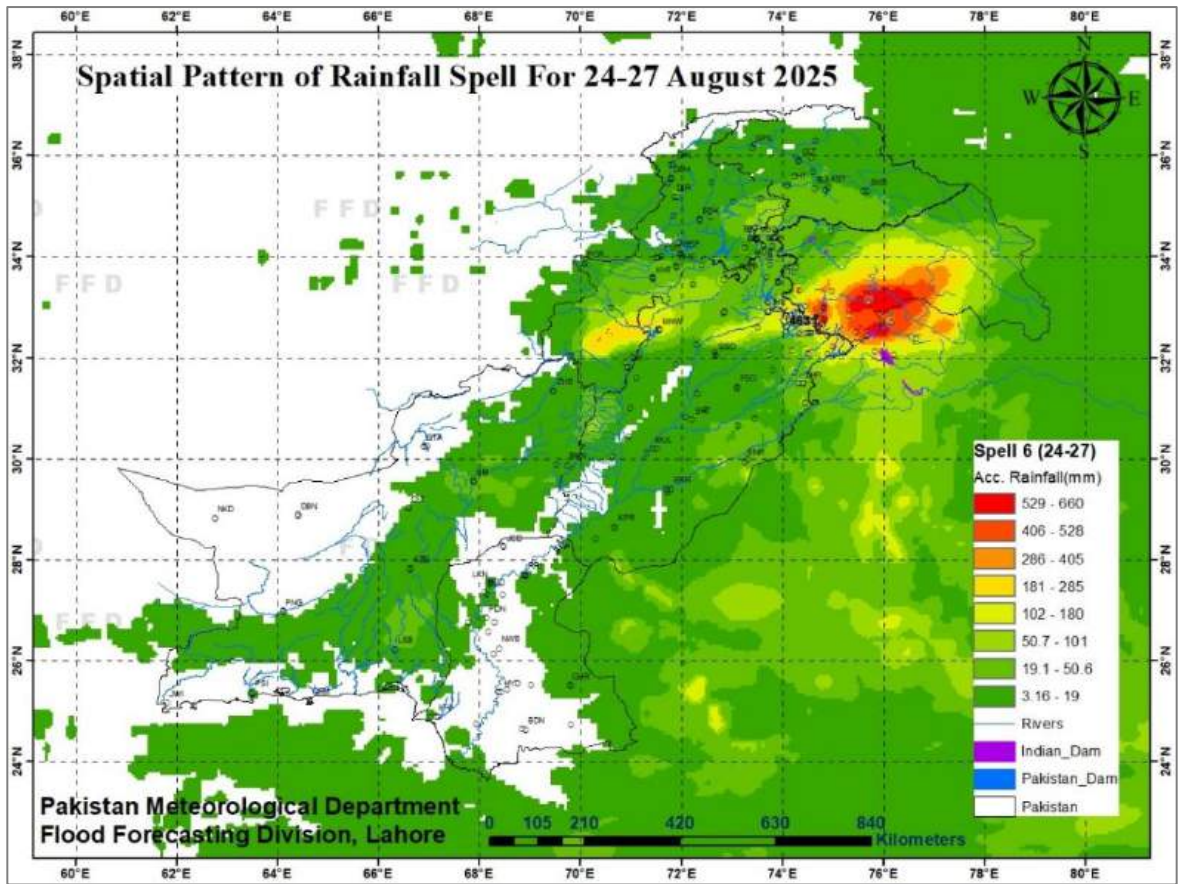
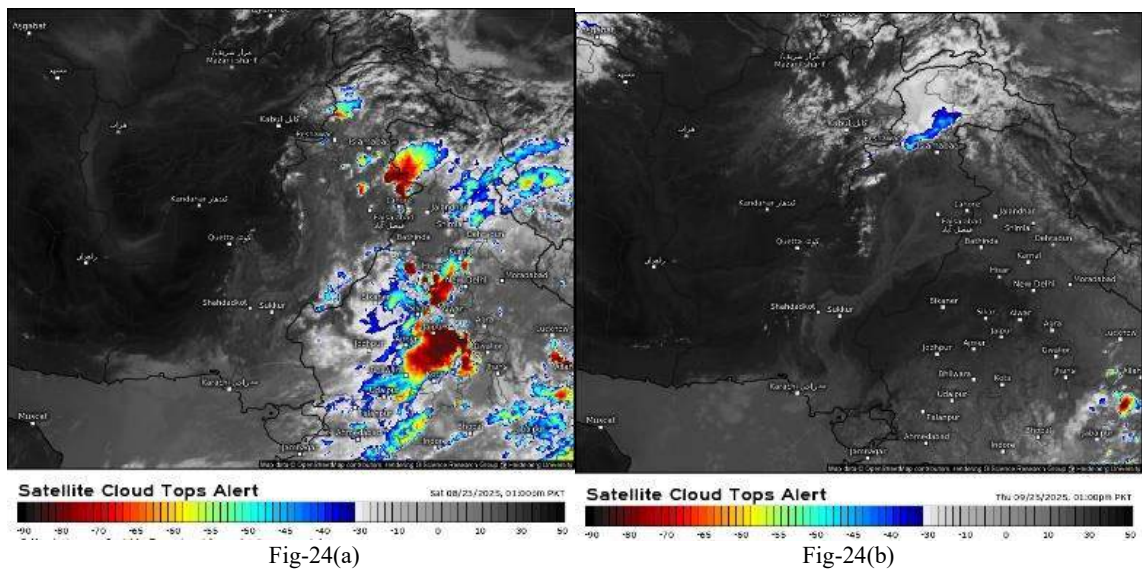


Fig-(23-b) 2nd Spell of Aug-2025, PMD, Radar & Satellite total merged rainfall
 Fig-(23) 2nd Spell of Aug-2025, Total Rainfall

Dense clouds observed by satellite during the spell are shown in the Fig-24.



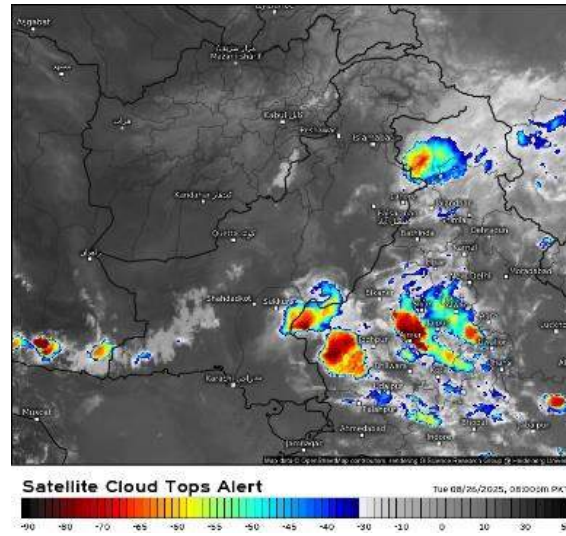


Fig-24(c)
Fig-(24) 2nd Spell of Aug-2025, Satellite images

During the spell, exceptionally high flood levels were observed at various gauges and barrages on the Chenab, Ravi, and Sutlej Rivers, as presented in Table 2. During the season, due to the suspension of routine information sharing under the Indus Waters Treaty, no quantitative real-time flow data were received for the Chenab, Ravi, and Sutlej Rivers. However, qualitative information regarding river flows was shared by India through its Ministry of External Affairs, which was of limited operational qualitative value.

As of 21 August 2025, major Indian reservoirs were already at high storage levels, with Thein (Ranjit Sagar) Dam on the Ravi River at 85% capacity, Pong Dam on the Beas River at 87%, and Bhakra Dam on the Sutlej River at 80% capacity. During the spell, Marala on the Chenab River, Jassar on the Ravi River, and Ganda Singh Wala on the Sutlej River attained Exceptional High Flood levels. Notably, Qadirabad Barrage recorded the highest peak discharge in its history, while Marala and Khanki Barrages observed the second-highest Maximum Flood Peaks on record.

Overall, the major rivers experienced prolonged periods of Exceptional and Very High Flood conditions. On the Chenab River, Exceptional High Flood levels persisted for approximately 10 hours at Marala. On the Ravi River, Exceptional High Flood conditions prevailed for about 15 hours at Jassar, primarily influenced by continuous regulated releases from Thein Dam in combination with rainfall-induced runoff. On the Sutlej River, Ganda Singh Wala experienced Exceptional High Flood levels for approximately 346 hours (14 days and 10 hours), driven by sustained releases from Pong and Bhakra Dams together with storm runoff.

4.3 Monthly maps of Total rainfall of August 2025.

During August 2025, no significant rainfall spell occurred during the period (01–11 August). However, above-normal temperatures (Annex-L & M) over northern areas accelerated snowmelt flows, resulting in increased flows in the Indus River at Tarbela. The accumulated satellite-based rainfall analysis for August 2025 (Fig-25-b) indicates that weather systems predominantly affected the northeastern part of Punjab, particularly the upper catchments of the eastern rivers, where maximum areal rainfall of approximately 1,032 mm was recorded.

The isohyetal map for August 2025 further shows that the highest point rainfall, exceeding 731 mm, was observed at Sialkot Cantt Observatory, while Rawalakot, Narowal, Kakul, and Gujrat each received more than 300 mm of rainfall during the month. Rainfall distribution across the remaining parts of the country is illustrated in Fig-25. Overall, rainfall was recorded at 96% of meteorological observatories nationwide, with Sialkot Cantt receiving the highest cumulative monthly rainfall of 731 mm. On 19 August, the maximum daily coverage was observed, when 82% of observation stations reported measurable precipitation. The highest 24-hour rainfall of 364 mm was recorded at Sialkot Cantt on 27 August. In contrast, observatories at Gwadar, Jiwani, Dalbandin, Nokkundi, and Panjgur in Balochistan reported no rainfall during the month.

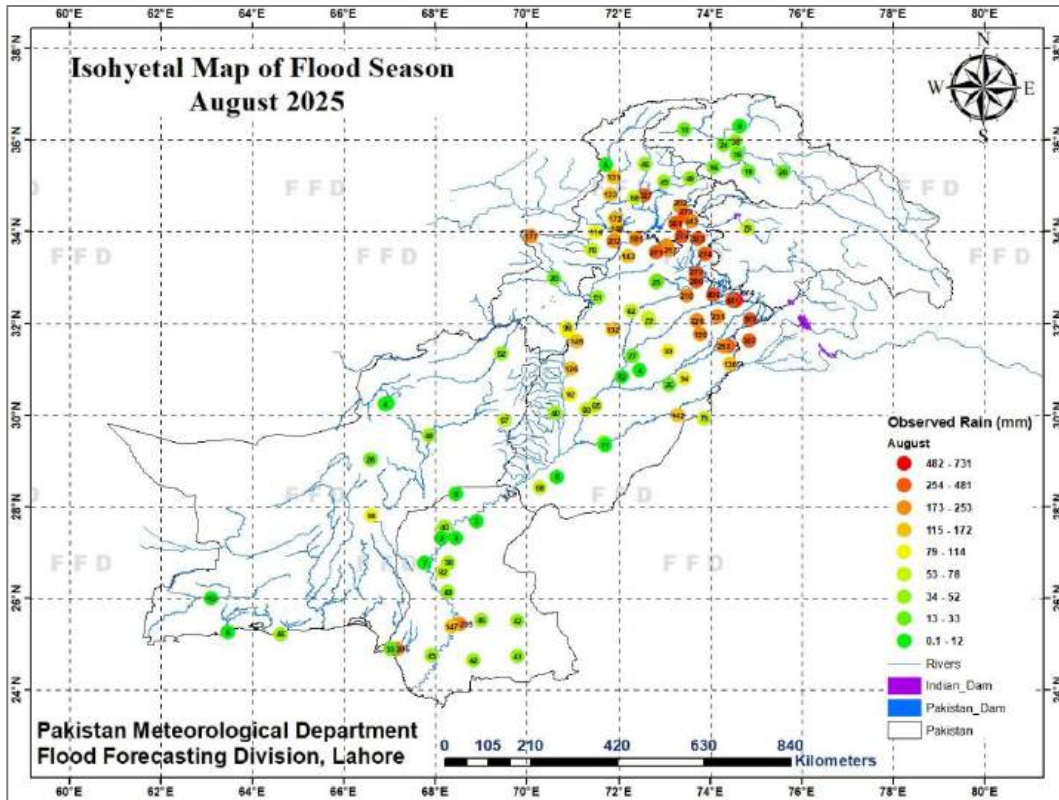


Fig-(25-a) Aug-2025, PMD total rainfall

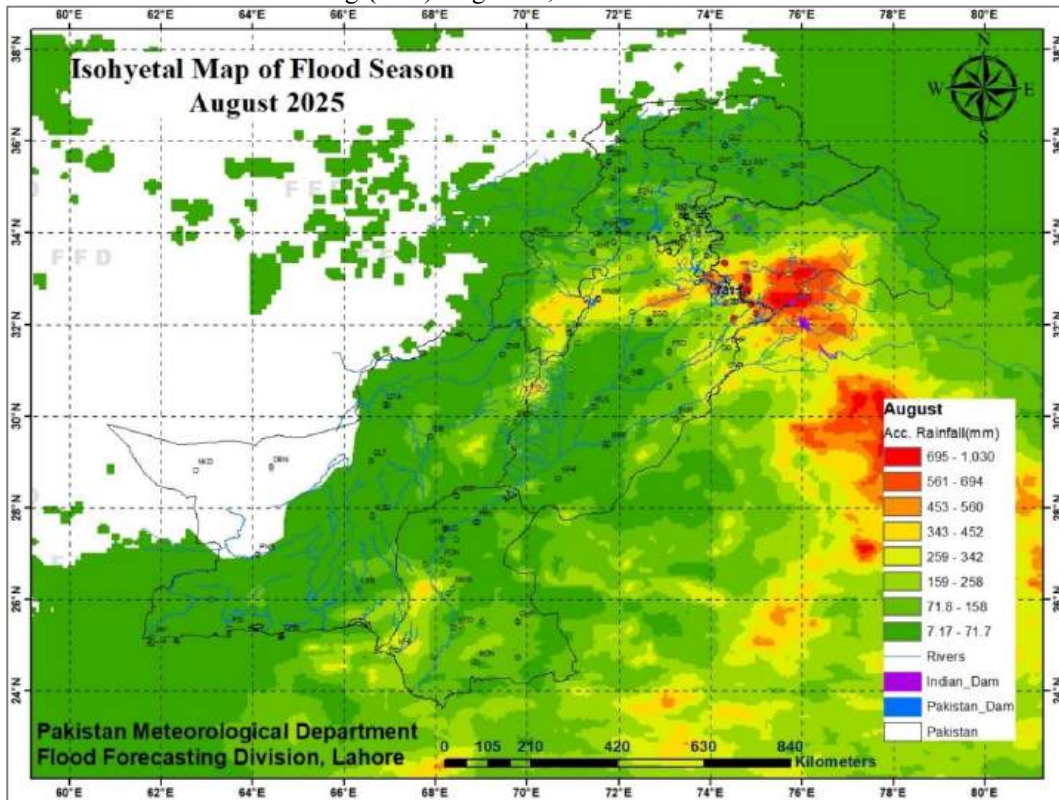


Fig-(25-b) Aug-2025, PMD, Radar & Satellite total merged rainfall

Fig-(25) August-2025, Total Rainfall

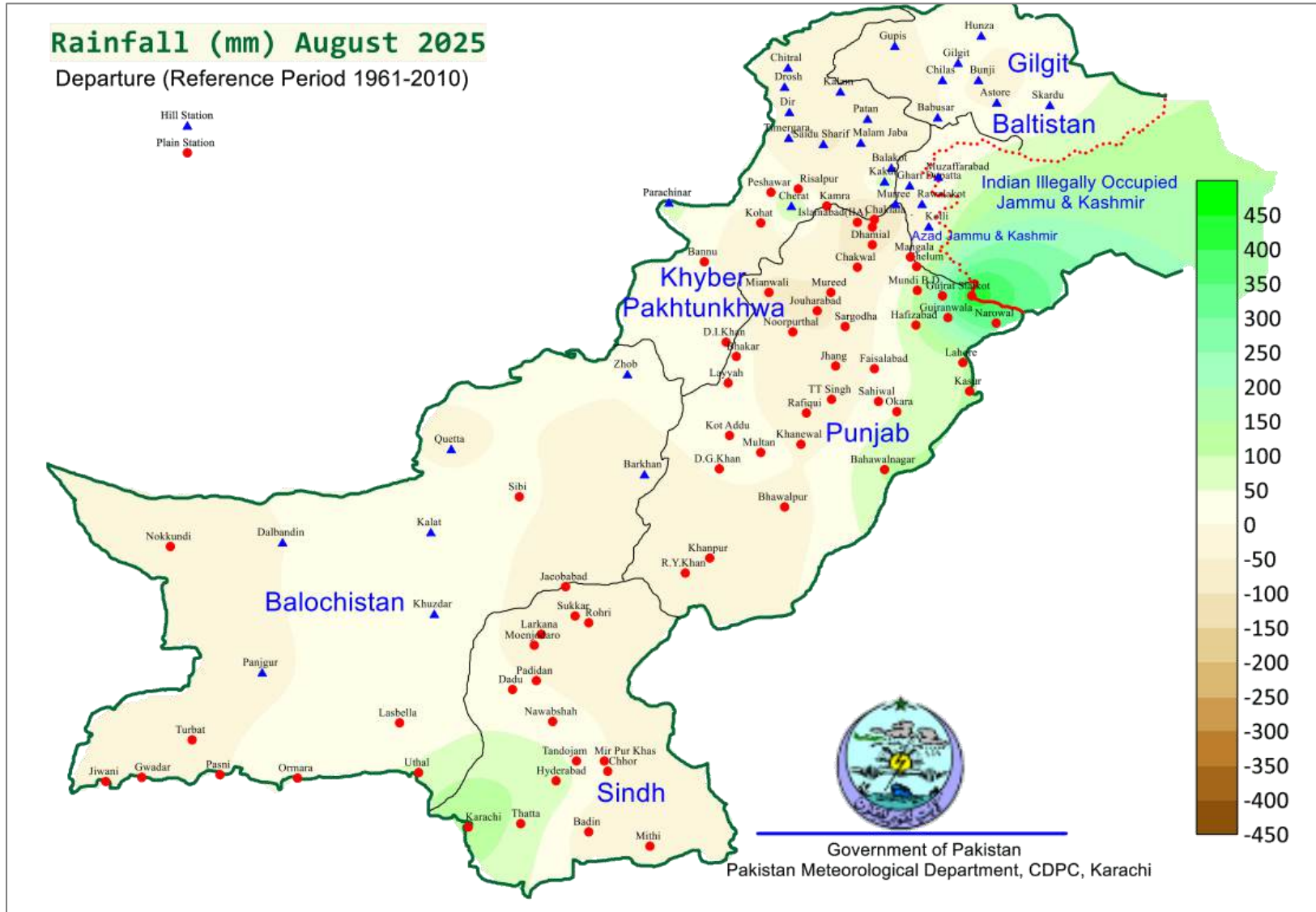


Fig-(26) August-2025, Monthly departure of rainfall

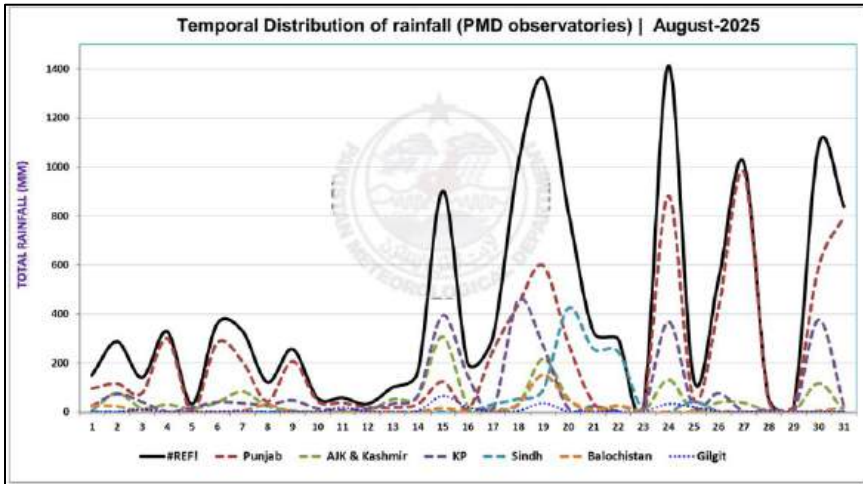


Fig-27(a)

	01 to 31 Aug 2025 Rainfall		
	normal (mm)	actual (mm)	Deviation (%)
Pakistan	56.2	62.5	11.2
Azad J&K	150.7	167.1	10.9
Balochistan	22.4	27.8	23.8
Gilgit-B	16.7	24.1	44.1
Khyber-PK	103.6	111.2	7.3
Punjab	93.3	103.3	10.6
Sindh	53.6	54.2	1.2

Fig-27(b)

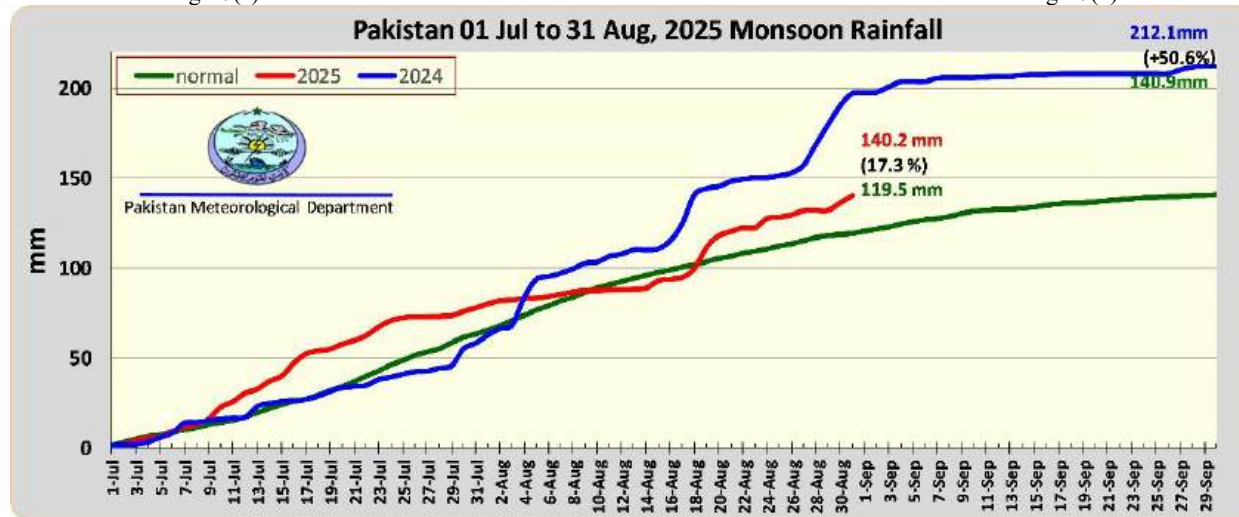


Fig-27(c)

Fig-(27) August-2025, Monthly Temporal Distribution , AWR & Rainfall Comparison

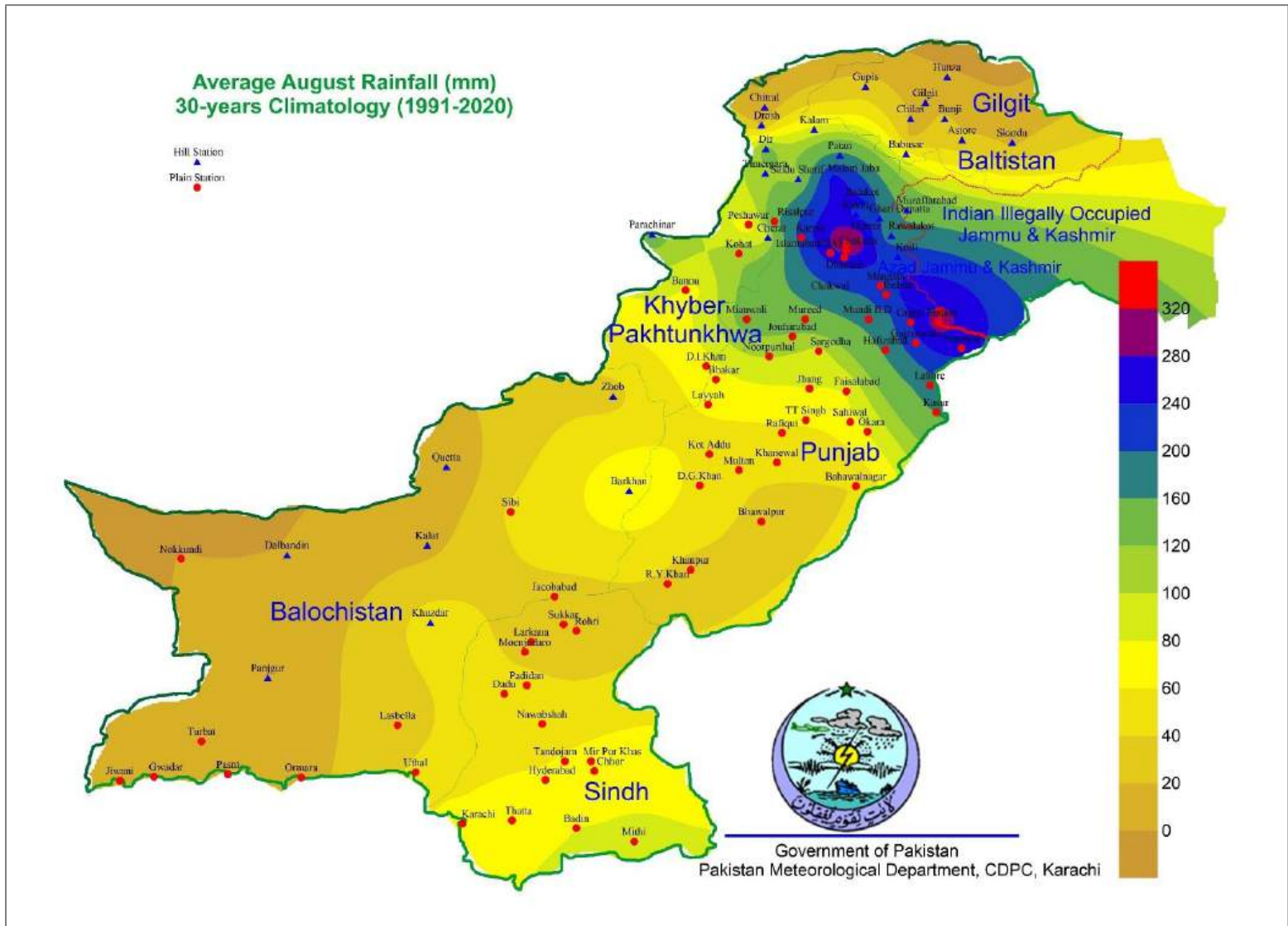


Fig-(28) August Climate Normal of Rainfall

4.4 Maximum Flood Peaks recorded during the month of August-2025.

The highest Maximum Flood Peaks during August 2025 were observed at all major river sites listed in Table 2. During the month, flows in the River Indus at Tarbela remained above Low Flood Level from 11–20 August, during which a peak of Medium Flood Level was recorded. In the River Kabul, flows generally remained below Low Flood Level; however, the river rose above Low Flood Level during 15–17 and 18–19 August, attaining a peak of Medium Flood Level, as shown in the hydrograph (Fig-29).

At Mangla on the River Jhelum, the river experienced one Very High Flood peak, one Medium Flood peak, and four Low Flood peaks during the month. Owing to the suspension of routine data sharing under the Indus Waters Treaty, no quantitative flow data were received for the Chenab, Ravi, and Sutlej Rivers. Information shared by India through diplomatic channels was qualitative in nature and of limited operational utility.

On the River Chenab at Marala, one Exceptional High Flood peak and four Medium Flood peaks were recorded during the period, while for most of the month flows remained close to the Low Flood Level. During the first flood wave, Marala attained an Exceptional High Flood level for approximately 10 hours, after which flows remained in the Low to Medium Flood range before the onset of the second flood wave. As the first flood wave routed downstream, Khanki Barrage experienced an Exceptional High Flood level for about 32 hours, mainly due to the combined effect of the main river flow and exceptionally high inflows from associated nullahs; thereafter, flows largely remained between Medium and High Flood levels prior to the second wave.

At Qadirabad Barrage, the first flood wave produced an Exceptional High Flood with the highest peak flow on record, and the barrage remained at Exceptional High Flood level for approximately 31 hours, followed by sustained Medium to High Flood conditions before the arrival of the second flood wave. By the end of August, the first flood wave reached Trimmu Barrage, where it attained Low Flood Level on 30 August.

On the River Ravi at Jassar, flows generally remained below flood level during August; however, the station recorded one Low Flood peak, one Medium Flood peak, and one Exceptional High Flood peak. Flooding on the Ravi was driven by a combination of storm rainfall runoff, controlled releases from the Indian Thein Dam, and additional inflows from associated tributary nullahs. During the flood wave, Jassar attained an Exceptional High Flood level for approximately 15 hours and subsequently remained mostly within the Medium to High

Flood range toward the end of August. Downstream, Shahdara attained an Exceptional High Flood level on 28 August, which persisted for about 28 hours, followed by flows fluctuating between Medium and High Flood levels. Balloki also experienced Exceptional High Flood conditions for approximately 48 hours toward the end of August. At Sidhnai, the flood wave crossed above Low Flood Level on 30 August at 0000 PST, with Maximum Flood Peaks remaining between Medium and High Flood levels by the end of the month.

On the River Sutlej, flows at Ganda Singh Wala (G.S. Wala) were largely governed by controlled releases from the upstream Indian reservoirs Pong and Bhakra Dams supplemented by rainfall runoff generated between the dams and G.S. Wala. As of 21 August 2025, major Indian reservoirs were operating at high storage levels, with Thein Dam on the Ravi River at 85%, Pong Dam on the Beas River at 87%, and Bhakra Dam on the Sutlej River at 80% of their respective capacities. Flows at G.S. Wala remained within the Low to Medium Flood range from 14 to 21 August, primarily due to controlled releases from Indian dams combined with local rainfall runoff downstream of the reservoirs. The river crossed the Medium Flood Level on 21 August at 1400 PST. With the approach of a monsoon low-pressure system, reservoir releases from the Indian dams increased, coinciding with heavy rainfall over the upstream and downstream catchments. Consequently, G.S. Wala attained High Flood Level on 23 August at 0700 PST and subsequently escalated to Exceptional High Flood conditions.

Exceptional High Flood Level persisted at G.S. Wala for approximately 346 hours. Thereafter, flows gradually receded, and the river fell to Low Flood Level on 24 September at 1200 PST.

During the monsoon season, rainfall runoff combined with accelerated snow and glacier melt, driven by above-normal temperatures over northern Pakistan, resulted in the River Indus at Tarbela receiving approximately 20% higher-than-normal inflows. Consequently, the Indus River at Tarbela reached Medium Flood Level and attained its Maximum Conservation Level (MCL) on 21 August 2025.

During August 2025, base flows at Tarbela remained above normal due to elevated temperatures in the upper Indus catchment, particularly at Chilas, Astor, Bunji and Gilgit. The higher temperatures accelerated snow and glacier melt, contributing to above-normal base flows. During August 2025, Tarbela received 1.74 MAF more inflow than normal, resulting in a total water availability of 52.65 MAF by the end of the month, which is 7.86 MAF above the normal level, as shown in Figure 47. In contrast, Mangla Dam received 0.01 MAF less inflow

than normal during August, and total water availability at the end of the month stood at 3.66 MAF below normal, as illustrated in Figure 50.

River	Site	Inflow	Flood Level	Date
Indus	Tarbela	460000	Medium	15/08/2025
	Attock	388400	Medium	16/08/2025
	Kalabagh	472391	Medium	18/08/2025
	Chashma	512635	High	17/08/2025
	Taunsa	501562	High	19/08/2025
	Guddu	547441	High	24/08/2025
	Sukkur	481721	Medium	25/08/2025
	Kotri	273845	Low	31/08/2025
Jhelum	Mangla	260000	V.High	18/08/2025
	Rasul	40525	Normal	31/08/2025
Chenab	Marala	902241	E.High	27/08/2025
	Khanki	1085750	E.High	27/08/2025
	Qadirabad	1077952	E.High	27/08/2025
	Cheniot Bridge	855001	E.High	29/08/2025
	Trimmu	493159	High	31/08/2025
	Punjnad	106833	Normal	25/08/2025
Ravi	Jassar	240500	E.High	27/08/2025
	Ravi Syphon	220628	E.High	28/08/2025
	Shahdara	219771	E.High	28/08/2025
	Balloki	223386	E.High	30/08/2025
	Sidhnai	59458	Medium	31/08/2025
Sutlej	GS Wala	385570	E.High	29/08/2025
	Sulemanki	154220	High	30/08/2025
	Islam	69730	Low	31/08/2025
	Mailsi Syphon	58287	Low	31/08/2025
Kabul	Nowshera	109900	Medium	16/08/2025
Nullahs	Bein-R	47875	E.High	26/08/2025
	Deg-R	77742	E.High	26/08/2025
	Ura-C	53077	E.High	27/08/2025
	Basantar-R	11766	V.High	27/08/2025
	Palku-C	45701	E.High	27/08/2025
DG Khan	Kaura	23747	Normal	30/08/2025
	Vehova	24000	Normal	30/08/2025
	Sanghar	35081	Normal	30/08/2025
	Sori Lund	4411	Normal	23/08/2025
	Vidore	39254	Medium	30/08/2025
	S.Sarwar	32643	Ex.High	30/08/2025
	Mithanwa	2188	Normal	30/08/2025
Rajanpur	Kaha	46235	Medium	18/08/2025
	Chachar	6113	Normal	30/08/2025
	Pitok	4496	Low	30/08/2025
	Sori Shumali	5040	Medium	30/08/2025
	Zangi	1860	Normal	19/08/2025
	Kala Bagga Khosra	2883	Normal	18/08/2025

Table 2: Maximum recorded Inflow/Peaks in August-2025

4.5 Rivers' Rim Station Hydrographs, August 2025.

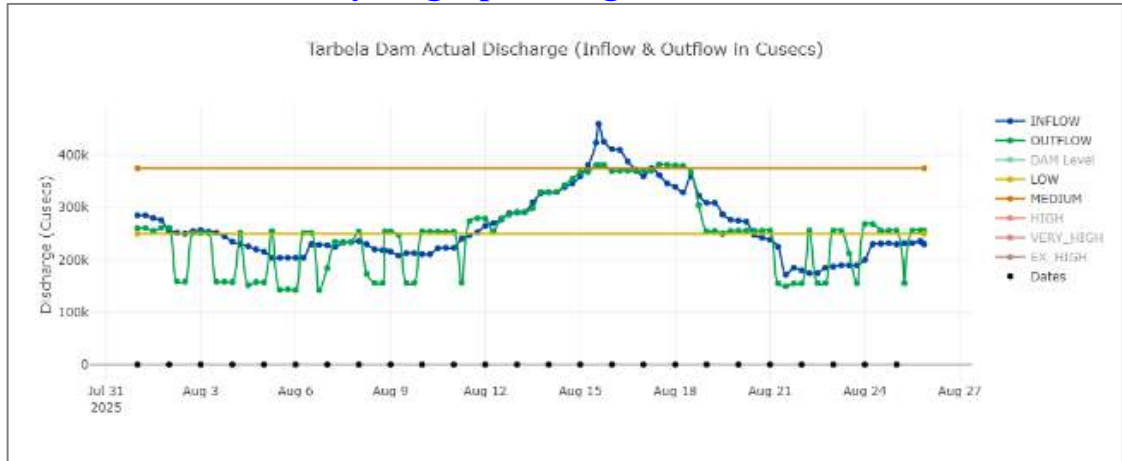


Fig-29(a)

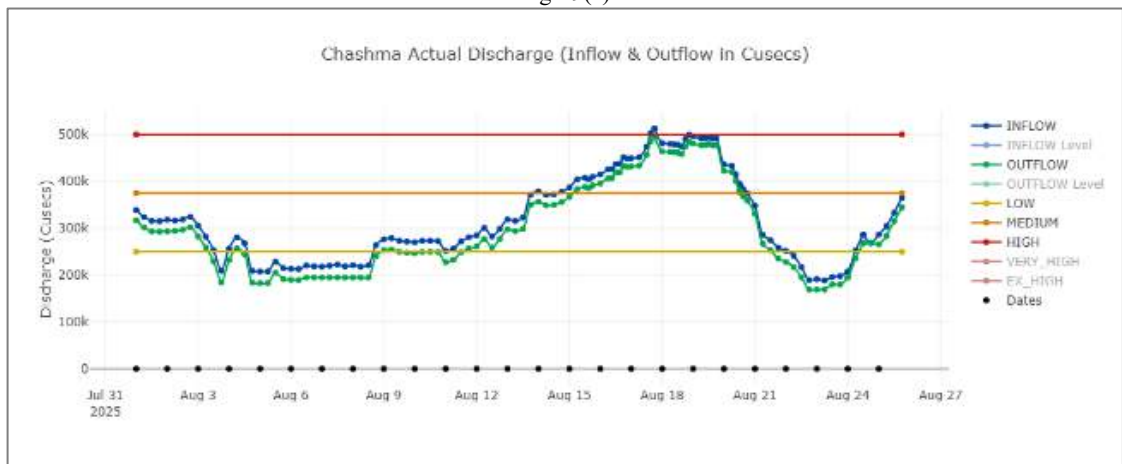


Fig-29(b)

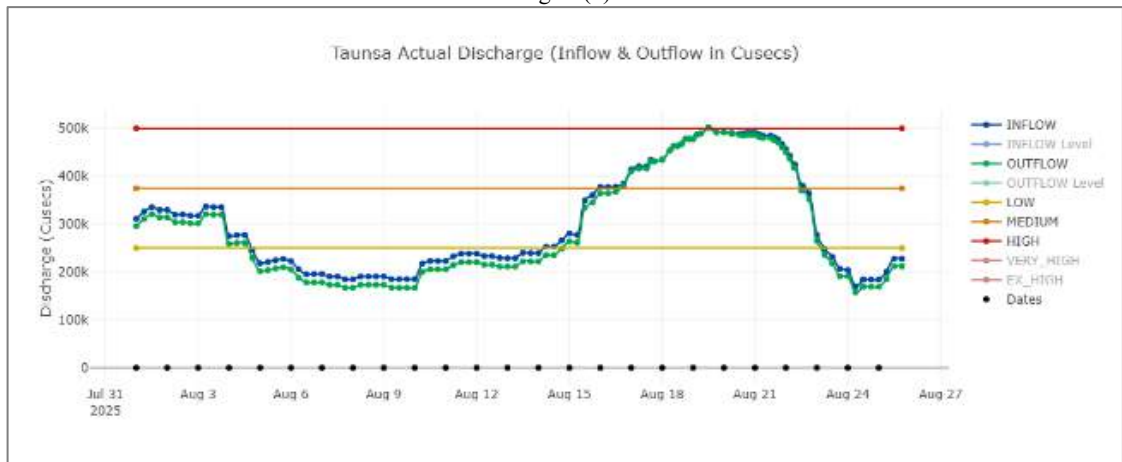


Fig-29(c)

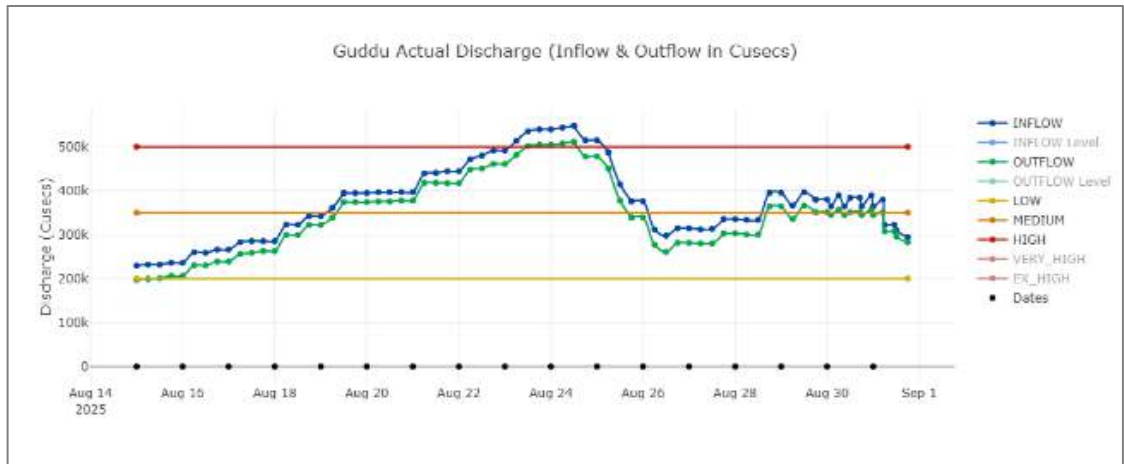


Fig-29(d)

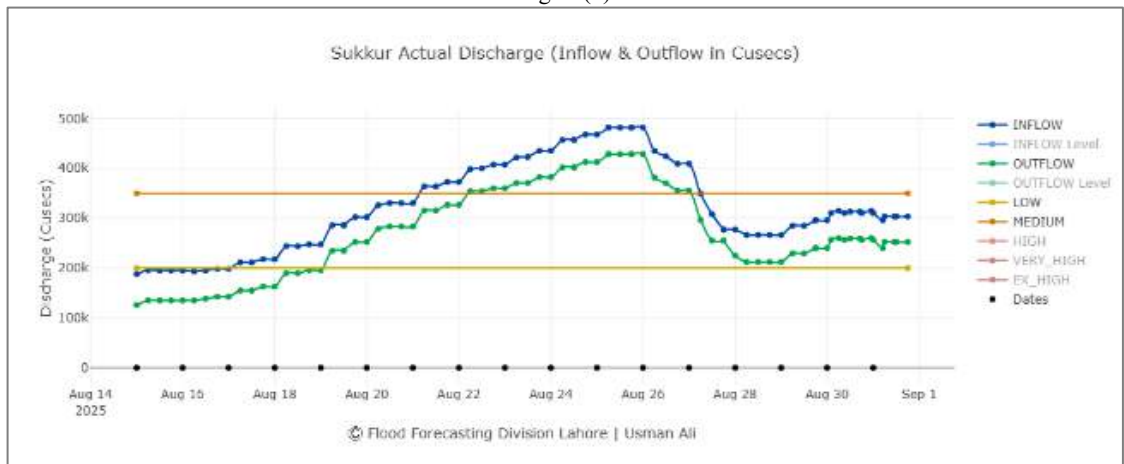


Fig-29(e)

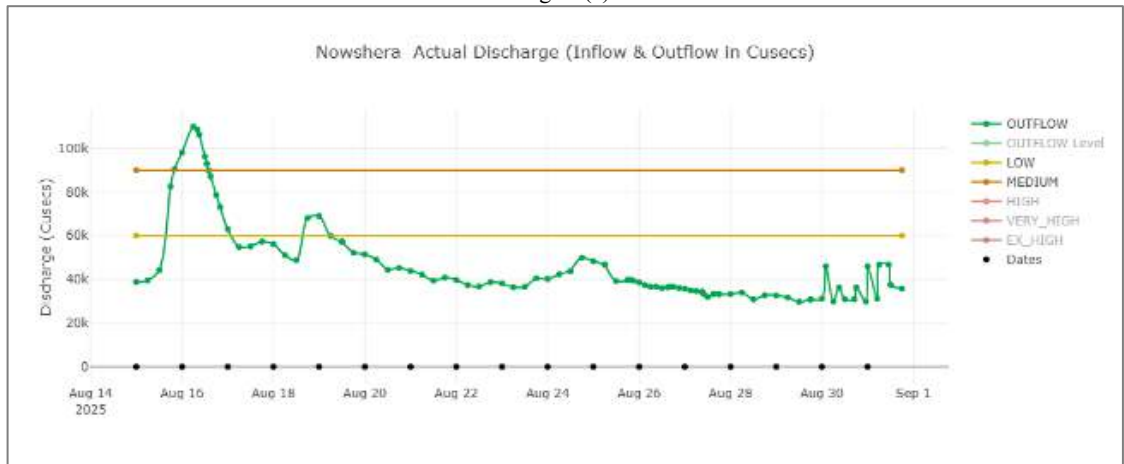


Fig-29(f)

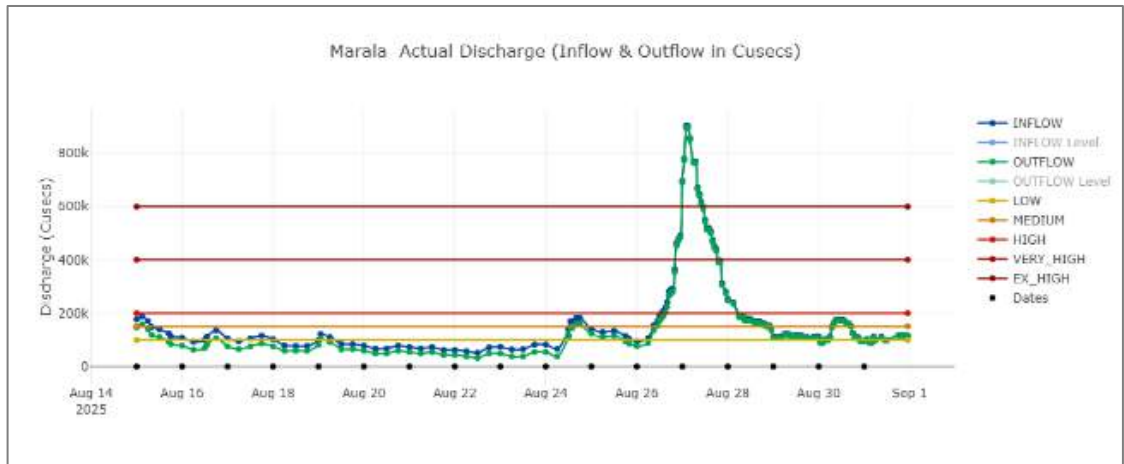


Fig-29(g)

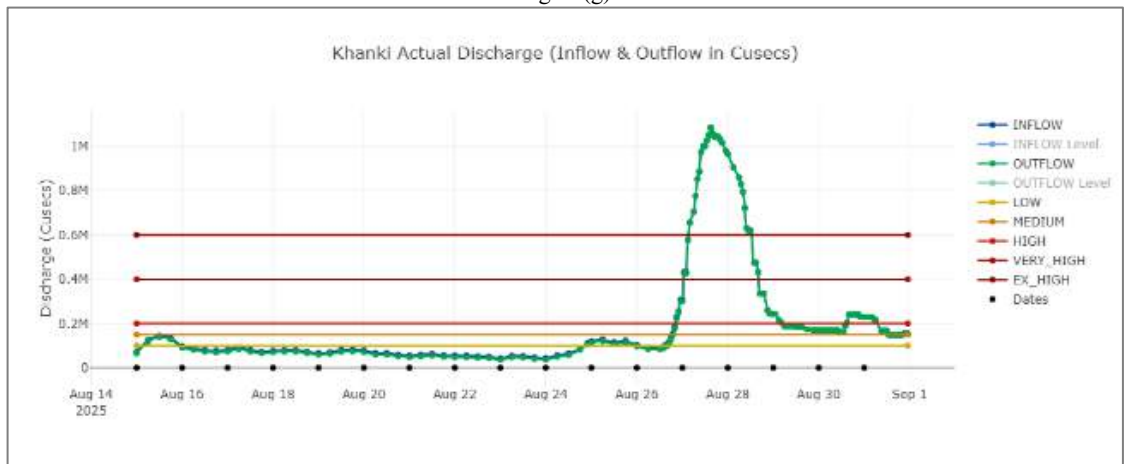


Fig-29(h)

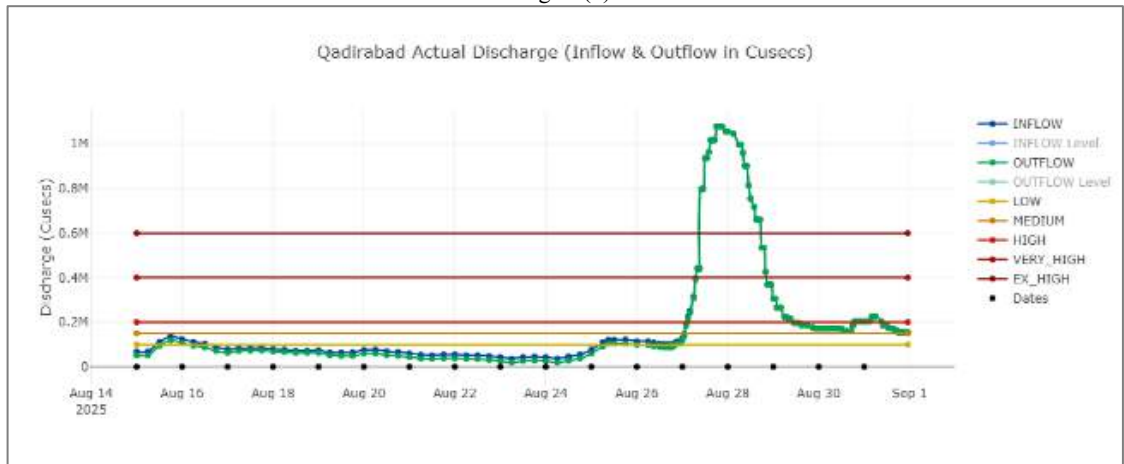


Fig-29(i)

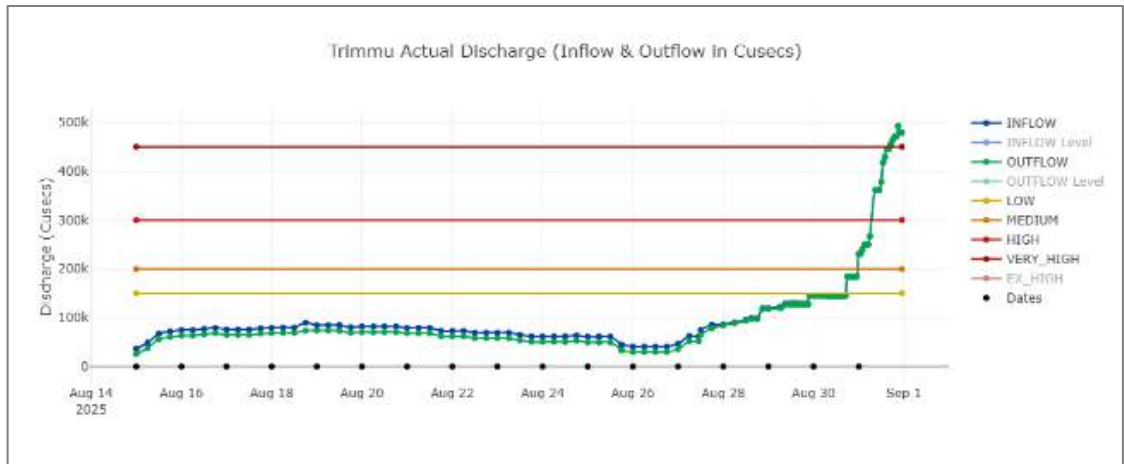


Fig-29(j)



Fig-29(k)

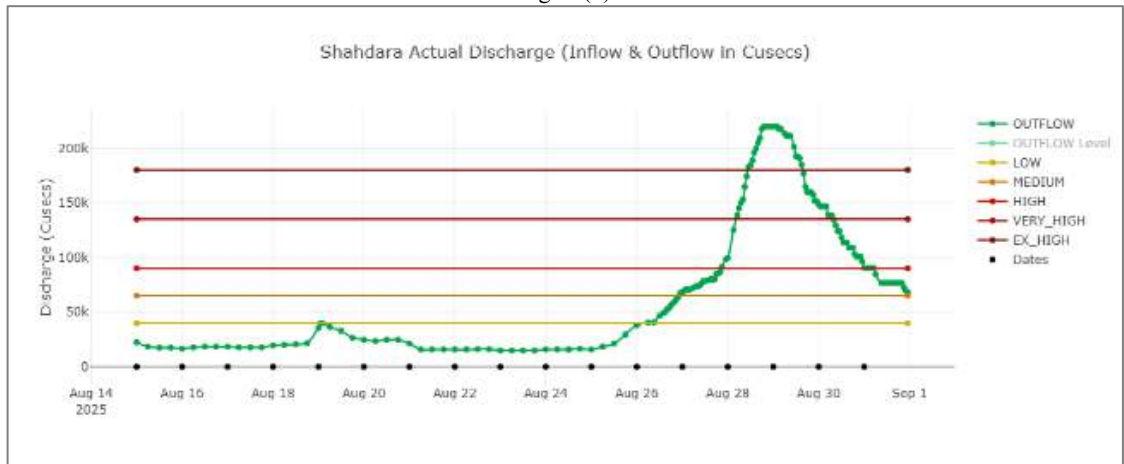


Fig-29(l)

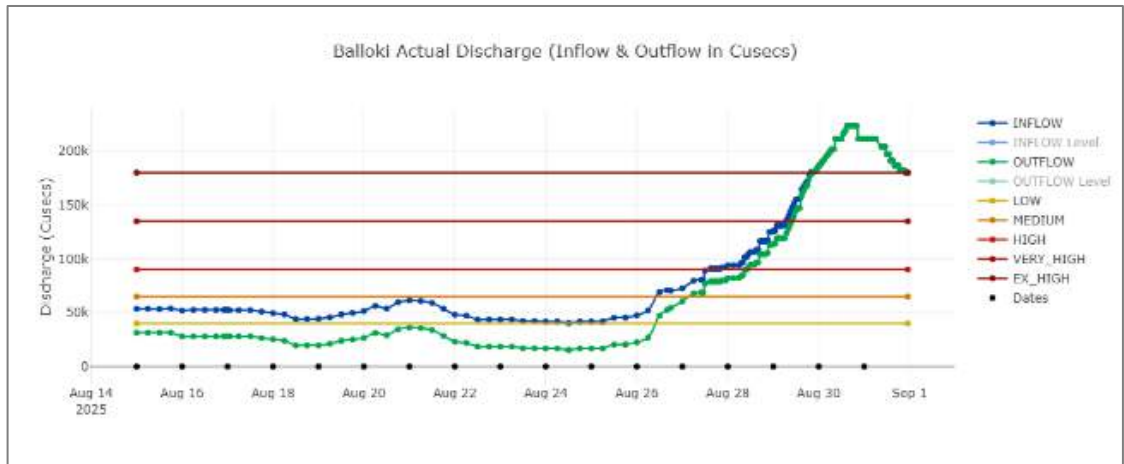


Fig-29(m)

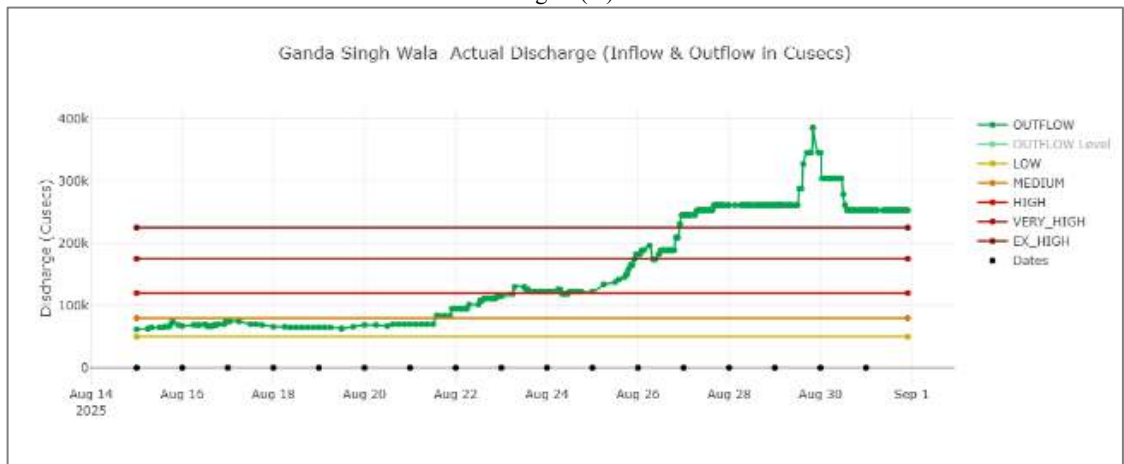


Fig-29(n)

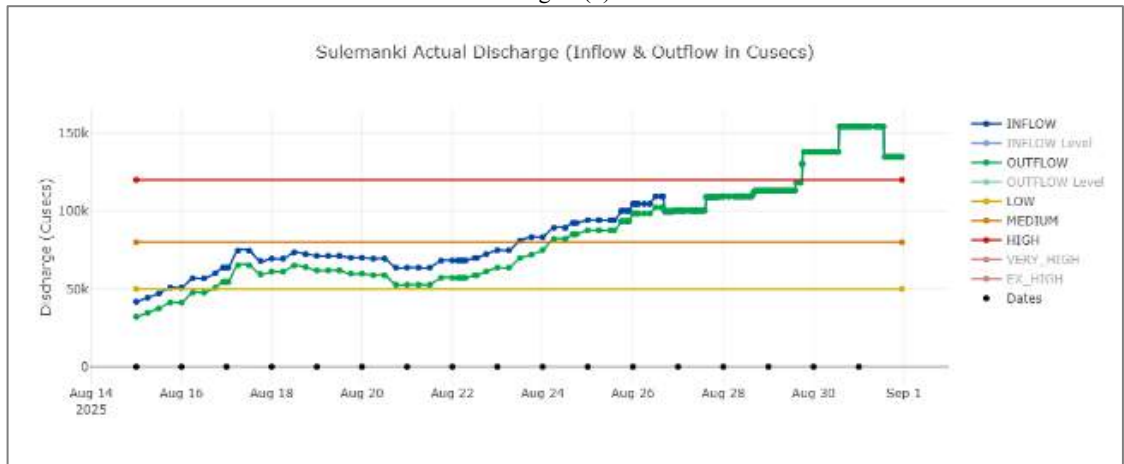
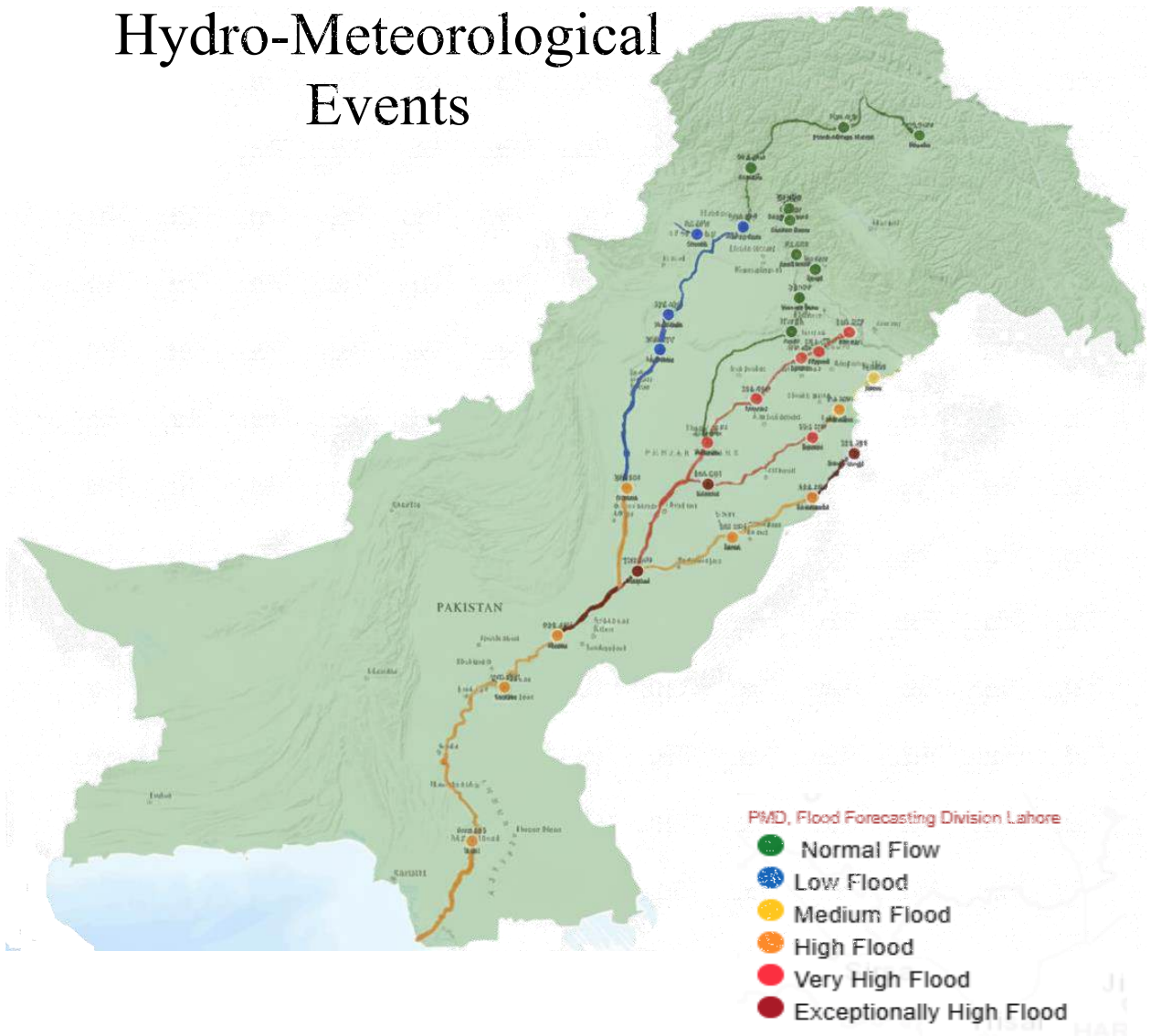


Fig-29(o)

Fig-(29) August-2025, Major sites Hydrograph

SEPTEMBER

Hydro-Meteorological Events



5 Significant Hydro-Met events during the month of September-2025.

During September 2025, two distinct rainfall spells were reported across the country. Medium to High in River Indus, Very High to Exceptional High Flood level recoded in River Chenab, Ravi & Sutlej while medium level Flood recoded in DG Khan Division Hill Torrent. Nationwide, rainfall was 52% above normal. Regions such as Azad Jammu & Kashmir - 34%, Gilgit Baltistan -22%, Sindh 316%, Balochistan 24%, Khyber Pakhtunkhwa -18% and Punjab 25%. By the end of July, the Tarbela reservoir was at 100% of its capacity, and Mangla reservoir was at 99%.

5.1 1st wet spell of September 2025 (30-Aug to 04-Sep).

The first wet spell of September 2025 remained active for approximately six days and was driven by the northwestward movement of a monsoon low originating over central India during late August. The system was supported by intermittent troughs of westerly waves and a persistent seasonal low over north to northwest Balochistan. Moderate to strong monsoon currents from the Bay of Bengal, with supplementary moisture from the Arabian Sea, provided sustained moisture supply to the upper catchments of the eastern rivers, particularly during the period from 30 August to 02 September. From 03 September onward, the system weakened as monsoon currents over the upper half of the country were cut off, resulting in a gradual reduction in rainfall activity, which largely subsided by 04 September. Fig-30 presents the 500 hPa and 850 hPa geopotential height fields along with 925 hPa moist wind flow, indicating the continued influence of a westerly wave over Pakistan during the spell. The presence of southeasterly winds at lower levels ensured strong moisture transport from the Bay of Bengal, with moderate contribution from the Arabian Sea.

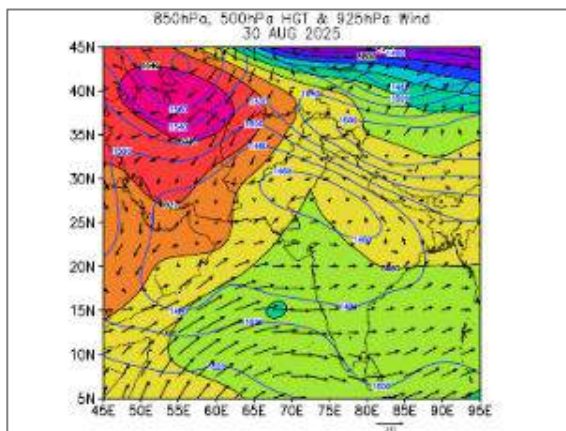


Fig-30(a)

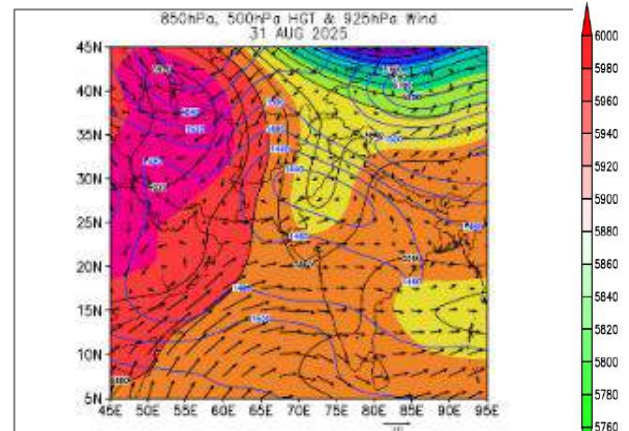
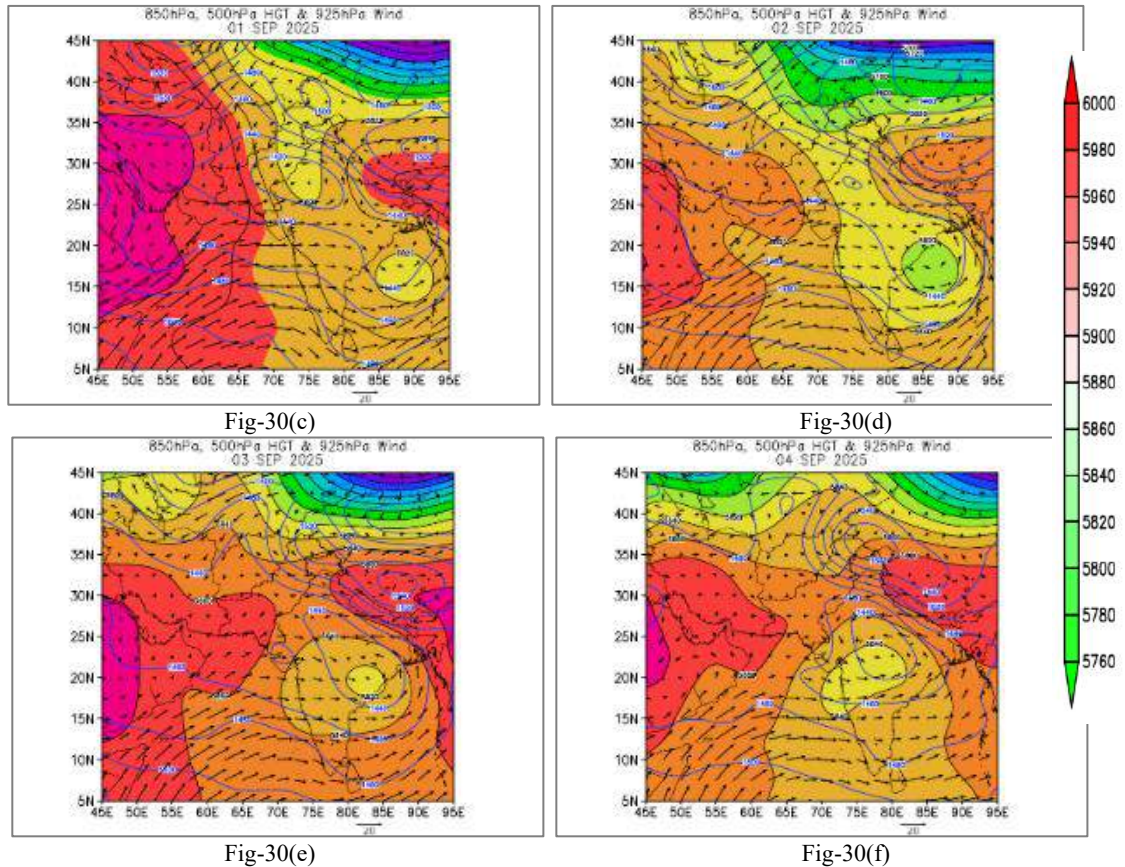


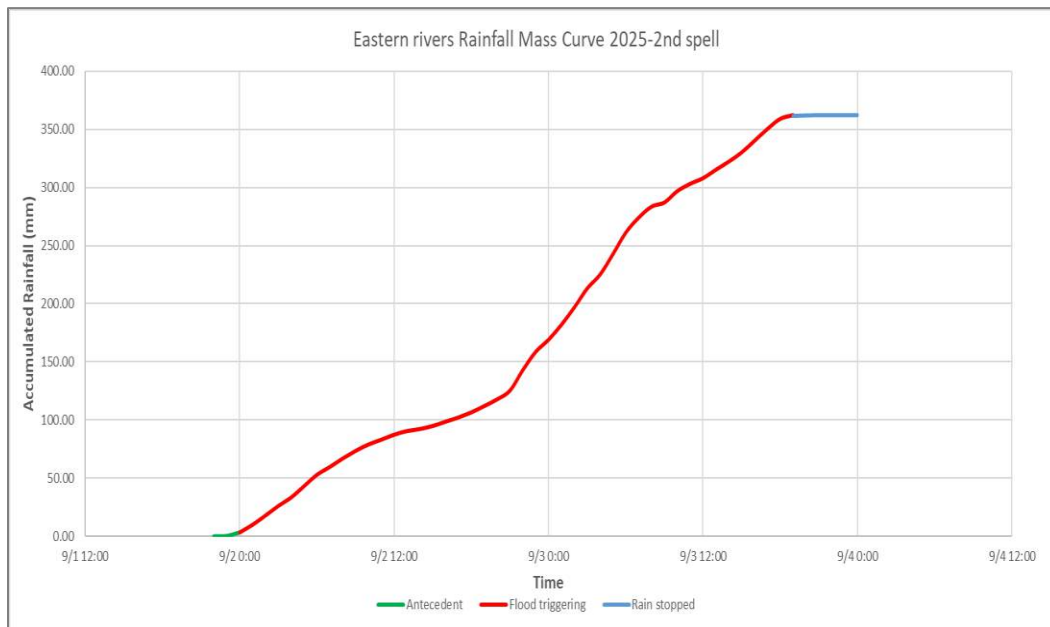
Fig-30(b)



Colour shades represent 500 hPa Geopotential Heights, Blue contour lines indicate 850 hPa Geopotential Heights and barbs show 925 hPa winds.

Fig-(30) 1st Spell of Sep-2025, 850 & 500 hPa geopotential height & 925 hPa winds map

As the monsoon weather system during this spell remained largely concentrated over the upper catchments of the eastern rivers, the Sialkot Weather Radar indicated maximum rainfall over these areas, corresponding to the second peak of the flood event. In the absence of ground-based rainfall information from Occupied Kashmir and adjoining regions of India, the Sialkot Radar served as the primary and most reliable source for assessing transboundary rainfall. The rainfall mass curve derived from Sialkot Weather Radar data is presented below.



According to the Sialkot Weather Radar, the rainfall spell over the eastern river catchments persisted for approximately 44 hours, producing an average accumulated rainfall of 362 mm across the affected areas. Specifically, the Ravi catchment received rainfall for 39 hours, resulting in an average accumulation of 100 mm, while the Chenab catchment experienced a 39-hour rainfall spell with an average accumulated rainfall of 245 mm. The Beas catchment experienced a prolonged, intermittent rainfall episodes.

During this spell, rainfall was recorded at 64% of meteorological observatories across the country. Sialkot Cantt recorded the highest cumulative rainfall of 209 mm. On 03 September, the maximum spatial coverage was observed, when 25% of observation stations reported measurable precipitation, and the highest 24-hour rainfall of 101 mm was recorded at Sialkot Airport. Sialkot Cantt received 209 mm rainfall during the spell. Other rainfall distribution during the spell over the country can also be seen from the Fig-31.

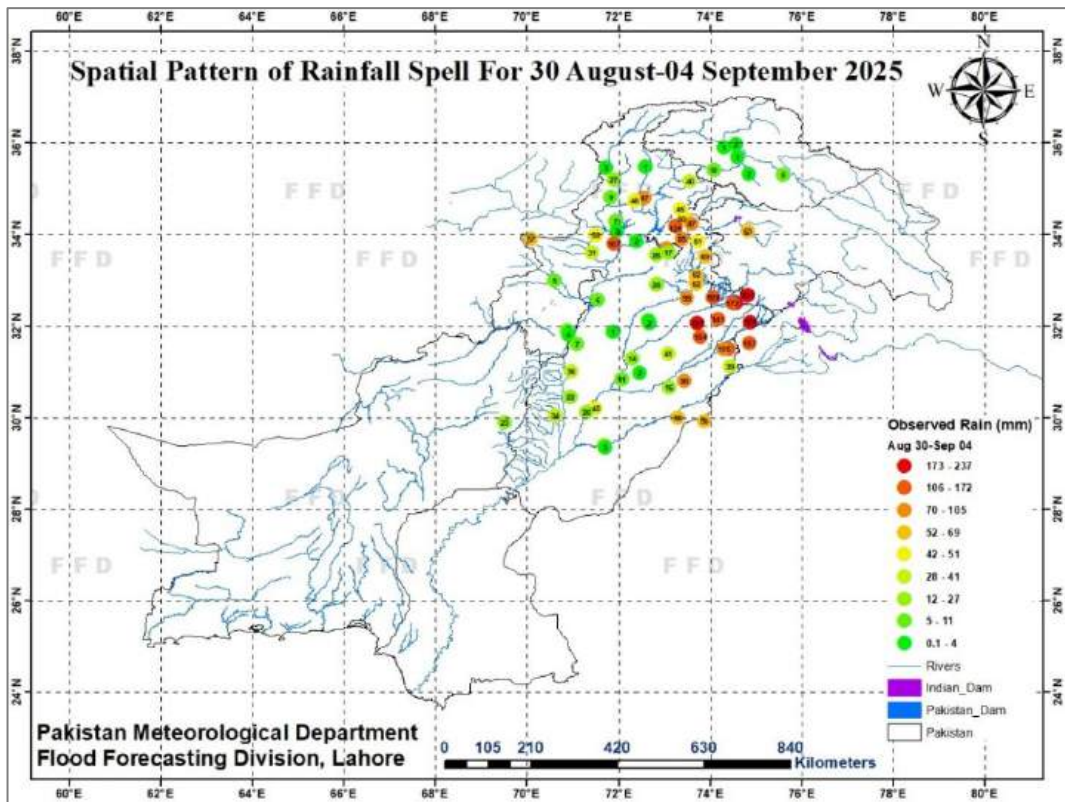


Fig-(31-a) 1st Spell of Sep-2025, PMD total rainfall

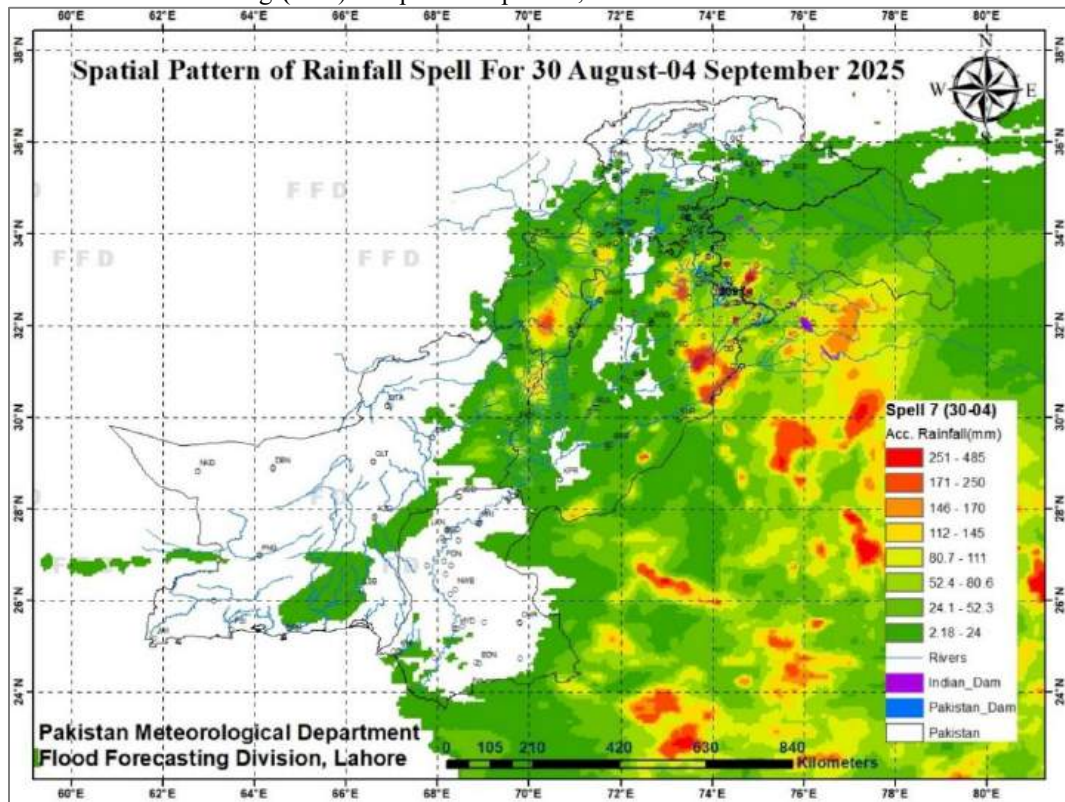


Fig-(31-b) 1st Spell of Sep-2025, PMD, Radar & Satellite total merged rainfall

Fig-(31) 1st Spell of Sep-2025, Total Rainfall

Position of significant cloud formation during the spell is shown in Fig-32.

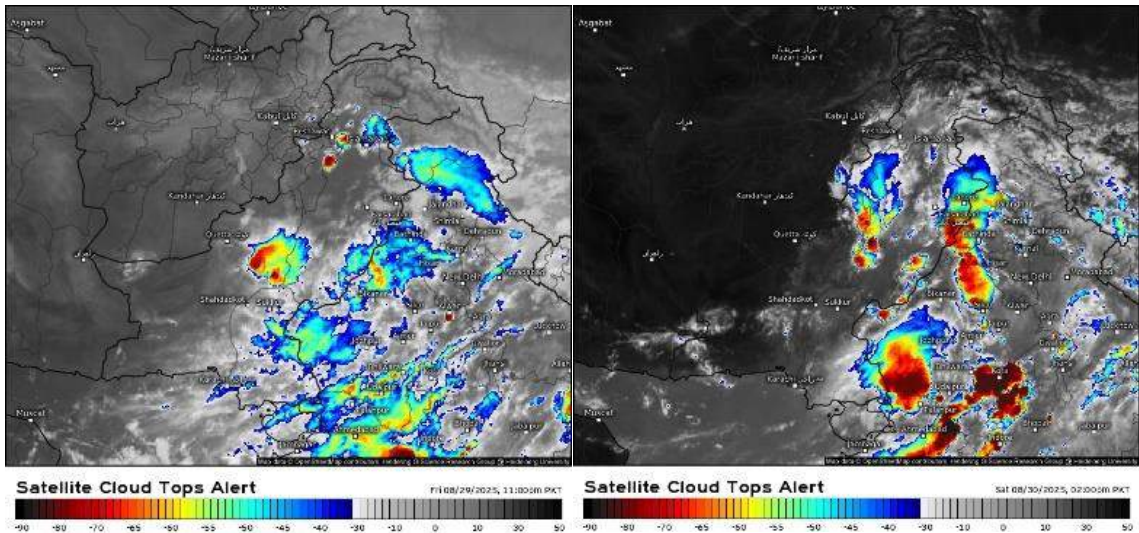


Fig-32(a)

Fig-32(b)

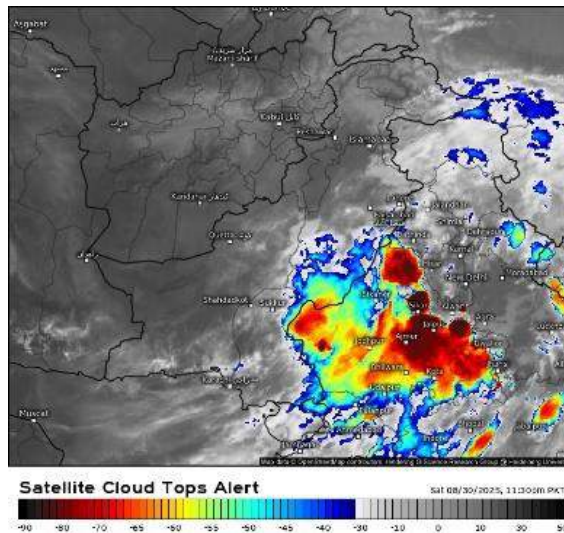


Fig-32(c)

Fig-(32) 1st Spell of Sep-2025, Satellite images

During the second flood peak, the reactivation of a monsoon low-pressure system generated renewed high flows in the eastern rivers. The River Chenab at Marala experienced a Very High Flood peak, remaining at Very High Flood Level from 03 September to 04 September at 0100 PST, for a duration of approximately 16 hours. On the River Ravi at Jassar, a Medium Flood peak was observed, with the river remaining at Medium Flood Level from 03 September to 05 September at 0600 PST, lasting about 43 hours. At Ganda Singh Wala on the River Sutlej, Exceptional High Flood conditions persisted for an extended period. The site remained at Exceptional High Flood Level from 26 August at 2200 PST to

09 September at 1900 PST, totaling 13 days and 21 hours. Flows at Jassar and Ganda Singh Wala were influenced by a combination of controlled releases from upstream Indian reservoirs, storm rainfall runoff, and additional inflows from associated tributary nullahs of the Ravi and Sutlej Rivers. Similarly, tributary nullahs of the Chenab and Ravi Rivers experienced High to Very High Flood conditions during this period. Notably, the Palkhu Nullah of the Chenab River remained above High Flood Level from 27 August at 0600 PST to 08 September at 1800 PST, for a duration of approximately 12 days and 12 hours, significantly contributing to sustained high flows in the Chenab River system.

5.2 2nd Wet Spell of September 2025 (07-10).

Second spell of September remained active for four days, The second wet spell of September 2025, spanning 07–10 September, was driven by a westward-moving monsoon low from central India, supported by a persistent seasonal low over western Balochistan and intermittent westerly wave troughs. Moderate to very strong monsoon currents from the Arabian Sea and Bay of Bengal penetrated southern and eastern parts of the country, bringing significant rainfall to Sindh, south Punjab, and eastern Balochistan.

The monsoon low intensified into a depression over southwest Rajasthan on 07 September and moved into southeast Sindh by 08 September, before weakening into a low near the Arabian Sea by 10 September. Rainfall was concentrated over southern and southeastern regions, with enhanced inflows to rivers in these areas. Fig-33 illustrates the associated 500 hPa and 850 hPa geopotential height patterns along with 925 hPa moisture transport during the spell, highlighting the supply of moist currents from the Arabian Sea and Bay of Bengal.

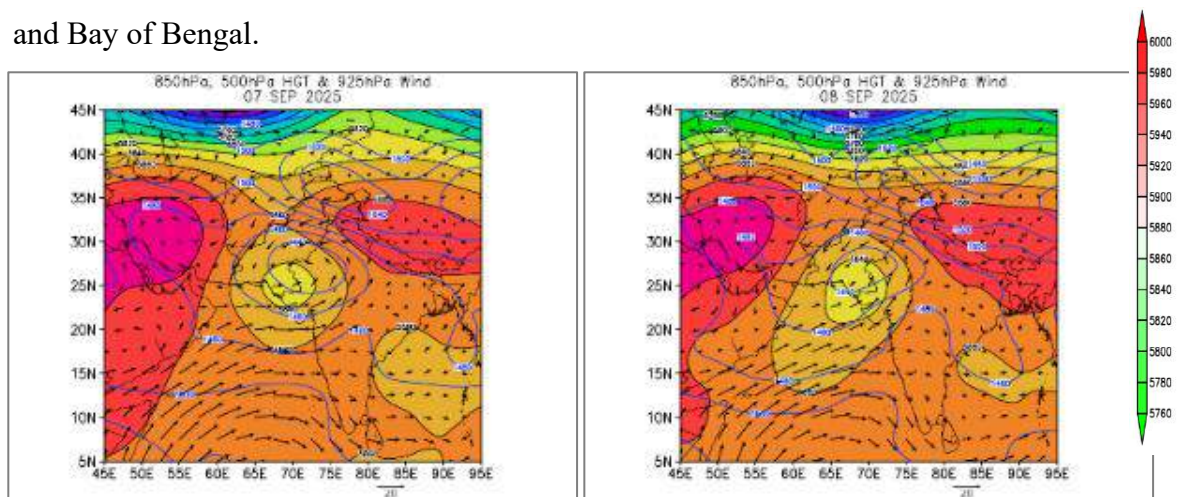


Fig-33(a)

Fig-33(b)

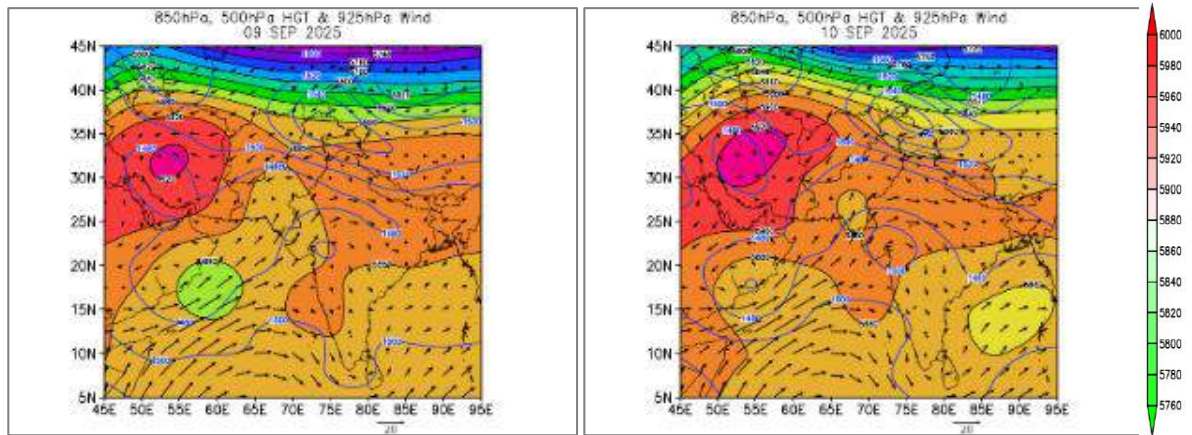


Fig-33(c)

Fig-33(d)

Colour shades represent 500 hPa Geopotential Heights, Blue contour lines indicate 850 hPa Geopotential Heights and barbs show 925 hPa winds.

Fig-(33) 2nd Spell of Sep-2025, 850 & 500 hPa geopotential height & 925 hPa winds map

During this spell, rainfall was recorded at 75% of meteorological observatories across the country. Thatta recorded the highest cumulative rainfall of 193 mm. On 07 September, the maximum spatial coverage was observed, when 27% of observation stations reported measurable precipitation, and the highest 24-hour rainfall of 110 mm was recorded at Thatta. Thatta received 193 mm rainfall during the spell. Other rainfall distribution during the spell over the country can also be seen from the Fig-34.

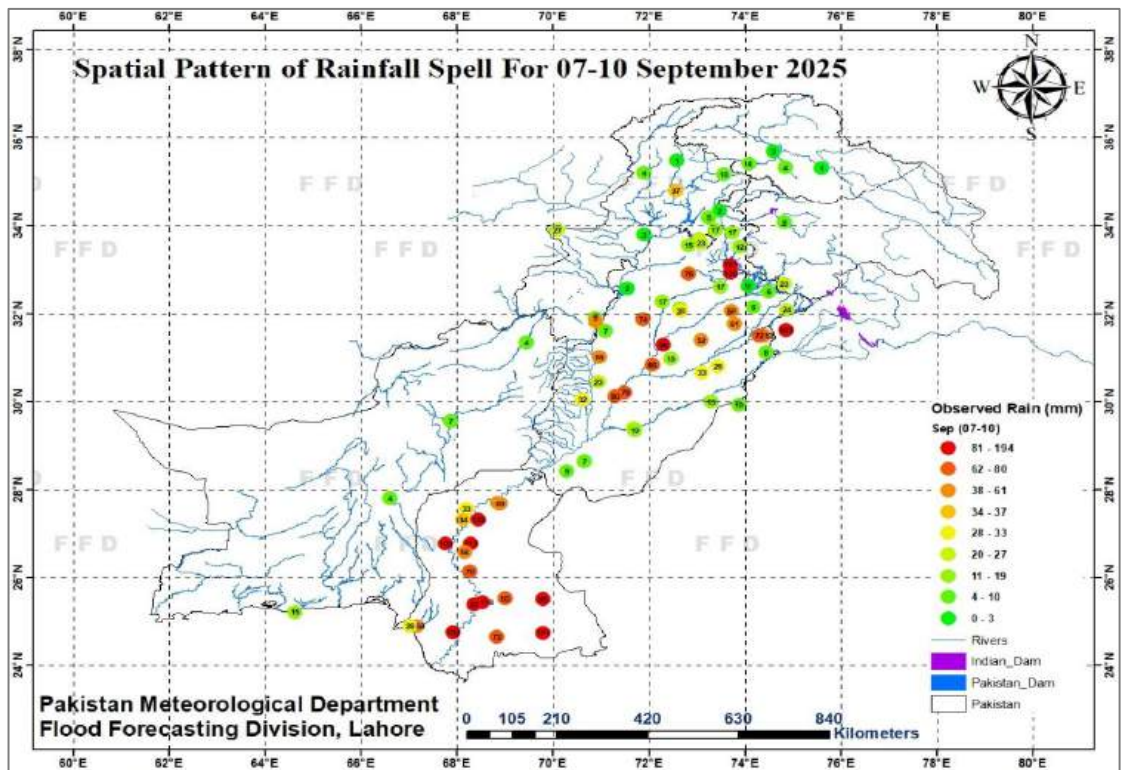


Fig-(34-a) 2nd Spell of Sep-2025, PMD total rainfall

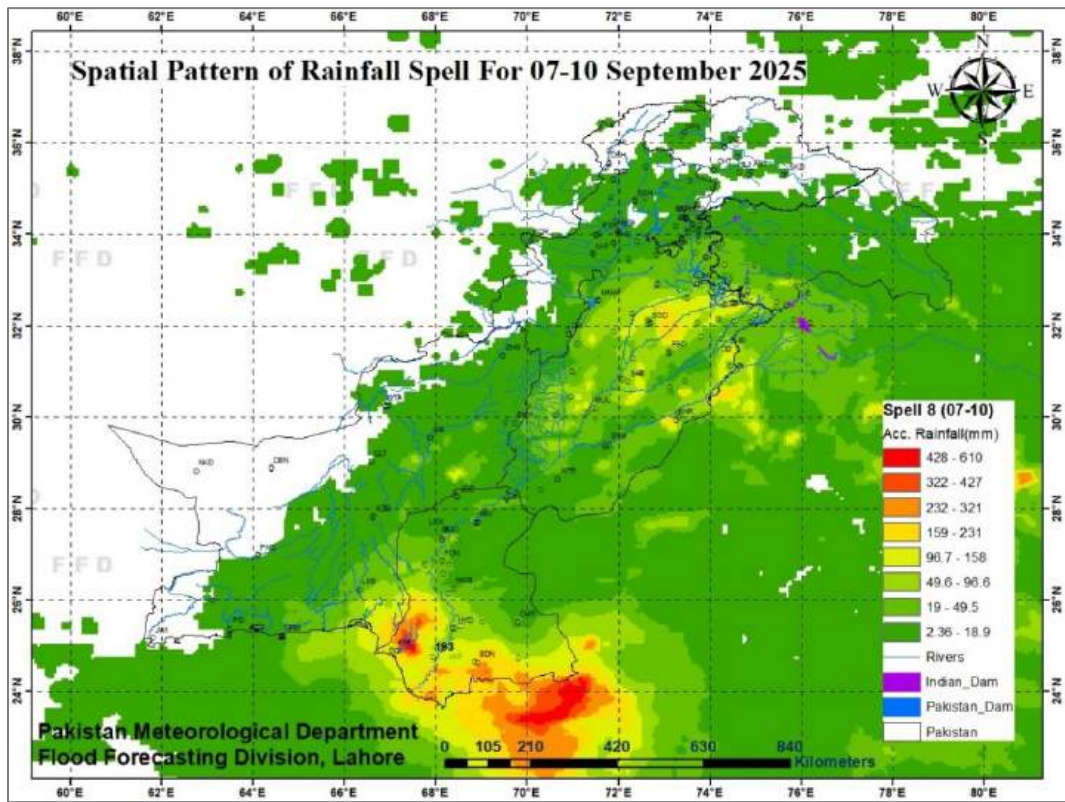


Fig-(34-b) 2nd Spell of Sep-2025, PMD, Radar & Satellite total merged rainfall
 Fig-(34) 2nd Spell of Sep-2025, Total Rainfall

Position of significant cloud formation during the spell is shown below.

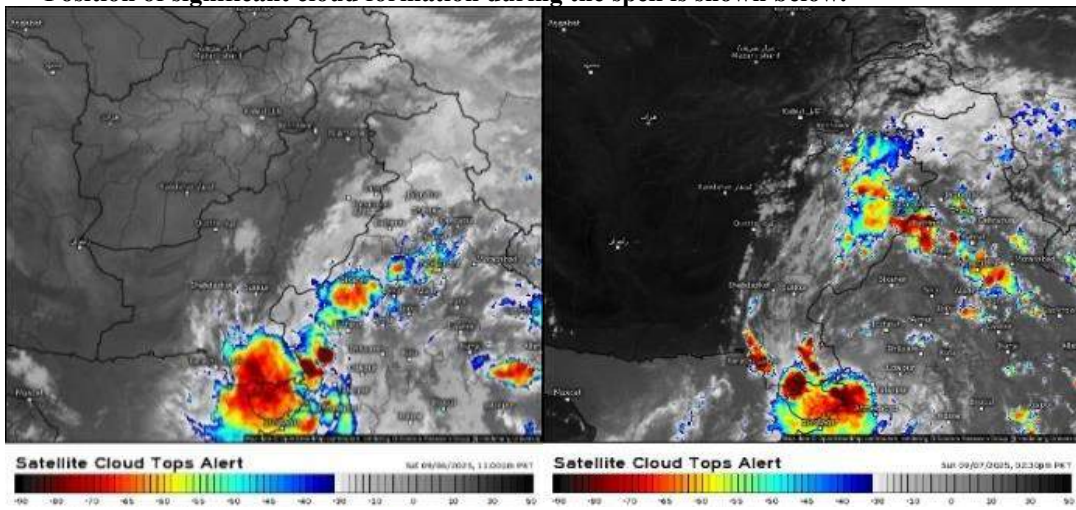


Fig-35(a)

Fig-35(b)

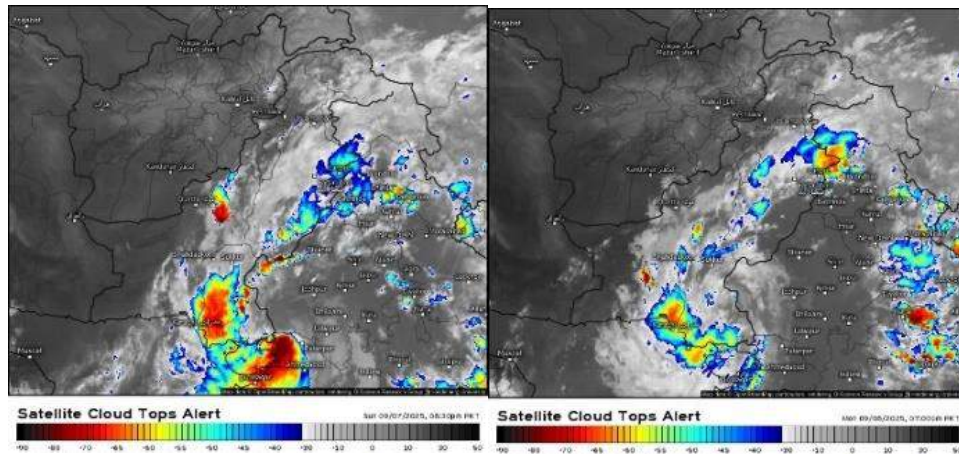


Fig-35(c)

Fig-35(d)

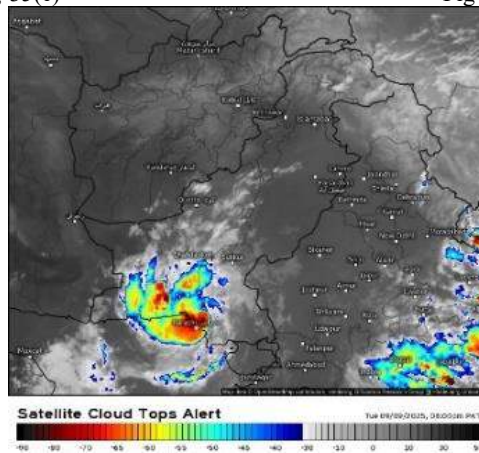


Fig-35(e)

Fig-(35) 2nd Spell satellite images of Sep-2025

During this spell, the rainfall primarily affected the central and southern parts of the country, resulting in minimal impact on the flows at rim stations, which largely remained within normal levels. The exception was the Sutlej River, which was on a falling trend. However, the flood wave in southern Punjab at Trimmu and in northern Sindh at Guddu, combined with this rainfall spell, exacerbated the difficulties faced by flood-affected populations.

5.3 Monthly maps of total rainfall of September-2025.

According to Sialkot radar during the 1st week of the September, in the upper catchment of eastern maximum rainfall 682 mm observed due to which 2nd flood wave generated in the eastern rivers as shown in Isohyetal Map in Fig-36 however, the point rainfall map of observatories for September 2025 indicates that the region with the maximum rainfall of over 197 mm is centered around Thatta, while Sialkot Cantt, Narowal and Mithi received more than 150 mm during the spell.

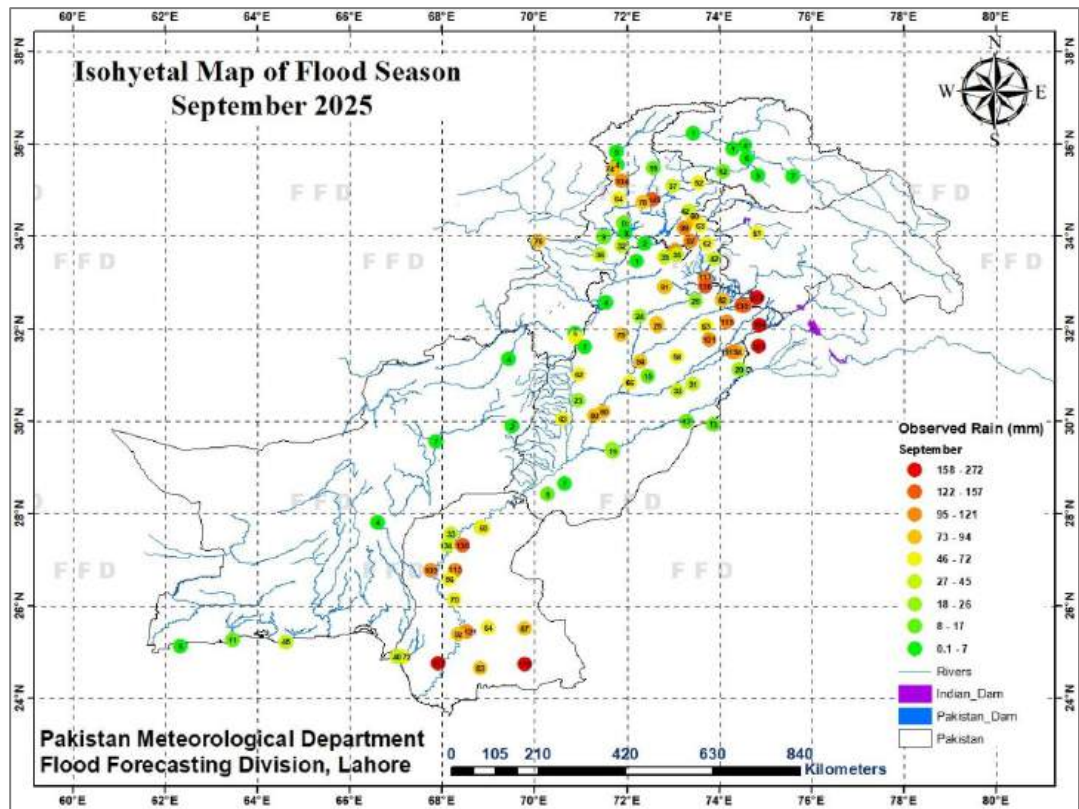


Fig-(36-a) September-2025, PMD total rainfall

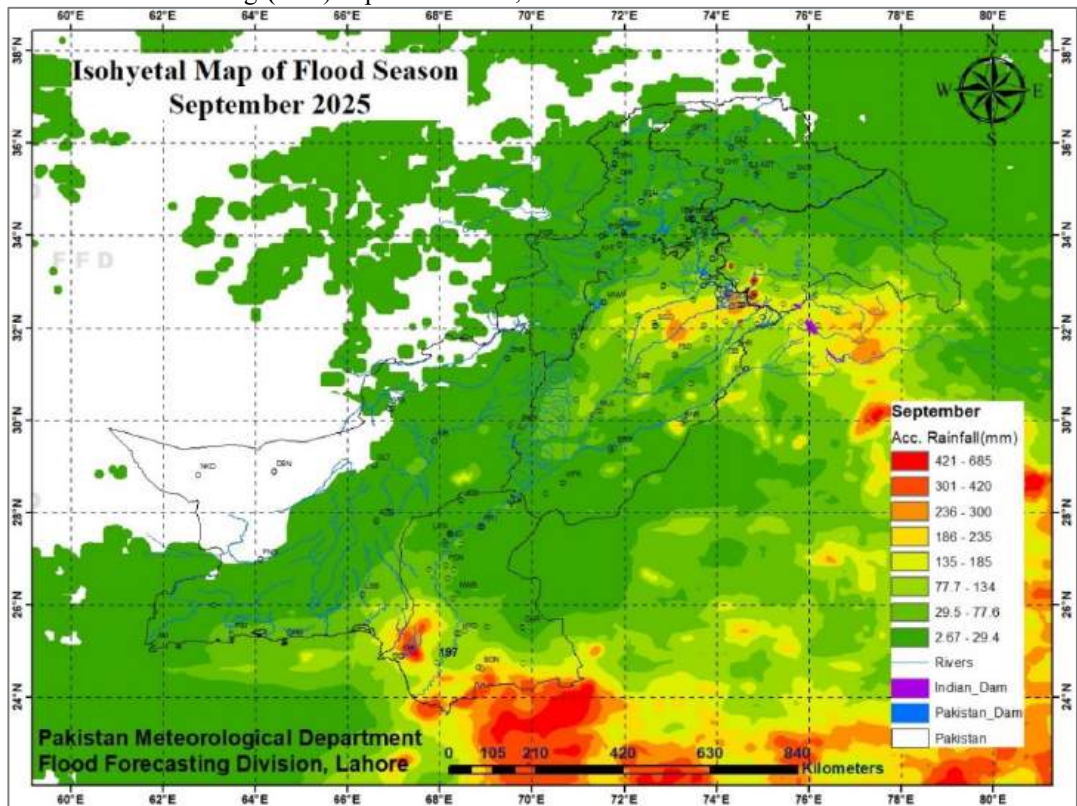


Fig-(36-b) September-2025, PMD, Radar & Satellite total merged rainfall

Fig-(36) September-2025, Total Rainfall

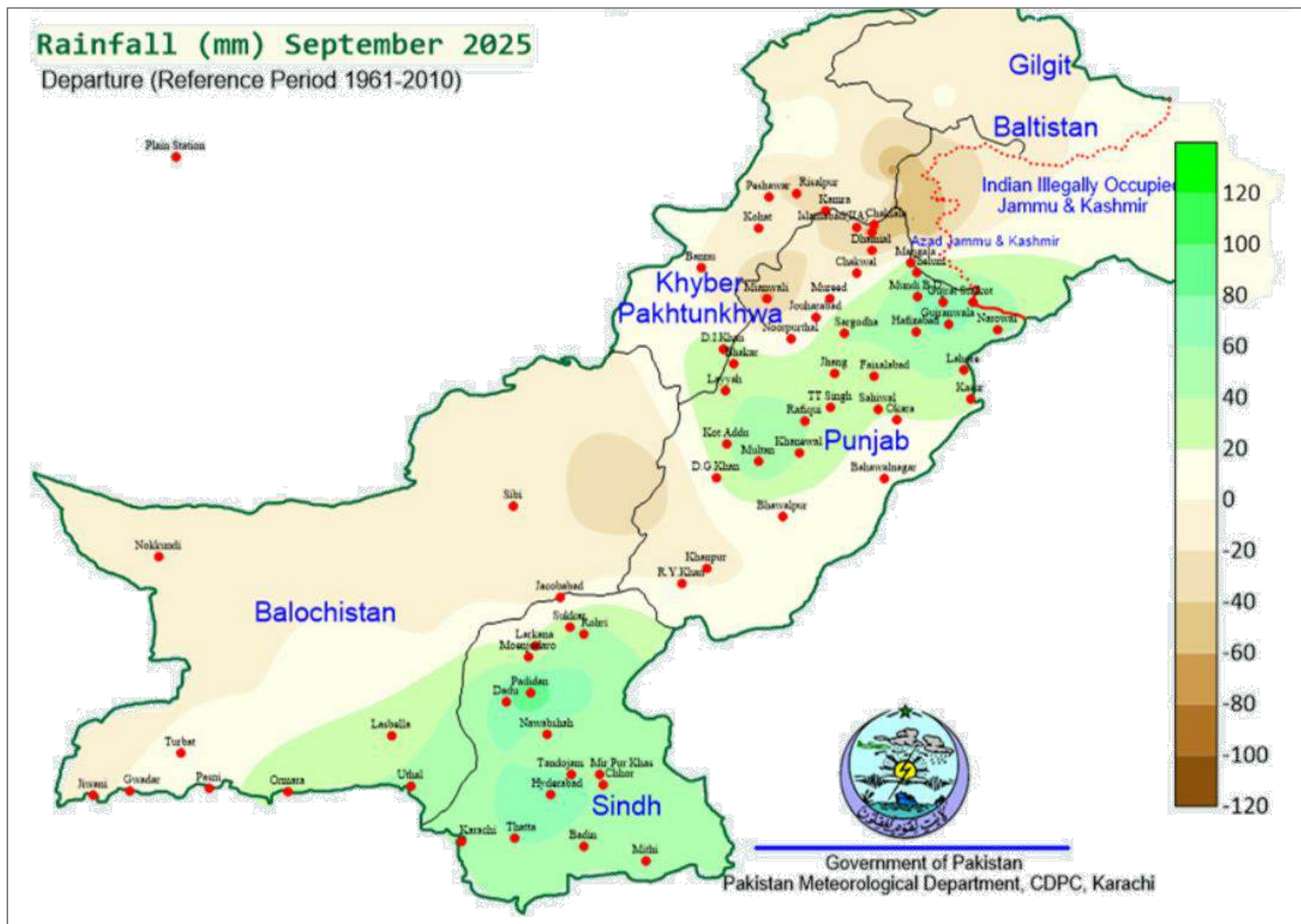


Fig-(37) September-2025, Monthly Departure Rainfall Departure

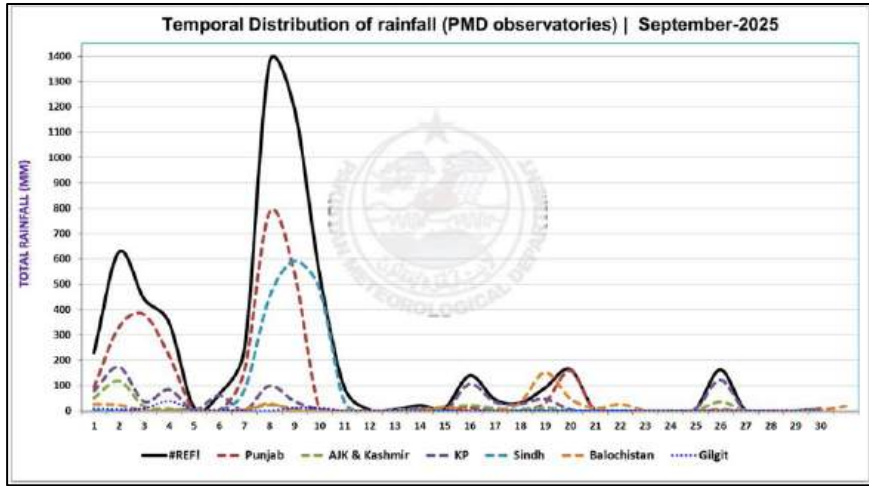


Fig-38(a)

	01 to 30 September, 2025 Rainfall		
	normal (mm)	actual (mm)	Dev (%)
Pakistan	21.4	32.6	52.4
Azad J&K	64.9	43.1	-33.6
Balochistan	6.2	7.7	23.7
Gilgit-B	9.7	7.6	-21.7
Khyber-PK	46.0	37.9	-17.7
Punjab	34.6	43.3	25.1
Sindh	19.9	82.9	315.9

Fig-38(b)

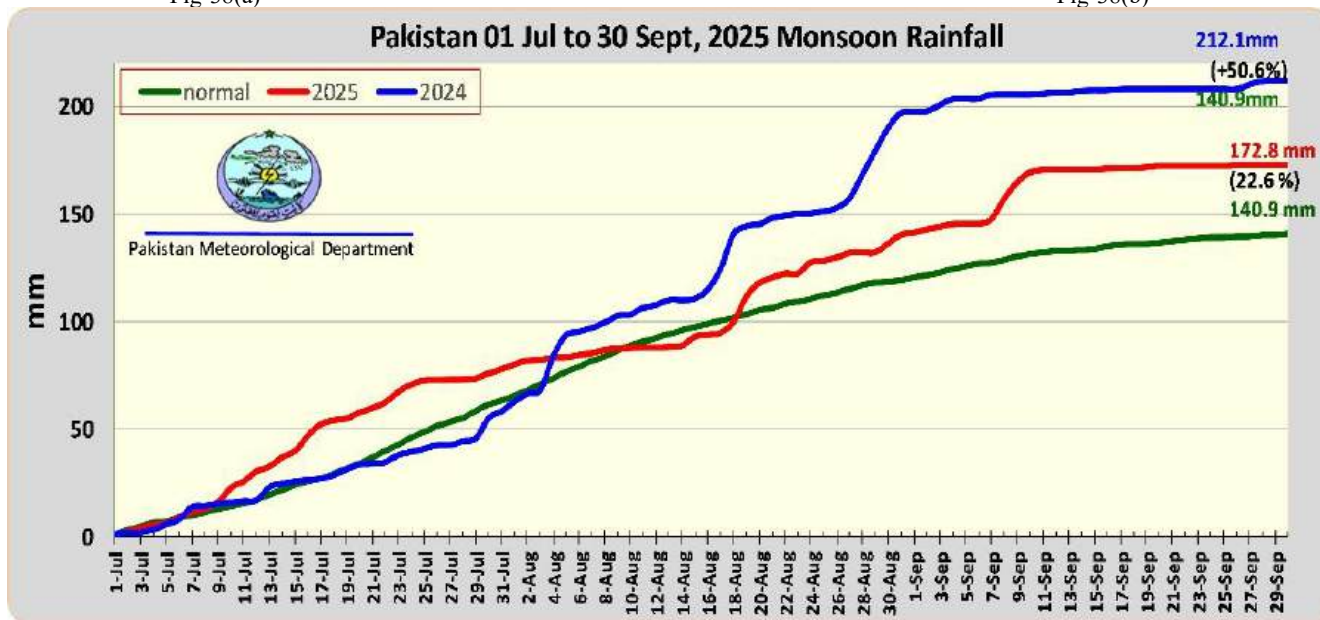


Fig-38(c)

Fig-(38) Monthly Temporal & AWR Rainfall Sep-2025

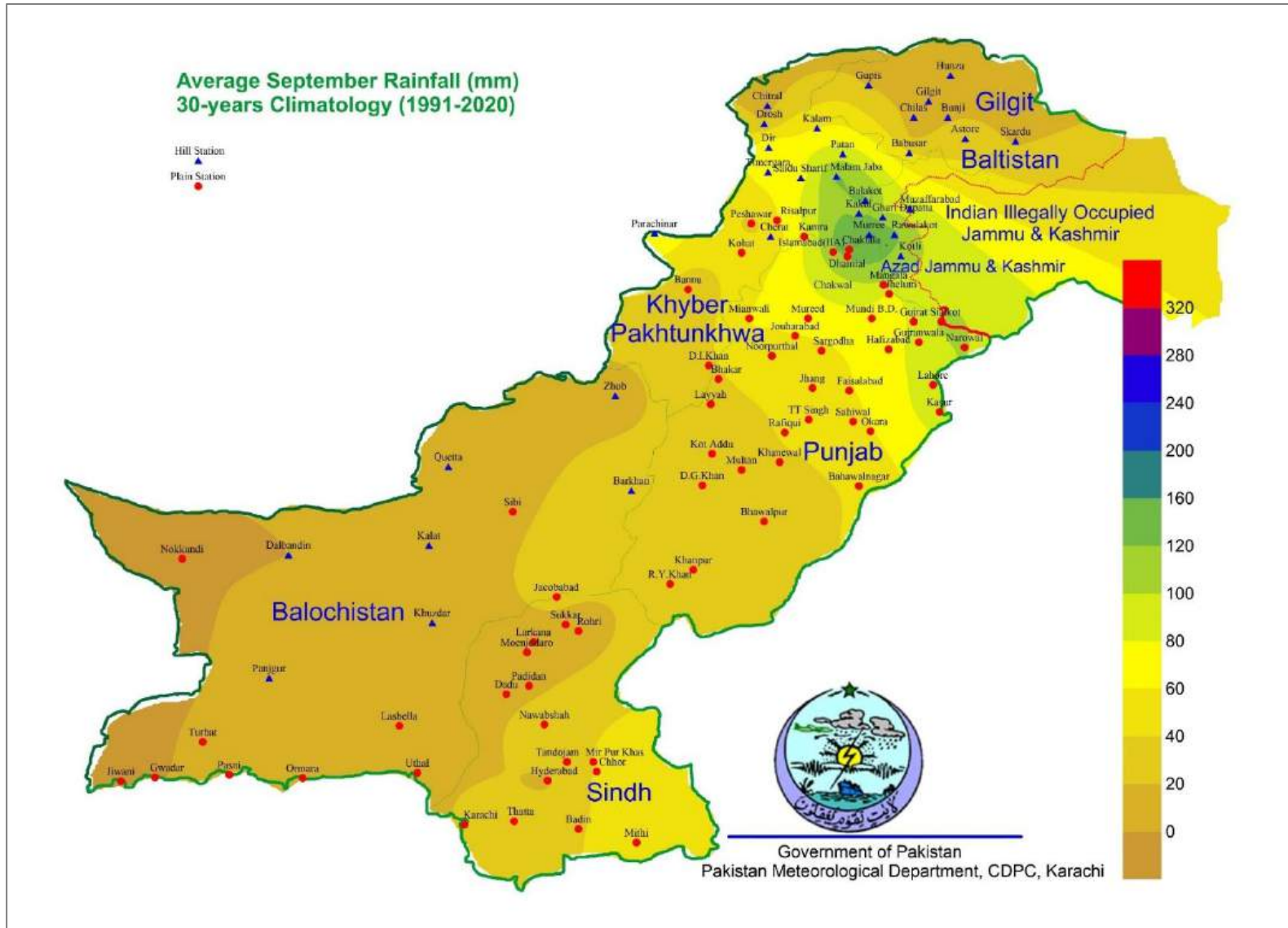


Fig-(39) September Climate Normal of Rainfall

5.4 Maximum Peaks recorded in the month of September 2025.

During the first spell of September, the maximum Maximum Flood Peaks were observed in the first week, as summarized in Table-3. Trimmu Barrage attained Very High Flood Level on 31 August during the first flood wave, which persisted for 31 hours. During the second flood wave, it again reached Very High Flood Level on 06 September, remaining so for 64 hours. Owing to back-to-back flood waves, flows at Trimmu remained above Medium Flood Level and finally receded below Low Flood Level on 11 September at 1800 PST. During the first flood wave, Sidhnai Barrage attained Exceptional High Flood Level for 56 hours. During the second flood wave, it again briefly touched the Exceptional High Flood Level for 24 hours, after which flows declined and fell below Low Flood Level on 15 September at 0600 PST. Islam Barrage remained at High Flood Level for approximately 73 hours, after which flows gradually receded and fell below Low Flood Level on 26 September at 0600 PST. During the first flood wave, Panjnad Headworks briefly attained Exceptional High Flood Level for about 11 hours, before receding to High Flood Level prior to the onset of the second flood wave. During the second flood wave, Panjnad again reached Exceptional High Flood Level, which persisted for 56 hours, before flows declined below Low Flood Level on 17 September at 1500 PST. Outflows from the Indus River at Taunsa Barrage were approximately 200,000 cusecs, contributing to the peak discharge observed at Guddu Barrage. The hydrograph in Fig-39 highlights the distinction between the two flood waves. However, due to widespread inundation and the delayed passage of the first flood wave, the first and second flood waves merged at Guddu Barrage. As a result, Guddu experienced a combined flood wave that persisted for approximately seven days. The river at Guddu attained High Flood Level for about 162 hours before receding below flood level on 25 September at 1200 PST. At Sukkur Barrage, High Flood Level conditions prevailed for nearly 102 hours, after which flows dropped below flood level on 25 September at 0600 PST. Further downstream at Kotri Barrage, flows reached Medium Flood Level and remained elevated for approximately 14 days, finally receding below flood level on 02 October at 0600 PST.

In September 2025, base flows at Tarbela remained above normal, driven by elevated temperatures in the upper Indus catchment that accelerated snow and glacier melt. As a result, Tarbela received 1.96 MAF more water than usual, bringing total water availability to 60.98 MAF by the end of the month 10.9 MAF above normal, as shown in Figure 47. Meanwhile,

Mangla Dam recorded a modest surplus of 0.31 MAF over its normal inflows during September; however, its total water availability at month-end remained 3.32 MAF below normal.

River	Site	Inflow	Flood Level	Date
Indus	Tarbela	202000	Normal	02/09/2025
	Attock	248800	Normal	01/09/2025
	Kalabagh	256526	Low	03/09/2025
	Chashma	252792	Low	04/09/2025
	Taunsa	249951	Normal	05/09/2025
	Guddu	635760	High	14/09/2025
	Sukkur	571801	High	16/09/2025
	Kotri	421075	Medium	27/09/2025
Jhelum	Mangla	103000	Low	07/09/2025
	Rasul	20100	Normal	08/09/2025
Chenab	Marala	549737	V.High	03/09/2025
	Khanki	564172	V.High	03/09/2025
	Qadirabad	557440	V.High	04/09/2025
	Cheniot Bridge	554998	V.High	05/09/2025
	Trimmu	550966	High	01/09/2025
	Punjnad	703698	E.High	12/09/2025
Ravi	Jassar	89820	Medium	03/09/2025
	Ravi Syphon	119771	High	06/09/2025
	Shahdara	118280	High	06/09/2025
	Balloki	179730	V.High	01/09/2025
	Sidhnai	193470	E.High	03/09/2025
Sutlej	GS Wala	335591	E.High	04/09/2025
	Sulemanki	142451	High	05/09/2025
	Islam	125104	High	09/09/2025
	Mailsi Syphon	120151	High	09/09/2025
Kabul	Nowshera	46400	Normal	02/09/2025
Nullahs	Bein-R	10122	Medium	02/09/2025
	Deg-R	20515	Medium	03/09/2025
	Ura-C	20718	V.High	04/09/2025
	Basantar-R	4905	Medium	04/09/2025
	Palku-C	10930	High	04/09/2025
DG Khan	Kaura	23747	Normal	08/06/2025
	Vehova	11859	Normal	07/09/2025
	Sanghar	19096	Normal	02/09/2025
	Sori Lund	16206	Normal	02/09/2025
	Vidore	26767	Medium	02/09/2025
	S.Sarwar	973	Normal	08/09/2025
Rajanpur	Kaha	981	Normal	08/09/2025
	Kala Bagga Khosra	5157	Low	07/09/2025

Table 3: Maximum recorded Inflow/Peaks in September-2025

5.5 Rim stations Hydrographs of September 2025 are as below

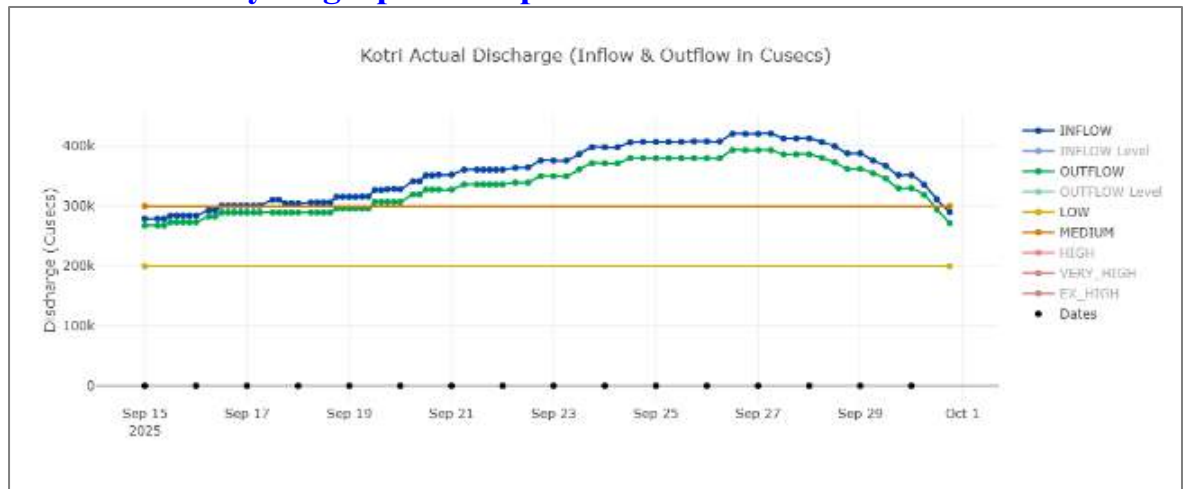


Fig-40(a)

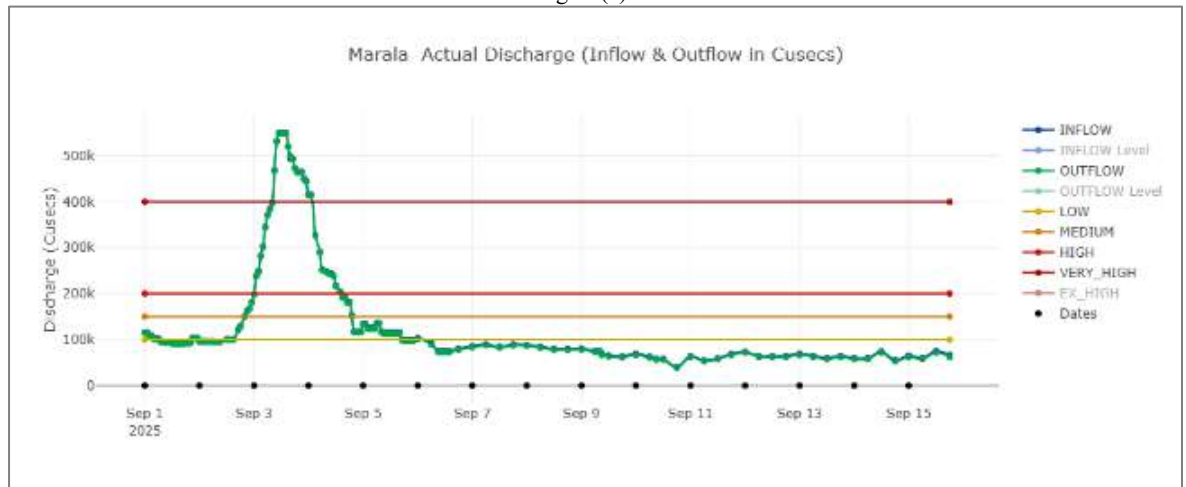


Fig-40(b)

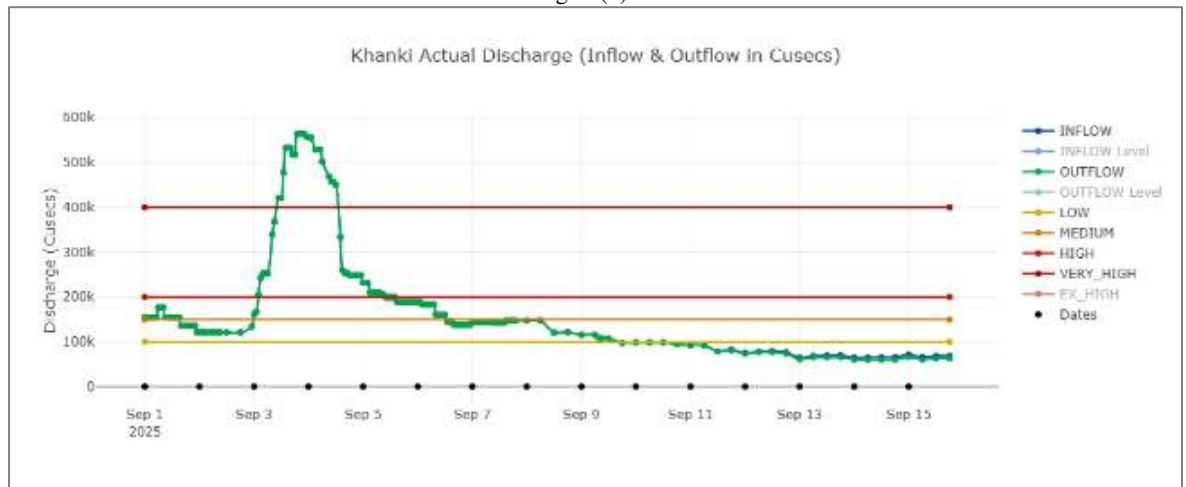


Fig-40(c)

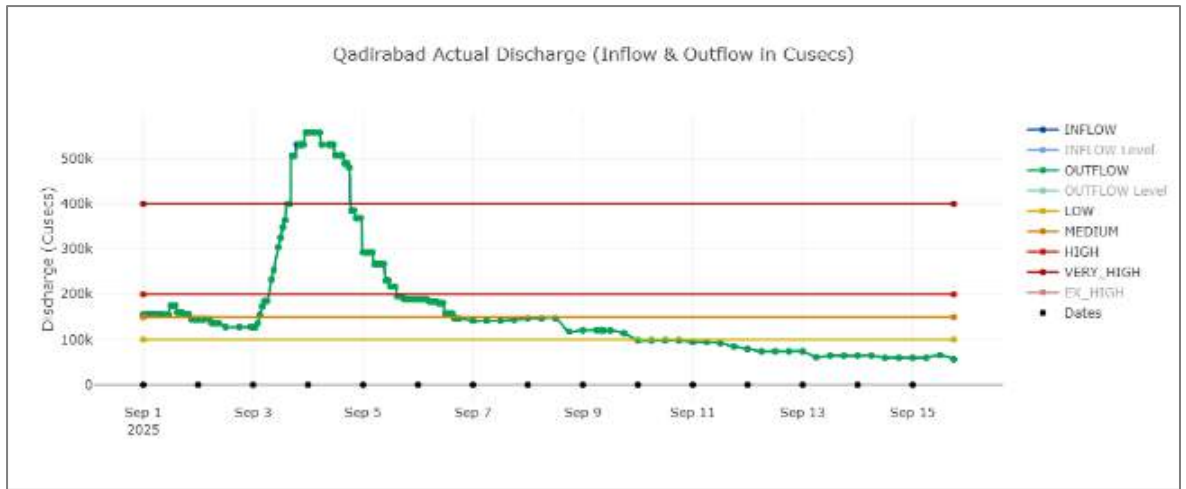


Fig-40(d)

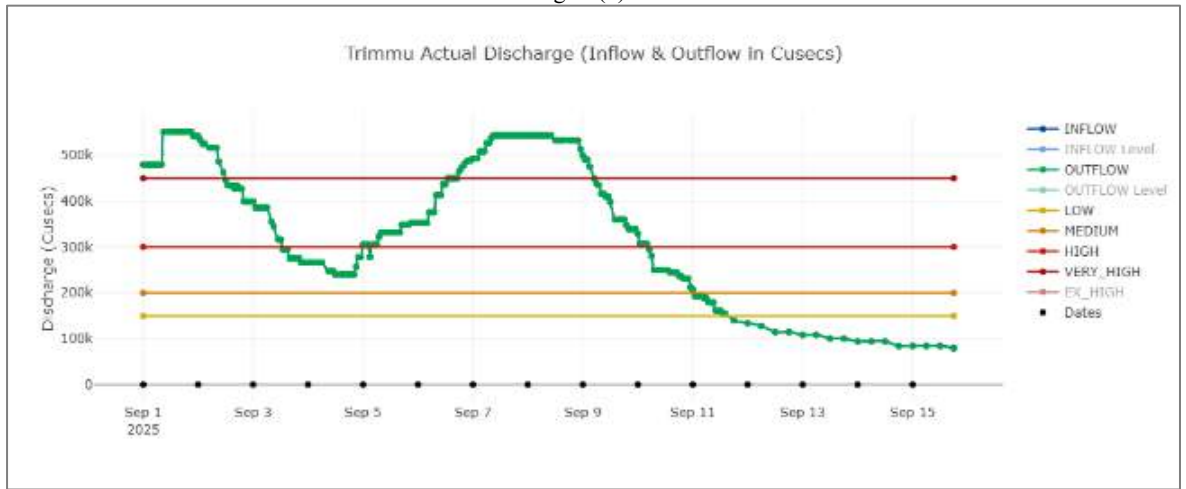


Fig-40(e)

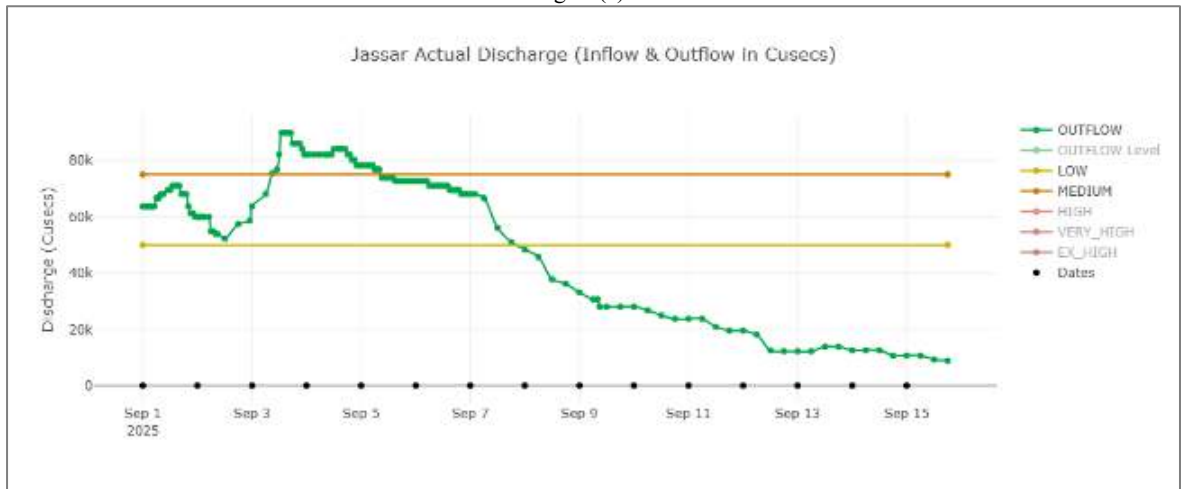


Fig-40(f)



Fig-40(g)

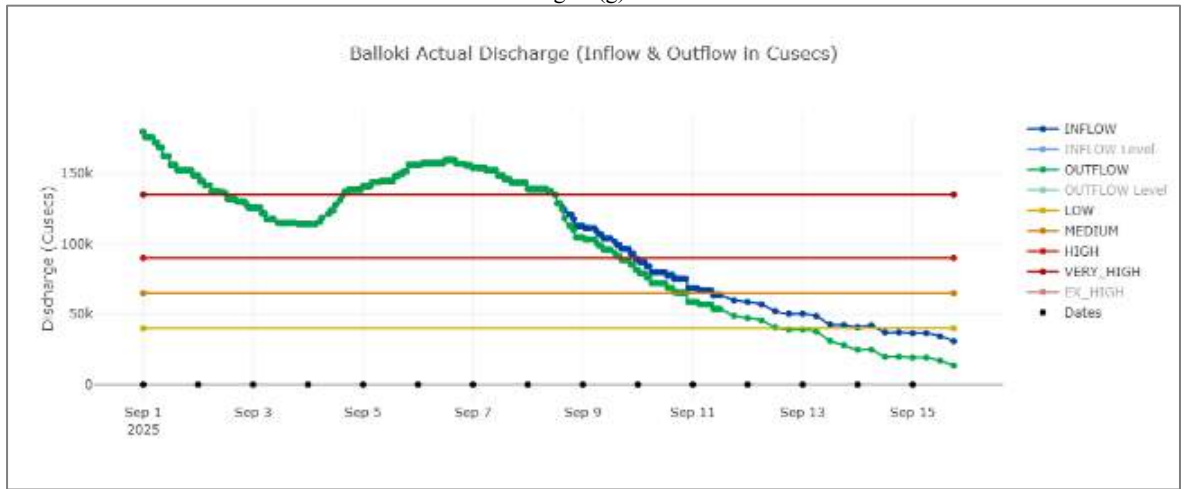


Fig-40(h)



Fig-40(i)

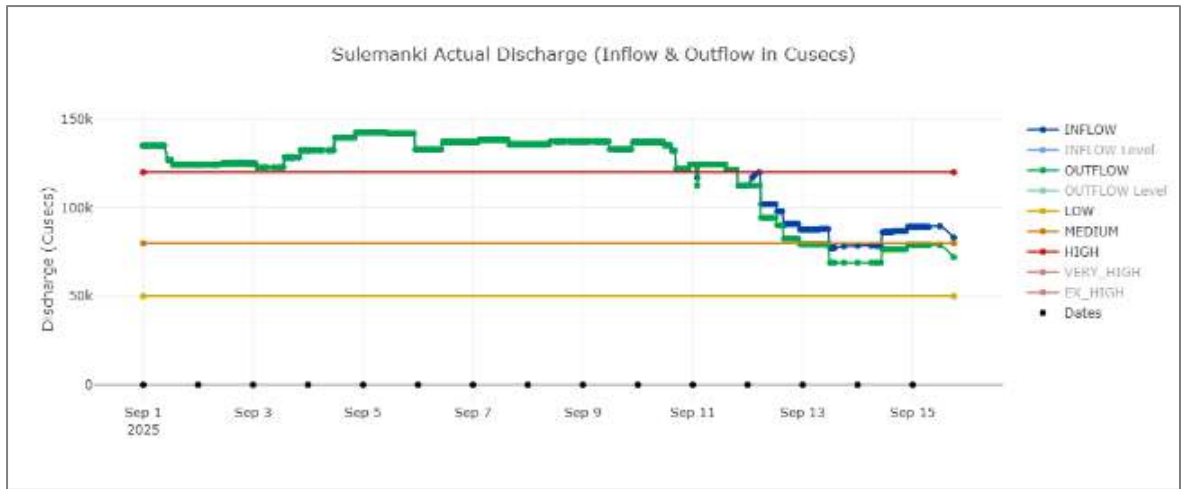


Fig-40(j)

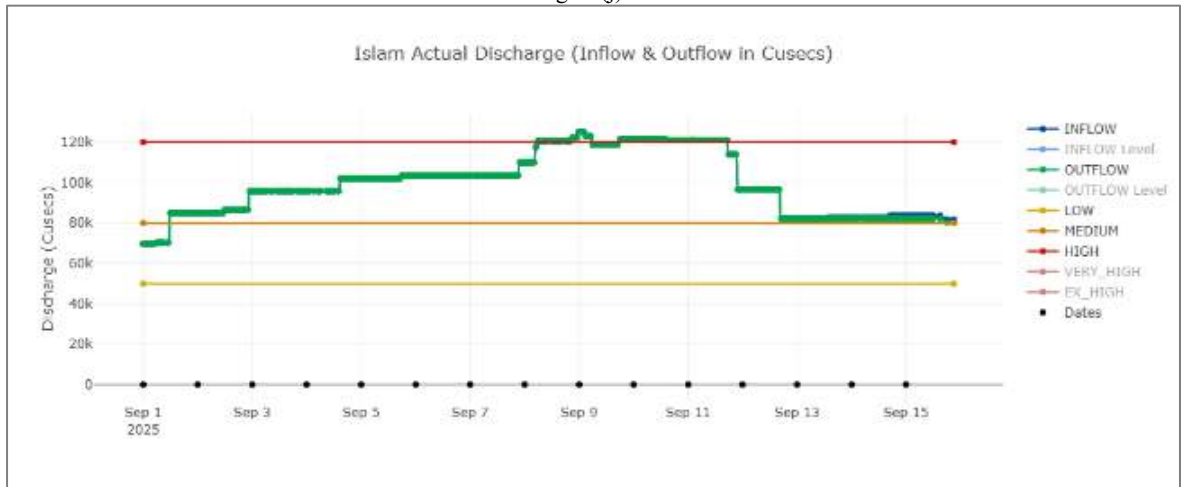
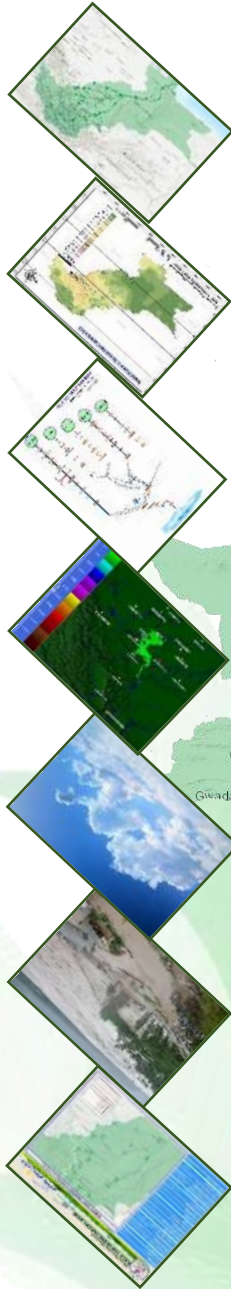


Fig-40(k)

Fig-(40) Rim Stations & Kotri Hydrograph of September-2025



SEASONAL

**Monsoon Low Tracks, Total
Rainfall, Departure & Area
Weighted Rainfall**



6 Tracks of Monsoon Lows during Monsoon Season-2025

During the 2025 monsoon season, nine distinct low-pressure systems and depressions formed over the Bay of Bengal, influencing weather patterns across the subcontinent. Their individual tracks are detailed below:

1st Monsoon Low (18–24 June 2025)

A well-marked low-pressure system developed over West Bengal and adjoining Jharkhand on 18 June. It moved westward into Jharkhand on 19 June, reaching northwest Jharkhand and adjoining areas by 20 June. The system weakened into a low-pressure area as it shifted northwestward, arriving in southwest Bihar on 21 June. It continued into southeast Uttar Pradesh on 22 June, moved westward into southern Uttar Pradesh on 23 June, and dissipated on 24 June.

2nd Monsoon Low (29 June–2 July 2025)

This system formed over the northwestern Bay of Bengal near the West Bengal coast on 29 June, remaining nearly stationary for a day. It then moved westward, reaching western Odisha by 1 July, before weakening and dissipating on 2 July.

3rd Monsoon Low (8–18 July 2025)

Developing over central West Bengal on 8 July, this low remained stationary for a day before moving westward into east Jharkhand on 10 July, where it intensified. It tracked west-northwestward into west Jharkhand (11 July), north Chhattisgarh (12 July), and north Madhya Pradesh (13 July). Drawing moisture from the Arabian Sea, it moved into east Rajasthan on 14 July, intensifying into a well-marked low over central Rajasthan on 15 July. The system then progressed toward Bahawalnagar (16 July) and Faisalabad (17 July), where it weakened into a low before dissipating on 18 July.

4th Monsoon Low (13–21 July 2025)

Forming south of West Bengal on 13 July, this system moved to east Jharkhand on 14 July, then northwestward into west Jharkhand (15 July) and slowly into northwest Jharkhand (16 July). It intensified into a well-marked low over northeast Madhya Pradesh on 17 July and further strengthened into a depression over northwest Madhya Pradesh on 18 July. It weakened back into a well-marked low over northwest Rajasthan on 19 July, then into a low upon reaching northeast Sindh on 20 July, before dissipating the next day.

5th Monsoon Low (25 July–2 August 2025)

This well-marked low developed over the northern Bay of Bengal on 25 July, moving westward to northwest Jharkhand by 26 July. It shifted into north Madhya Pradesh on 27 July, remaining stationary until 28 July, then slowly moved toward northwest Madhya Pradesh on 29 July, where it stalled again for a day. On 31 July, it tracked toward southwest Uttar Pradesh, continuing westward into west Haryana by 1 August, before dissipating on 2 August.

6th Low-Pressure System (18–27 August 2025)

Originating over the northwest Bay of Bengal on 18 August, this system intensified into a depression over southeast Odisha on 19 August. It weakened into a low-pressure area the next day and moved rapidly northwestward into central Chhattisgarh. On 21 August, it shifted westward over northwest Madhya Pradesh, then northward into southwest Uttar Pradesh by 22 August. Over the next two days, it lingered over northeast Rajasthan, re-intensified into a well-marked low over north Rajasthan, moved toward southern Punjab and adjoining Haryana on 26 August, weakened into a trough on 27 August, and dissipated.

7th Monsoon Low (28 August–3 September 2025)

This low developed over north Chhattisgarh on 28 August, moving northwestward to northeast Madhya Pradesh the next day and then westward to north Madhya Pradesh by 30 August. Upon reaching northwest Rajasthan on 31 August, it intensified into a well-marked low. It moved toward southwest Haryana and adjoining areas on 1 September, remained stationary for a day, weakened into a low, and further degenerated into a trough on 3 September.

8th Monsoon Low (2–10 September 2025)

Forming over the northwest Bay of Bengal on 2 September, this system remained stationary for a day before intensifying into a well-marked low. It moved northwestward into northern Odisha on 4 September and continued into northern Madhya Pradesh the next day. Changing direction to the southwest, it reached south Rajasthan on 6 September, where it intensified into a depression. It continued southwestward into southwest Rajasthan the following day and entered southeast Sindh as a depression on 8 September, lying near Hyderabad on 9 September. The system weakened into a low and moved southwestward toward the Arabian Sea south of Ormara, where it dissipated.

9th Monsoon Depression (26 September–5 October 2025)

The final system of the season developed over the western Bay of Bengal on 26 September, moving westward into southern Chhattisgarh the next day. It tracked rapidly northwestward into north Maharashtra on 28 September, then southwestward into southeast Gujarat on 29 September, where it weakened into a well-marked low and drifted slowly toward west Gujarat. On 1 October, it entered the northeast Arabian Sea, remained stationary for a day, and re-intensified into a depression. By 3 October, it further strengthened into a deep depression located about 400 km south of Karachi.

On 4 October, it intensified into Cyclonic Storm Shakti, moving away from Pakistan's coast (approx. 450 km south of Karachi). The storm continued westward, passing about 200 km from Masirah Island (Oman coast) on 5 October, before gradually moving southward, weakening, and dissipating.

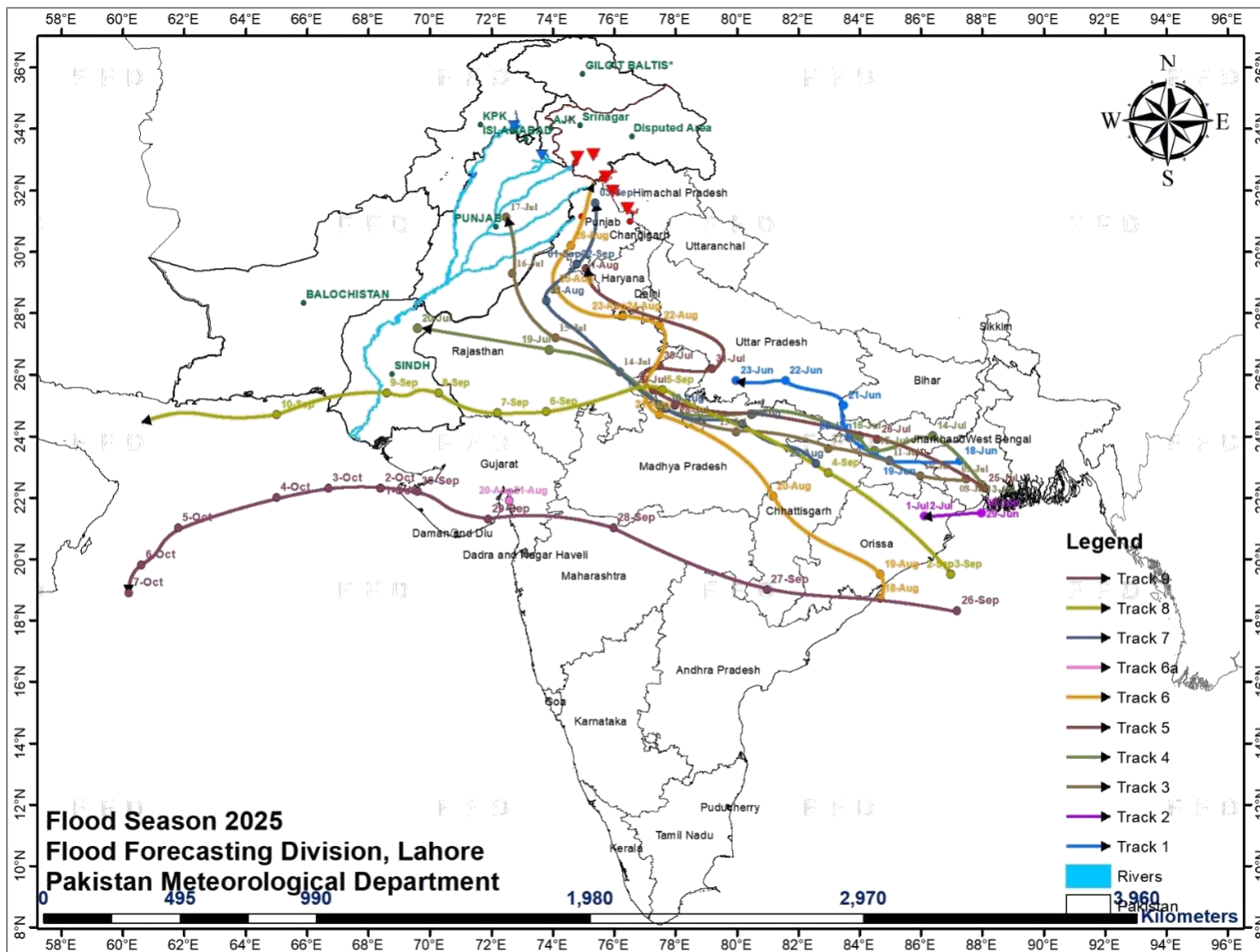


Fig-(41) Tracks of Monsoon Lows, Flood Season 2025

7 Seasonal rainfall pattern 1st Jul-30th Sep,2025.

From July through September 2025, Pakistan experienced multiple significant rainfall spells, primarily affecting the upper and eastern river catchments, driven by monsoon lows, depressions, and westerly waves. The first wet spell occurred in mid-July, with monsoon currents from both the Arabian Sea and Bay of Bengal penetrating the country. Rainfall was widespread over northern Punjab and Khyber Pakhtunkhwa, with heavier totals in the upper catchments of the Jhelum, Chenab, and Ravi Rivers. August saw two major wet spells. The first spell, combined with above-normal temperatures, accelerated snow and glacier melt in northern Pakistan, increasing flows in the Indus River at Tarbela. The second wet spell (mid- to late-August) produced exceptional rainfall over the Chenab, Ravi, and Sutlej catchments. Marala, Jassar, and Ganda Singh Wala recorded Exceptional High Floods, with prolonged high flows exacerbated by elevated Indian reservoir levels and tributary inflows. Sialkot Weather Radar indicated up to 362 mm of rainfall over 44–55 hours in the eastern catchments. Early September experienced a six-day wet spell driven by a northwestward-moving monsoon low from central India, supported by westerly waves and a seasonal low over Balochistan. Moderate to strong monsoon currents supplied moisture to the upper catchments of the eastern rivers, generating renewed flood peaks in Chenab, Ravi, and Sutlej. Exceptional High Flood conditions persisted at Ganda Singh Wala for nearly 14 days, while medium and very high flood peaks occurred at Jassar, Marala, and associated nullahs. Later in September, the southern and central parts of the country received localized rainfall, with limited impact on rim-station flows but aggravating flood conditions in southern Punjab and north Sindh.

Seasonal rainfall distribution during the period is presented in Fig-41(a). The point rainfall map in Fig-41(b) indicates that the region of maximum precipitation approximately 900 mm was observed over northern and northeastern Punjab, including Rawalpindi, Lahore, and Sialkot. Other areas receiving extreme rainfall exceeding 700 mm include Mandi Bahauddin, Mangla, Narowal, and Kakul. Rainfall recorded at other observatories during the season is also summarized below.

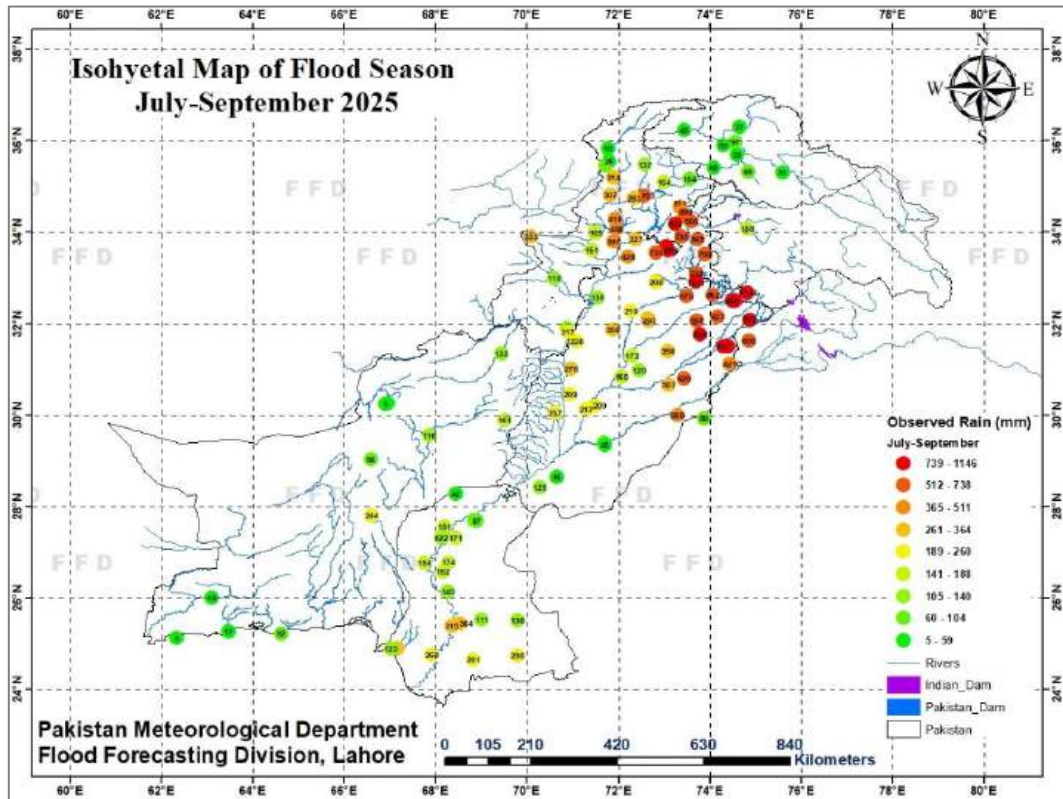


Fig (42-a) PMD Seasonal total rainfall

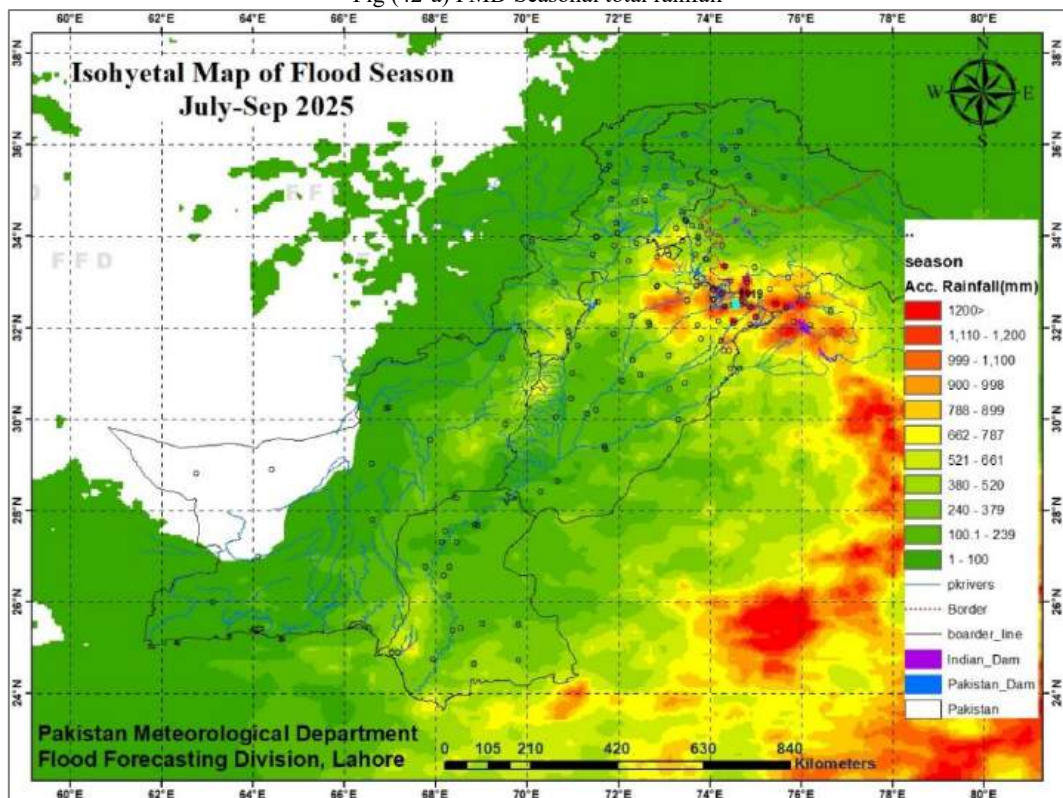


Fig (42-b) Seasonal PMD, Radar & Satellite total merged rainfall

Fig-(42) Seasonal Total Rainfall-2025

7.1 Departure Anomaly during the Season July-September 2025.

Monsoon rainfall during 2025 was above average (+23%) with national total rainfall of 172.8mm. Monsoon rainfall was above average over Punjab with (+34%), Gilgit Baltistan (GB) with (+31%), Balochistan with (+28%) and Sindh with (+26%). Whereas AJK with (+5) and Khyber Pakhtunkhwa (KP) with (+2%) were near average.

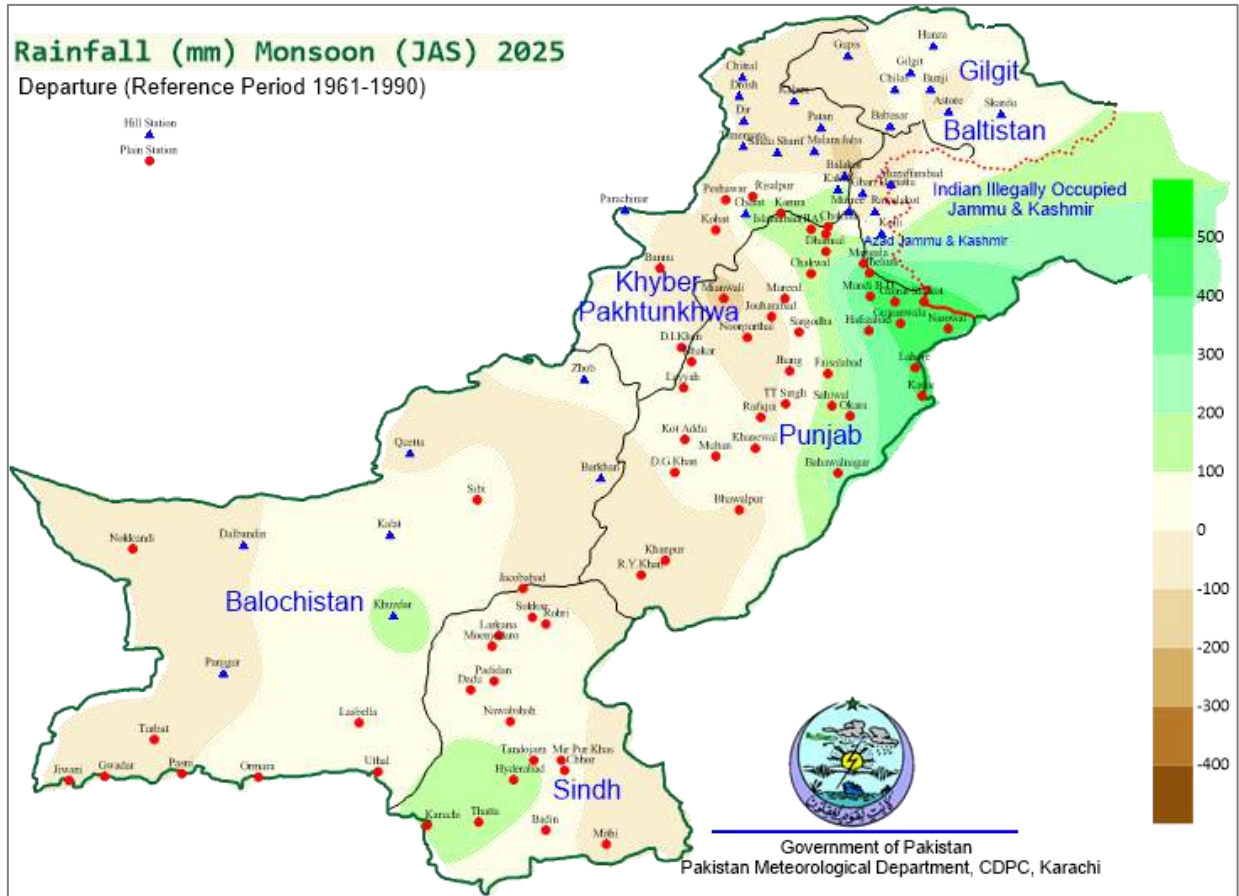


Fig-(43) Seasonal PMD Total Rainfall Departure July-Sep-25

7.2 Seasonal Area Weighted Rainfall July-September 2025.

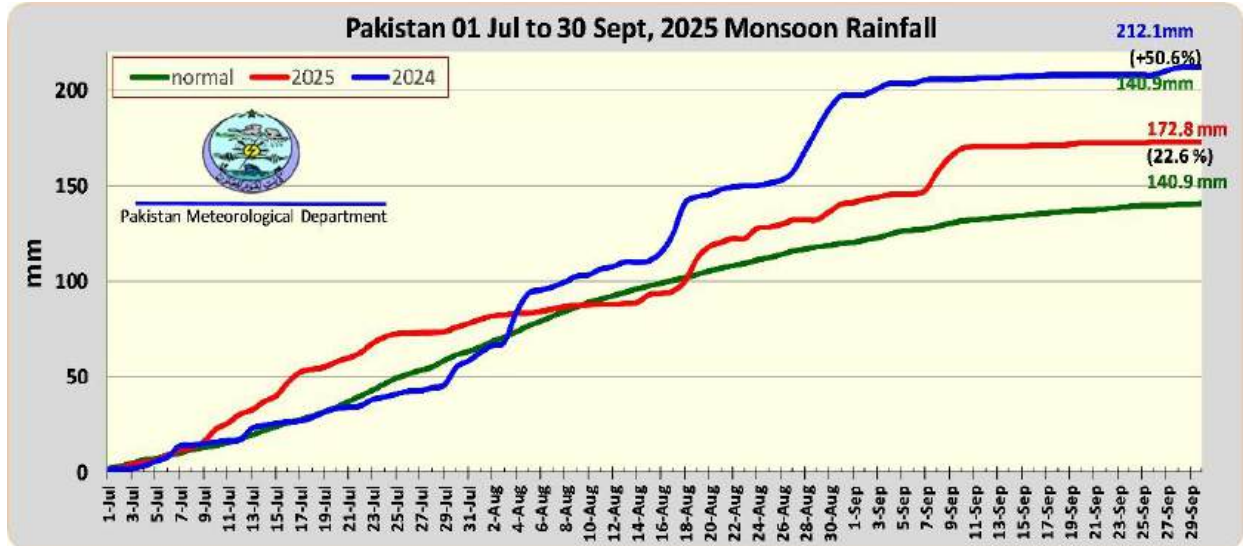


Fig-(44) Monsoon Progress & AWR Comparison July-Sept (JAS) 2025


MONSOON 2025 RAINFALL (mm)			
	01 Jul to 30 Sept, 2025 Rainfall		
	normal (mm)	actual (mm)	Deviation (%)
Pakistan	140.9	172.8	22.6
Azad J&K	389.5	407.8	4.7
Balochistan	58.3	74.8	28.2
Gilgit-B	39.7	51.9	30.6
Khyber-PK	256.3	260.6	1.7
Punjab	231.9	310.1	33.7
Sindh	133.7	168.8	26.2

Fig-(45) Monsoon AWR July-Sept (JAS) 2025.

7.3 Average/Normal Monsoon (JAS) Rainfall.

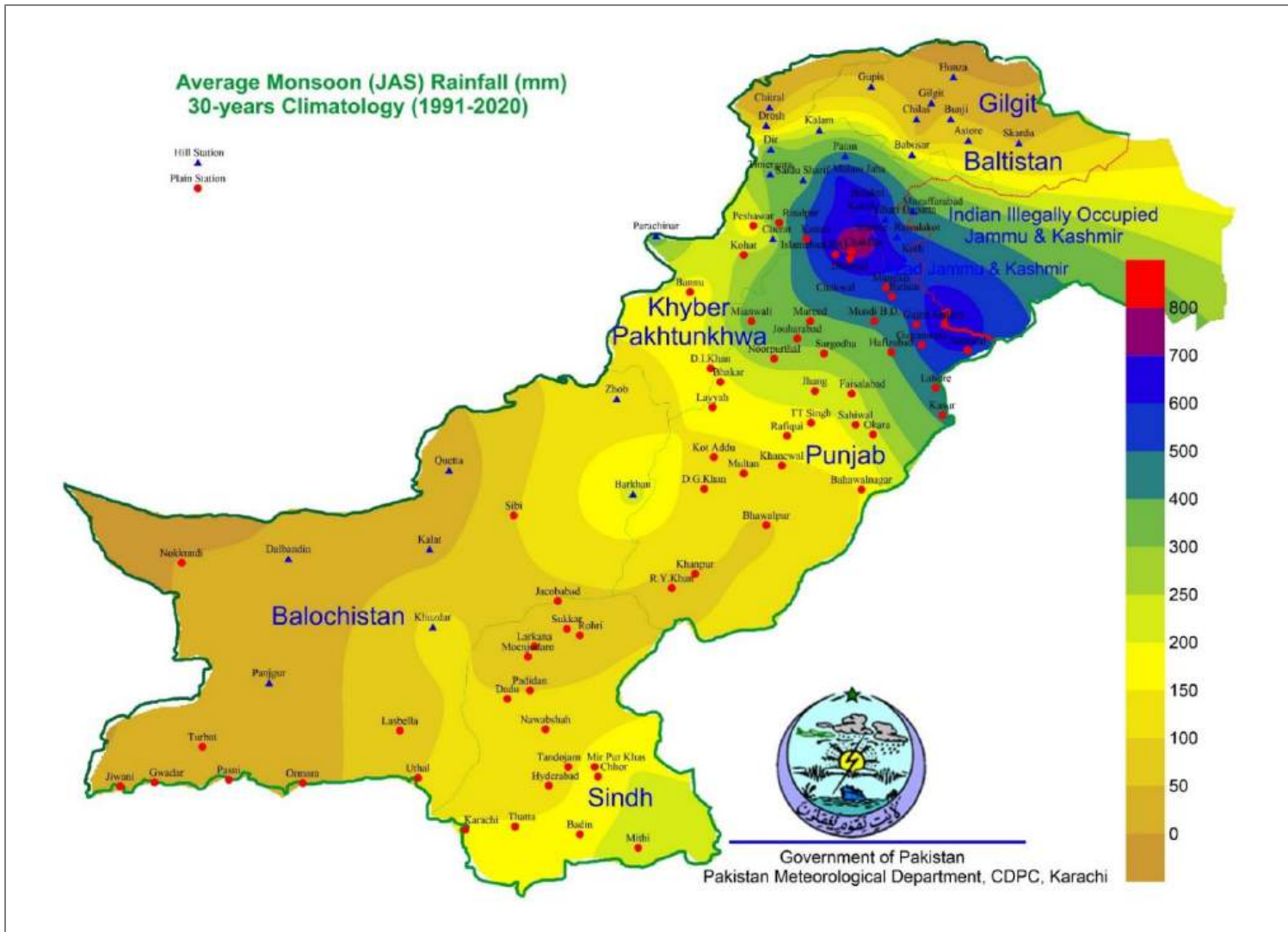
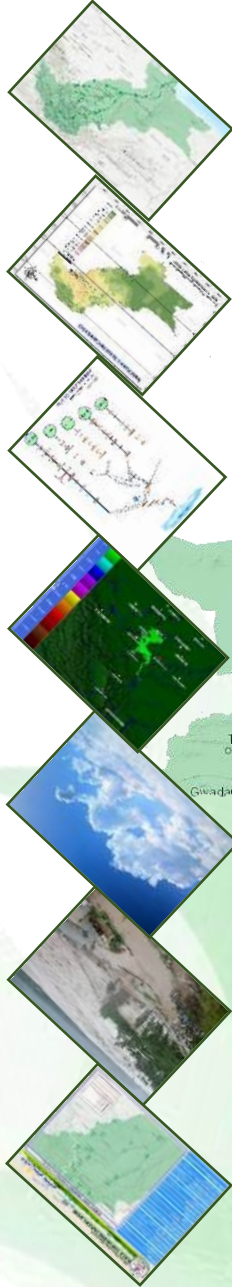


Fig-(46) Seasonal PMD Climate normal (JAS)



Conclusion & Recommendations



8 Conclusion & Recommendations.

8.1 Synthesis and Hydro meteorological Insights:

The 2025 Monsoon Season stands as a definitive case study in the complex interplay of atmospheric dynamics, hydrological response, and human-induced factors that drive severe flooding in Pakistan. This report has meticulously chronicled the sequence of hydro-meteorological events, revealing a pattern of compounded risks that tested forecasting systems and infrastructure resilience to their limits. The season was not defined by a single cataclysmic event, but by a cascading series of interconnected phenomena, underscoring the multifaceted nature of modern flood disasters.

8.2 Hydro-Meteorological Synthesis of the Season:

The season's character was shaped by a persistent and vigorous synoptic regime. A quasi-stationary seasonal low over Balochistan acted as a semi-permanent moisture sink, while the frequent interaction between penetrating westerly waves and the monsoon trough created repeated episodes of enhanced uplift and convergence. This interaction was the primary catalyst for the major rainfall spells, particularly in July and August.

The nine tracked monsoon low-pressure systems and depressions, originating from the Bay of Bengal, served as dynamic moisture pumps. Their westward trajectories, often steered by mid-level westerlies, determined the spatial focus of extreme precipitation. The most impactful systems (notably the third, sixth, and eighth lows) took paths that directed their moisture plumes directly into the upper catchments of the eastern rivers (Chenab, Ravi, Sutlej) and the Jhelum basin. The Sialkot Weather Radar data was pivotal, quantifying these transboundary precipitation events where ground data was absent, revealing staggering accumulations up to 570 mm over 55 hours in the eastern catchments during the late-August spell.

A critical, non-meteorological amplifier was the anthropogenic hydrological management upstream. With major Indian reservoirs (Thein, Pong, Bhakra) at 80-87% capacity ahead of the peak spells, significant and sustained regulated releases were necessitated by incoming flood waves. These managed discharges synchronized with heavy natural rainfall-runoff downstream, creating a "piggyback" effect that led to the Exceptional High Flood (EHF) levels. The Sutlej River at Ganda Singh Wala exemplified this, where EHF conditions persisted for approximately 346 hours (14 days), a duration overwhelmingly influenced by controlled spill from upstream dams.

Persistently high temperatures (Annex-L & M) in Gilgit-Baltistan and Khyber Pakhtunkhwa (e.g. 48.5°C at Chilas) accelerated snow and ice melt in the upper Indus catchment. This meltwater contributed to elevated base flows in the Indus system, which were then superimposed upon flood waves generated by monsoon rainfall, leading to prolonged Medium to High Flood levels at Tarbela and downstream barrages.

8.3 Operational Response and Hydro-Meteorological Forecasting Challenges:

The FFD's performance was commendable within significant constraints. The accurate prediction of wet spell timing and intensity allowed for qualitative warnings of "Exceptionally High Flood" risks. Effective coordination for reservoir management at Tarbela and Mangla was a success in hydrological mitigation, preventing catastrophic releases.

However, profound challenges were exposed:

1. The Transboundary Data Blackout: The suspension of the Indus Waters Treaty data-sharing mechanism transformed a hydro-meteorological forecasting exercise into a hydro-meteorological estimation crisis. The lack of real-time inflow data at the rim stations (Marala, Jassar, G.S. Wala) during critical rising limbs of the hydrograph removed the primary hydrological input for flood routing models. Forecasting relied on extrapolation from radar-estimated rainfall and delayed qualitative advisories, inherently increasing uncertainty in peak timing and magnitude.

2. The Need for Integration: The events underscored the insufficiency of models that treat meteorological and hydrological processes in silos. Future systems must seamlessly integrate:

- Radar- and satellite-based Quantitative Precipitation Estimates (QPE) and Forecasts (QPF).
- Snowmelt and Glacial Melt Modules driven by temperature and radiation data.
- Reservoir Operation Algorithms to account for anthropogenic flow regulation.
- Distributed Hydrological Models for the transboundary catchments.

8.4 Strategic Recommendations for a Hydro-Meteorologically Resilient Future:

1. Establish Redundant Transboundary Monitoring: While diplomatic efforts to restore treaty mandated data sharing are paramount, we must concurrently invest in independent monitoring capacity. This includes expanding the radar network along the eastern border, deploying satellite-based river discharge measurement techniques, and enhancing hydrological intelligence gathering.

2. **Compound Flood Forecasting:** Development of a National Compound Flood Forecast Model. This model would concurrently simulate fluvial floods from rainfall, swell floods from snow/glacier melt, and the influence of reservoir operations, providing a unified assessment of total water-related risk.

3. **Enhance Forecast Product Specificity:** Move beyond basin-wide warnings to impact-based forecasting. Products should explicitly link forecasted hydro-meteorological conditions (e.g., "300mm of rain in 48 hours over the Chenab headwaters, coinciding with high releases from upstream reservoirs") to expected impacts on specific infrastructures and communities.

4. **Fortify Hydrometric Infrastructure:** Prioritize the modernization and expansion of the national stream gauge network, ensuring real-time telemetry and robustness against extreme events. This is essential for ground-truthing radar/satellite data and improving model calibration.

5. **Foster Hydro-Meteorological Literacy:** Build capacity within disaster management agencies and the public to understand the nuanced drivers of floods—not just "heavy rain," but the combination of depression tracks, westerly wave interactions, upstream reservoir levels, and temperature-driven melt.

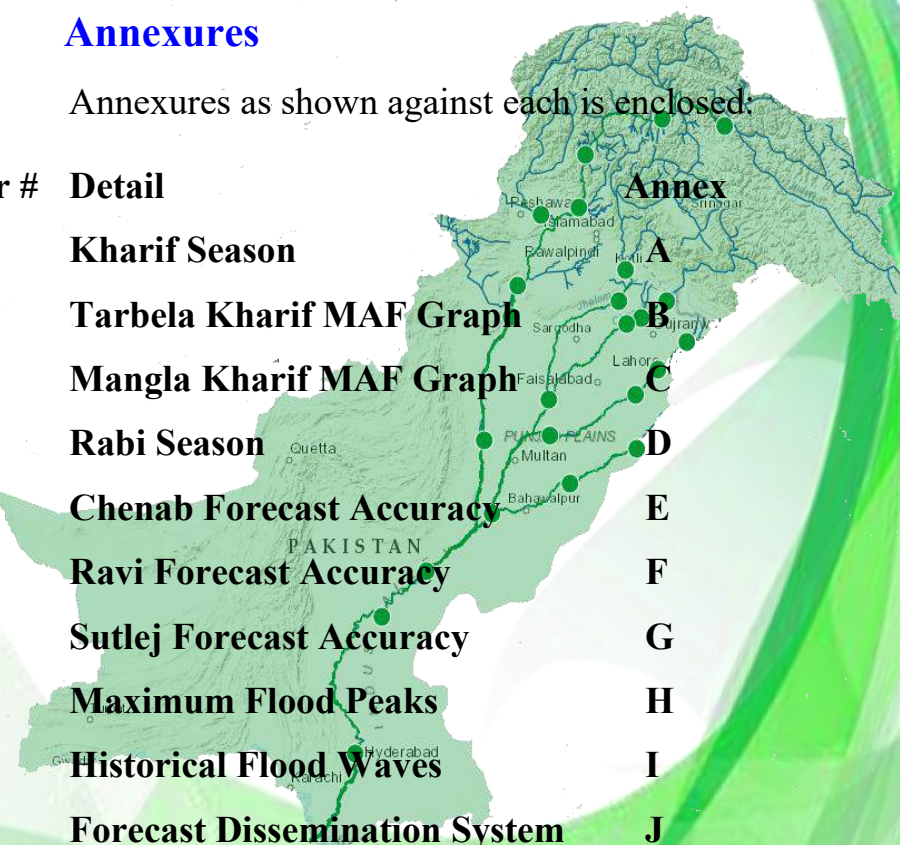
8.5 Conclusion:

The 2025 floods were a powerful demonstration of hydro-meteorology in action, where the atmosphere's behavior dictated the hydrology of the plains, and human water management decisions downstream. The season revealed that Pakistan's flood vulnerability is now a product of a quadruple nexus: intensified meteorological events due to climate change, complex hydrological responses across transboundary basins, critical geopolitical constraints on data and the geomorphological modifications in the river channels by human interventions. The path forward demands a paradigm shift from reactive flood fighting to proactive hydro-meteorological risk governance. By leveraging observational technology, advancing predictive science, and insisting on data transparency, Pakistan can transform its forecasting system from one that primarily warns of floods to one that comprehensively manages water-related risks in an era of climate and geopolitical uncertainty.

9 Annexures

Annexures as shown against each is enclosed:

Sr #	Detail	
a	Kharif Season	A
b	Tarbela Kharif MAF Graph	B
c	Mangla Kharif MAF Graph	C
d	Rabi Season	D
e	Chenab Forecast Accuracy	E
f	Ravi Forecast Accuracy	F
g	Sutlej Forecast Accuracy	G
h	Maximum Flood Peaks	H
i	Historical Flood Waves	I
j	Forecast Dissemination System	J
k	Flood Limits	K
l	Max Temp Anomalies (JAS-2025)	L
M	Min Temp Anomalies (JAS-2025)	M



Annex-A

Kharif Season Water Availability (MAF) Forecast.

The water availability (in MAF) forecast on the basis of prevailing hydrometeorological conditions was issued on 19th March 2025 for River Indus at Tarbela & for River Jhelum at Mangla. A comparison of forecasted and observed volume (MAF) is shown below.

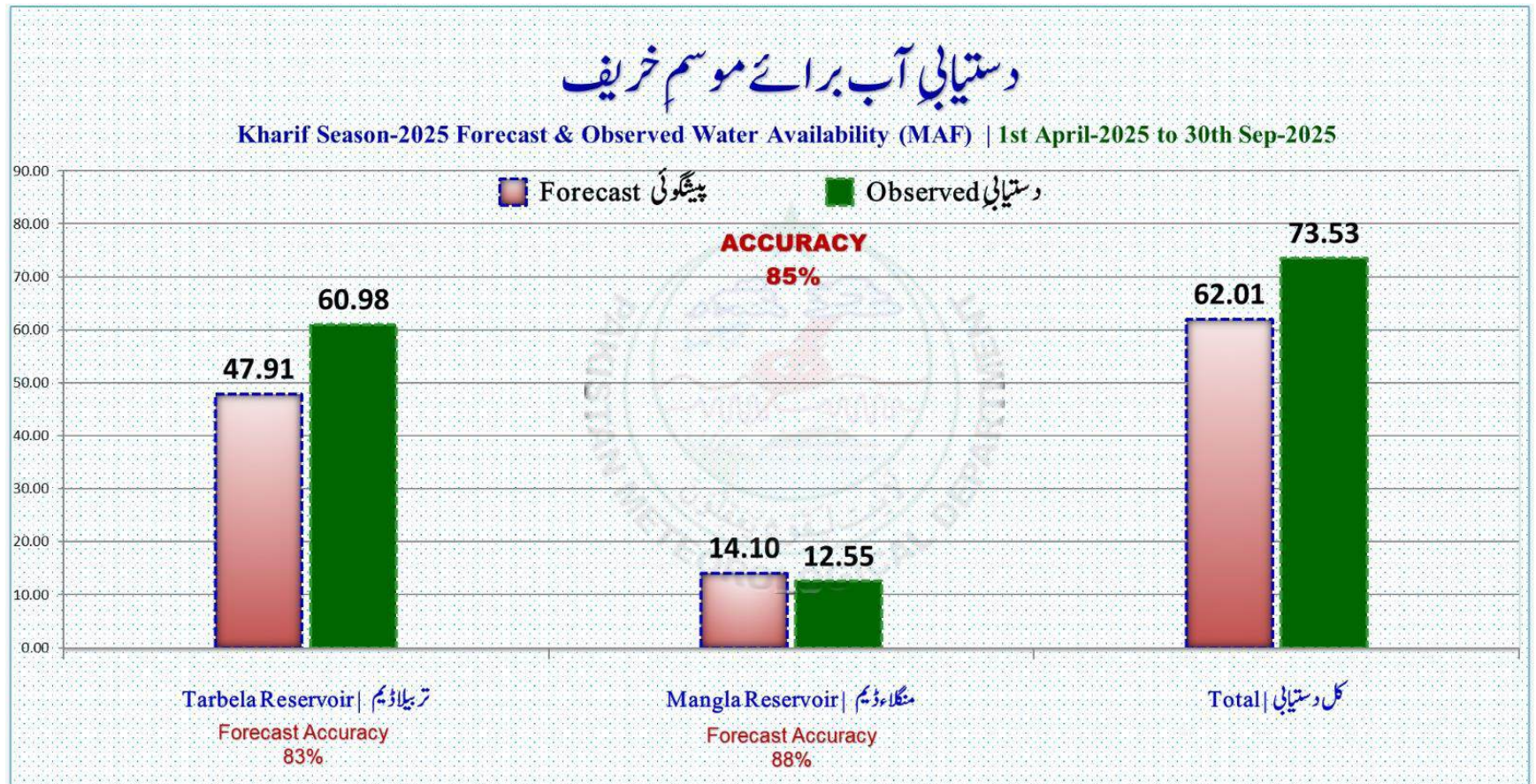


Fig-(47) Kharif Season forecasted & Observed MAF (April-Sep-25).

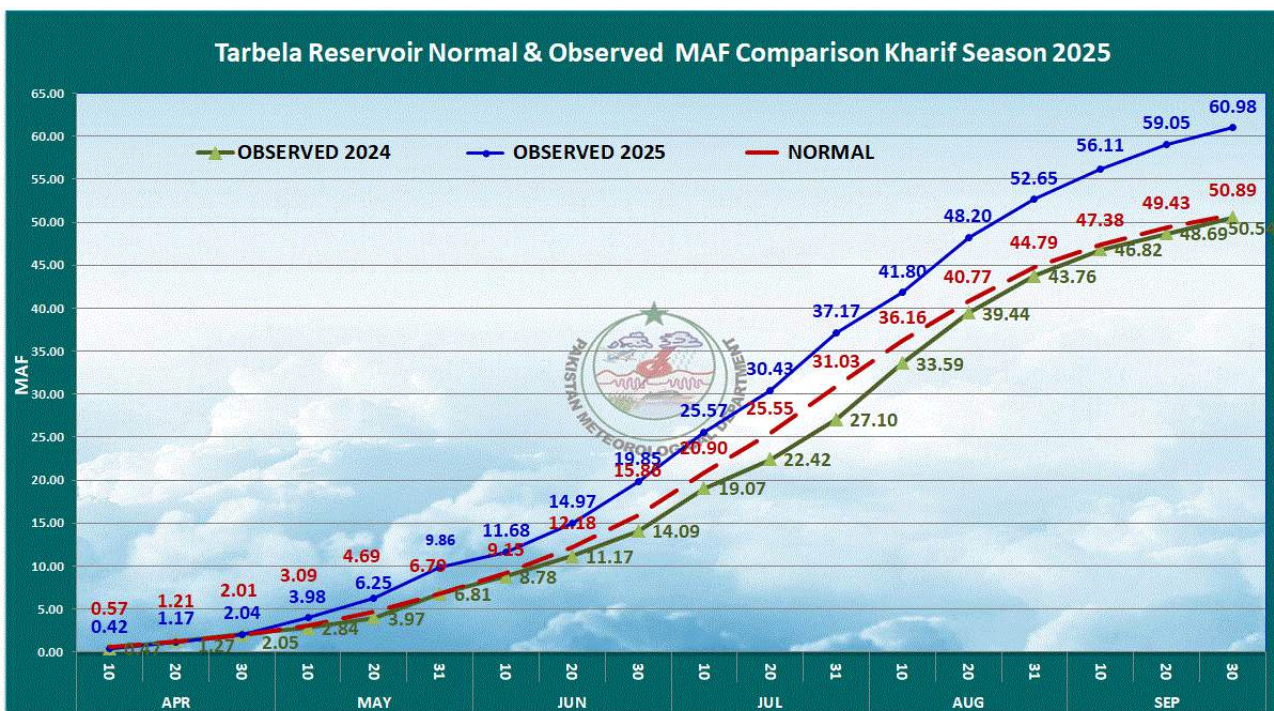


Fig-(48) Kharif Season Tarbela Observed MAF (April-Sep-25)

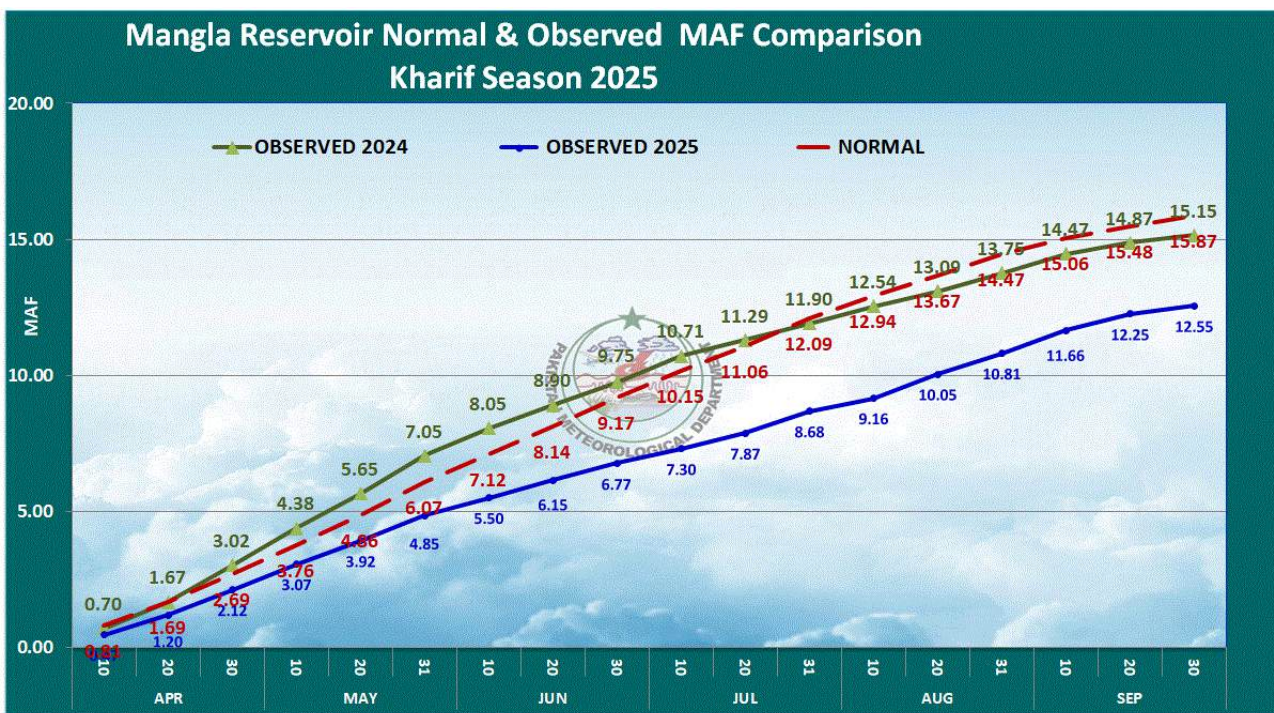


Fig-(49) Kharif Season Mangla Observed MAF (April-Sep-25)

Rabi Season Water Availability (MAF) Forecast.

Similarly, the water availability forecast for Rabi season is issued on 06th October 2025 for River Indus at Tarbela & for River Jhelum at Mangla and is shown below.

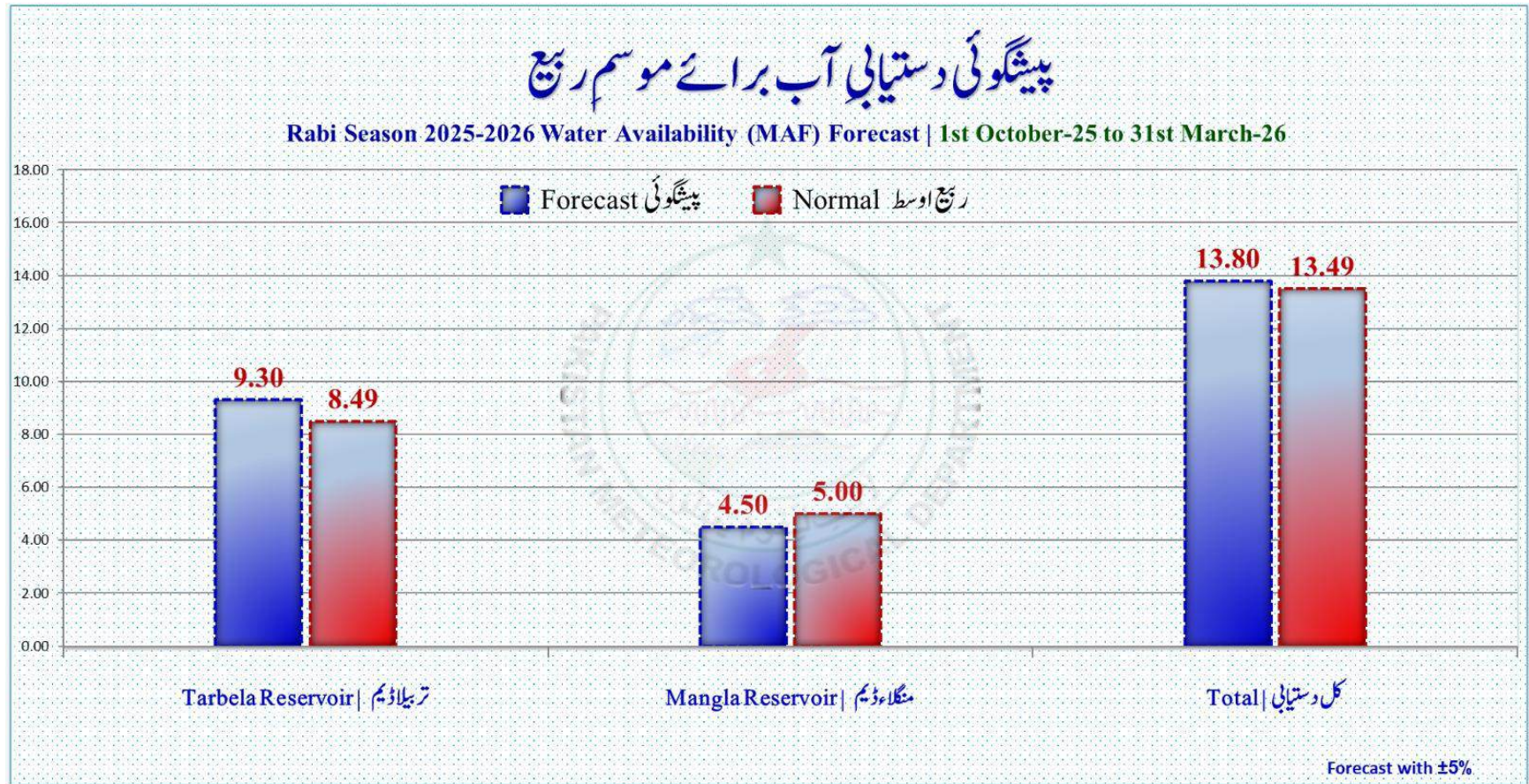


Fig-(50) Rabi Season forecast MAF (Oct-2025 to March-2025)

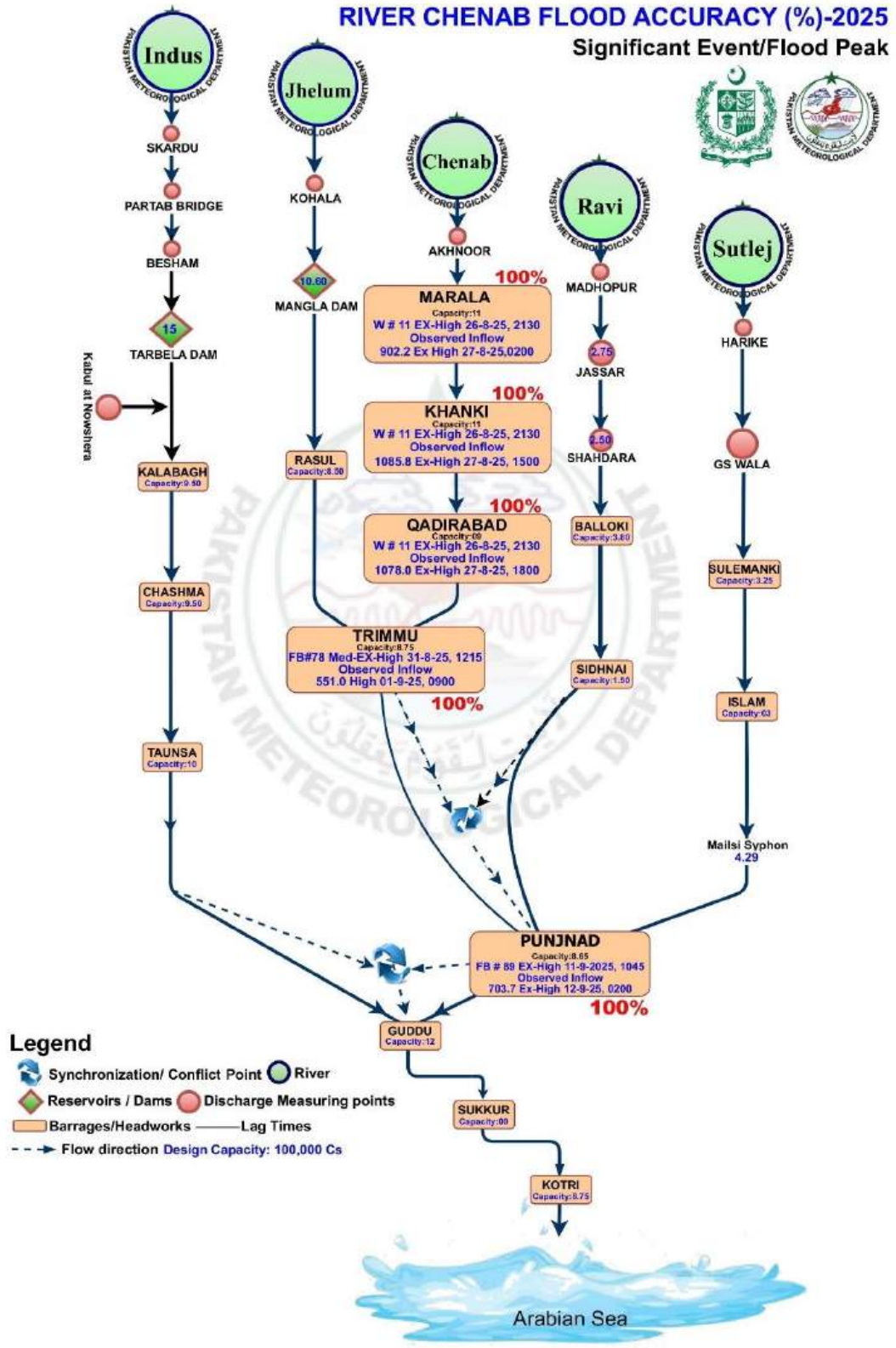


Fig-(51) Chenab Flood Forecast Accuracy 2025

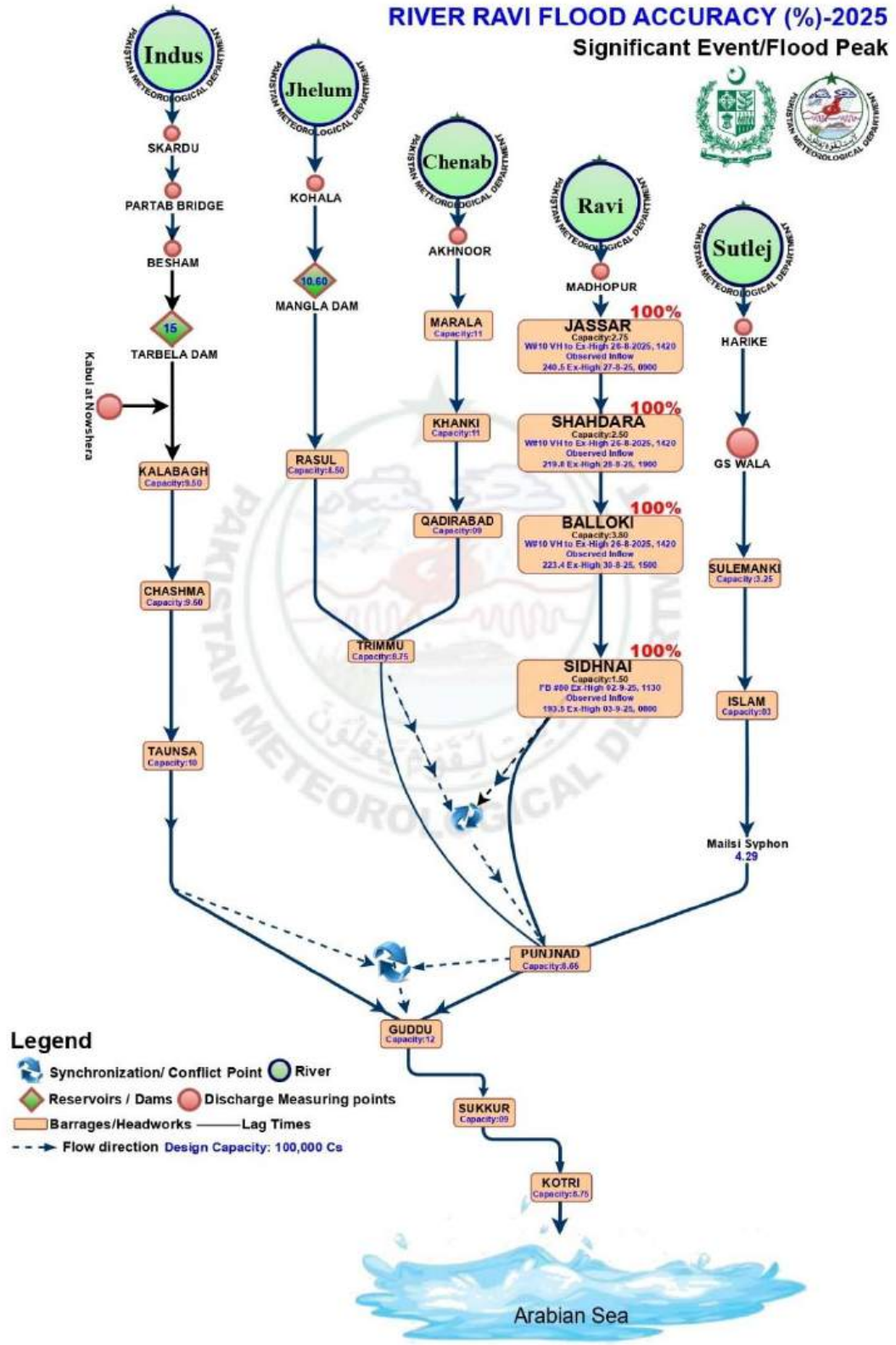


Fig-(52) Ravi Flood Forecast Accuracy 2025

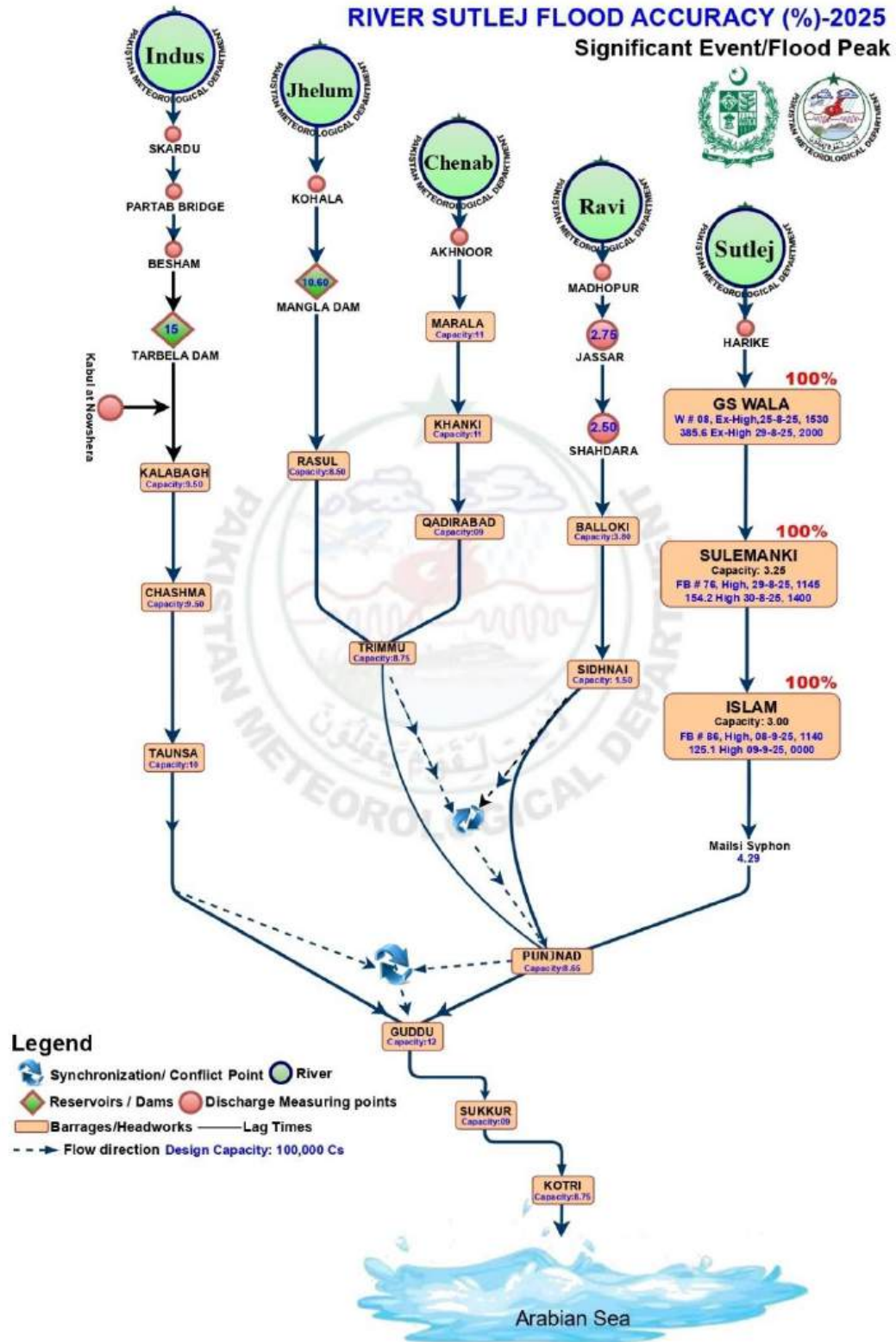


Fig-(53) Sutlej Flood Forecast Accuracy 2025

Maximum Flood Peaks Discharge (Cusecs) during Flood Season-2025.

Maximum Flood Peaks recorded during Flood Season-2025 is shown below

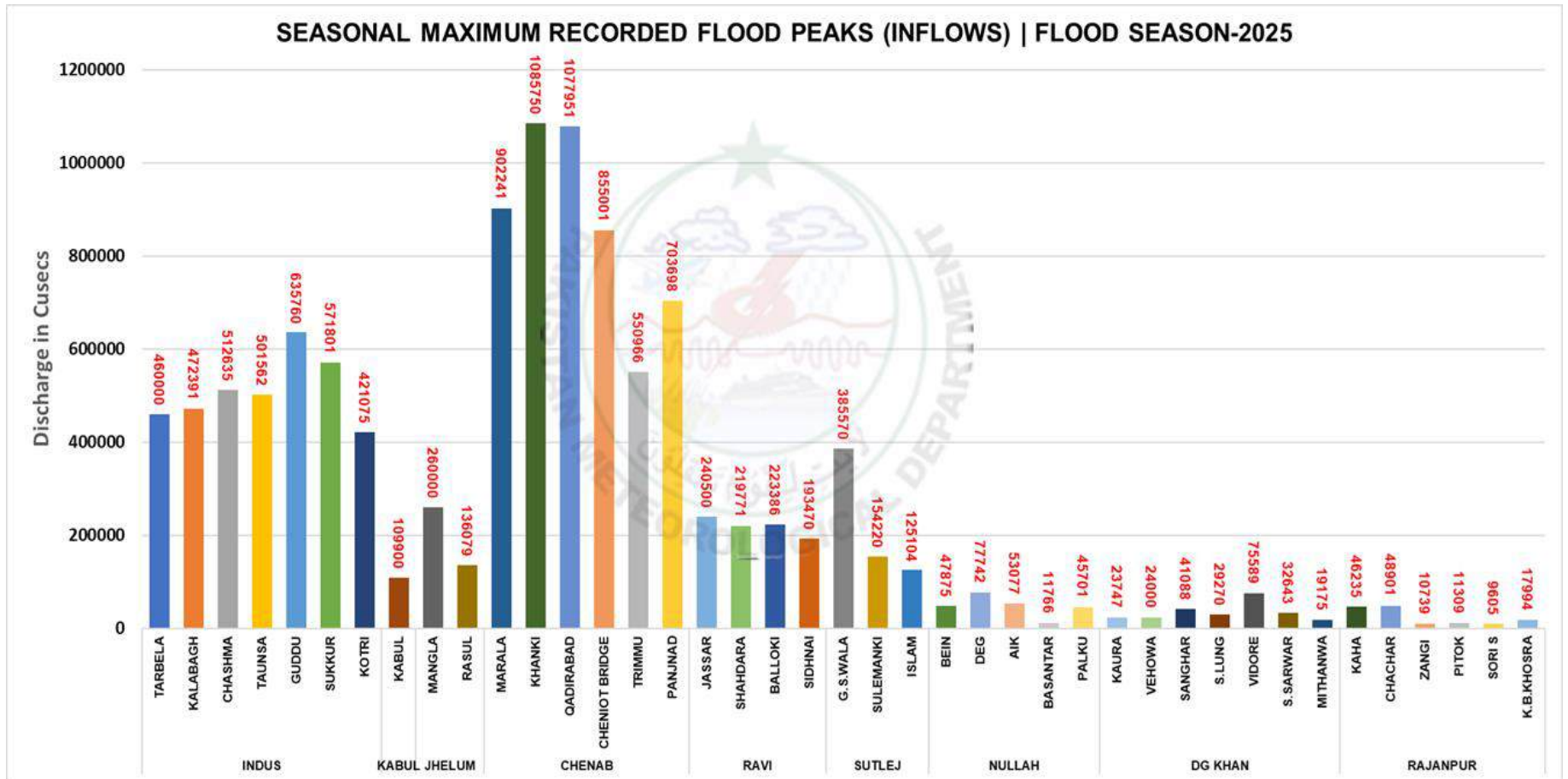


Fig-(54) Maximum Observed Peaks 2025

Historical Flood Waves during Flood Seasons.

FLOOD WAVES											
1st, 2nd, 3rd Historical Flood Waves River's Maximum Observed Peaks Discharge											
During Monsoon (15th June - 15th October) Since 1928											
River	Site	Design Capacity	1st Wave			2nd Wave			3rd Wave		
			Cusecs	Date	Flood level	Cusecs	Date	Flood level	Cusecs	Date	Flood level
Indus	Tarbela	1500000	832000	30-07-2010	EH	510000	31-07-1989	H	500000	10-09-1992	H
	Kalabagh	950000	950005	14-07-1942	EH	937453	30-07-2010	EH	862000	02-08-1976	EH
	Chashma	950000	1038873	01-08-2010	EH	786600	03-08-1976	VH	689100	29-08-1983	VH
	Taunsa	1000000	959991	02-08-2010	VH	789000	22-07-1958	VH	675233	07-08-1976	VH
	Guddu	1200000	1199672	15-08-1976	EH	1172292	13-08-1986	EH	1162653	31-07-1988	EH
	Sukkur	900000	1166574	15-08-1986	EH	1161000	16-08-1976	EH	1130220	09-08-2010	EH
	Kotri	875000	980329	14-08-1956	EH	964897	27-08-2010	EH	826369	25-08-1994	EH
Jhelum	Mangla	1060000	1090000	10-09-1992	EH	1060000	29-08-1929	EH	1045000	04-07-1959	EH
	Rasul	850000	952170	10-09-1992	EH	876000	05-07-1959	EH	875000	29-08-1929	EH
Chenab	Marala	1100000	1100000	26-08-1957	EH	902240	27-08-2025	EH	870795	05-07-1959	EH
	Khanki	1100000	1086410	27-08-1959	EH	1085750	27-08-2025	EH	1021018	05-07-1959	EH
	Qadirabad	900000	1077952	27-08-2025	EH	948530	11-09-1992	EH	904285	07-09-2014	EH
	Trimmu	875000	944333	04-09-1928	EH	888117	14-09-1992	EH	706433	06-08-1976	EH
	Panjand	865000	802516	17-08-1973	EH	744152	18-09-1992	EH	710000	12-08-1976	EH
Ravi	Jassar	275000	680000	04-10-1955	EH	Overflow	25-09-1988	EH	328000	27-08-1957	EH
	Shahdara	250000	576000	27-09-1988	EH	542000	06-10-1955	EH	237380	11-08-1973	EH
	Balloki	380000	389845	28-09-1988	EH	275000	22-09-1950	EH	275000	08-10-1955	EH
	Sidhnai	150000	330210	02-10-1988	EH	244348	15-08-1976	EH	212340	12-09-1995	EH
Sutlej	Sulemanki	325000	598872	08-10-1955	EH	399453	30-09-1988	EH	360412	30-09-1947	EH
	Islam	300000	492581	11-10-1955	EH	308425	04-10-1988	EH	285254	04-10-1947	EH

Note: H=High VH=Very High EH= Exceptionally High

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Table 4: Historical Flood Waves

Flood Forecast Dissemination

Annex-J

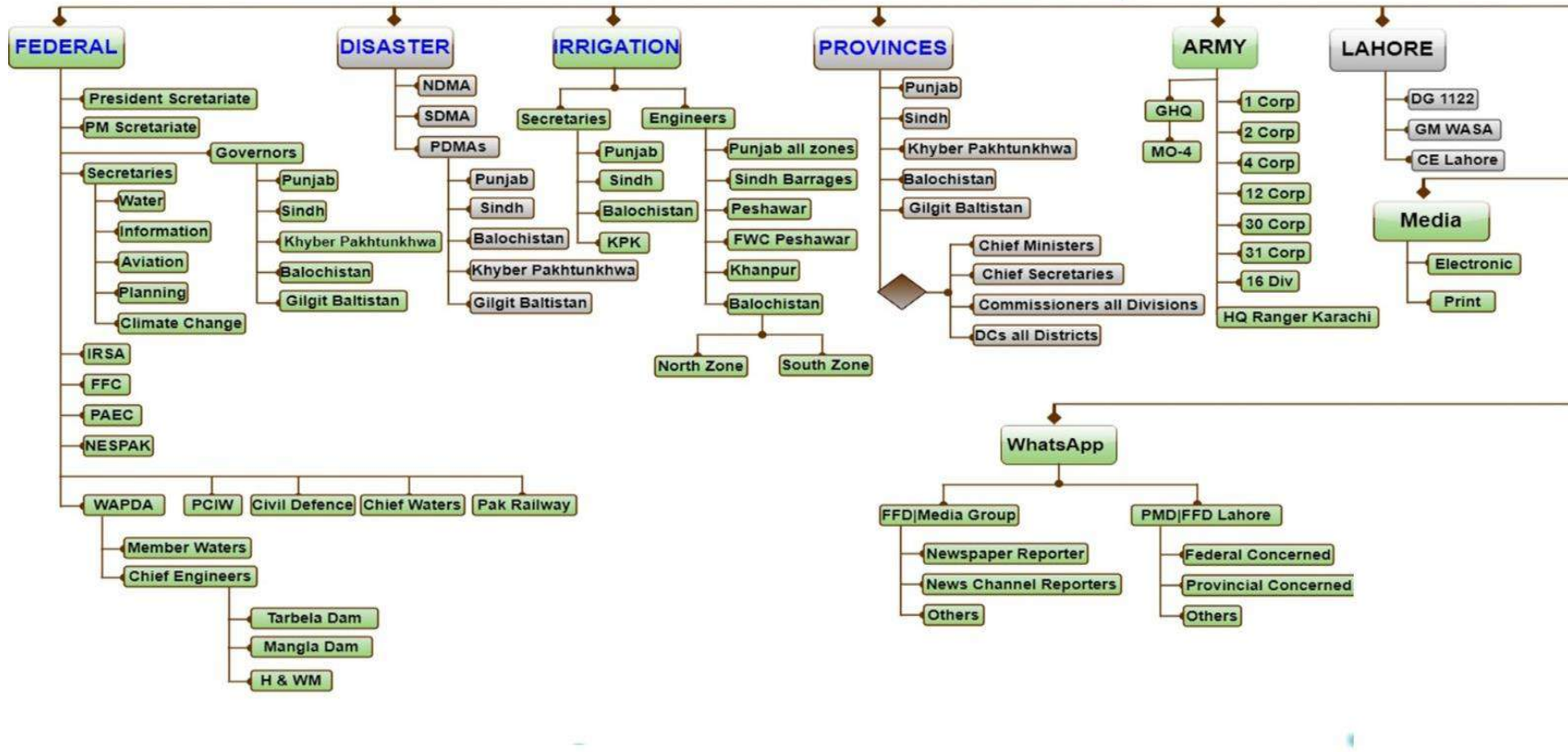


Fig-(55) Flood Forecast Dissemination Chart

Flood limits (in lakhs of cusecs)

Annex-K

River	Station	Design	Low	Medium	High	Very High	Exceptional
Indus River	Tarbela	15	2.5	3.75	5	6.5	8
	Attock	-	2.5	3.75	5	6.5	8
	Kalabagh	9.5	2.5	3.75	5	6.5	8
	Chashma	9.5	2.5	3.75	5	6.5	8
	Taunsa	10	2.5	3.75	5	6.5	8
	Guddu	12	2	3.5	5	7	9
	Sukkur	9	2	3.5	5	7	9
	Kotri	8.75	2	3	4.5	6.5	8
Jhelum River	Kohala	-	1	1.5	2	3	4
	Mangla	10.6	0.75	1.1	1.5	2.25	3
	Rasul	8.5	0.75	1.1	1.5	2.25	3
Chenab River	Jammu Tawi	-	0.2	0.7	0.83	1.7	-
	Akhnur	-	0.75	1.97	2.97	3.5	-
	Marala	11	1	1.5	2	4	6
	Khanki	11	1	1.5	2	4	6
	Qadirabad	9	1	1.5	2	4	6
	Chinot Bridge	8.07	1	1.5	2	4	6
	Trimmu	8.75	1.5	2	3	4.5	6
	Panjnad	8.65	1.5	2.5	4	5.5	7
Ravi River	Jassar	2.75	0.5	0.75	1	1.5	2
	Syphon	4.5	0.4	0.65	0.9	1.35	1.8
	Shahdara	2.5	0.4	0.65	0.9	1.35	1.8
	Balloki	3.8	0.4	0.65	0.9	1.35	1.8
	Sidhnai	1.5	0.3	0.46	0.6	0.9	1.3
Sutlej River	Suleimanki	3.25	0.5	0.8	1.2	1.75	2.25
	Islam	3	0.5	0.8	1.2	1.75	2.25
	G.S. Wala	-	0.5	0.8	1.2	1.75	2.25
NULLAHS LIMITS (In Cusecs)							
Nullahs	Bein (Chak Amru)	-	1300	7000	20000	30000	35000 & Above
	Bein (Shakargarh)	-	1600	3000	24000	26000	43000 & Above
	Aik (Ura)	-	2000	9000	13000	16000	33000 & Above
	Basantar (Jassar)	-	4100	4700	7500	11600	17800 & Above
	Deg (Kingra Bridge)	-	10000	15000	22000	30000	-
	Palku (Wazirabad)	-	2500	3100	5000	25000	26000 & Above

Table 5: Rivers' major sites Flood Limits

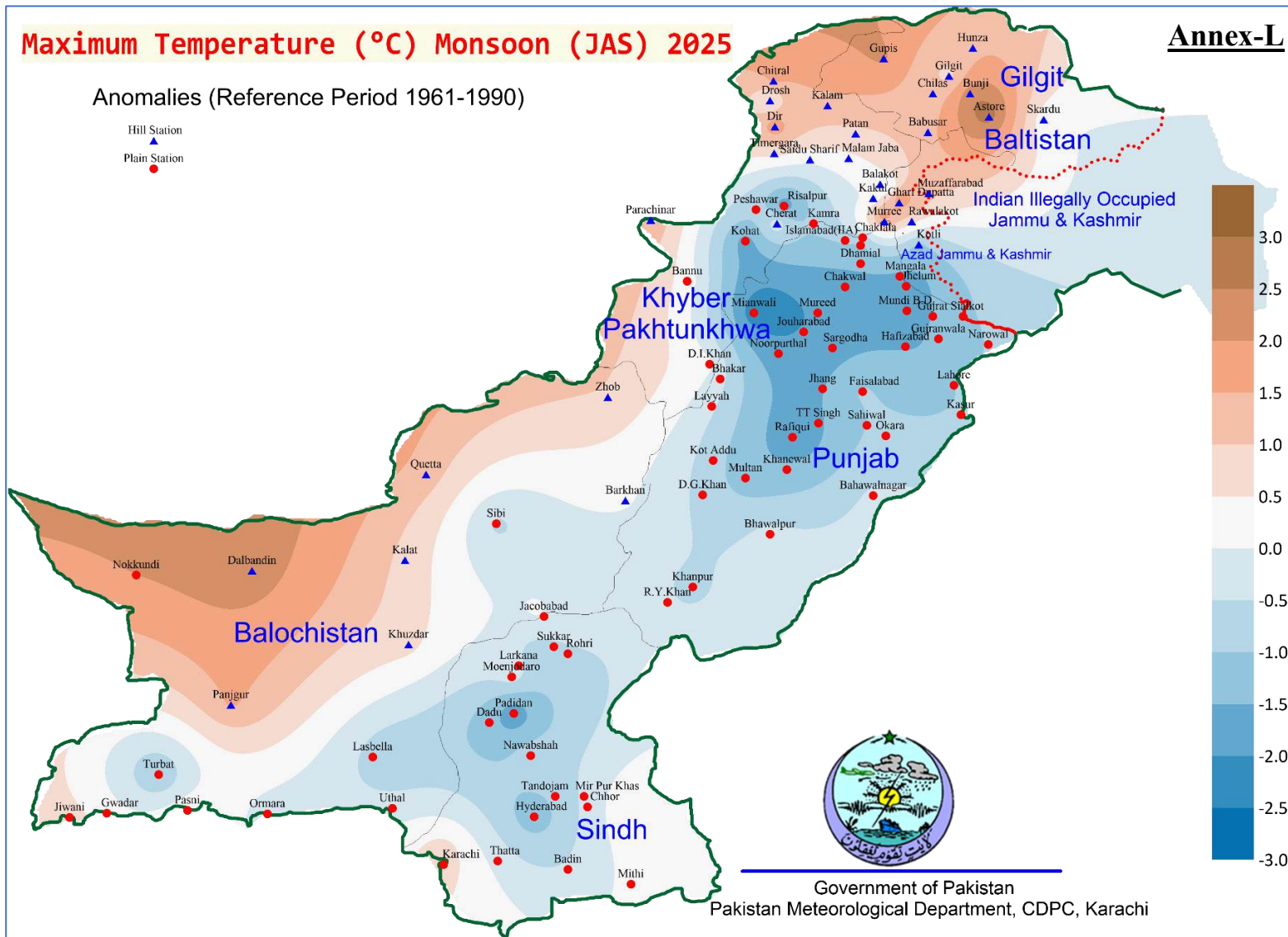


Fig-(56) Maximum Temp Anomalies (JAS-2025)

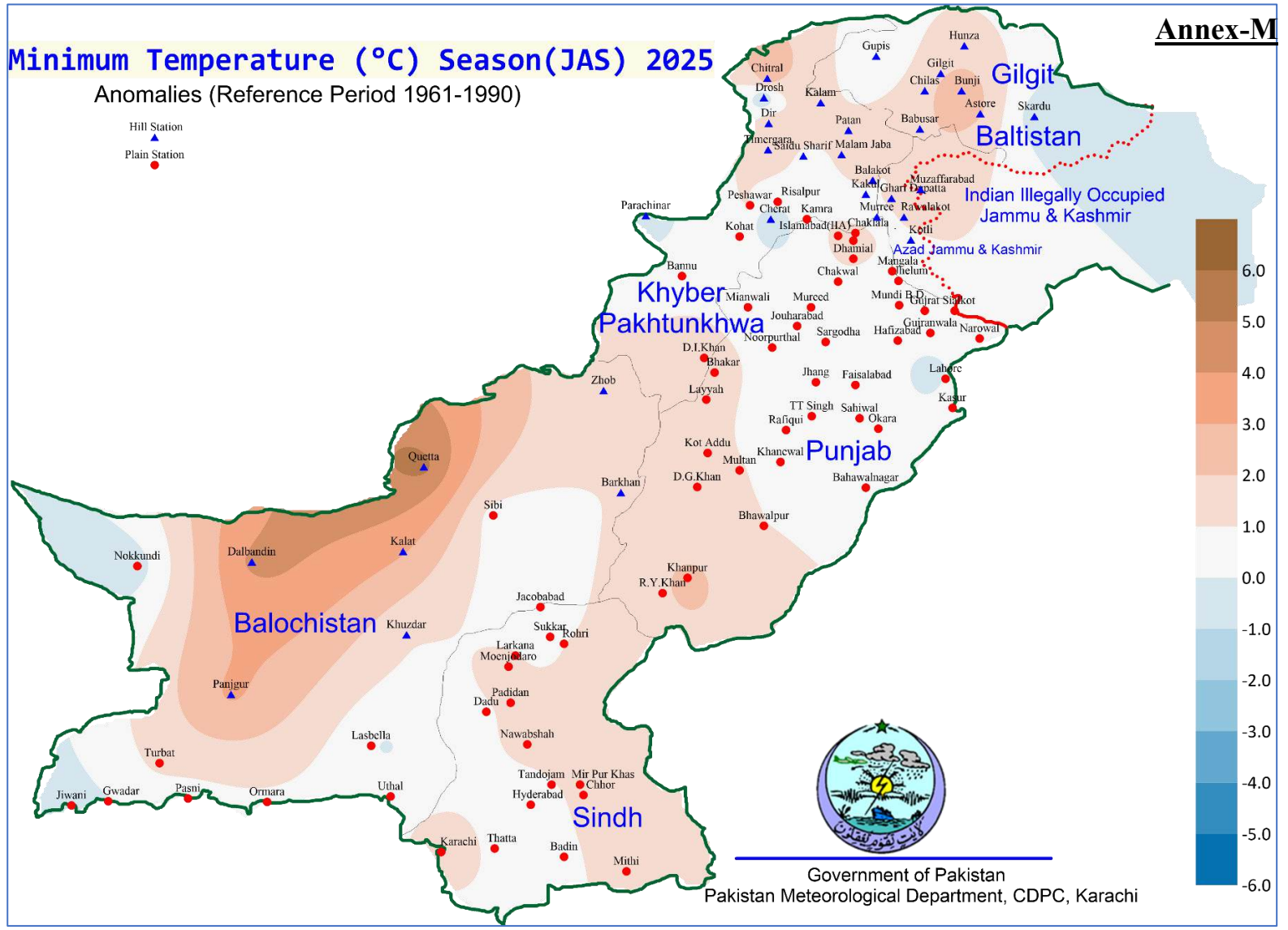


Fig-(57) Minimum Temp Anomalies (JAS-2025)