Flood Report 2024

Hydro-Meteorological

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 Flood Forecasting Division Lahore (FFD) monitored the Flood Season 2024 carefully through its Hydrometeorological 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 Flood Forecasting Division Lahore. This year Flood Season 2024 Monsoon Report is attached. This report is prepared under the supervision of Director General (DG) Met Services.

Shahid Abbas is the Chief Meteorologist at the Flood Forecasting Division (FFD) in Lahore, a critical role that places him at the forefront of flood prediction and management in Pakistan. With a rich background in meteorology and hydrology, He brings a wealth of knowledge and experience to the FFD. His primary responsibility involves the analysis and interpretation of meteorological data to provide accurate flood forecasts, which are crucial for disaster preparedness and response. He has been instrumental in enhancing the capabilities of the FFD through the adoption of advanced forecasting tools and techniques. His work ensures timely warnings and valuable information to government agencies and the public, helping to mitigate the adverse effects of floods. Known for his dedication and precision, Shahid Abbas's contributions are vital in safeguarding communities and infrastructure from the devastating impacts of flooding. His leadership and expertise continue to strengthen Pakistan's resilience against natural calamities.

- Flood Forecasting Division Lahore
  Chief Meteorologist, Secretariate
- Ph: +92-42-99200208
- Fax: +92-42-99200209
- Operational 24/7: +92-42-99200139
- Email: ffdlhr@yahoo.com

Contents

List of Acronyms

- AJK Azad Jammu & Kashmir
- CDPC Climate Data Processing Centre
- DCO District Coordination Officer
- FFC Federal Flood Commission
- FFD Flood Forecasting Division
- IFAS Integrated Flood Analysis System
- IRSA Indus River System Authority
- KPK Khyber Pakhtunkhwa
- MAF Million Acre Feet
- 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
- PMD Pakistan Meteorological Department
- SDMA State Disaster Management Authority
- WAPDA Water And Power Development Authority
- XEN Executive Engineer
- BoB Bay of Bengal

1 Flood Forecasting Division Lahore (FFD Lahore).

Flood Forecasting Division (FFD), Lahore, the specialized unit of Pakistan Meteorological Department (PMD), plays a pivotal role in the Flood Forecasting & issuance of Warnings to concerned quarters. It obtains hydro-meteorological data from the various National and International sources, which is then analyzed to produce Weather /Flood Forecasts & Warnings and Disseminated to various Federal/Provincial organizations and electronic/print media through various means and also uploaded on FFD Website.

1.1 FFD Lahore Objectives

Floods are without doubt the most devastating natural disasters, striking numerous regions in the world each year. During the last decades the trend in flood damages has been growing exponentially. This is a consequence of the increasing frequency of heavy rain, changes in upstream land-use and a continuously increasing concentration of population and assets in flood prone areas. Flood Forecasting forms an important tool in reducing vulnerabilities and flood risk and form an important ingredient of the strategy to "live with floods", thereby contributing to national sustainable development.

The Flood Forecasting Division (FFD) is serving the nation to improve the capacity of Meteorological and Hydrological services to jointly deliver timely and more accurate products and services required in Flood Forecasting and Warning and in collaborating with disaster managers, active in flood emergency preparedness and response.

1.2 Expected Results

Improved quantitative and qualitative weather forecasting products are available in such a way that these can be directly used for Flood Forecasting;

I. Medium-range weather forecasting and climate prediction tools can be applied to extend warning times and produce pre-warning information;
II. NMHSs have improved their capacity to cooperate to jointly deliver timely and accurate flood forecasting information;
III. Integrated weather, climate and hydrological forecasting information are available in a relevant format for use by civil organizations responsible for disaster preparedness and mitigation.

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. During the 2024 monsoon season, no major flood-inducing rainfall events occurred over the upper catchments of the Indus, Jhelum, or Chenab rivers.

3 Executive summary

- Quantitatively, during 2024 Monsoon Seasonal rainfall has been accrued 212.1 mm against the Long Period Average (LPA) of 140.9 mm.
- This year monsoon season set on 29th June 2024 over Pakistan, two days earlier than its normal date (1st July) and withdrew during third week of September 2024. However, significant continuous rainfall occurred during August.
- Seasonal low over Balochistan remained less marked during most of the season.
- Base flows in river Kabul at Nowshera during Kharif season remained above normal with total volume mor than 22 MAF against its normal about 18 MAF.
- Elevated maximum and minimum temperatures in Skardu and its surrounding areas resulted in an increased base flow in the Indus River, enabling Tarbela Dam to reach its maximum conservation level (MCL) on August 19. The reservoir maintained this level for 25 consecutive days.
- At multiple instances, two low-pressure systems remained active concurrently over South Asia.
- A remarkable and rare atmospheric phenomenon occurred during the 2024 monsoon season in August: the unprecedented formation of Cyclonic Storm ASNA. A land depression in the Rann of Kutch coastal region intensified unexpectedly, developing into a cyclonic storm. This rare transition defies typical monsoon patterns, where cyclonic systems usually originate over oceans rather than land.
- River Jhelum remained calm during the monsoon season and could not achieved its MCL.
- Hill Torrents of DG Khan remained active during the monsoon season.
- During the flood season, the Flood Forecasting Division (FFD) Lahore actively monitored and forecasted hydrological conditions, maintaining close collaboration with Tarbela Dam management and the GHQ Engineering Directorate. This cooperation was particularly critical when Tarbela Dam approached its Maximum Conservation Level (MCL) and maintained its position for several days.
- Pakistan experienced above average rainfall during the entire monsoon season, with a 51% deviation from the normal. On a regional scale, Punjab received above average rainfall (+48%), while Azad Jammu and Kashmir (AJK) (-21%) and Khyber Pakhtunkhwa (KP)

(-5%) received below-average rainfall. Sindh (+108%) and Balochistan (+111%) recorded above-average rainfall, and Gilgit-Baltistan (GB) experienced (+2%) above normal rainfall.

- Nine rain-bearing spells occurred during the monsoon season 2024.
- 09 monsoon lows/Depressions developed in the season however only five of them approached the country or in vicinity of Pakistan.
- The supply of hydro-meteorological data from WAPDA, Punjab, Sindh & Khyber Pakhtunkhwa irrigation departments remained satisfactory.
- All the concerned federal and provincial authorities, the general public, along with print and electronic media were kept in touch with the prevailing weather/flood conditions through phone, fax & other electronic sources.
- The overall accuracy of forecast issued by FFD during the Monsoon Season 2024 was up to the mark.

4 Tracks of Monsoon Lows during Monsoon Season-2024

- The first Monsoon Low, which was located in the vicinity of the country, developed over the Bay of Bengal on 26th July. This system initially moved in a west-northwest direction, gradually approaching the western region of Madhya Pradesh. It traveled, bringing heavy rainfall and significant weather patterns to the areas along its path. After reaching the western part of Madhya Pradesh, the system began to shift in a westerly direction, continuing its journey across the country. By 31st July, the system dissipated south of Gwadar, in the Arabian Sea, marking the end of its influence over the region.
- The second Monsoon Low developed on 1st August over the northwest region of Uttar Pradesh. This weather system followed a southwestward course, gradually making its way towards the country. On 3rd August, it entered the landmass, affecting areas in the eastern parts of the country, and continued its movement across the region. However, by 5th August, it lost strength and dissipated near the coastal regions of Balochistan, marking the end of its impact on the local weather patterns.
- The third Monsoon Low emerged over the state of Jharkhand on 2nd August. This system traveled in a nearly west-northwest direction, moving steadily across the India. By 7th August, it had been observed over the Bahawalpur division in Pakistan, where it brought moderate to heavy rainfall to the area. The system then began to change course, recurving towards the Punjab region of India, where it continued to bring significant rainfall and cloud cover.
- The fourth Monsoon Low also developed over Jharkhand, India, on 8th August. This system began its movement towards Pakistan, where it intensified and became a key weather system in the region. By 16th August, it was located near the border of Pakistan and continued to move towards the southern parts of the country, including Sindh and Balochistan. As it progressed, it brought increased rainfall to these regions.
- Finally, the fifth and last weather system of the monsoon season developed over the head of the Bay of Bengal on 20th August. It started its journey by moving steadily in a westerly direction, maintaining a consistent path across India. Over the next several days, the system strengthened as it approached the southern parts of Sindh, and by the time it reached the Arabian Sea, it had become a significant weather event. It continued moving westward until it finally dissipated over the southwest Arabian Sea.

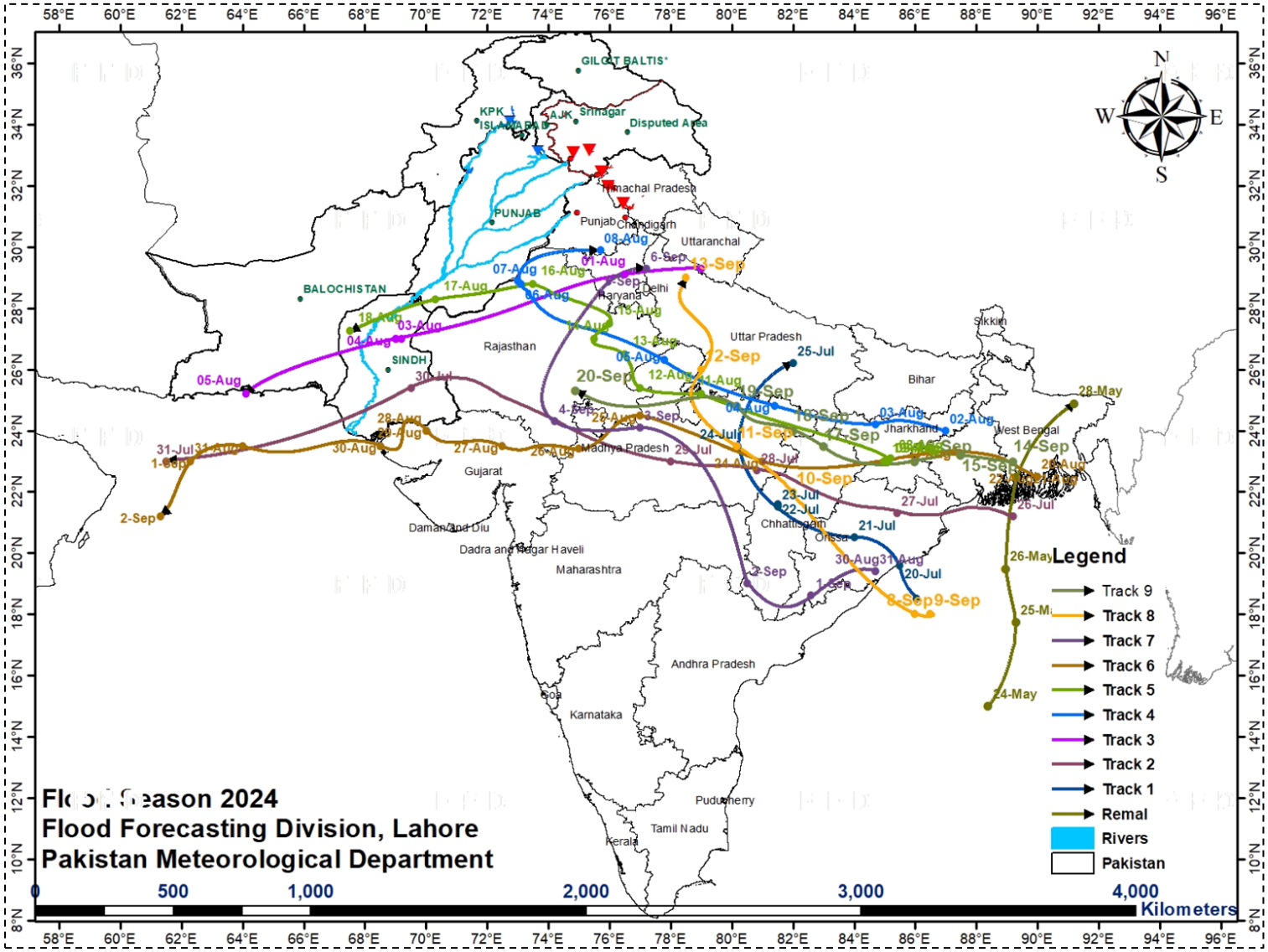
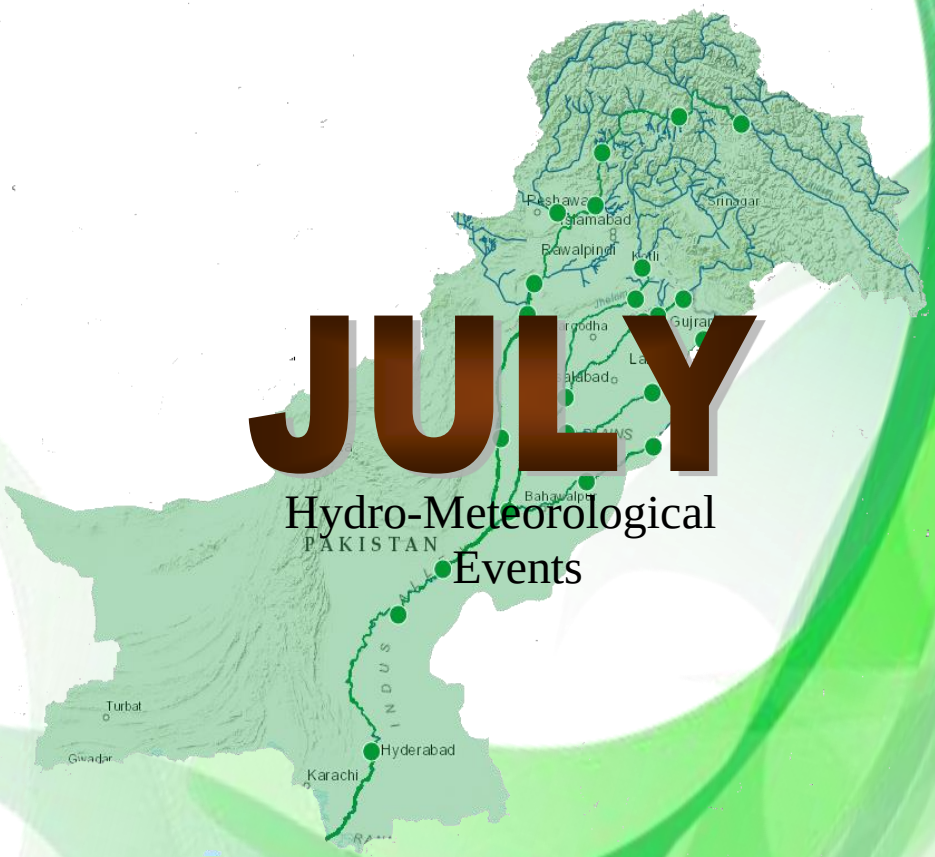


Fig (1) Seasonal Monsoon Tracks 2024



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Hydro-Meteorological Events

5 Significant Hydro-Meteorological events during the month of July-2024.

During July 2024, four distinct rainfall spells were reported across the country. Overall, no significant flooding was observed in the major rivers, except for a moderate flood peak at upstream Mangla. Nationwide, rainfall was 8% below normal. Regions such as Azad Jammu & Kashmir, Gilgit Baltistan, and Sindh experienced significantly below-normal rainfall. Balochistan recorded 22% above normal and Punjab saw an 8% increase compared to average levels. By the end of July, the Tarbela reservoir was at 78% of its capacity, and Mangla reservoir was at 60%.

5.1 1st wet spell of July 2024 (04th-07th)

The first wet spell of July 2024 which remained active for four days was mainly due to the presence of a westerly trough accompanied by moderate to strong moist currents from the Arabian Sea as well as Bay of Bengal. 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 favorable conditions for the system. A steep pressure gradient was also observed over the northern parts of Afghanistan during this period. Figure 2 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 southwesterly winds at 925 hPa ensured an adequate supply of moisture from the Arabian Sea and Bay of Bengal.

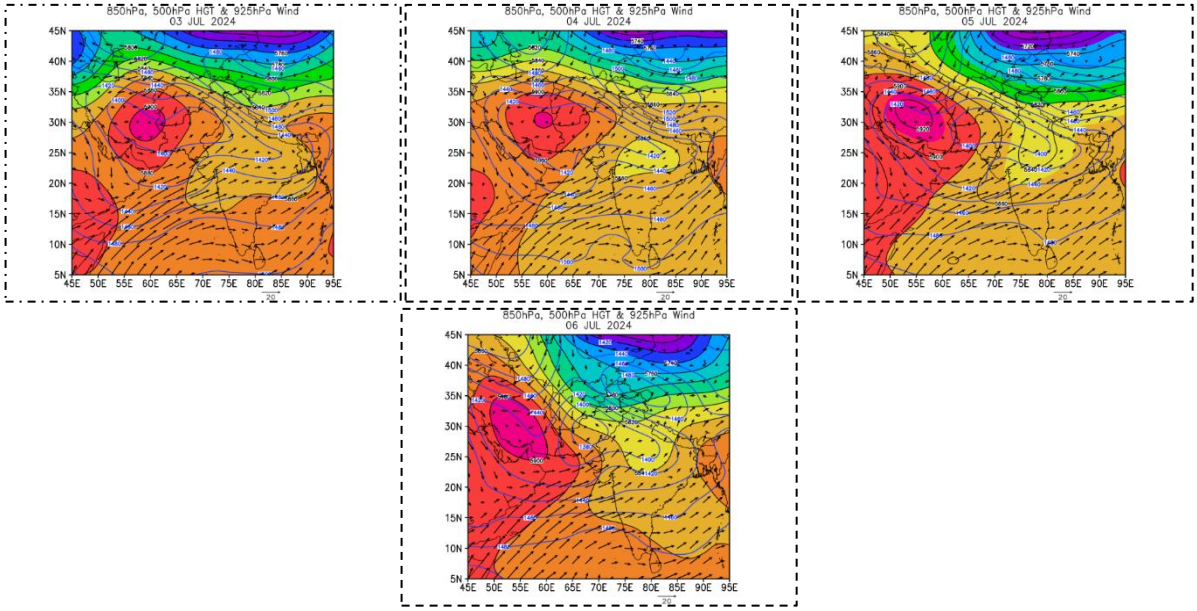


Fig (2)) 850 & 500 hPa Geopotential Height & 925 hpa winds map of 1st spell of July-24

The isohyetal map in Figure 3 indicates the center of the highest rainfall, exceeding 80 mm, over northern and northeastern Punjab, particularly around Sialkot. Light to moderate rainfall was also observed in scattered areas of Kashmir and other regions of the country.

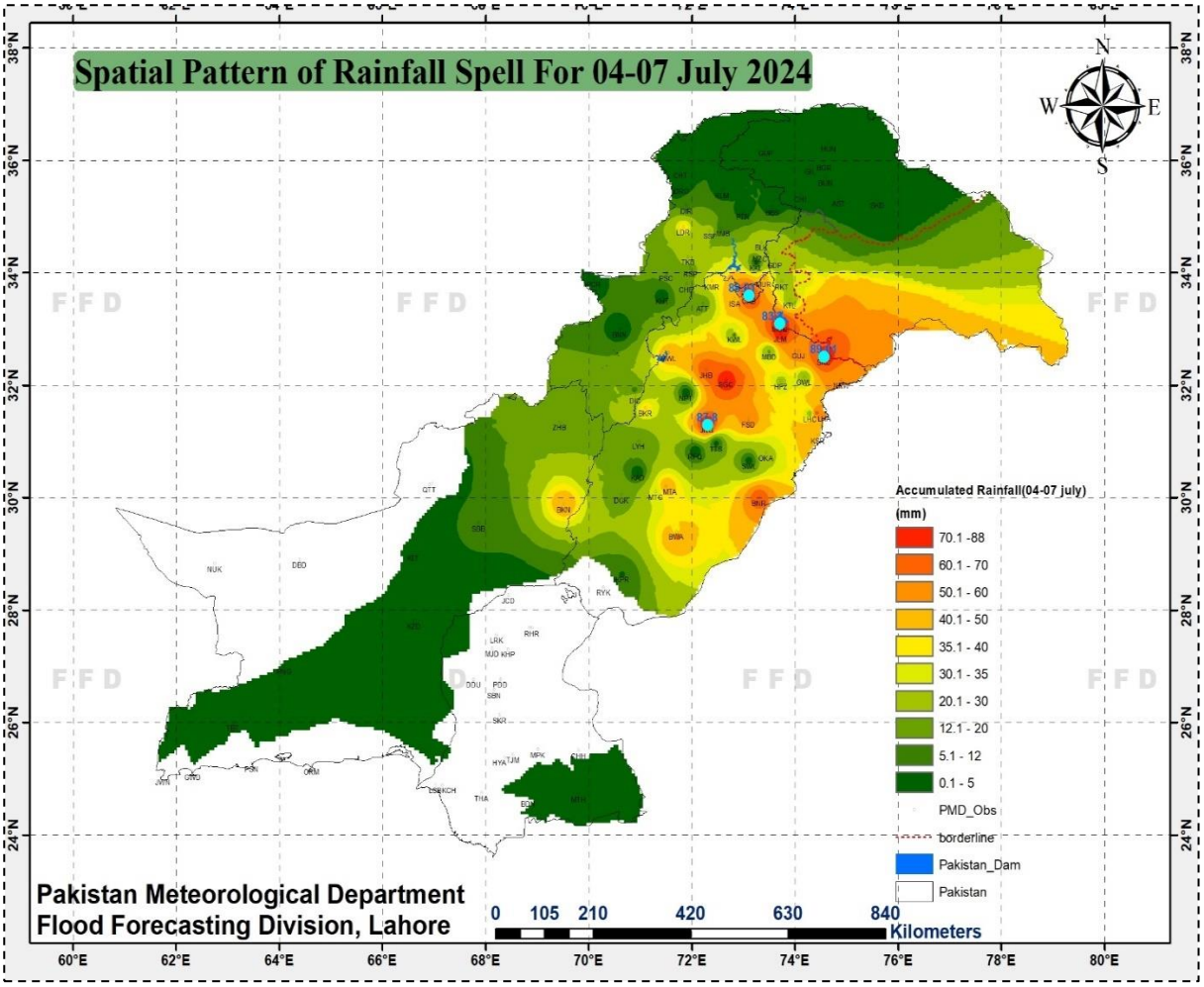
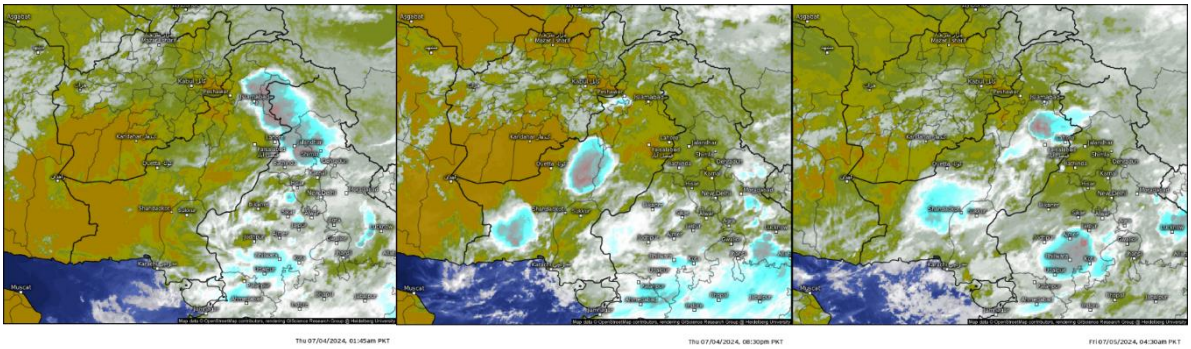


Fig (3) 1st Spell of July Total Rainfall

Satellite images during the spell are shown below in Fig (4)



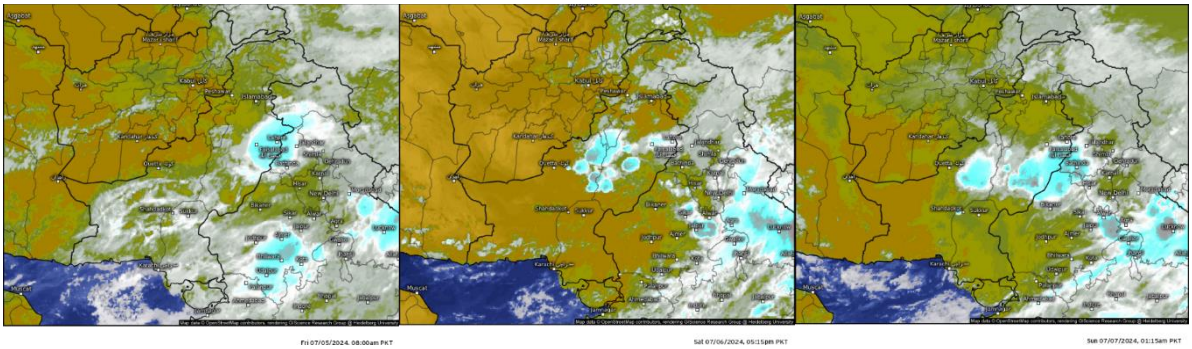


Fig (4) Satellite images of 1st Spell of July

5.2 2nd wet spell of July 2024 (11th –13th).

Second wet spell of July 2024 remained active for three days and was mainly due to the presence of a subsequent westerly waves accompanied by moderate to strong moist winds from Arabian Sea along with directional convergence over upper Punjab and active monsoon trough axis below the foothills of Himalayas. Fig (5) 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. South westly winds at 925 hPa are also present ensuring strong moisture supply from the Arabian Sea.

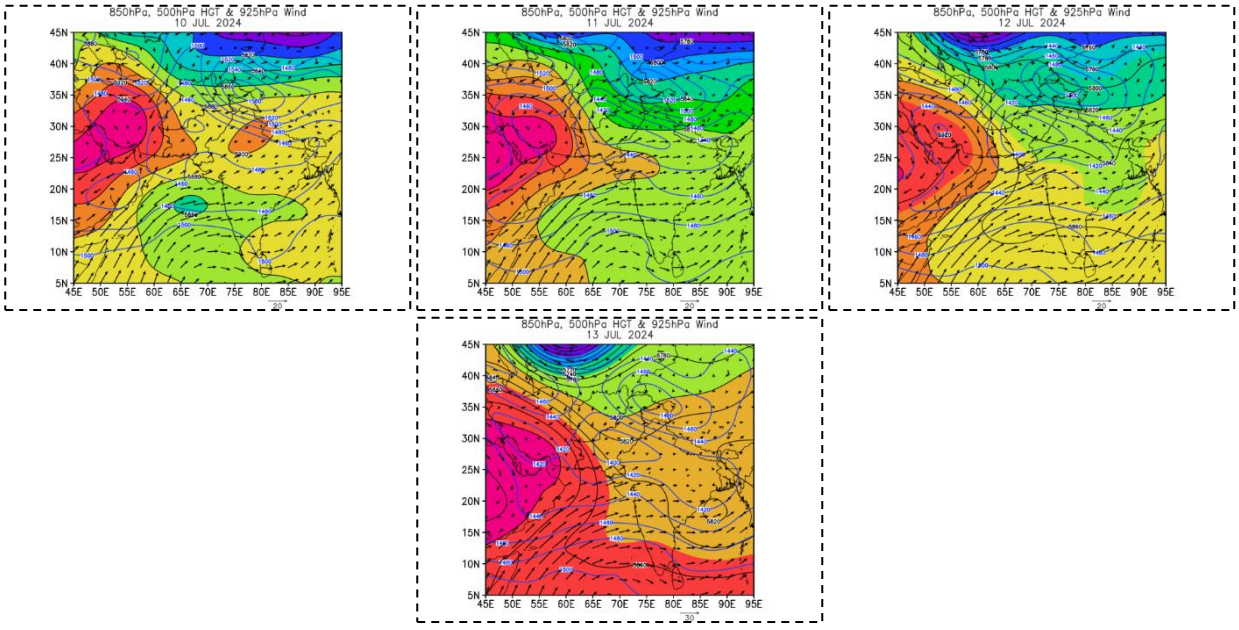


Fig (5)) 850 & 500 hPa Geopotential Height & 925 hpa winds map 2nd spell of July.

Lahore Airport received 100 mm rainfall during the spell. Other rainfall distribution during the spell over the country can also be seen from the Fig (6).

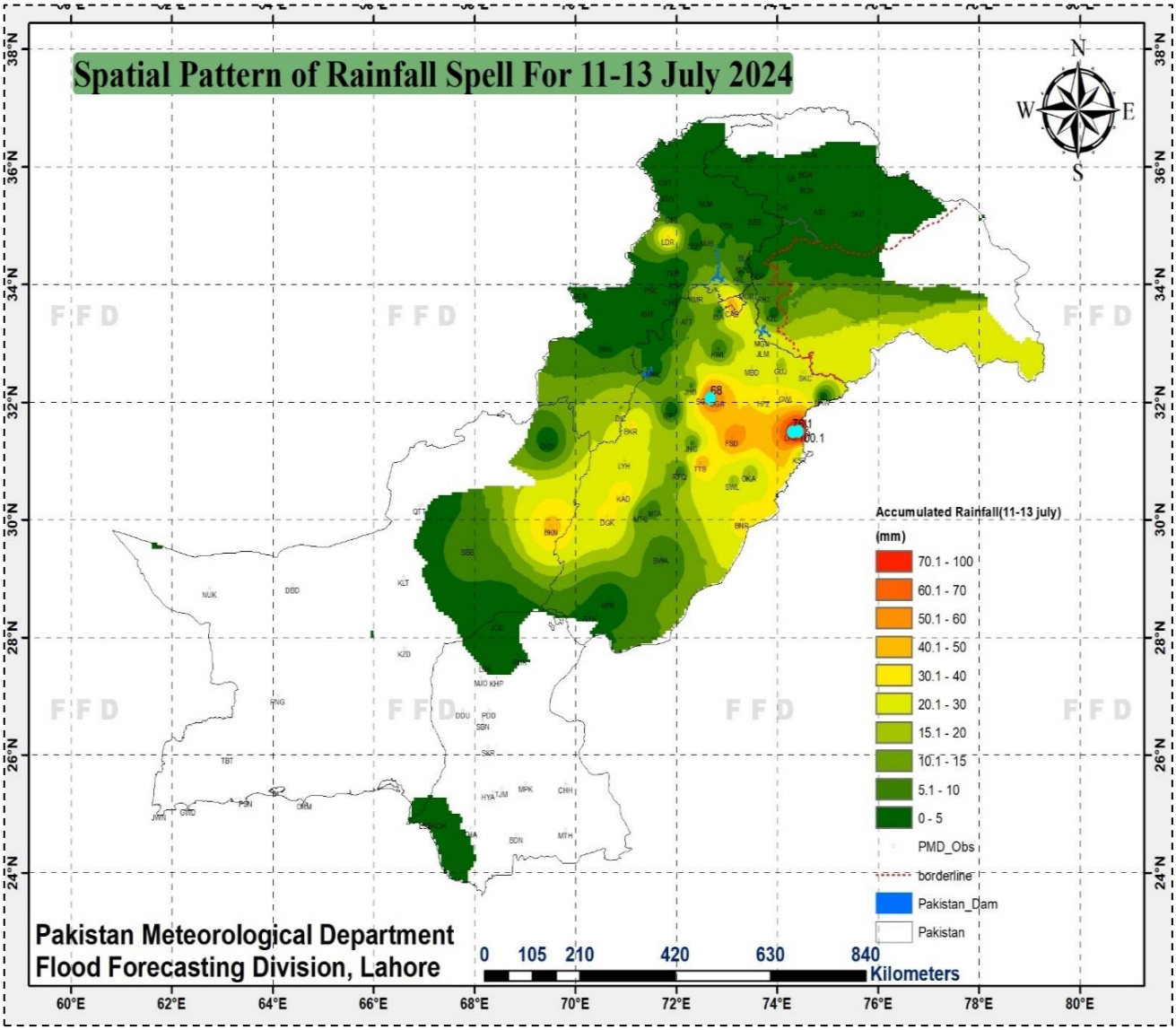
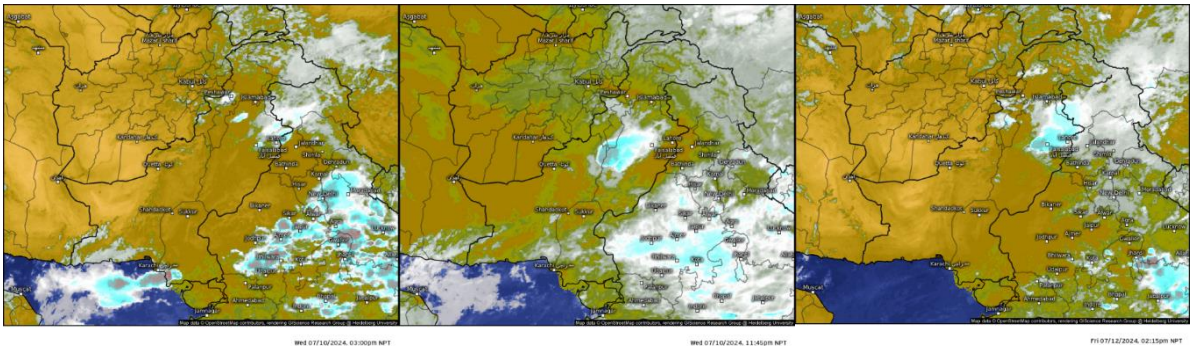


Fig (6) 2nd Spell of July total Rainfall

Dense clouds observed by satellite during the spell are illustrated in Figure 7.



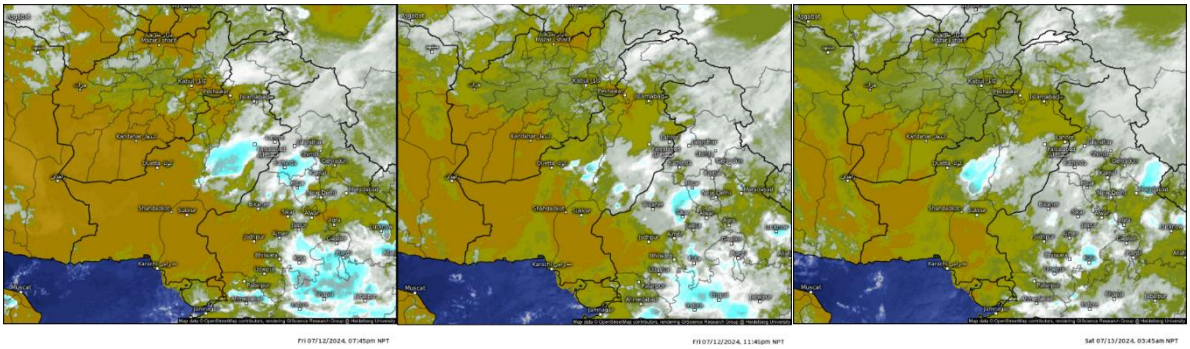


Fig (7) Satellite images of 2nd Spell of July

5.3 3rd Spell of July 2024 (22nd – 24th).

Third wet spell of July 2024 remained active for three days and was mainly due to the presence of a subsequent westerly waves accompanied by moderate moist winds from the Bay of Bengal and Arabian Sea. The active monsoon trough south of the Himalayas also contributed to the spell. Fig (8) 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 southwesterly winds at 925 hPa were also present, ensuring a moderate supply of moisture from the Bay of Bengal and the Arabian Sea.

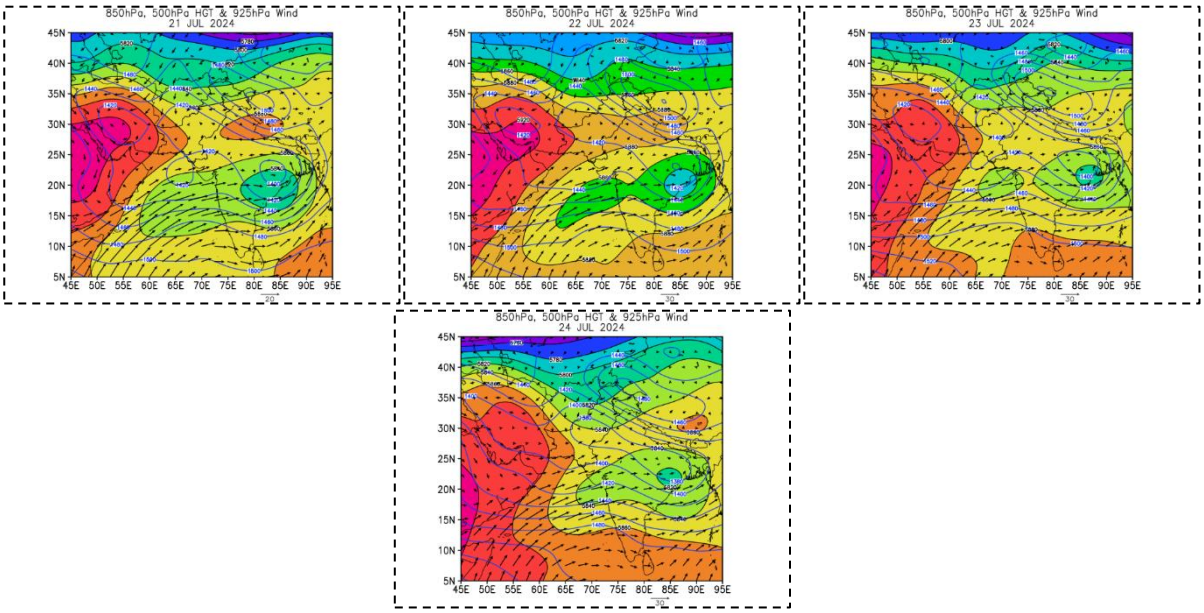


Fig (8)) 850 & 500 hPa Geopotential Height & 925 hpa winds map 3rd spell of July.

Maximum rainfall during the spell occurred over northern and northeastern Punjab, with Sialkot Airport receiving over 120 mm. Mandi Bahauddin recorded 100 mm, while Gujranwala and Gujrat each observed more than 70 mm of rain. Rainfall amounts across the rest of the country are illustrated in Figure 9.

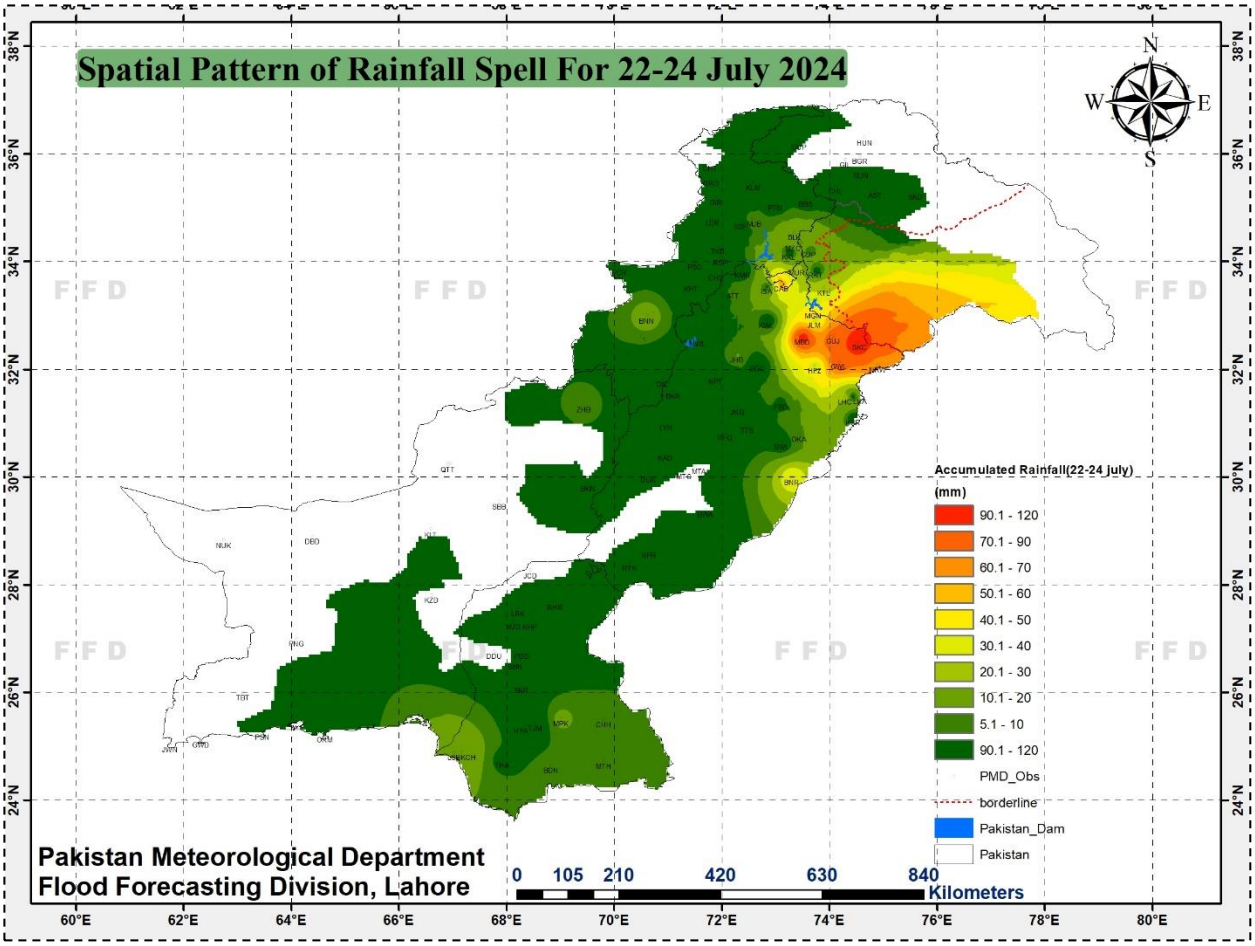
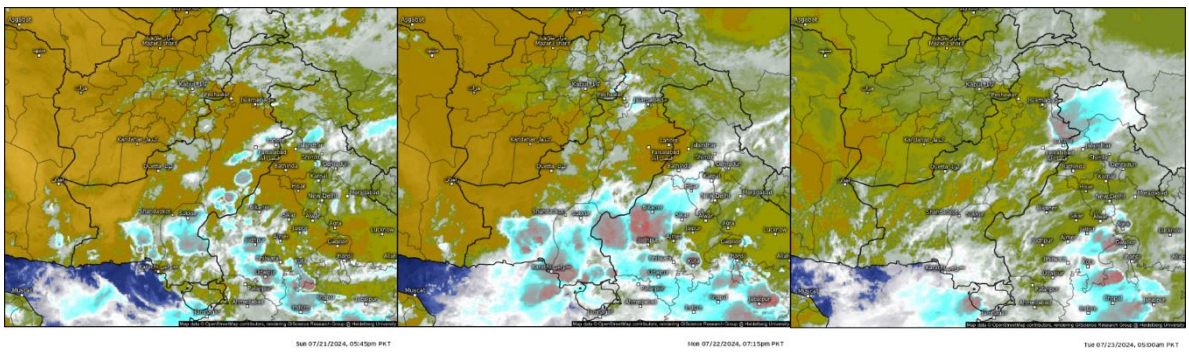


Fig (9) 3rd Spell of July total Rainfall

Dense clouds observed by satellite during the spell is shown in the Fig (10).



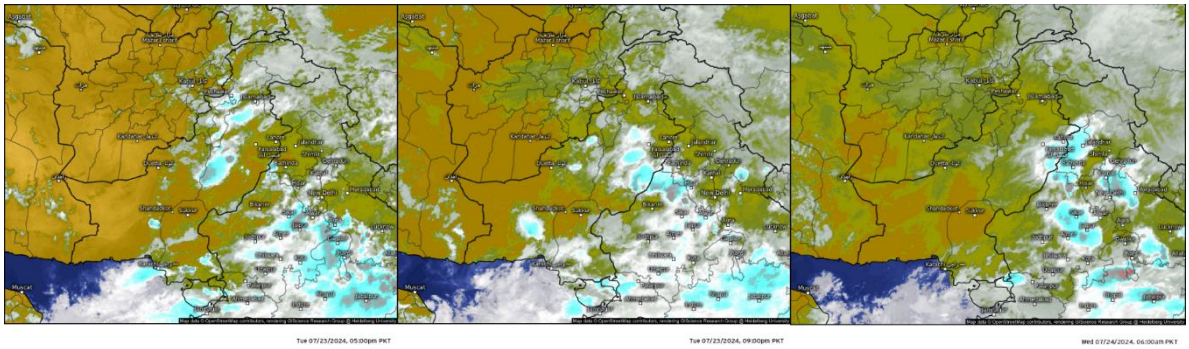


Fig (10) Satellite images of 3rd Spell of July

5.4 4th Spell of July-August 2024 (30th July – 02nd).

Fourth wet spell of July 2024 remained active for four days and was mainly due to the presence of a strong westerly waves accompanied by strong moist winds from the Bay of Bengal and Arabian Sea up to 7000 feet. The well-marked seasonal low over Balochistan, along with the low-pressure area in Haryana, also reinforces the effects of the weather system across the country. Fig (11) 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 winds at 925 hPa were also present, ensuring a strong moisture supply from the Bay of Bengal and moderate moisture currents from the Arabian Sea.

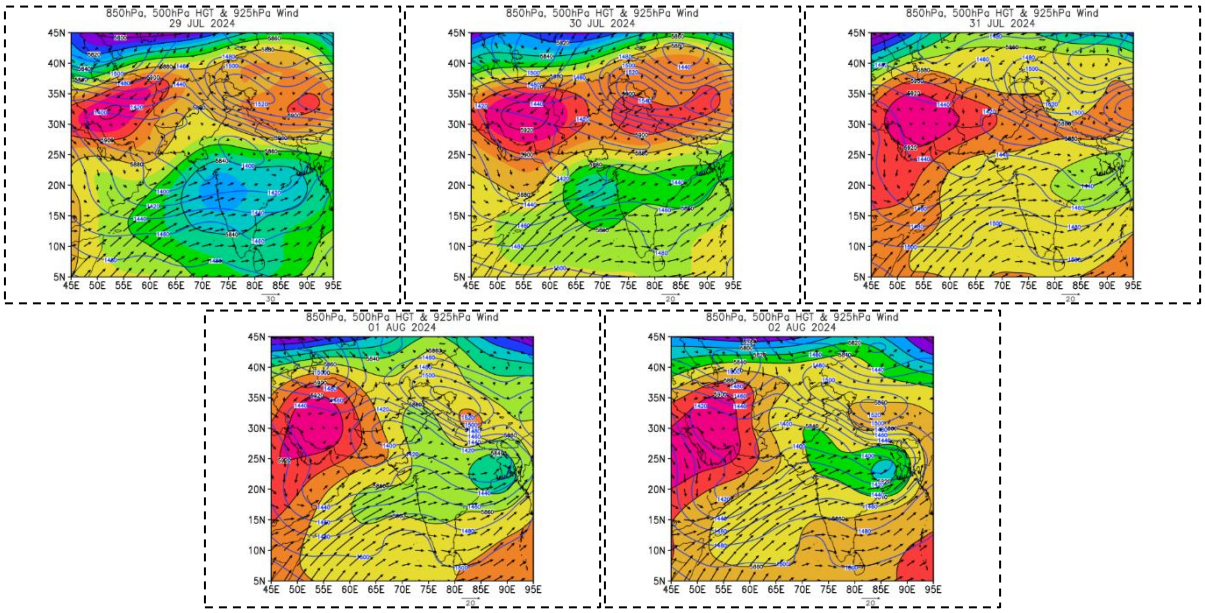


Fig (11)) 850 & 500 hPa Geopotential Height & 925 hpa winds map 4th spell of July.

Lahore Airport received 376 mm rainfall during the spell. More than 100 mm was recorded from Gujranwala, Balakot, Kamra, Cherat, Dir and Muzaffarabad. Rainfall received in rest of the country can also be seen from the Fig (12)

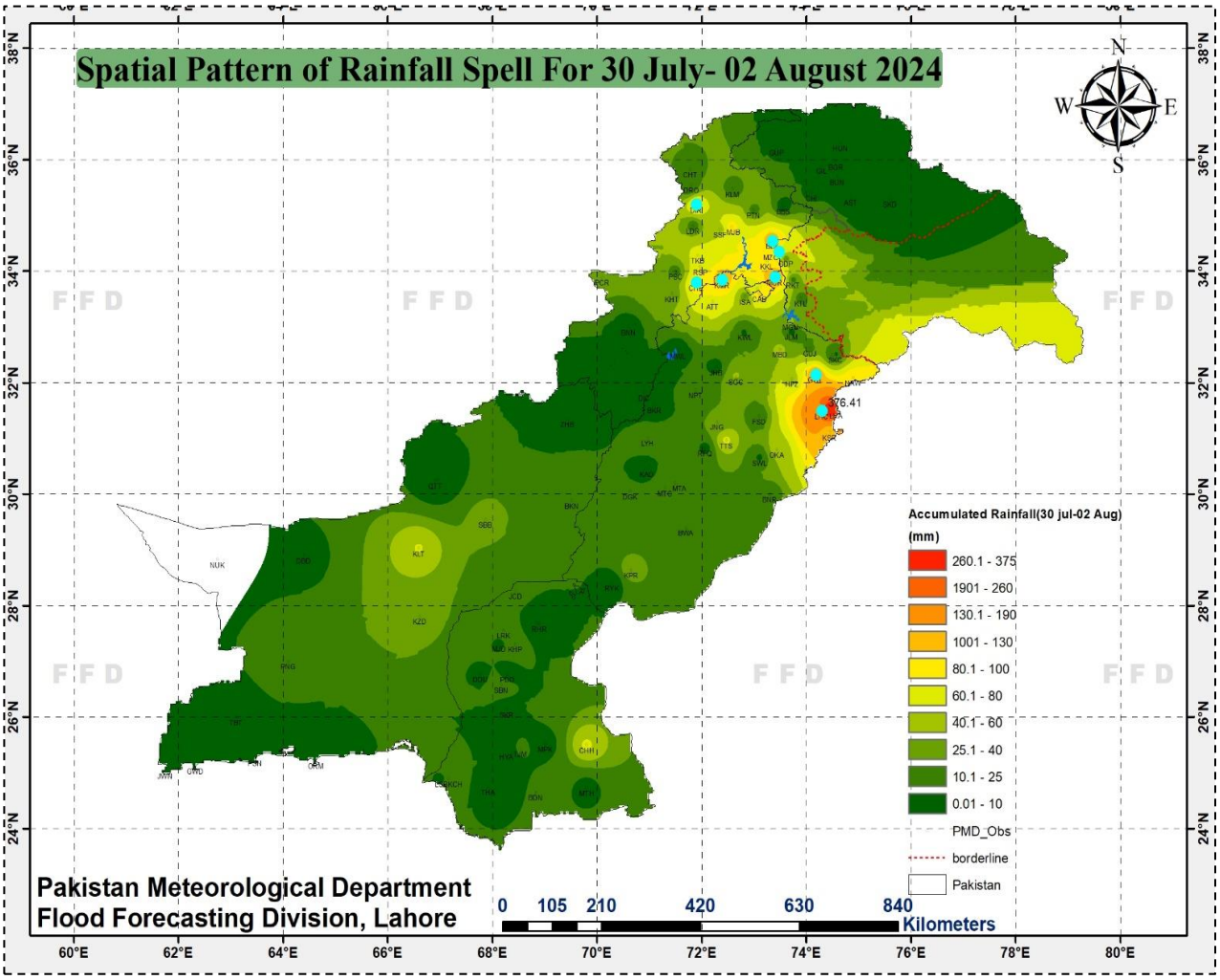
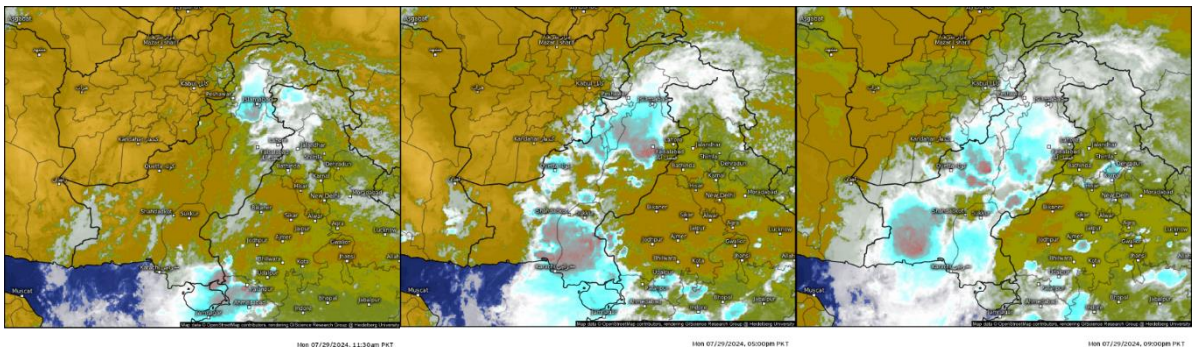


Fig (12) 4th Spell of July total Rainfall

Dense clouds observed by satellite during the spell are shown in the Fig (13).



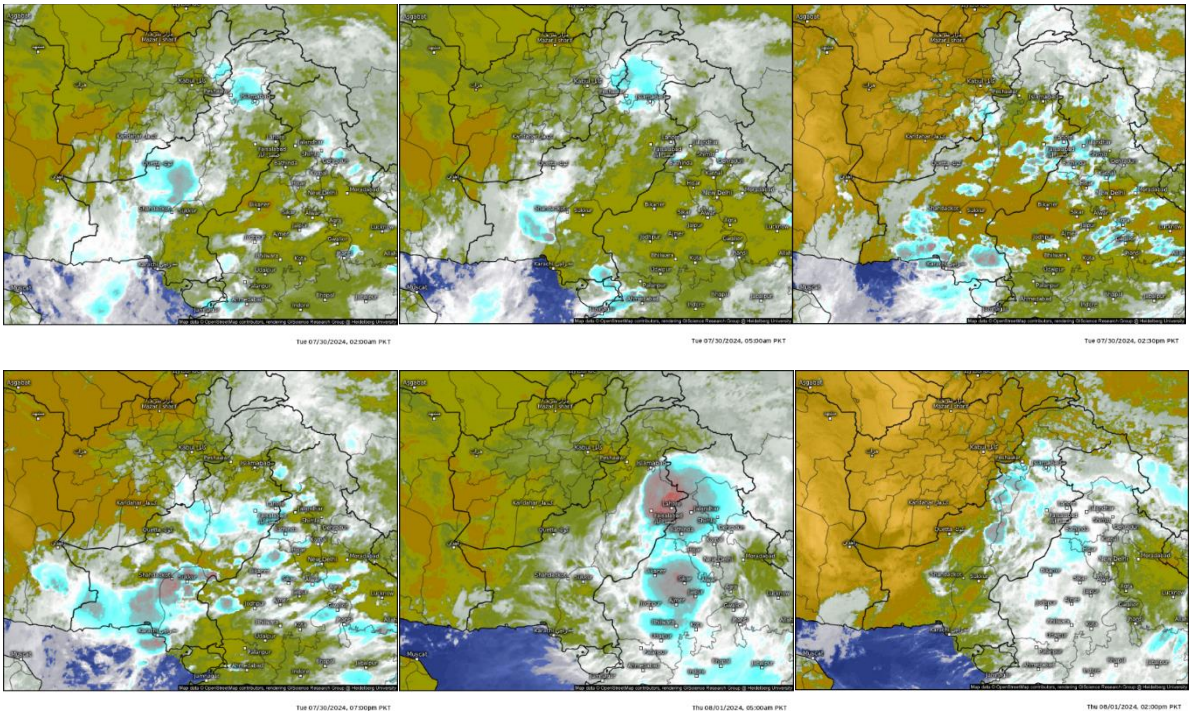


Fig (13) Satellite images of 4th Spell of July

5.5 Monthly maps of Total rainfall & Departure and Temporal Distribution & Area Weighted rainfall during July 2024.

The isohyetal map for July 2024 indicates that the region with the maximum rainfall of over 450 mm is centered around Sialkot, while Chaklala, Gujrat, Mandi Bahauddin, and Lahore received more than 300 mm. The region receiving more than 100 mm of rainfall was located in southern Sindh. Rainfall amounts across the rest of the country are depicted in Figure 14, the isohyetal map.

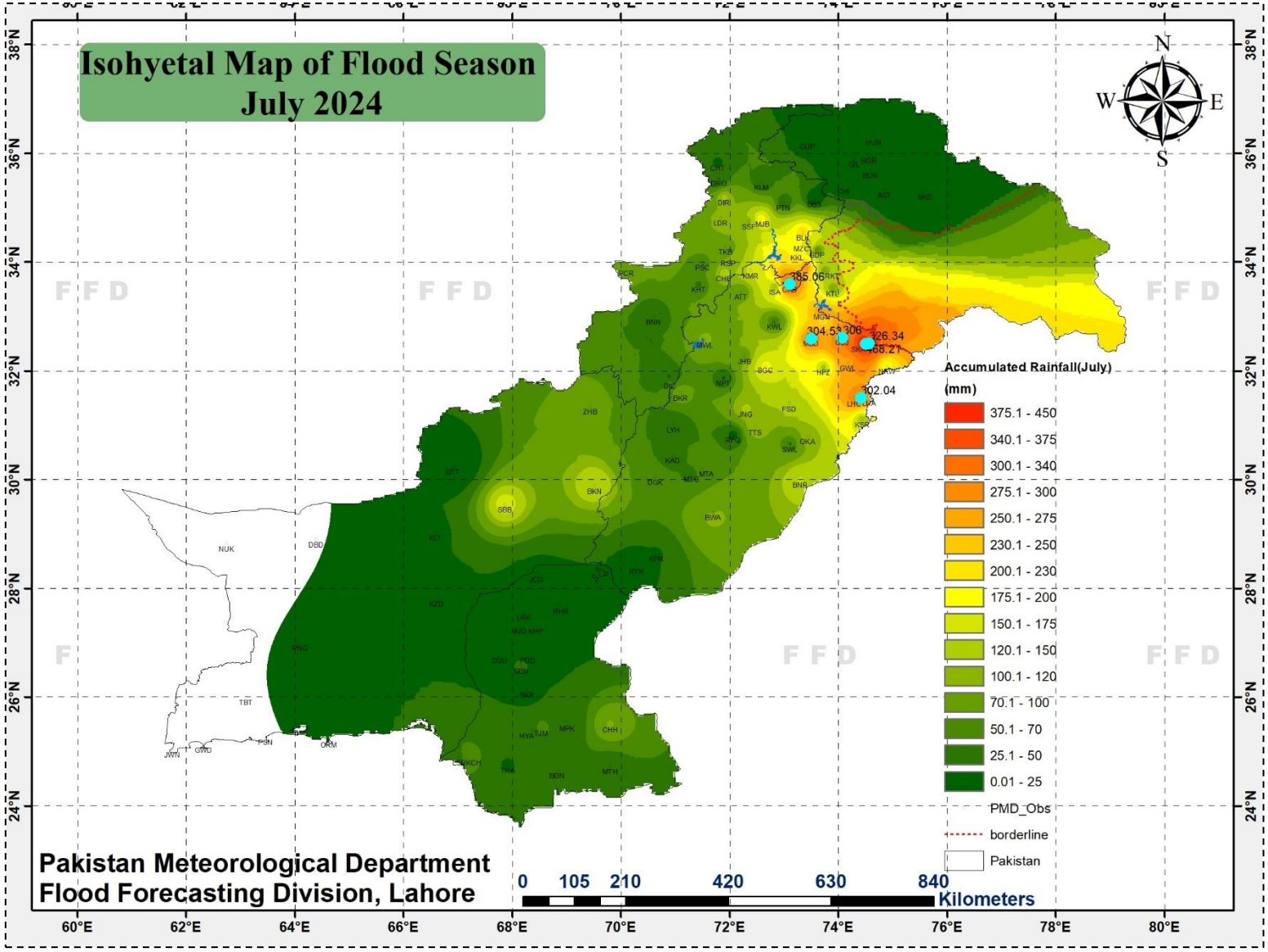


Fig (14) Monthly total rainfall map of July 2024.

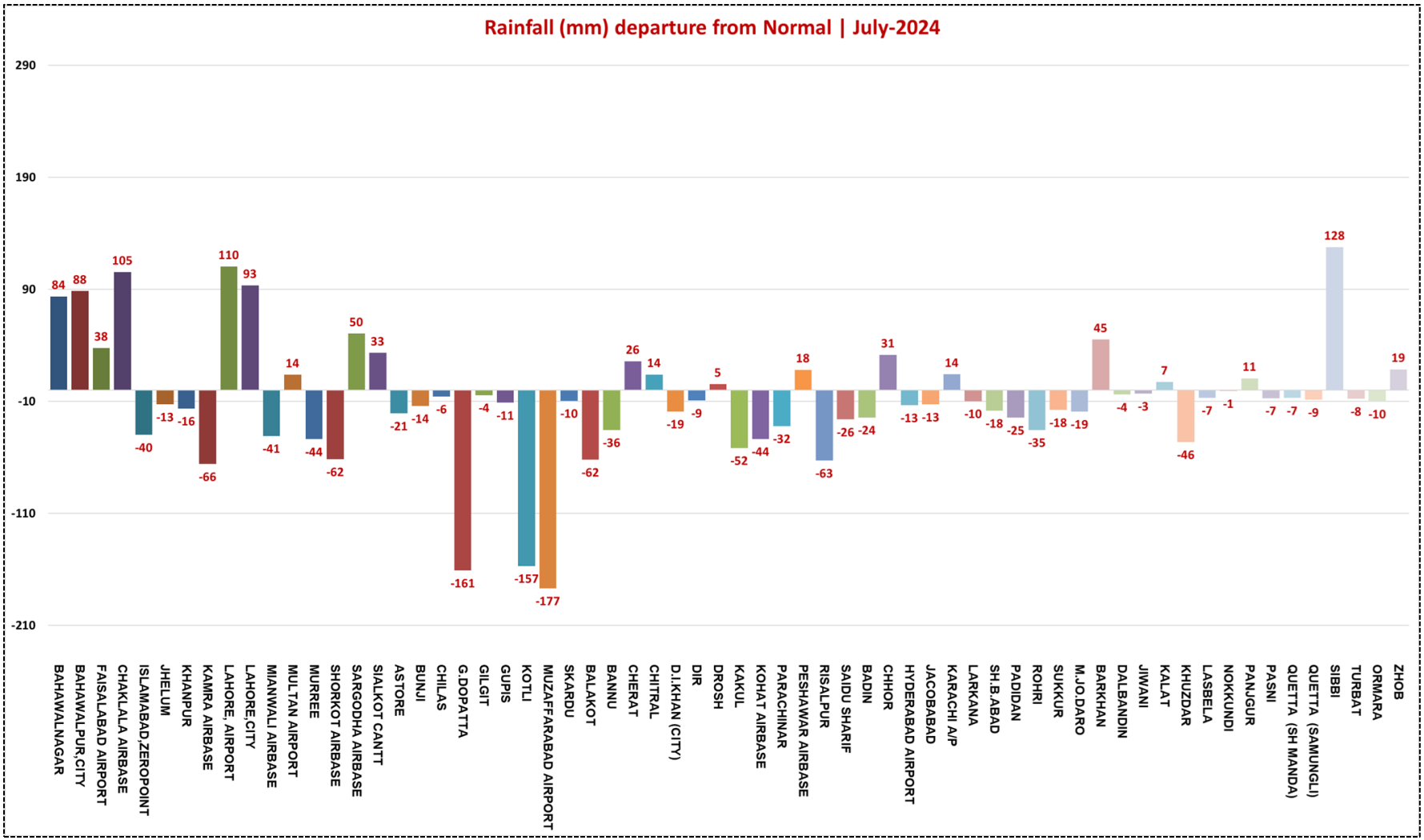


Fig (15) Monthly total rainfall Departure graph of July-2024.

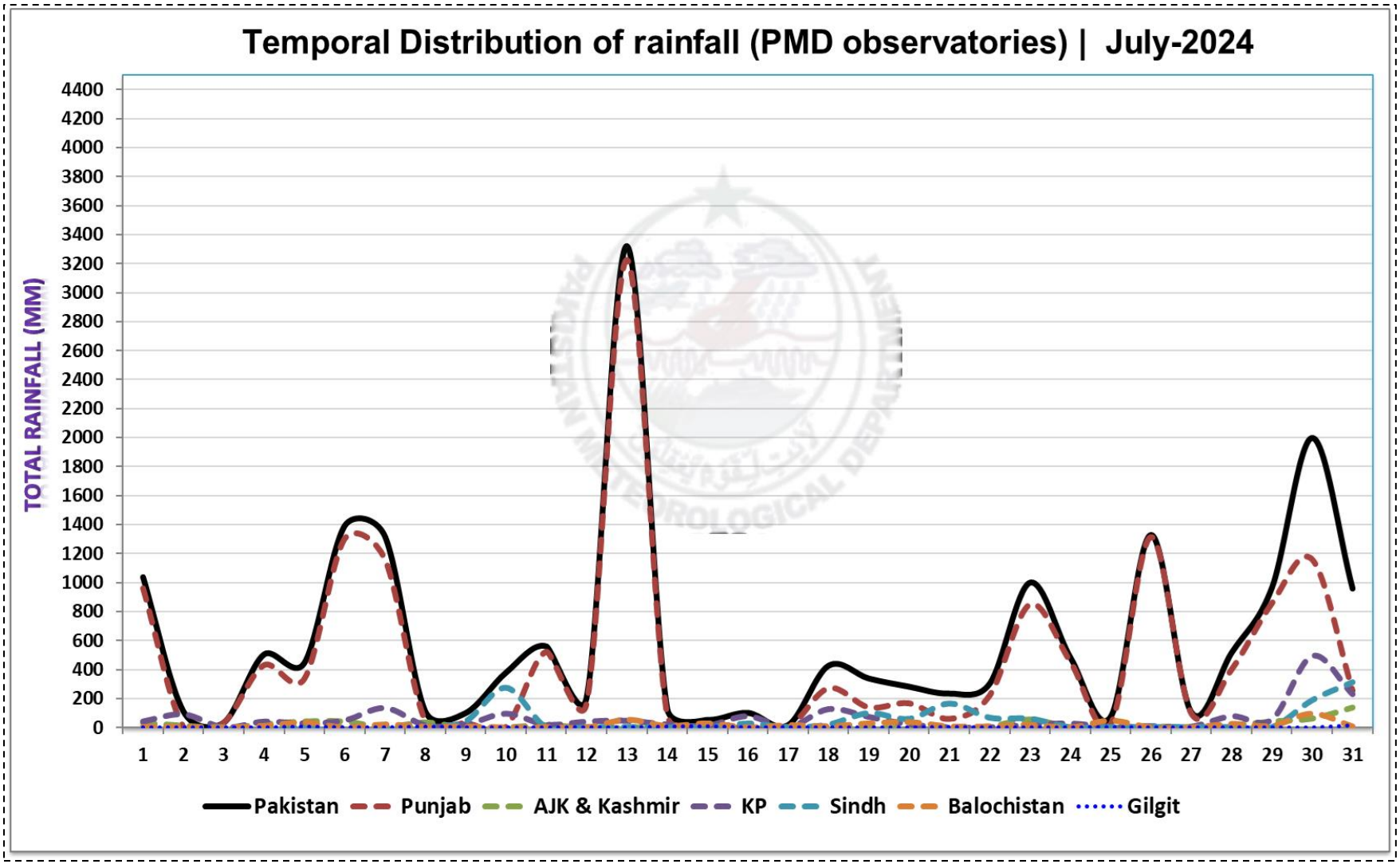


Fig (16) Monthly Rainfall Temporal distribution of July-2024

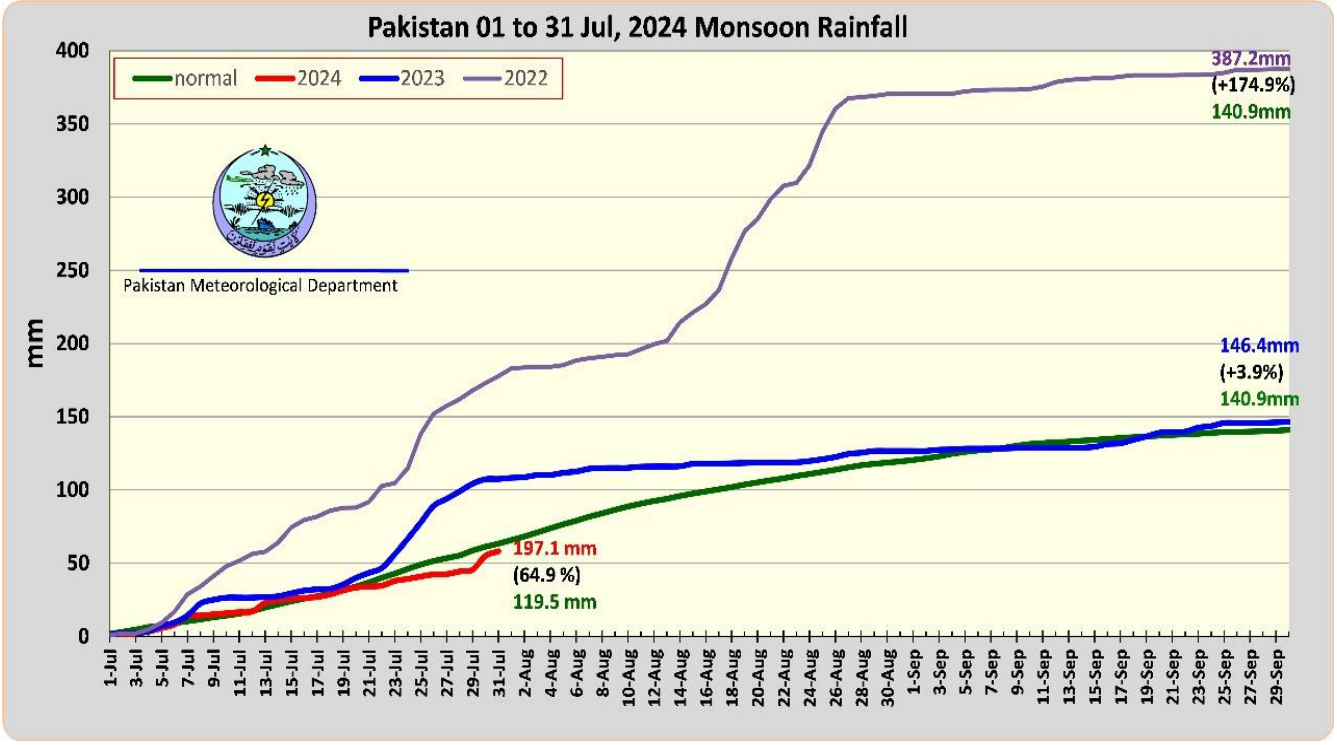


Fig (17) Monsoon Progress & Area Weighted Rainfall Comparison up to 31-July-2024

	01 to 31 July, 2024 Rainfall		
	normal (mm)	actual (mm)	Dev (%)
Pakistan	63.3	58.2	-8
Azad J&K	173.9	94.7	-46
Balochistan	29.7	36.3	22
Gilgit-B	13.3	5.3	-60
Khyber-PK	106.7	82.8	-22
Punjab	104.0	112.4	8
Sindh	60.2	33.8	-44

Fig (18) Monthly Area Weighted Rainfall of July-2024

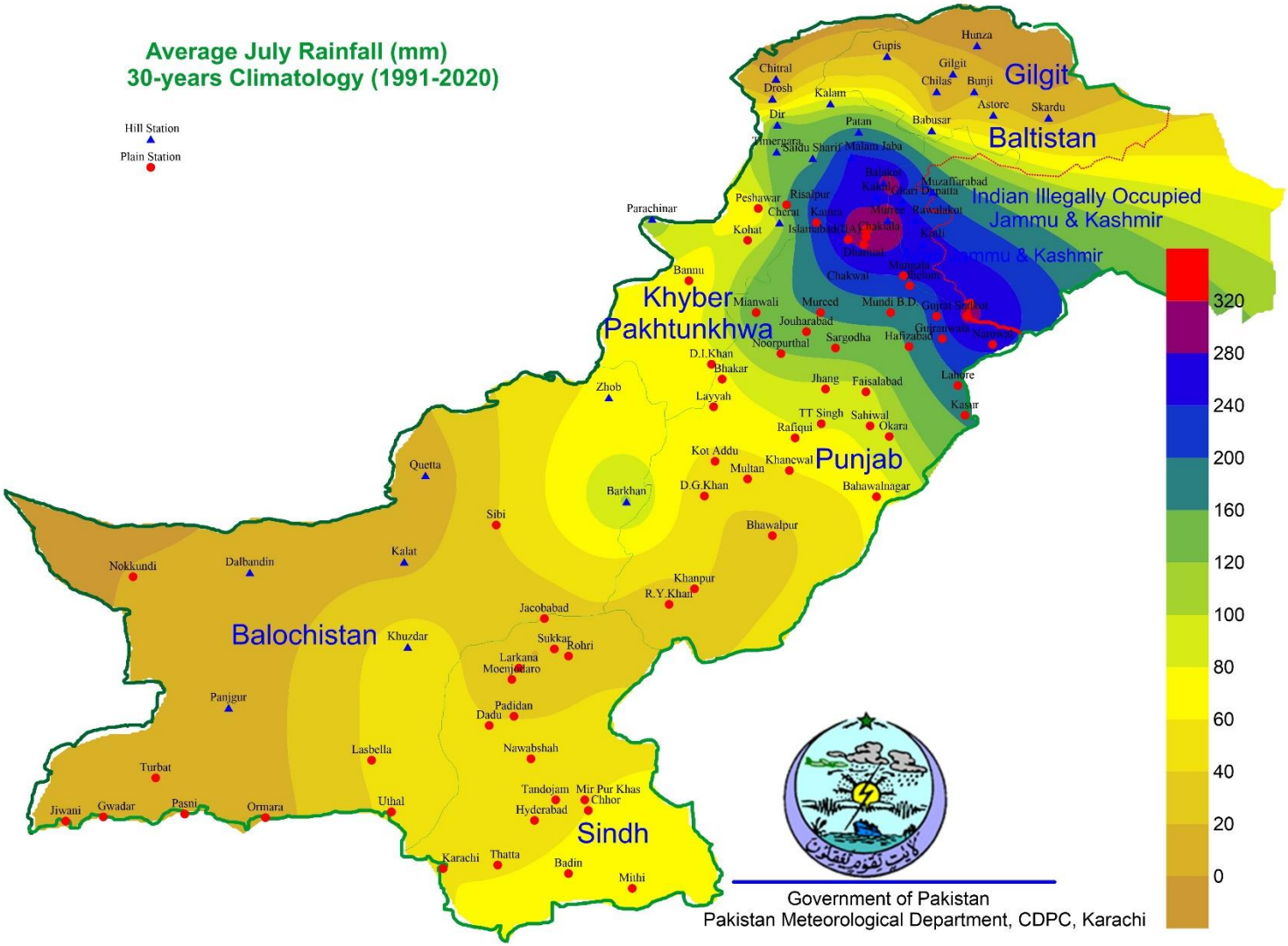


Fig (19) July Climate normal of Rainfall

5.6 Peak flows recorded during the month of July-2024.

Peak Flows Observed in July-2024				
River	Sites	Inflow	Flood Level	Recorded Date
Indus	Tarbela	318000	Low	31/07/2024
	Attock	326500	Low	31/07/2024
	Kalabagh	269221	Low	31/07/2024
	Chashma	273391	Low	16/07/2024
	Taunsa	226965	Normal	30/07/2024
	Guddu	192897	Normal	15/07/2024
	Sukkur	140276	Normal	15/07/2024
	Kotri	84720	Normal	21/07/2024
Jhelum	Mangla	114600	Medium	04/07/2024
	Rasul	36074	Normal	01/07/2024
Chenab	Marala	98897	Normal	06/07/2024
	Khanki	95053	Normal	07/07/2024
	Qadirabad	93130	Normal	07/07/2024
	Trimmu	46457	Normal	10/07/2024
	Punjnad	35191	Normal	13/07/2024
Ravi	Jassar	26800	Normal	24/07/2024
	Shahdara	24755	Normal	25/07/2024
	Balloki	48280	Low	26/07/2024
	Sidhnai	26094	Normal	28/07/2024
Sutlej	GS Wala	5436	Normal	07/07/2024
	Sulemanki	21929	Normal	11/07/2024
	Islam	8627	Normal	14/07/2024
	Mailsi Syphon	1272	Normal	21/07/2024
Kabul	Nowshera	105500	Medium	31/07/2024
DG Khan	Kaura	23747	Normal	11/07/2024
	Vehova	24000	Normal	18/07/2024
	Sanghar	47403	Normal	11/07/2024
	Sori Lund	39758	Medium	12/07/2024
	Vidore	65924	High	12/07/2024
	S.Sarwar	16384	Medium	11/07/2024
	Mithanwa	2188	Normal	13/07/2024
Rajanpur	Kaha	12700	Normal	23/07/2024
	Chachar	7350	Normal	14/07/2024
	Sori Janubi	4459	Normal	20/07/2024
	Kala Bagga Khosra	4380	Normal	14/07/2024

Table 1: Maximum recorded Inflow/Peaks in July-2024

5.7 Rivers' Rim Station Hydrographs, July 2024

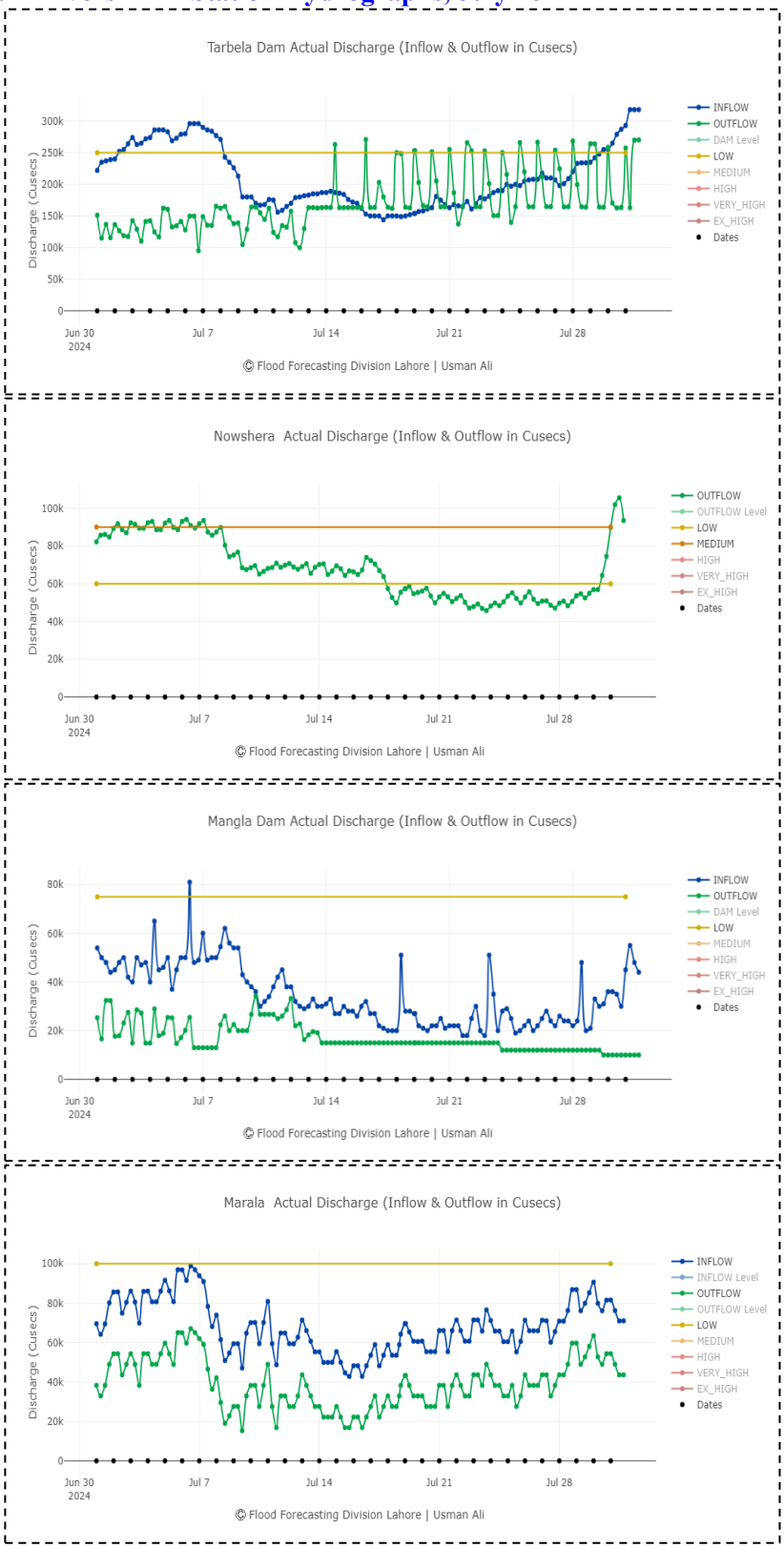


Fig (20) Rim stations & Nowshera at Kabul Hydrograph July-2024

AUGUST

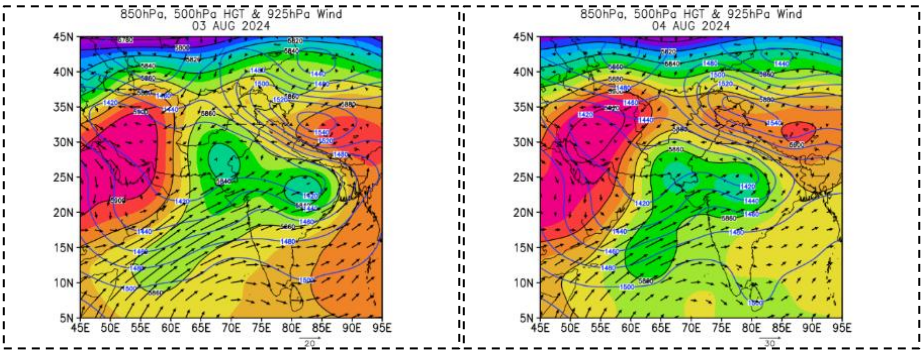
Hydro-Meteorological Events

6 Significant Hydro-Meteorological events during the month of August 2024.

During August 2024, four distinct rainfall spells were reported across the country. Overall, a high flood peak was observed over upstream Mangla while river Indus downstream Tarbela and River Chenab from Marala up to Qadirabad & river Kabul at Nowshera attained up to medium level peaks. High to exceptionally high levels of flash floods were reported in the hill torrents of DG khan division. The monsoon remained quite active over the country, resulting in 147% above-average rainfall. Significantly above-normal rainfall was recorded in Balochistan and Sindh, while Gilgit Baltistan and Punjab also experienced above-normal rainfall. Additionally, Azad Jammu & Kashmir and Khyber Pakhtunkhwa registered slightly above-normal rainfall. By the end of August, Tarbela reservoir attained 100% of its capacity, while Mangla reservoir was at 78%. Tarbela attained its maximum conservation level (MCL) on 19th August. MCL continuously sustained up to 12th September. By the end of August, Mangla reservoir was at 78% of its MCL.

6.1 1st wet spell of August 2024 (04th-06th).

The first wet spell of August 2024, which remained active for three days, was primarily due to the presence of a strong westerly trough and a low-pressure area over northeastern Sindh extending up to 500 hPa. This was accompanied by moderate to strong moist currents from both the Arabian Sea and the Bay of Bengal. Well marked seasonal low with its central pressure of 994 hpa also provided favorable conditions for the wet spell. Fig (21) 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.



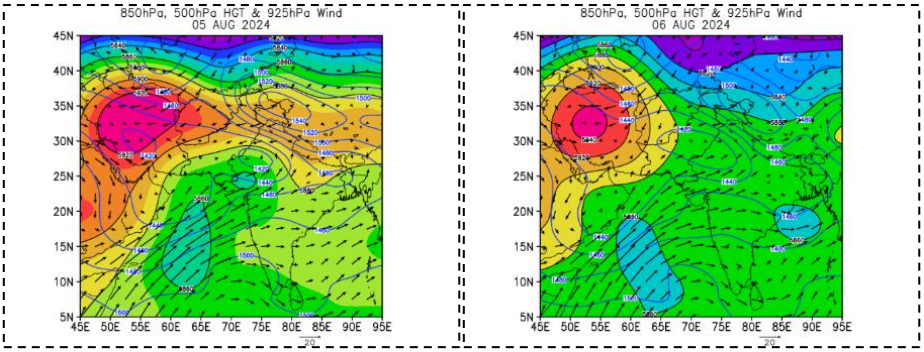


Fig (21)) 850 & 500 hPa Geopotential Height & 925 hpa winds map of 1st spell of august

The isohyetal map in Figure 22 shows the center of maximum rainfall, exceeding 175 mm, over Cherat. Sakrand, Shaheed Benazirabad, Mirpur Khas, Balakot & Rahim Yar Khan recorded more than 100 mm. Rainfall distribution recorded over the rest of the country is also shown below in Fig (22).

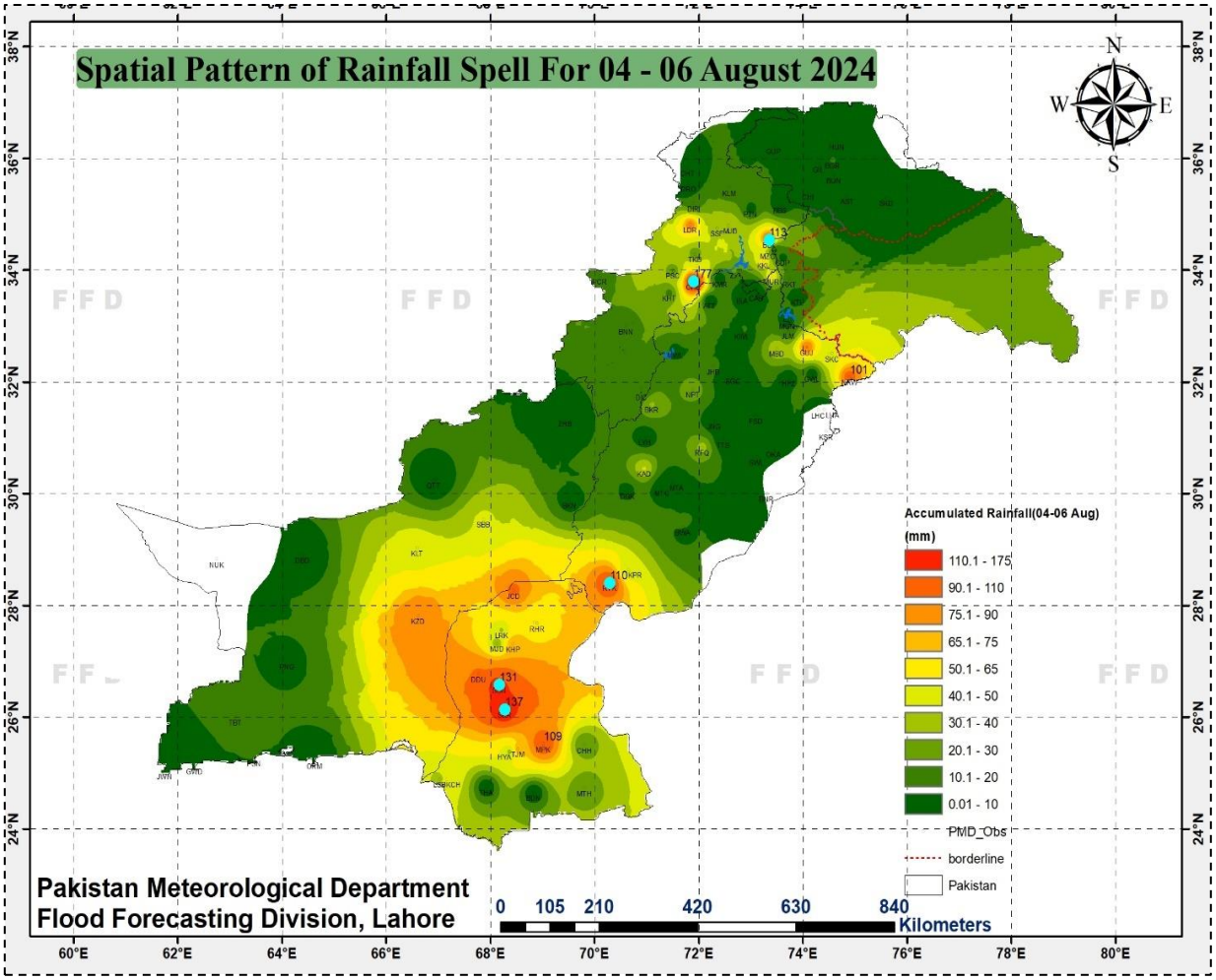


Fig (22) 1st Spell of August Total Rainfall

Satellite images during the spell are shown below in Fig (23)

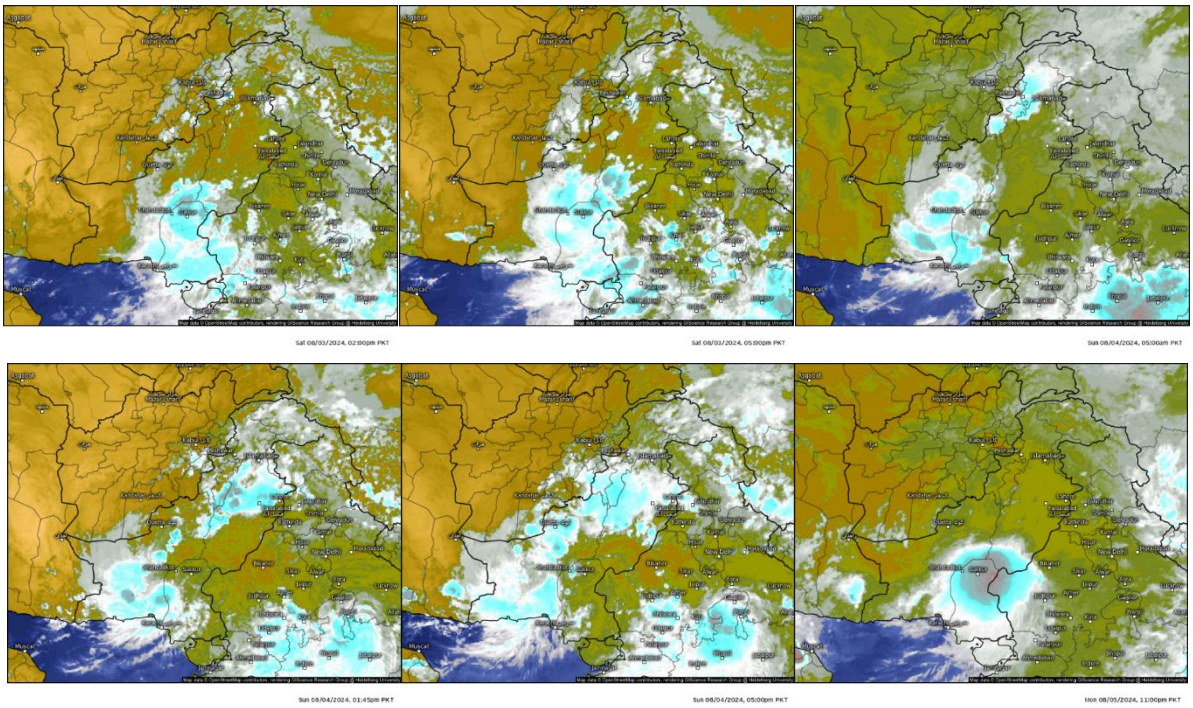
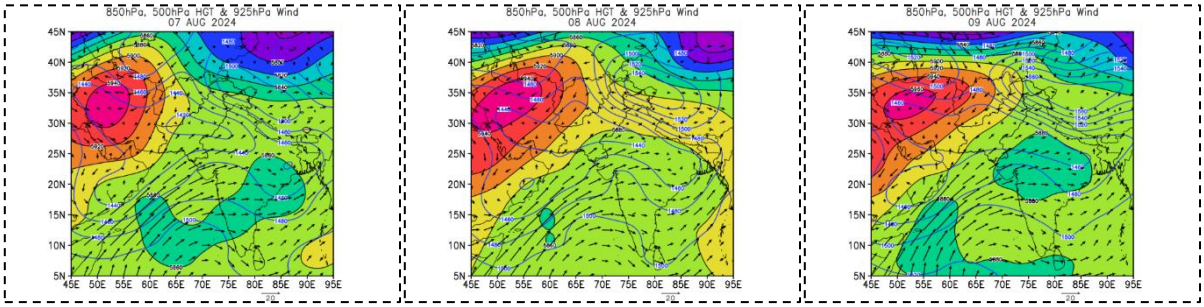


Fig (23) Satellite images of 1st Spell of August

6.2 2nd wet spell of August 2024 (8th – 12th).

Second long wet spell of August 2024 remained active for five days and was mainly due to the presence of a westerly wave, active monsoon trough and moderate to strong moist currents from the Bay of Bengal and Arabian Sea. Fig (24) 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 winds at 925 hPa were also present ensuring strong moisture supply from the Bay of Bengal and moderate moist currents from Arabian Sea.



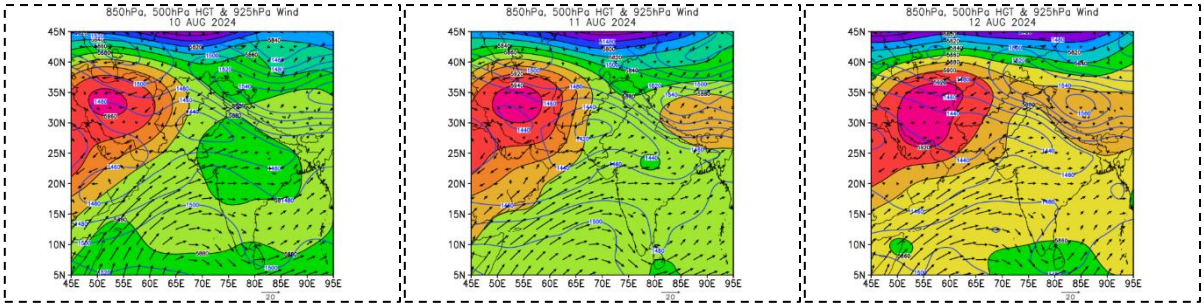


Fig (24) 850 & 500 hPa Geopotential Height & 925 hpa winds map 2nd spell of August

Islamabad Airport received 254 mm rainfall during the spell. Chaklala, Narowal, Malam Jabba & Risalpur received more than 100 mm rainfall. Rainfall received in rest of the country can also be seen from the Fig (25)

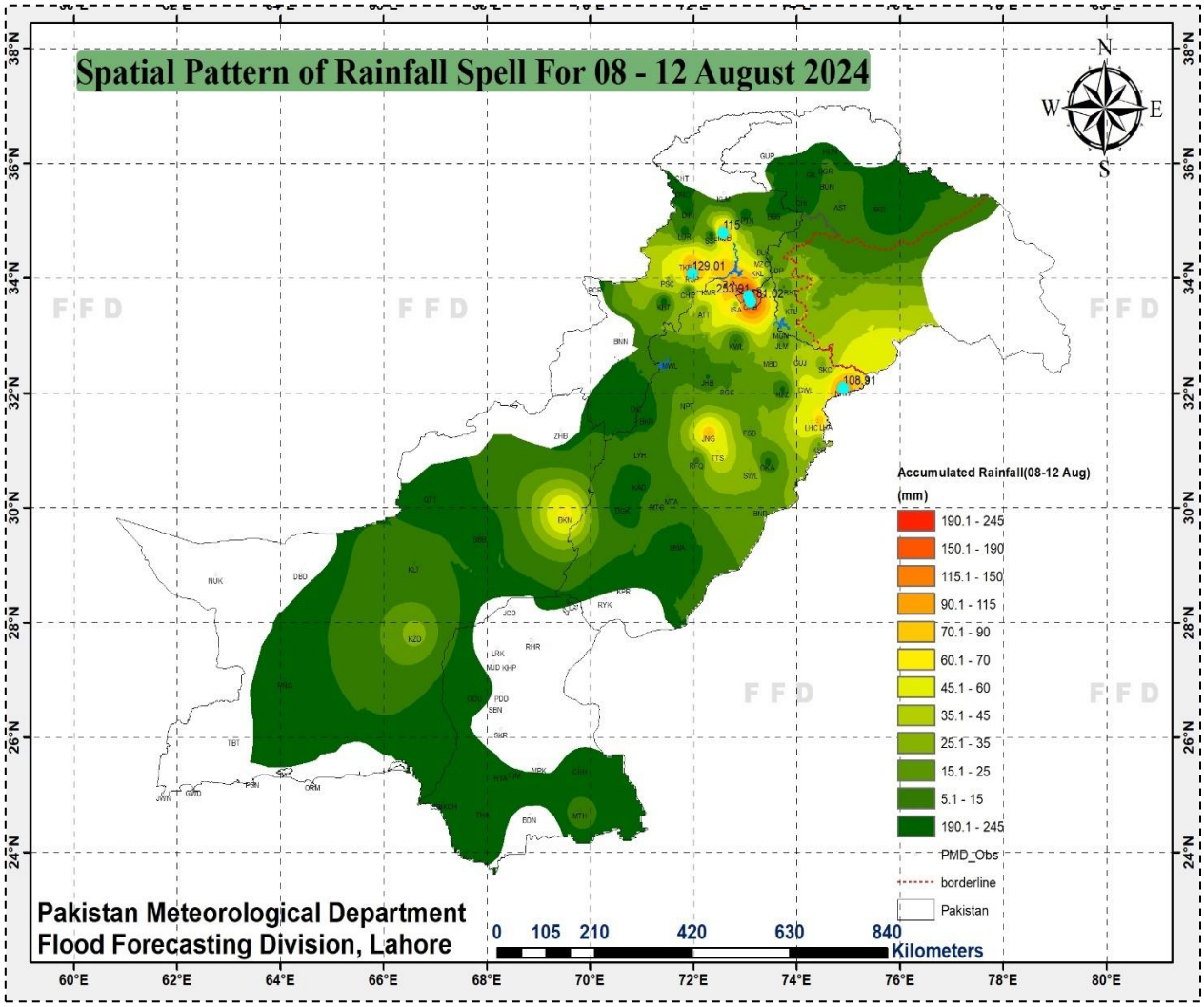


Fig (25) 2nd Spell of August total Rainfall

Dense clouds observed by satellite during the spell are shown in the Fig (26).

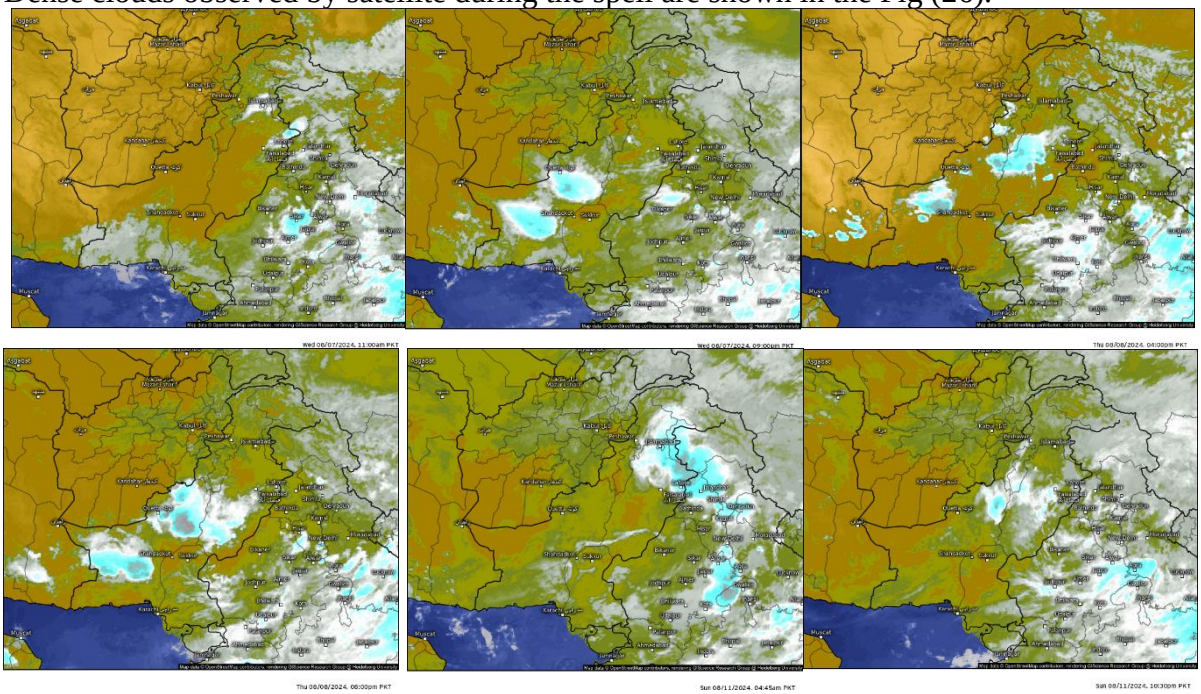
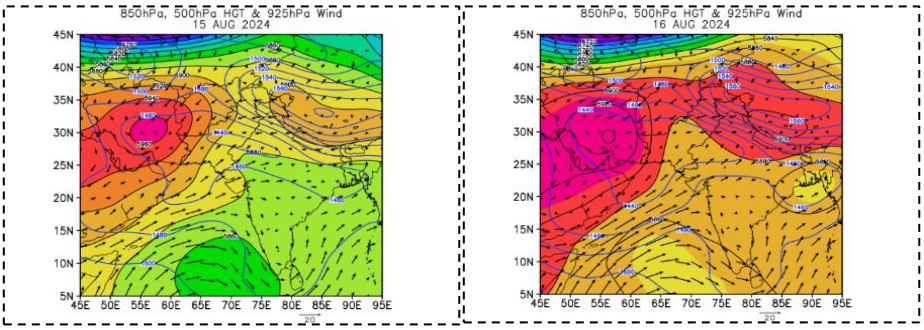


Fig (26) Satellite images of 2nd Spell of August

6.3 3rd Spell of August 2024 (16th -18th).

Third wet spell of August 2024 remained active for three days and was mainly due to the presence of strong westerly wave along with a Jetstream over Afghanistan. Upper air circulation over northwest Rajasthan and adjoining Pakistan along with southwest wind speed divergence over east Sindh and Rajasthan & southeast wind divergence over Indian Punjab while directional convergence over south Punjab and adjoining Sindh reinforced the rain bearing system. Fig (27) 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 winds at 925 hPa were also present ensuring strong moisture supply from the Bay of Bengal and moderate moist currents from Arabian Sea.



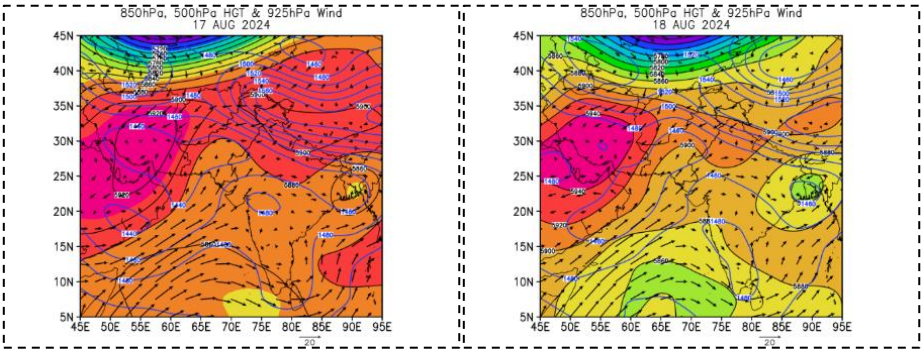


Fig (27) 850 & 500 hPa Geopotential Height & 925 hpa winds map 3rd spell of August.

The system was centered over Sindh which produced widespread rainfall of more than 100 mm. Highest rain of more than 180 mm recorded at Khairpur and more than 150 mm at Chhor. Rainfall received in rest of the country can also be seen from the Fig (28)

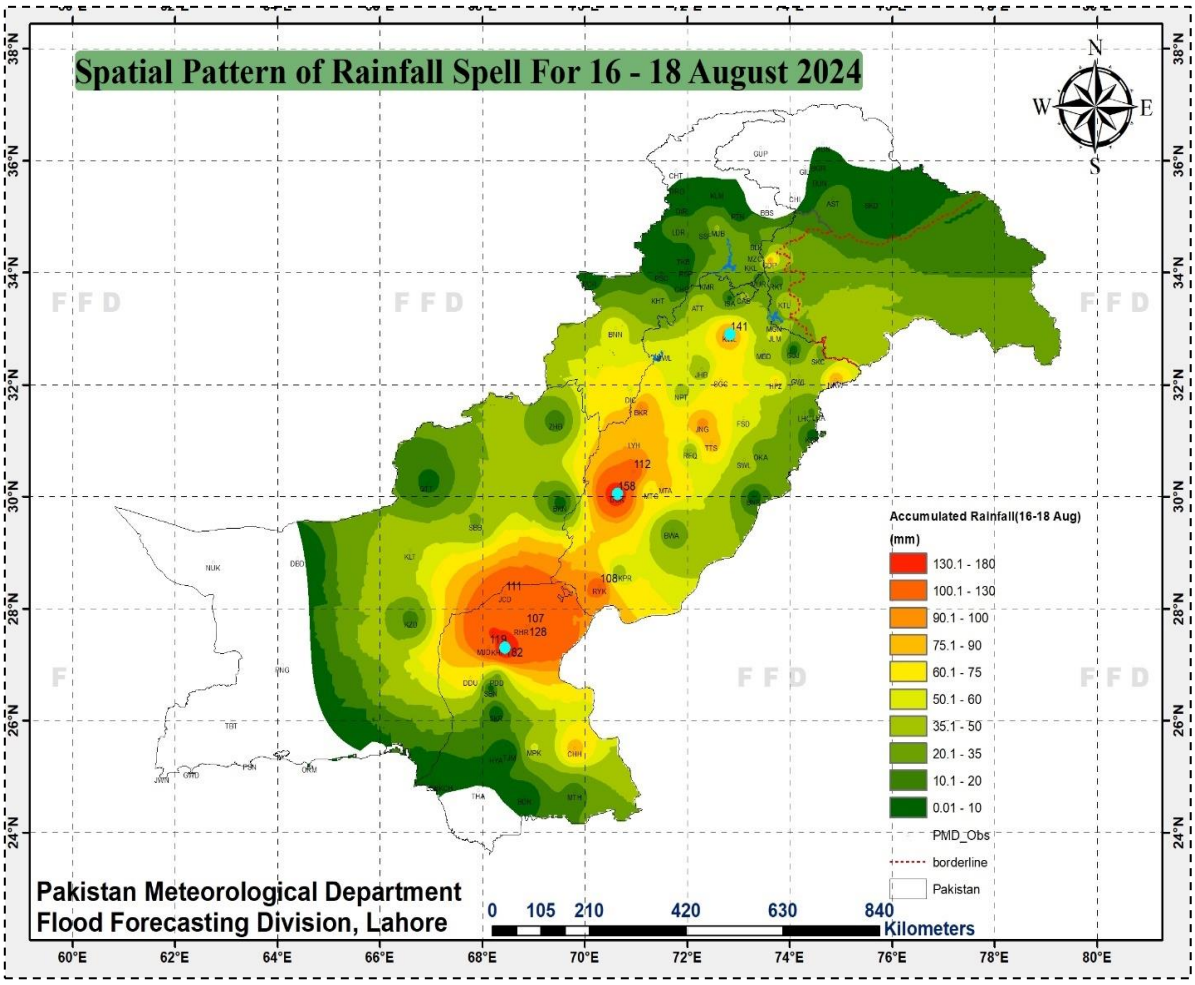


Fig (28) 3rd Spell of August total Rainfall

Dense clouds observed by satellite during the spell is shown in the Fig (29).

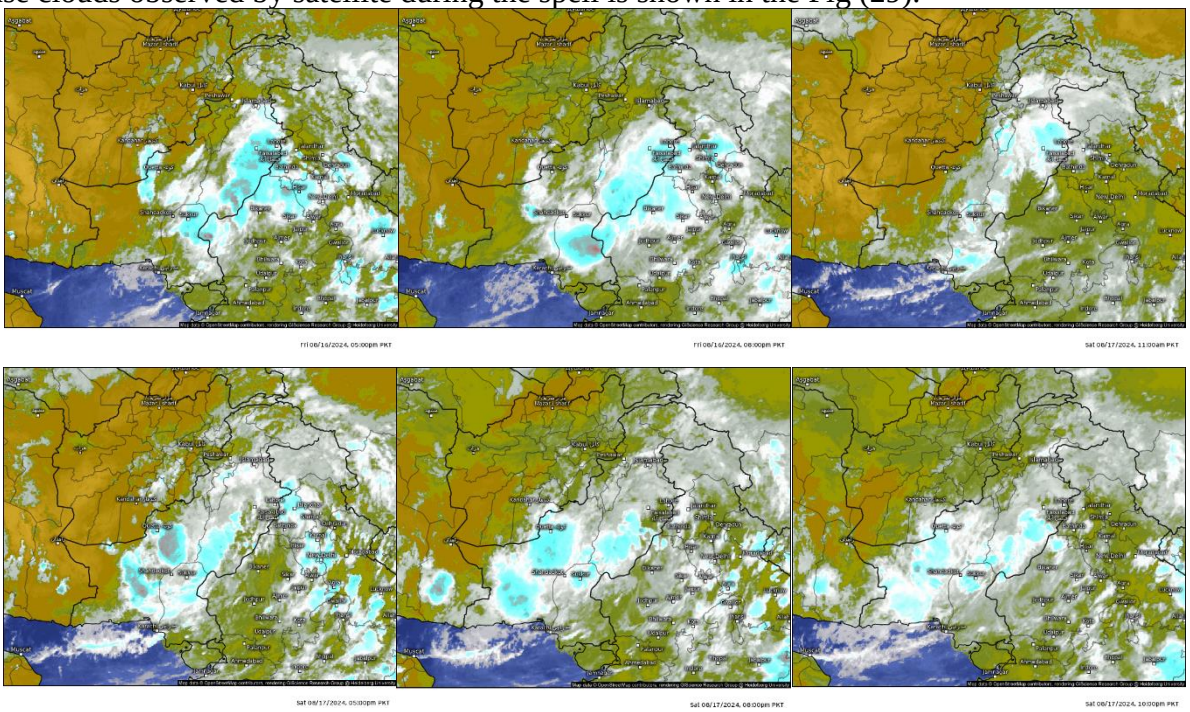
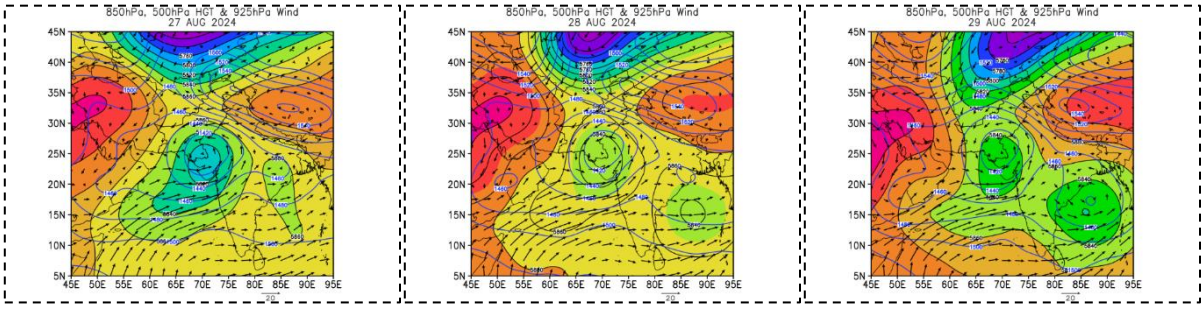


Fig (29) Satellite images of 3rd Spell of July

6.4 4th Spell of August 2024 (28th -31st August)

The fourth wet spell of August 2024 remained active for three days, primarily due to the presence of a deep depression, extending vertically up to 9 km, in the vicinity of the country. This was accompanied by a trough of westerly waves over northeastern Afghanistan and strong moist winds from the Bay of Bengal and Arabian Sea extending up to 10,000 feet. Fig (30) 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 winds at 925 hPa were also present ensuring strong moisture supply from the Bay of Bengal and moderate moist currents from Arabian Sea.



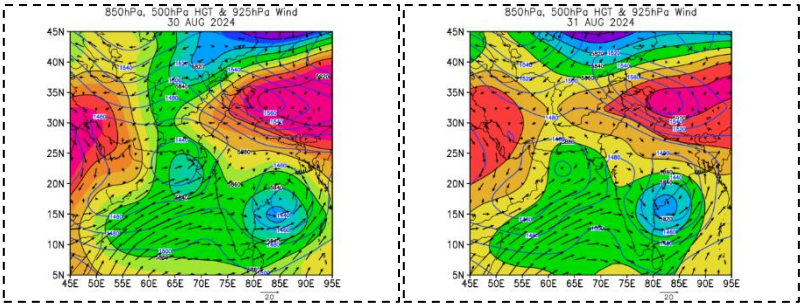


Fig (30) 850 & 500 hPa Geopotential Height & 925 hpa winds map 4th spell of August.

In this spell rainfall was mainly concentrated over Sindh and upper catchments of river Jhelum. The weather system produced widespread rainfall of more than 100 mm. Highest rain of more than 180 mm recorded at Badin and more than 130 mm at Thatta. Muzaffarabad and Mangla observed more than 170 mm. Rainfall received in rest of the country can also be seen from the Fig (31)

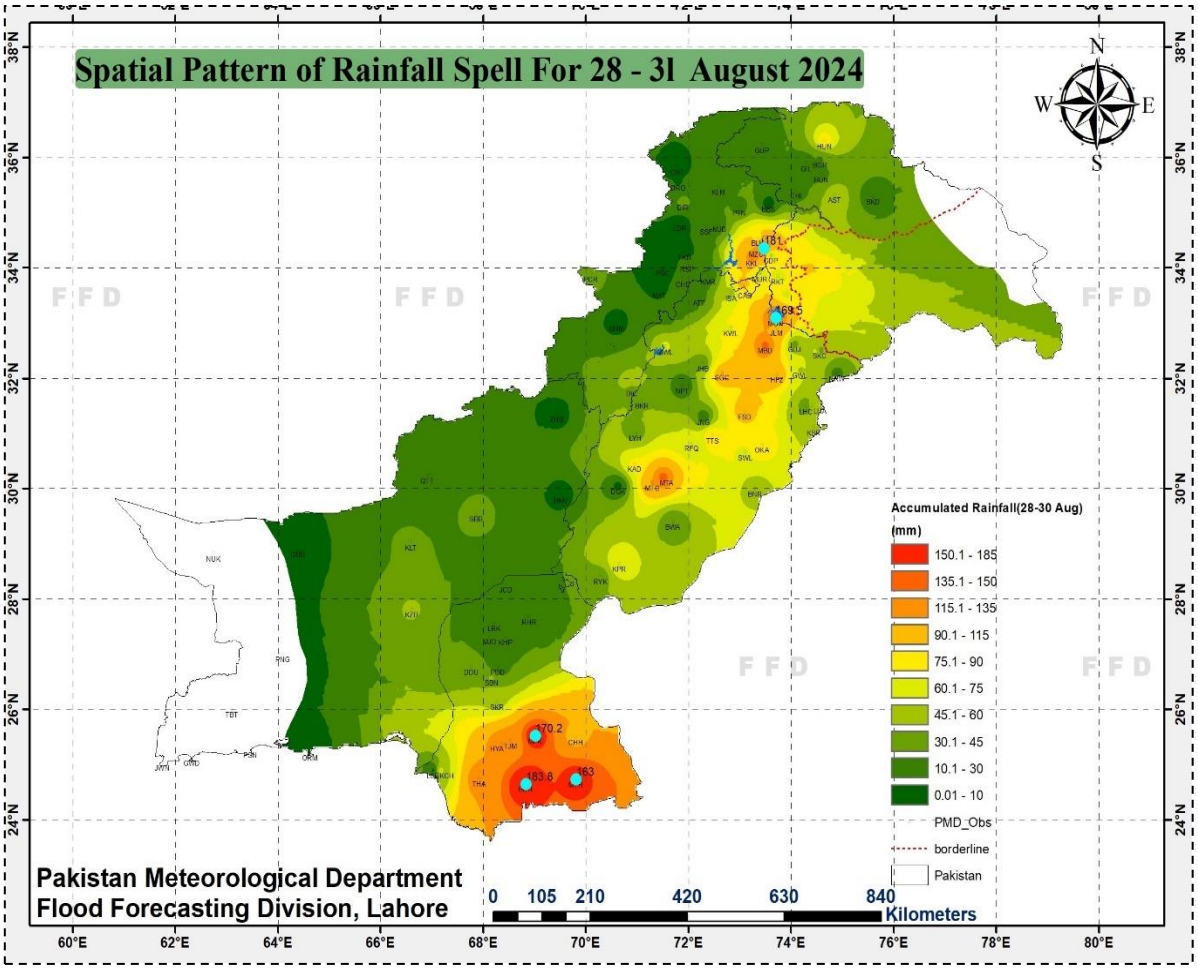


Fig (31) 4th Spell of August total Rainfall

Dense clouds observed by satellite during the spell are shown in the Fig (32).

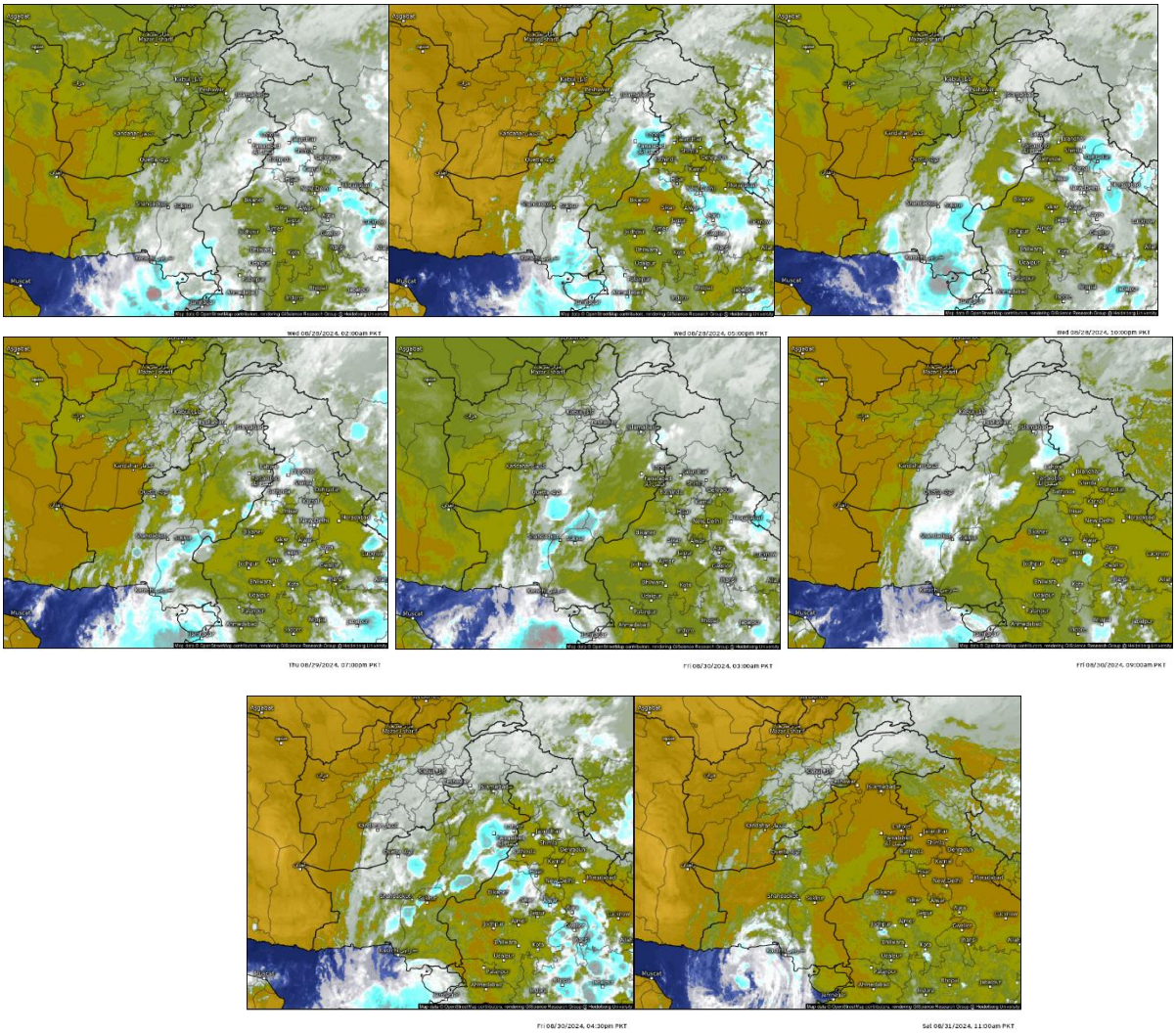


Fig (32) Satellite images of 4th Spell of August

6.5 Monthly maps of Total rainfall & Departure and graph of Temporal Distribution & Area Weighted Rainfall during August 2024.

Isohytal map of August 2024 indicates that the maximum rainfall region lies around Lahore. The region of the second maximum rainfall lies in Khyber Pakhtunkhwa at Balakot. Most parts of Sindh, Punjab, north Balochistan, Khyber Pakhtunkhwa and Kashmir received more than 180 mm of rainfall as shown in the Fig (33)

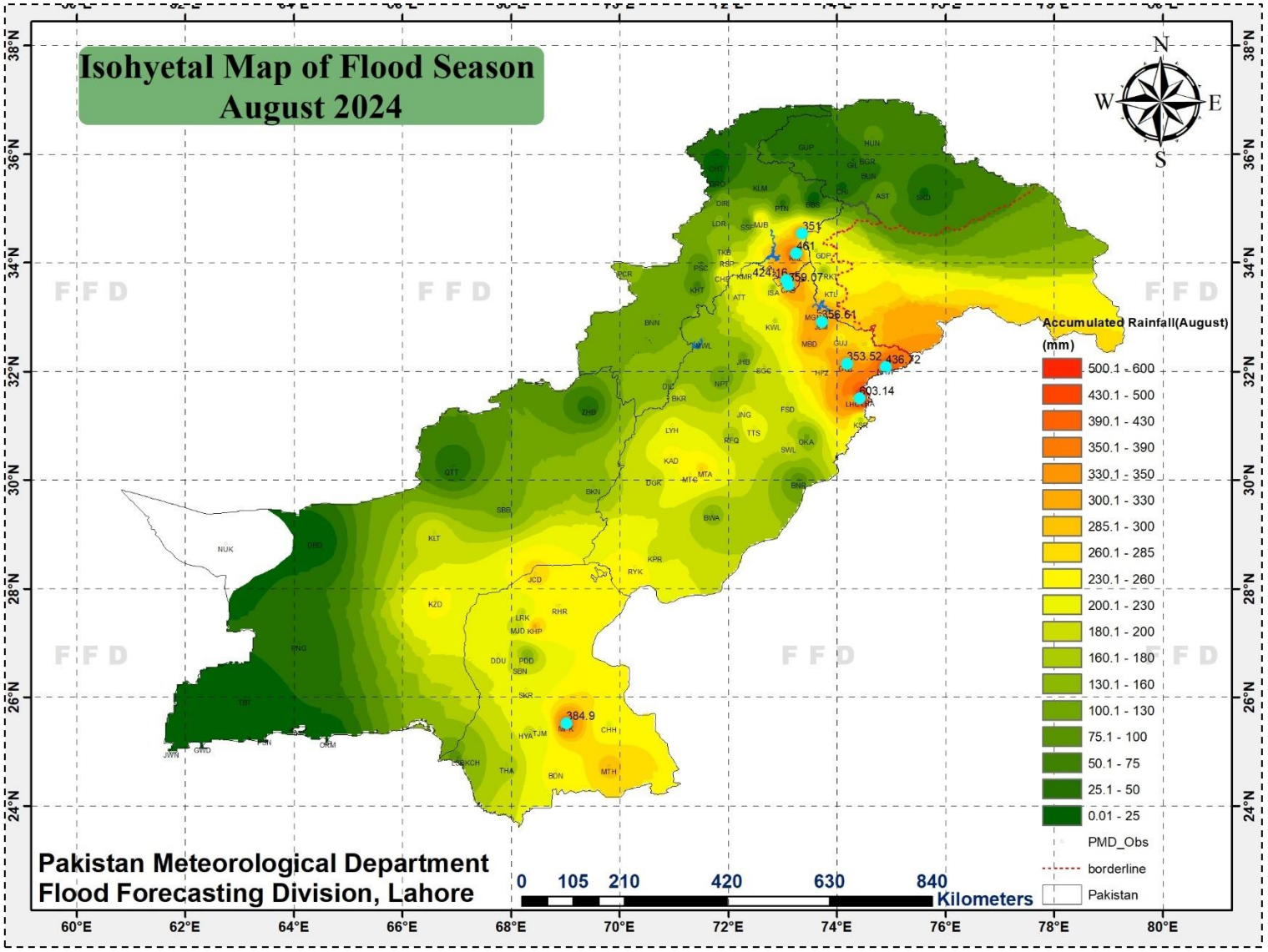


Fig (33) Monthly total rainfall map of August- 2024.

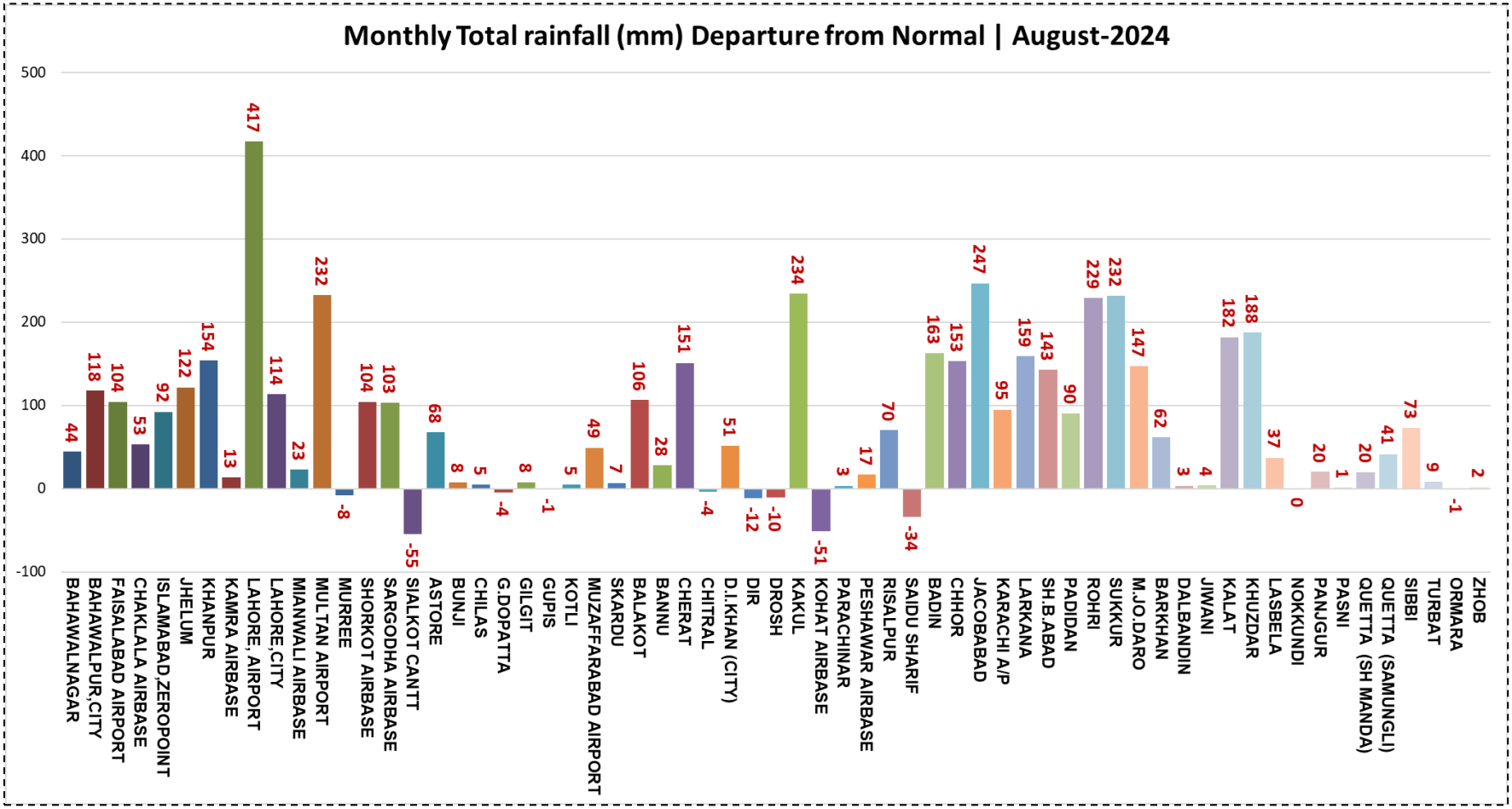


Fig (34) Monthly total rainfall graph of August 2024.

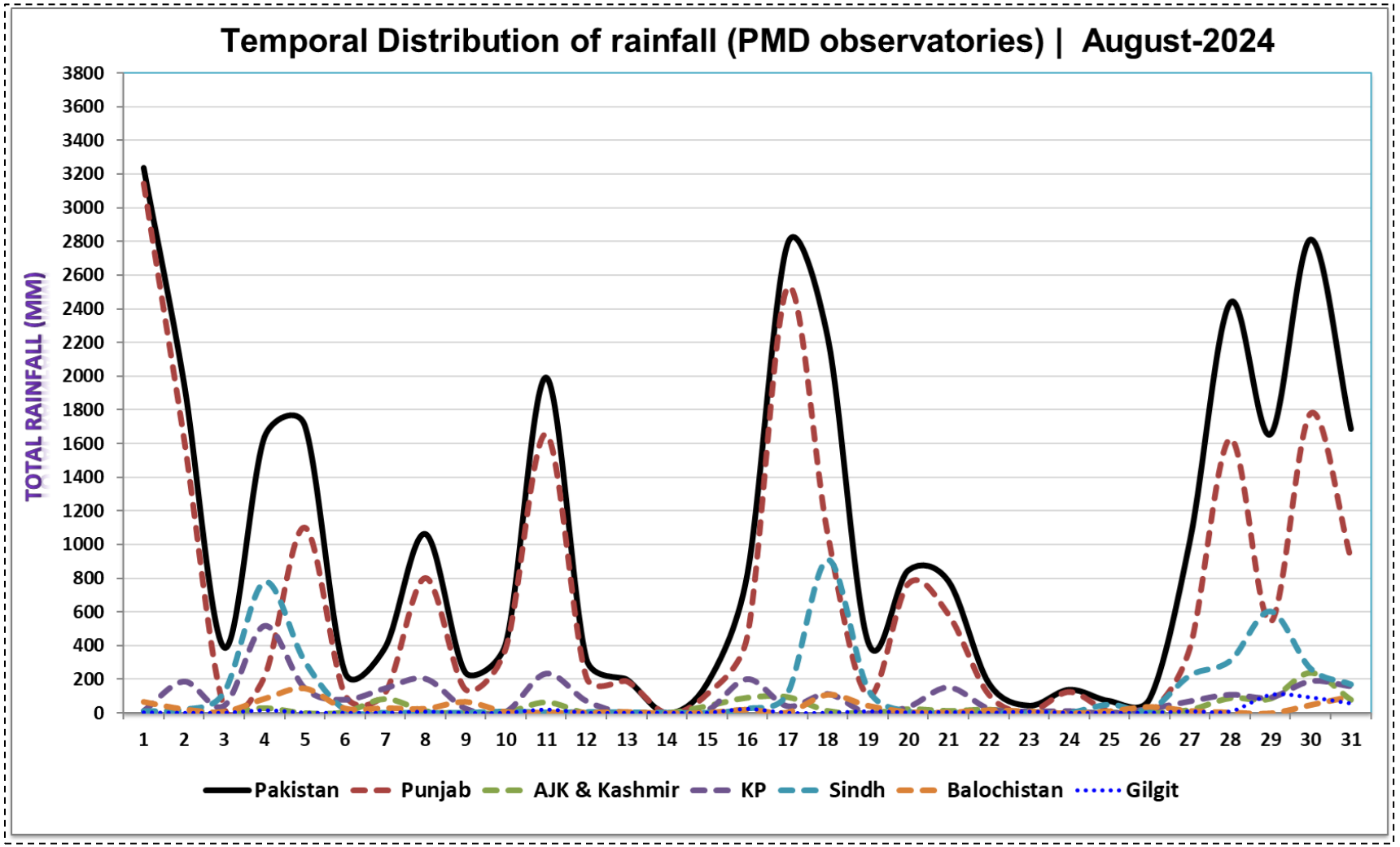


Fig (35) Monthly Rainfall Temporal distribution of August

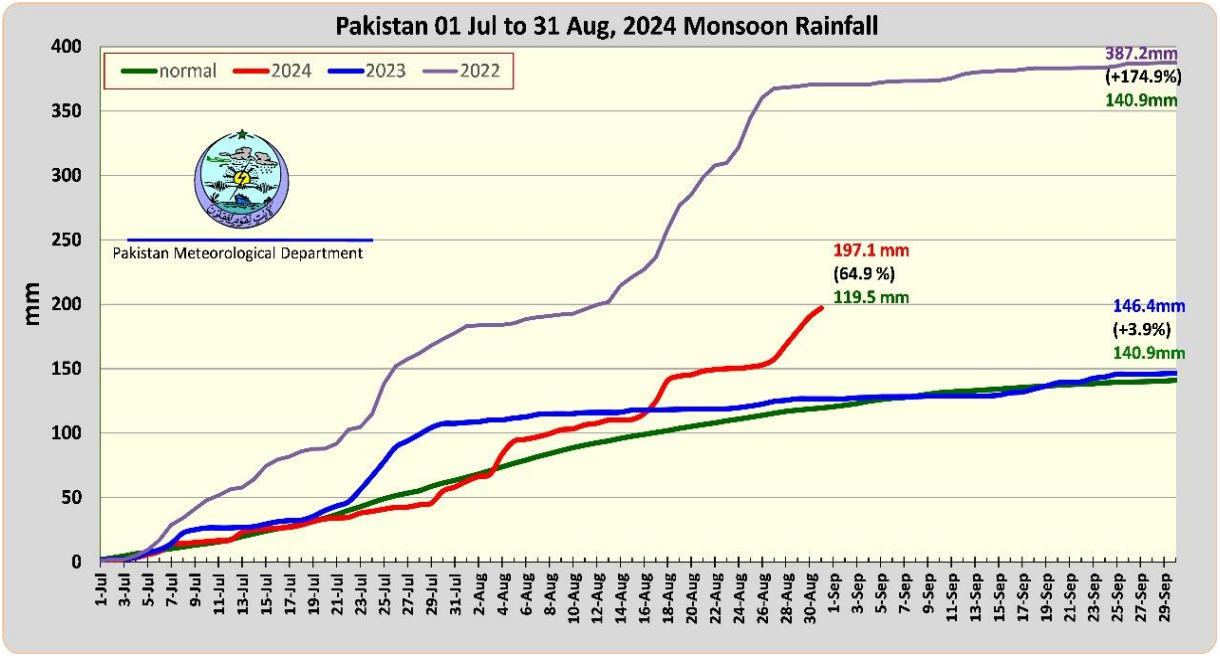


Fig (36) Monsoon Progress & Area Weighted Rainfall Comparison up to August-2024

	01 to 31 August 2024 Rainfall		
	normal (mm)	actual (mm)	Deviation (%)
Pakistan	56.2	138.9	147
Azad J&K	150.7	170.5	13
Balochistan	22.4	82.2	266
Gilgit-B	16.7	30.9	85
Khyber-PK	103.6	133.0	28
Punjab	93.3	200.7	115
Sindh	53.6	234.5	338

Fig (37) Area Weighted Rainfall, August-2024

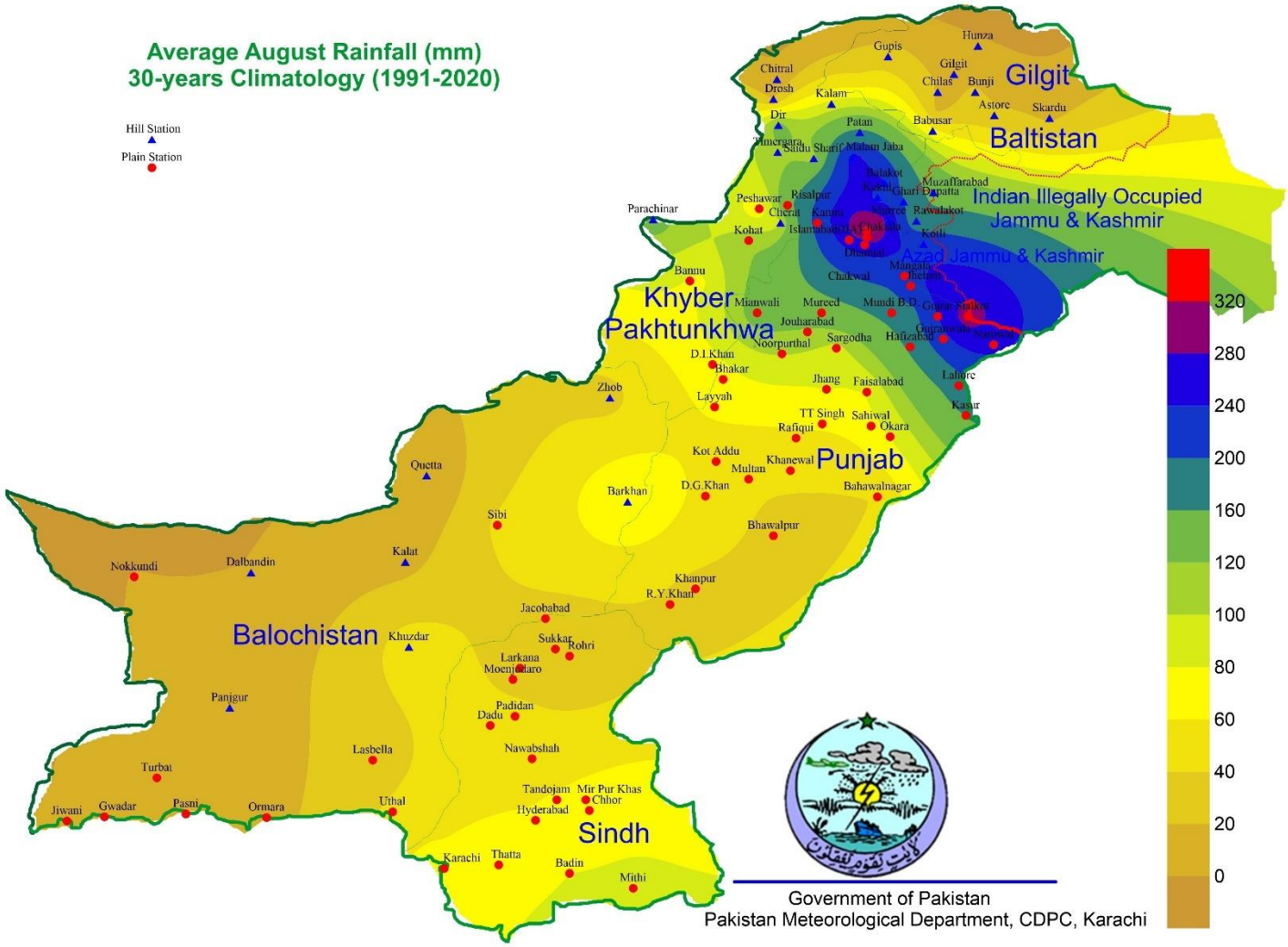


Fig (38) August Climate Normal of Rainfall

6.6 Peak flows recorded during the month of August-2024.

Peak Flows Observed in August-2024				
River	Sites	Inflow	Flood Level	Recorded Date
Indus	Tarbela	350000	Low	08/08/2024
	Kalabagh	401723	**Medium**	09/08/2024
	Chashma	432686	**Medium**	09/08/2024
	Taunsa	442170	**Medium**	11/08/2024
	Guddu	431321	**Medium**	12/08/2024
	Sukkur	401060	**Medium**	24/08/2024
	Kotri	337218	**Medium**	31/08/2024
Jhelum	Mangla	176000	**High**	30/08/2024
	Rasul	67835	Normal	31/08/2024
Chenab	Marala	178750	**Medium**	15/08/2024
	Khanki	177109	**Medium**	16/08/2024
	Qadirabad	166323	**Medium**	16/08/2024
	Trimmu	96280	Normal	19/08/2024
	Punjnad	72320	Normal	25/08/2024
Ravi	Jassar	49400	Normal	16/08/2024
	Shahdara	28014	Normal	17/08/2024
	Balloki	56340	Low	19/08/2024
	Sidhnai	32814	Low	17/08/2024
Sutlej	GS Wala	19659	Normal	14/08/2024
	Sulemanki	24941	Normal	05/08/2024
	Islam	12545	Normal	22/08/2024
Kabul	Nowshera	114200	**Medium**	05/08/2024
DG Khan	Kaura	23747	Normal	04/08/2024
	Vehova	41364	Medium	04/08/2024
	Sanghar	35081	Normal	04/08/2024
	Sori Lund	16206	Normal	17/08/2024
	Vidore	75589	**High**	18/08/2024
	S.Sarwar	29701	**High**	18/08/2024
	Mithanwa	26695	**Medium**	18/08/2024
Rajanpur	Kaha	105276	**Ex.High**	18/08/2024
	Chachar	63840	**Ex.High**	18/08/2024
	Pitok	15600	**Ex.High**	18/08/2024
	Sori Shumali	7250	**Medium**	21/08/2024
	Sori Janubi	16560	**High**	18/08/2024
	Zangi	33600	**Ex High**	18/08/2024
	Kala Bagga Khosra	27640	**Ex.High**	18/08/2024

Table 2: Maximum recorded Inflow/Peaks in August-2024

6.7 Rivers' Rim Station Hydrographs, August 2024

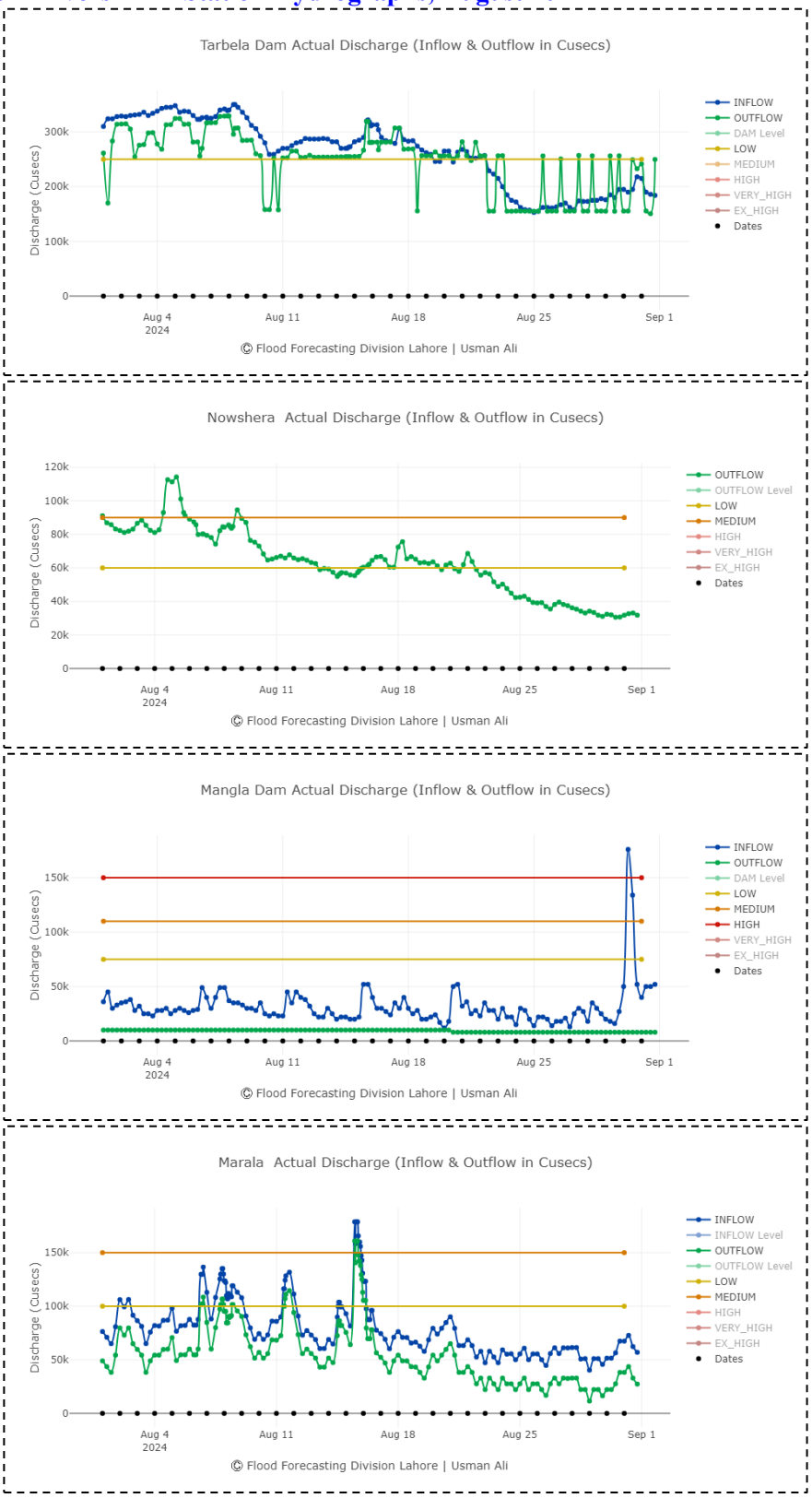
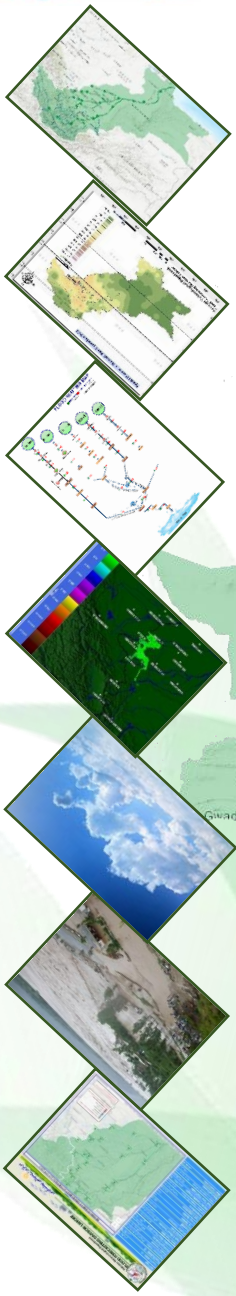
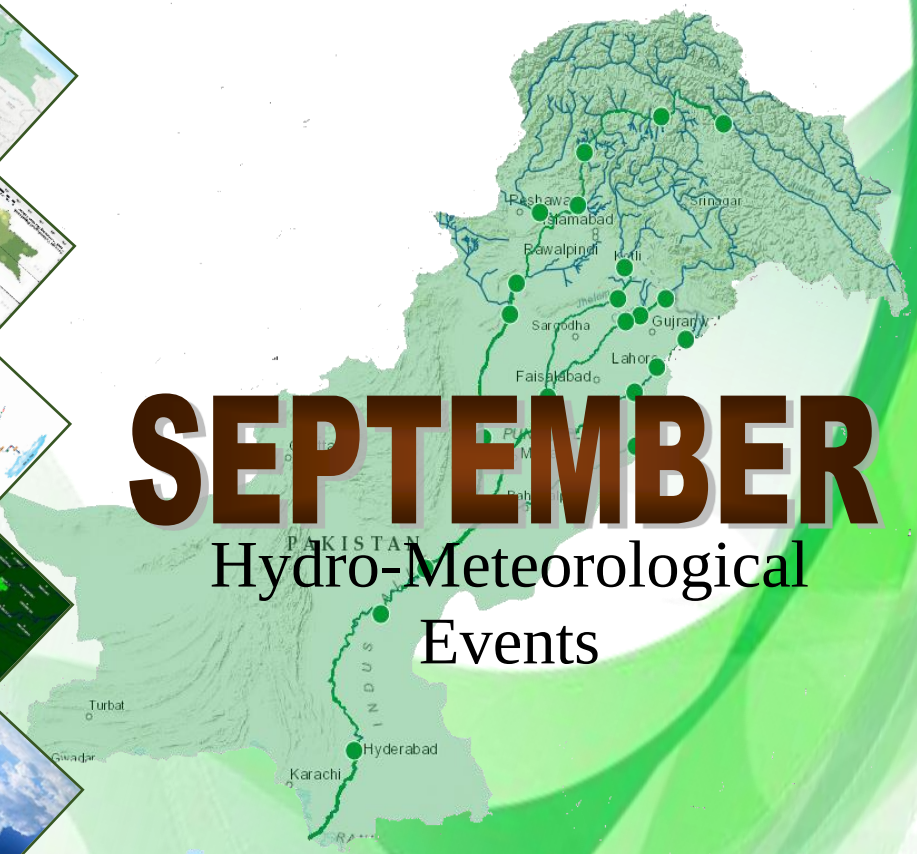


Fig (39) Rim Stations Hydrograph of August

PAKISTAN METEOROLOGICAL DEPARTMENT

فلڈ فور کاسٹنگ ڈویژن لاہور





SEPTEMBER

Hydro-Meteorological Events

7 Significant Hydro-Met events during the month of September-2024.

September remained mainly dry over the most parts of the country. During the month of September, only one wet spell was observed. Almost all the rivers remained in the state of their normal flows. During the month, higher temperatures in the upper catchments of the Indus River resulted in increased base flows, with water available at the upstream Tarbela reservoir recorded at 6.78 million acre-feet (MAF), compared to the normal of 6.1 MAF. Meanwhile, the Mangla reservoir received a water volume close to its normal value of 1.4 MAF.

7.1 1st wet spell of September 2024 (27th – 29th).

The only spell of September remained active for three days. During this event light to moderate rain with heavy falls at isolated places was reported from north Punjab at Chaklala, Jhelum and Mangla along with Islamabad. This situation was created due to the presence of a westerly wave over north of Pakistan, interacting with necessary moisture available as shown in Fig (40)

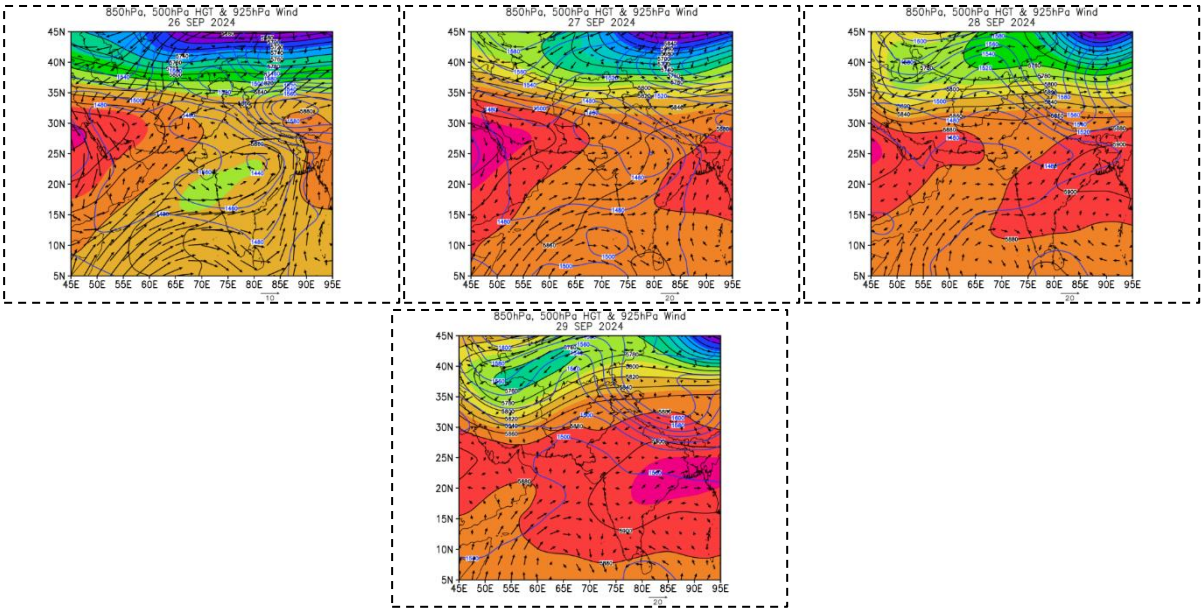


Fig (40) 850 & 500 hPa geopotential height & 925 hPa winds map 1st spell of September

Rainfall distribution during the spell is shown below. The center of maximum rain is located one around Chaklala & Mangla.

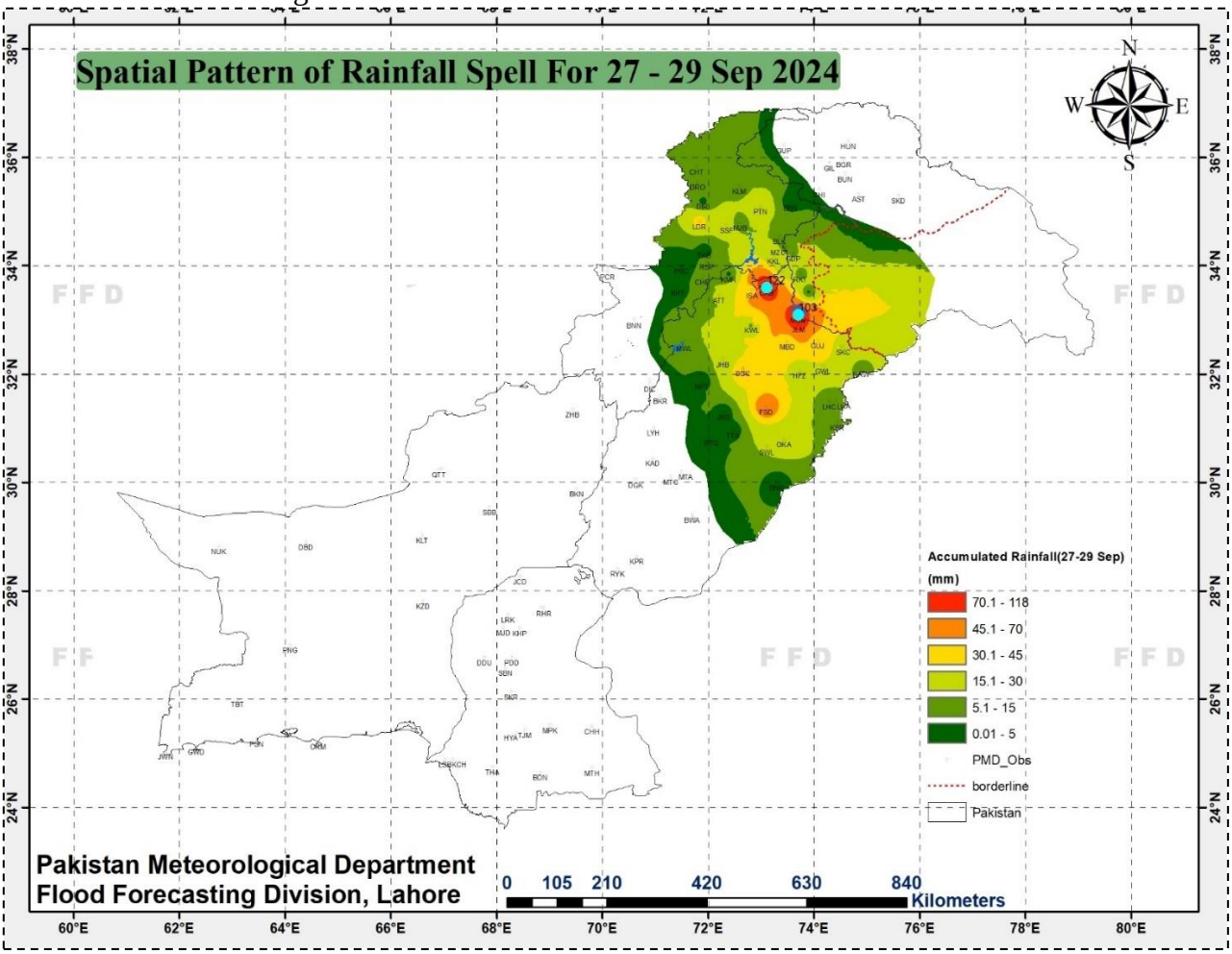


Fig (41) 1st Spell total rainfall of September

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

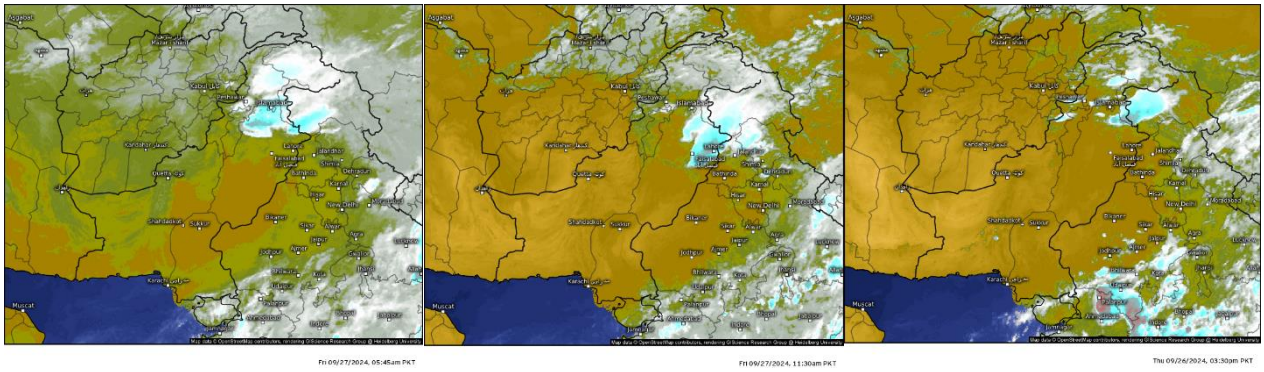


Fig (42) 1st Spell satellite images

7.2 Monthly maps of Total rainfall & Departure and graphs of Temporal Distribution & Area Weighted Rainfall during September-2024.

The center of maximum rainfall of more than 180 mm during September is located around Islamabad and Rawalpindi, second maximum of more than 100 mm around Sialkot and Mangla. Rest of the rainfall distribution can be seen in the Fig (43).

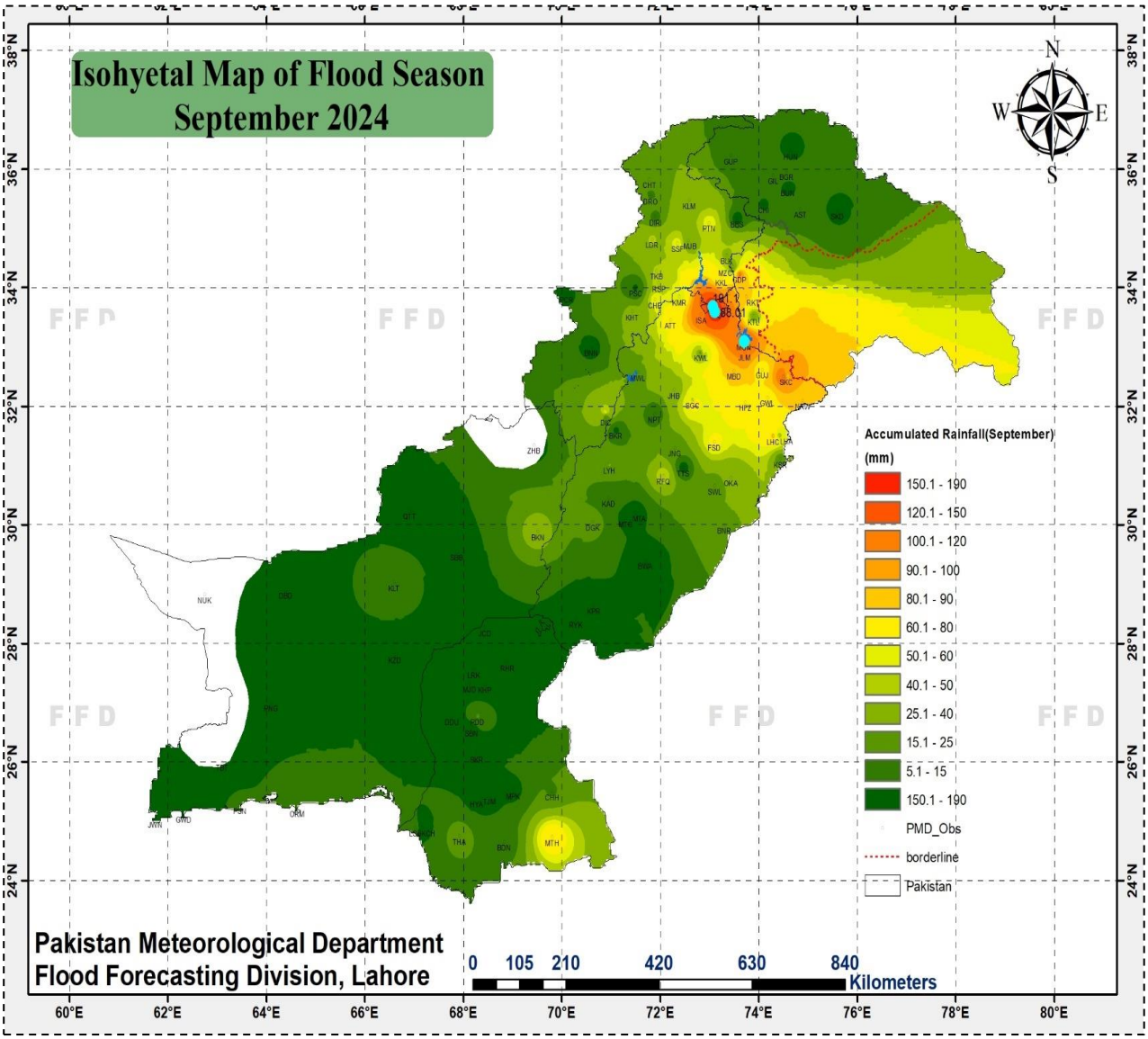


Fig (43) Monthly Total rainfall of September

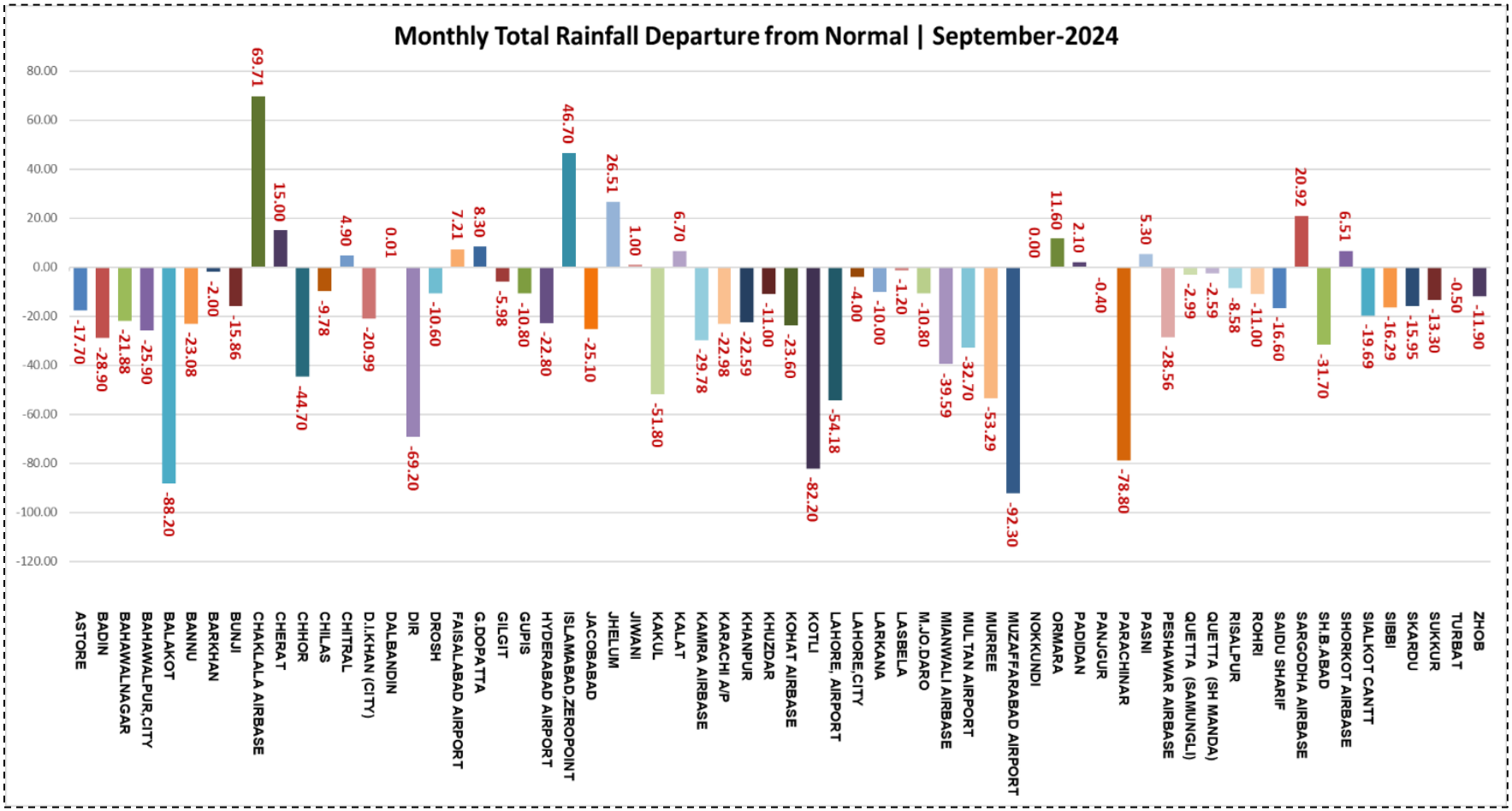


Fig (44) Monthly Total Rainfall Departure of September

Fig (45) shows the monthly rainfall temporal distribution during the month of september.

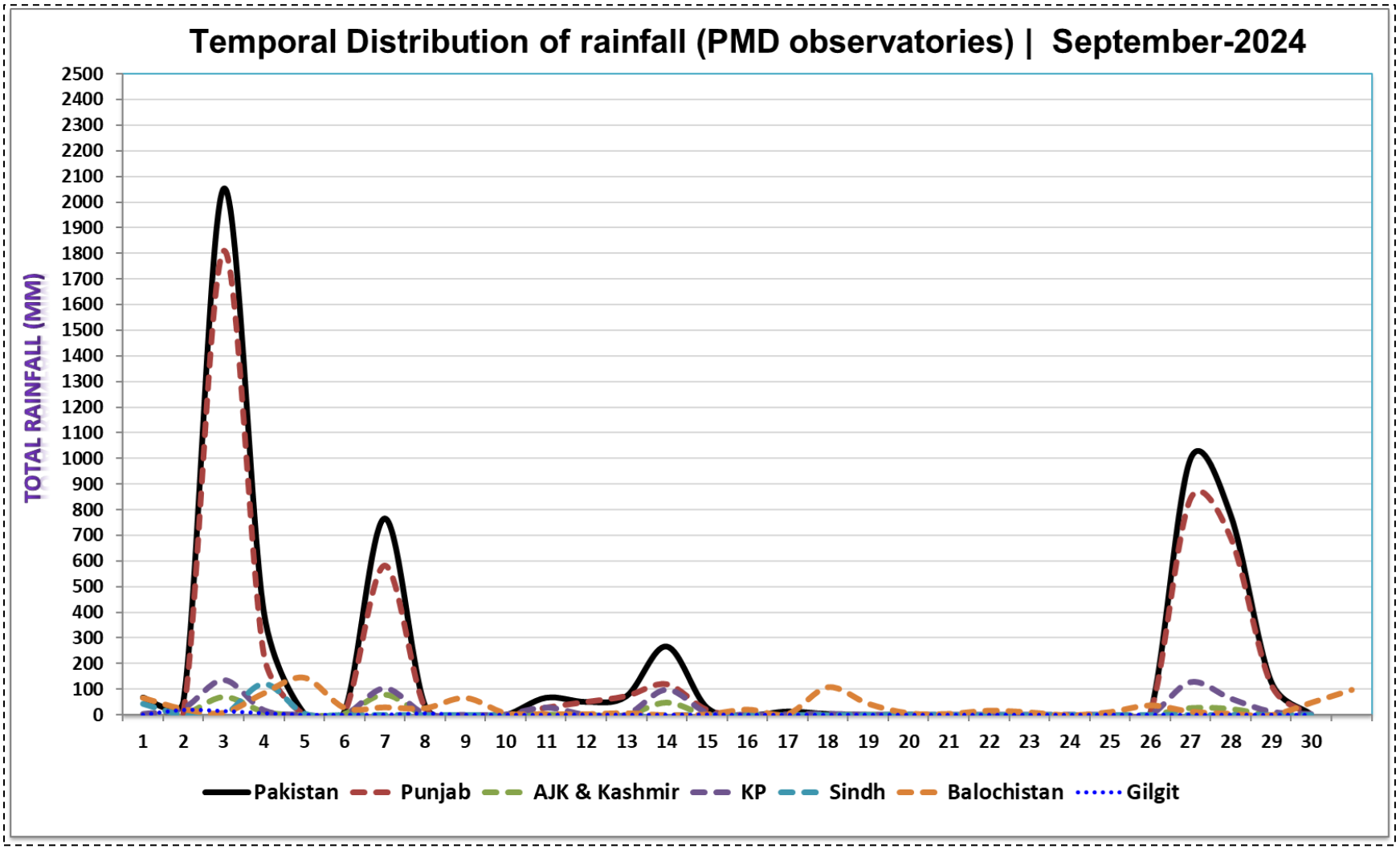


Fig (45) Monthly Total rainfall Temporal Distribution Sep-2024

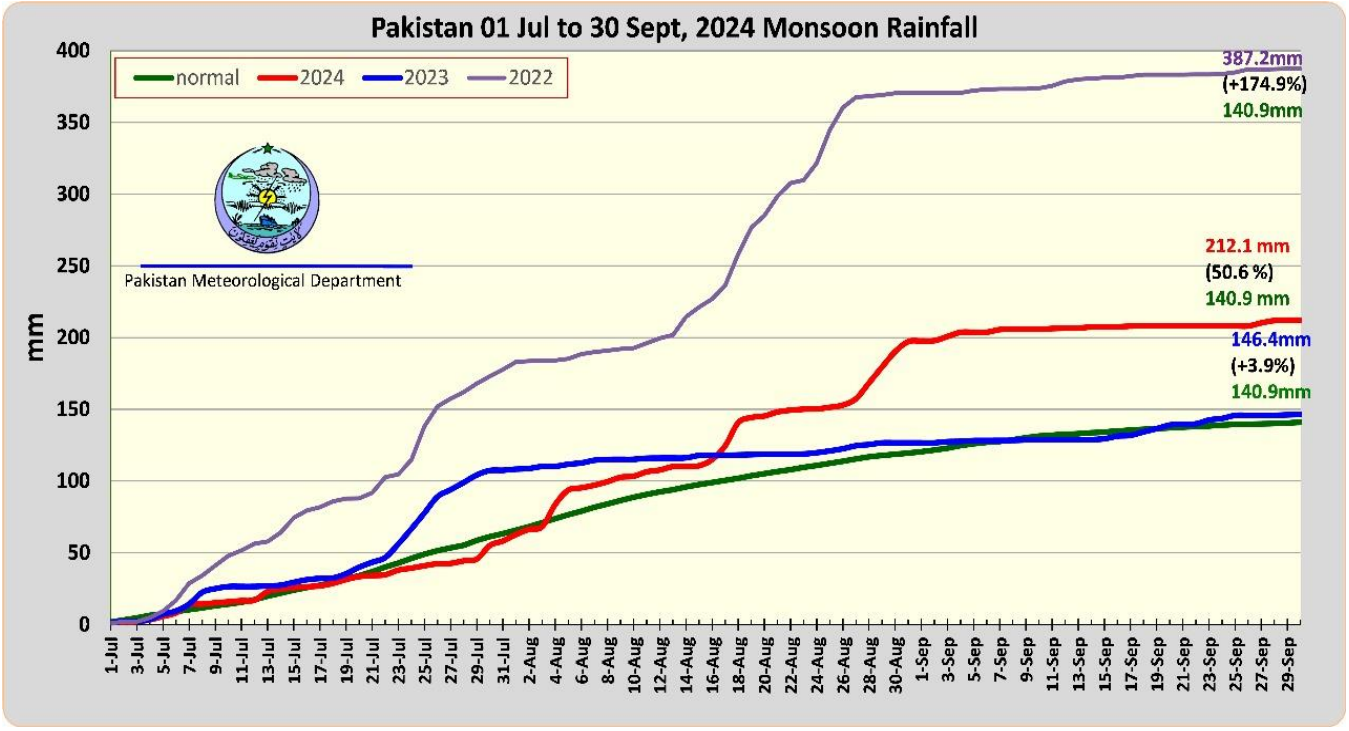


Fig (46) Monsoon Progress & Area Weighted Rainfall Comparison up to Sep-2024

	September, 2024 Rainfall		
	normal (mm)	actual (mm)	Dev (%)
Pakistan	21.4	15.0	-30
Azad J&K	64.9	41.4	-36
Balochistan	6.2	4.4	-29
Gilgit-B	9.7	4.3	-56
Khyber-PK	46.0	26.3	-43
Punjab	34.6	30.9	-11
Sindh	19.9	10.6	-47

Fig (47) Monthly Area Weighted Rainfall of Sep-2024

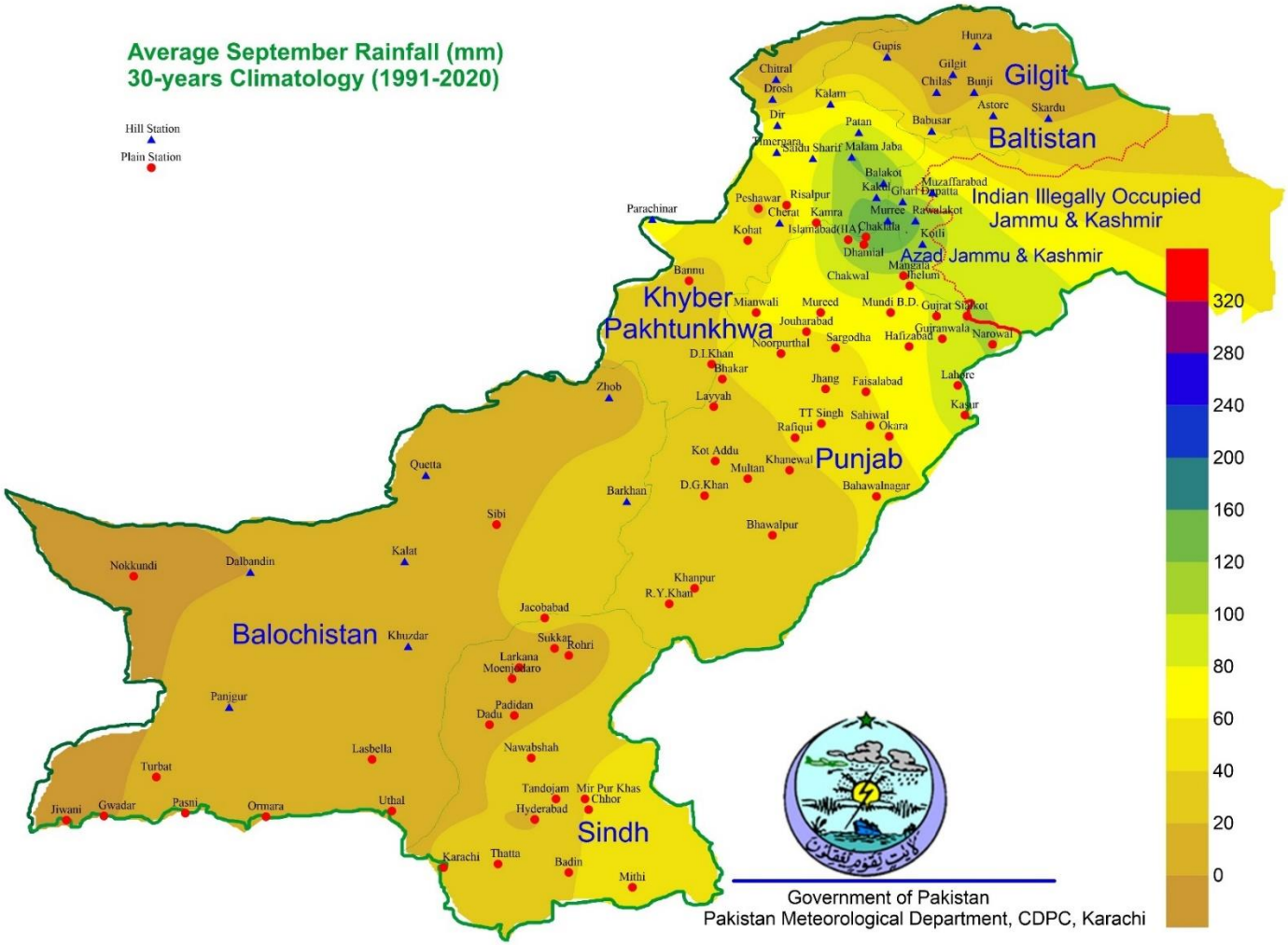


Fig (48) September Climate Normal of Rainfall

7.3 Maximum Peaks recorded in the month of September 2024 are as below

Peak Flows Observed in Sep-2024				
River	Sites	Inflow	Flood Level	Recorded Date
Indus	Tarbela	183000	**Normal**	01/09/2024
	Kalabagh	244055	**Normal**	03/09/2024
	Chashma	282536	**Low**	01/09/2024
	Taunsa	221077	**Normal**	03/09/2024
	Guddu	234968	Low	03/09/2024
	Sukkur	201030	Low	04/09/2024
	Kotri	342368	Medium	04/09/2024
Jhelum	Mangla	52000	Normal	03/09/2024
	Rasul	48243	**Normal**	29/09/2024
Chenab	Marala	79033	Normal	03/09/2024
	Khanki	68057	Normal	01/09/2024
	Qadirabad	61572	Normal	01/09/2024
	Trimmu	88084	Normal	04/09/2024
	Punjnad	63992	Normal	09/09/2024
Ravi	Jassar	5845	Normal	05/09/2024
	Shahdara	18930	Normal	06/09/2024
	Balloki	50340	Low	01/09/2024
	Sidhnai	33795	**Low**	03/09/2024
Sutlej	GS Wala	5436	Normal	06/09/2024
	Sulemanki	19607	Normal	08/09/2024
	Islam	11276	Normal	03/09/2024
Kabul	Nowshera	34900	Normal	05/09/2024
DG Khan	Kaura	40000	Medium	03/09/2024
	Vehova	38696	Normal	03/09/2024
	Sanghar	26064	Normal	03/09/2024
	Sori Lund	51460	High	03/09/2024
	Vidore	32012	Medium	10/09/2024
	S.Sarwar	9370	Normal	03/09/2024

Table 3: Maximum recorded Inflow/Peaks in September-2024

7.4 Rim stations Hydrographs of September 2024 are as below

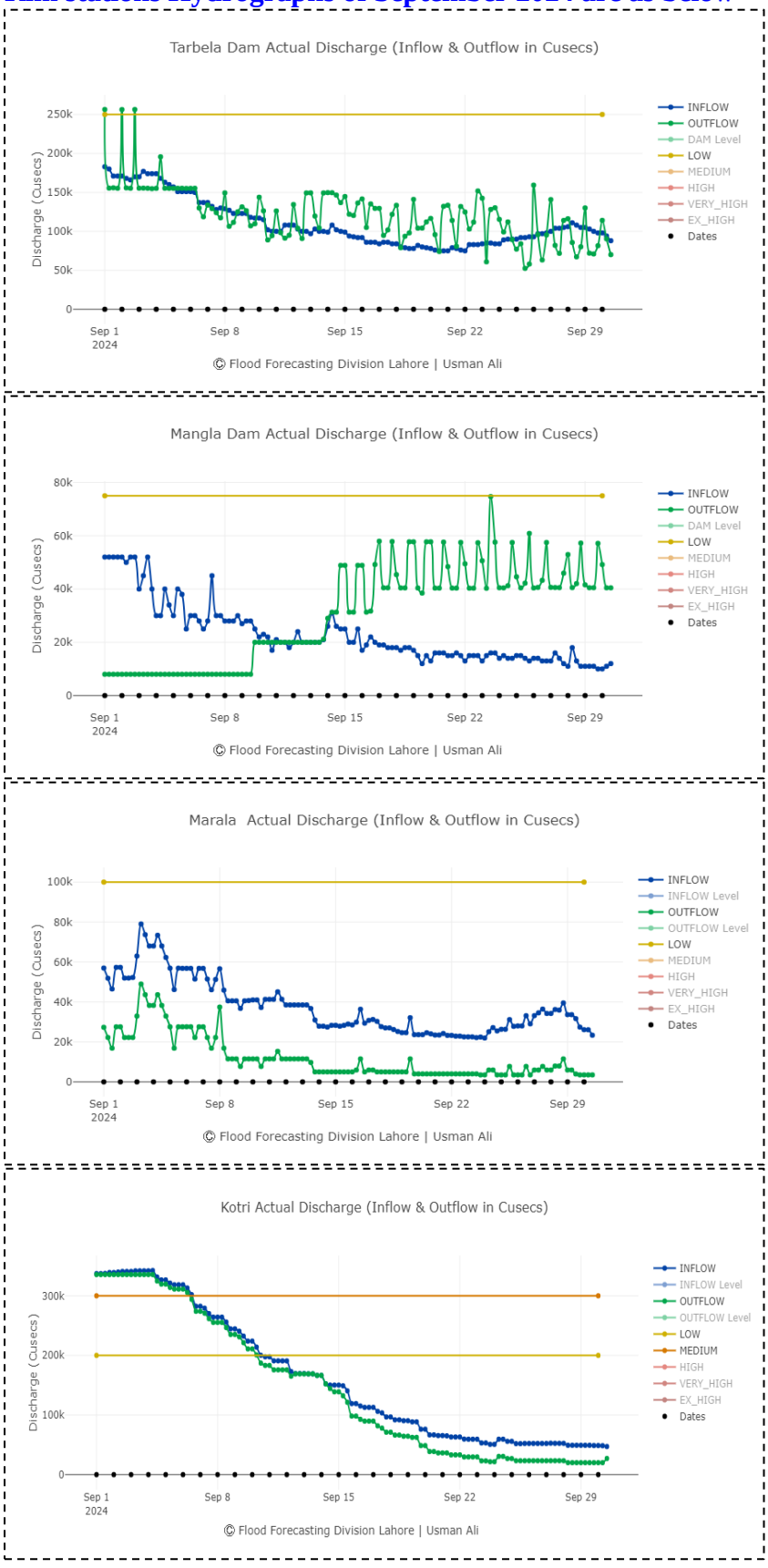


Fig (49) Rim Stations & Kotri Hydrograph of September-2024

PAKISTAN METEOROLOGICAL DEPARTMENT

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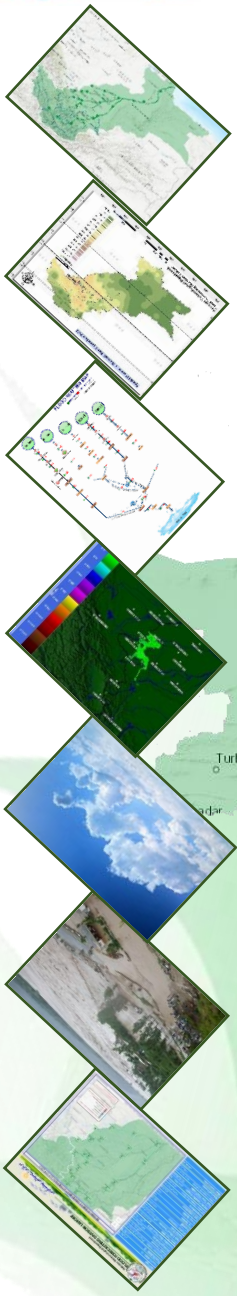

SEASONAL

Departure Anomaly, Total Rainfall & Area Weighted

8 Seasonal rainfall pattern 1st Jul-30th Sep,2024.

Seasonal rainfall distribution during the season is shown in Fig (50). Region of maximum precipitation (around 900 mm) is located over north & northeast Punjab (Rawalpindi, Lahore and Sialkot). Other extreme rainfall of more than 700 mm is located over Mandi Bahauddin, Mangla, Narowal and Kakul. Rainfall recorded over rest of the observatories during the season is also shown below.

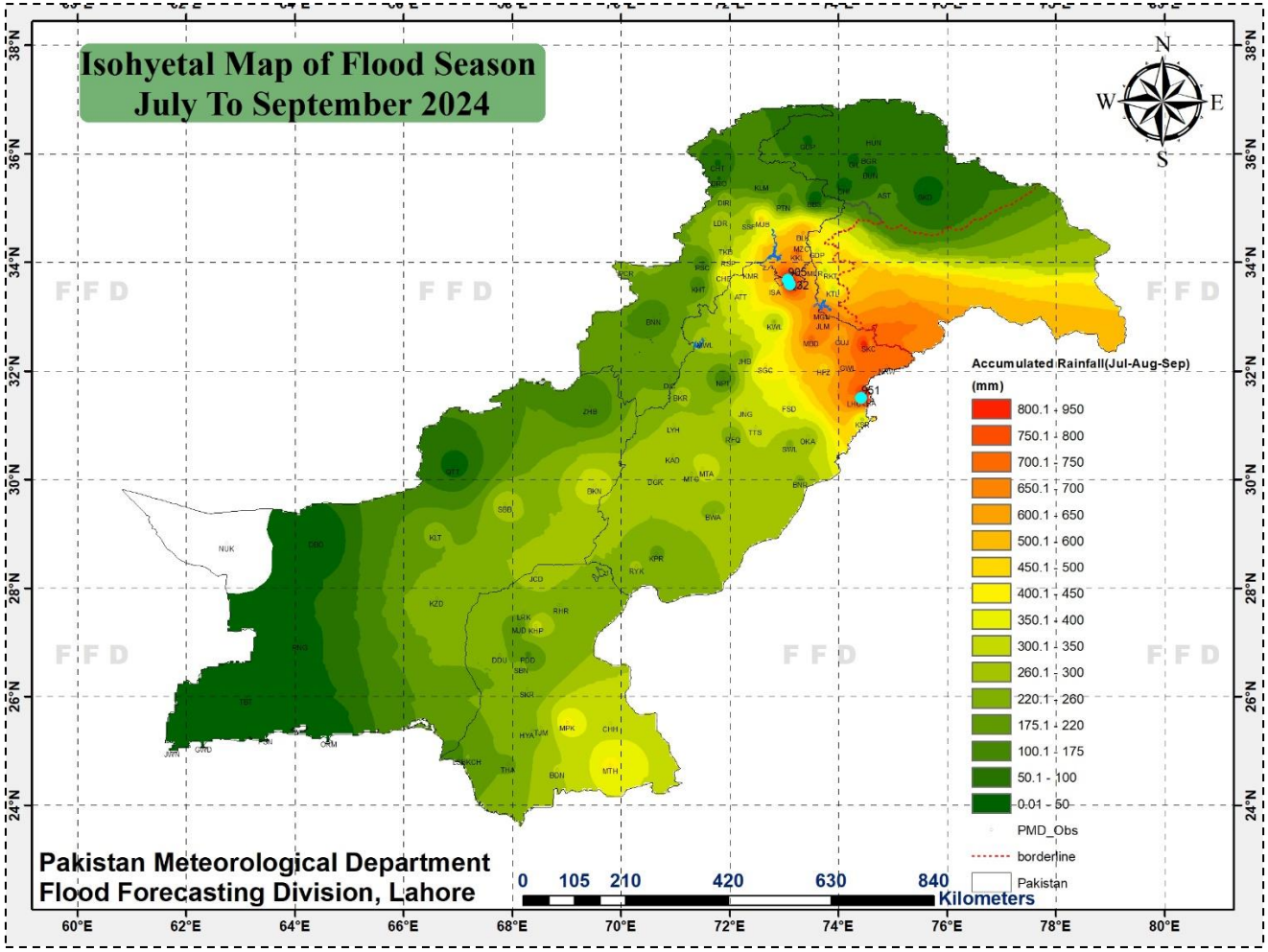

Fig (50) Seasonal total rainfall map of July-Sep-2024.

8.1 Departure Anomaly during the Season July-September 2024.

Pakistan experienced above-average rainfall during the entire monsoon season, with a +51% deviation from the normal. On a regional scale, Punjab received above average rainfall (+48%), while Azad Jammu and Kashmir (AJK) (-21%) and Khyber Pakhtunkhwa (KP) (-5%) received below-average rainfall. Sindh (+108%) and Balochistan (+111%) received above-average rainfall, and Gilgit-Baltistan (GB) experienced slightly +2% above normal rainfall.

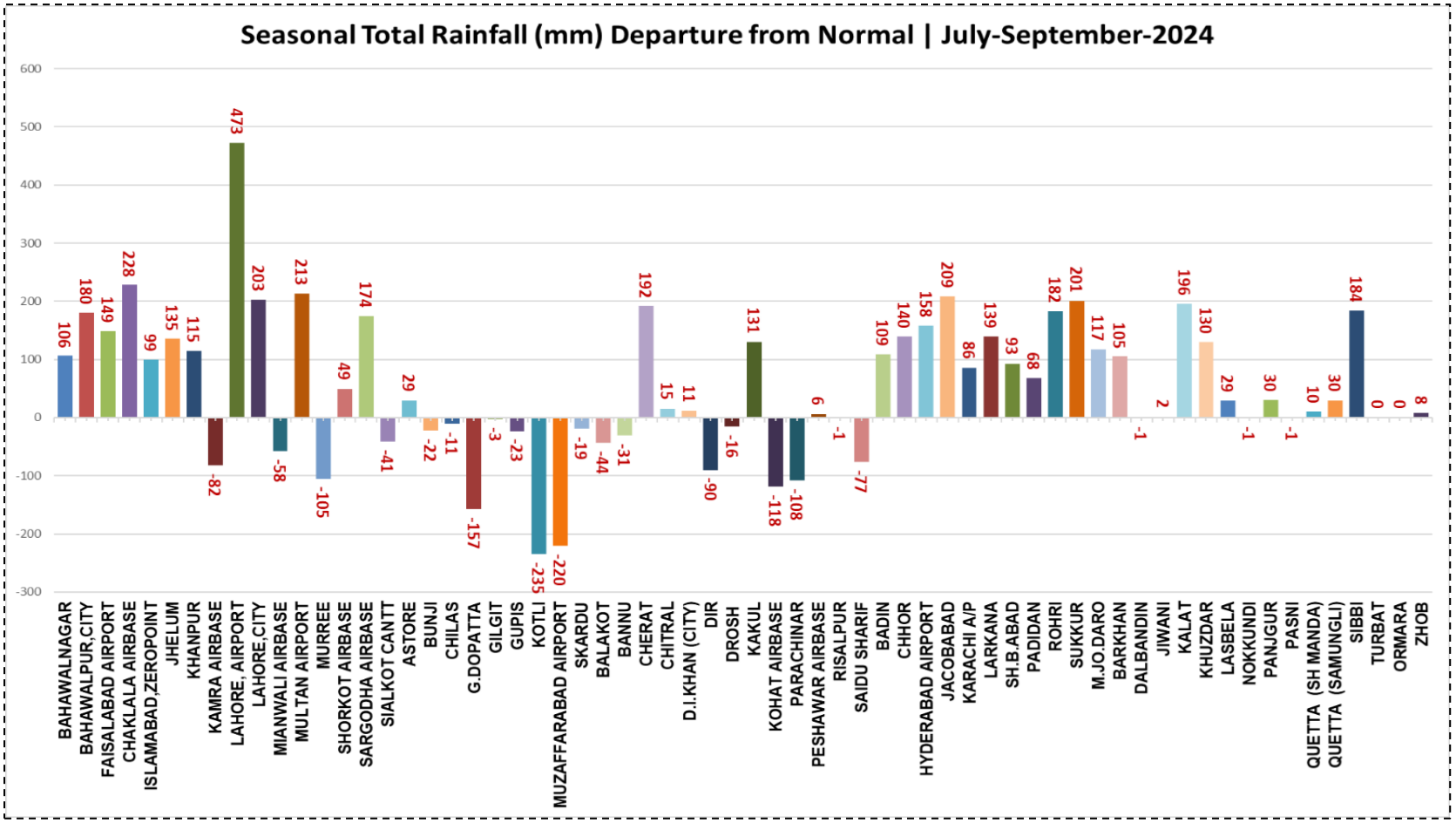

Fig (51) Seasonal Total Rainfall Departure July-Sep-24.

8.2 Pakistan Based Temporal Rainfall (mm) Distribution (July-September) 2024

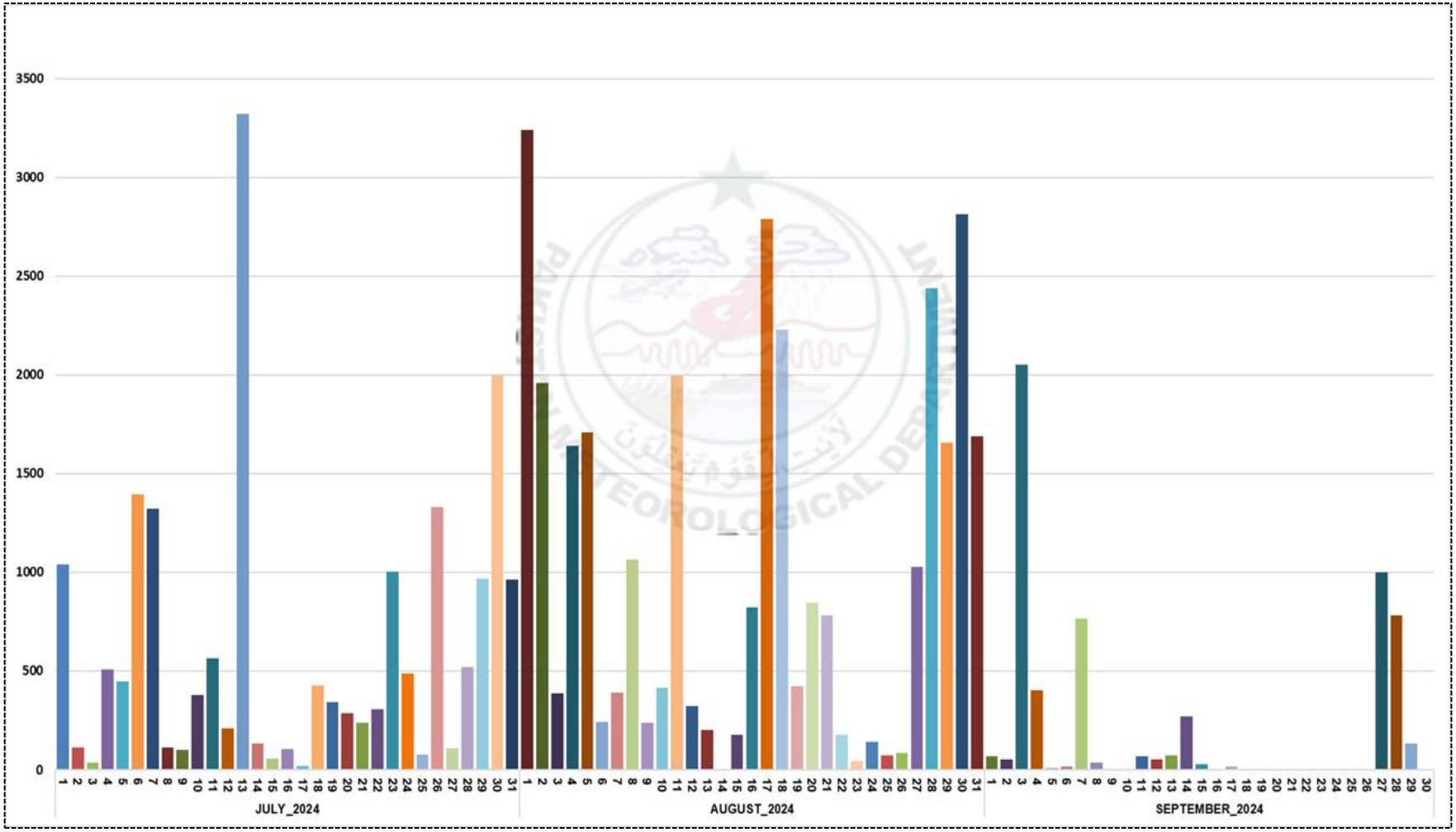

Fig (52) Pakistan Based Temporal Rainfall Distribution (July-September) 2024

8.3 Seasonal Area Weighted precipitation during July-September 2024.

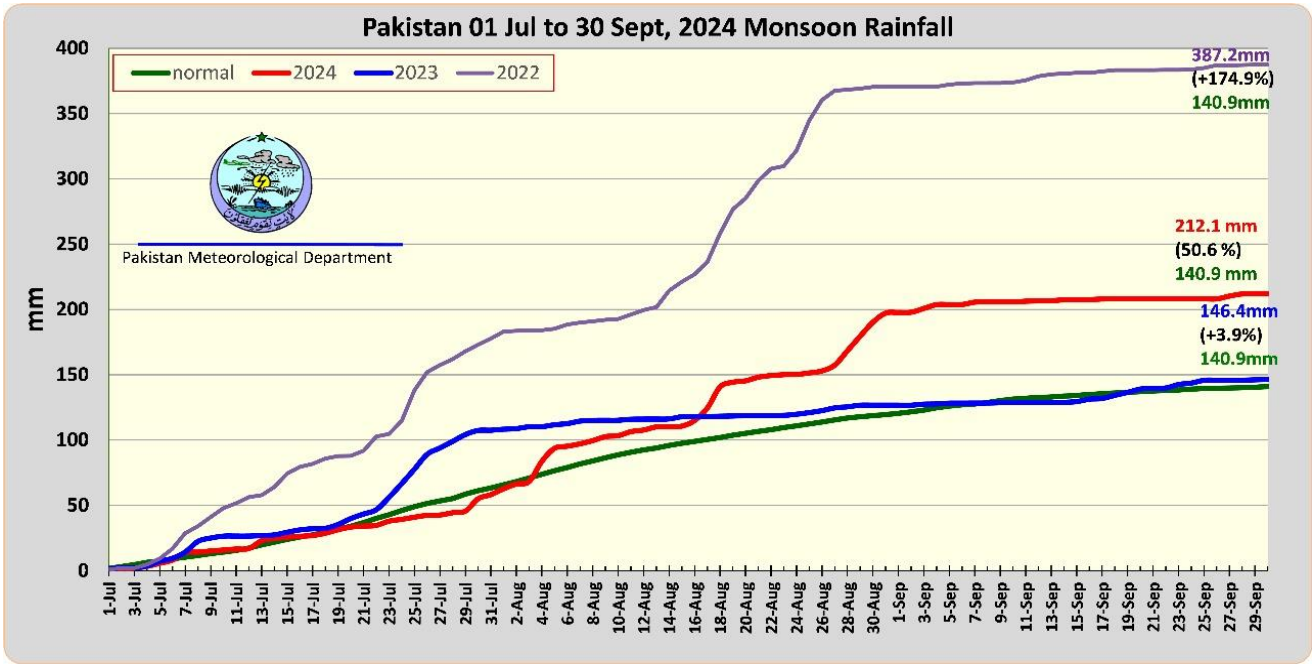

Fig (53) Monsoon Progress & AWR Comparison July-Sept (JAS) 2024.

MONSOON 2024 RAINFALL (mm)			
	01 Jul to 30 Sept, 2024 Rainfall		
	normal (mm)	actual (mm)	Deviation (%)
Pakistan	140.9	212.1	51
Azad J&K	389.5	306.5	-21
Balochistan	58.3	122.9	111
Gilgit-B	39.7	40.5	2
Khyber-PK	256.3	242.6	-5
Punjab	231.9	344.0	48
Sindh	133.7	278.4	108

Fig (54) Monsoon AWR July-Sept (JAS) 2024.

8.4 Average/Normal Monsoon (JAS) Rainfall.

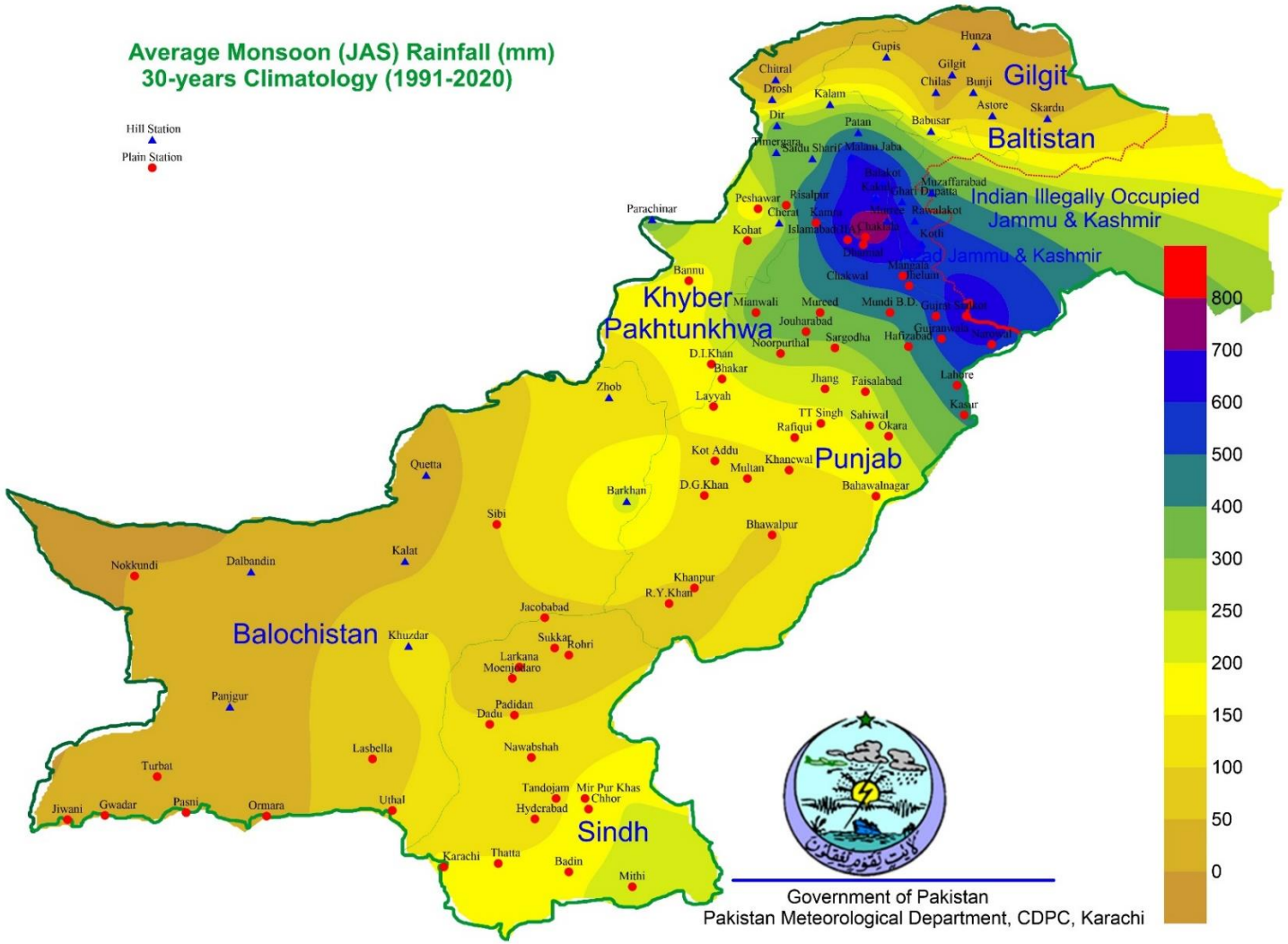

Fig (55) Seasonal Climate normal (JAS)

PAKISTAN METEOROLOGICAL DEPARTMENT

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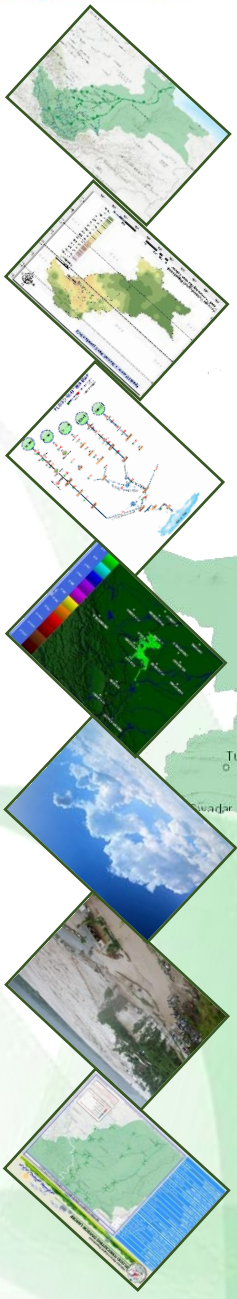

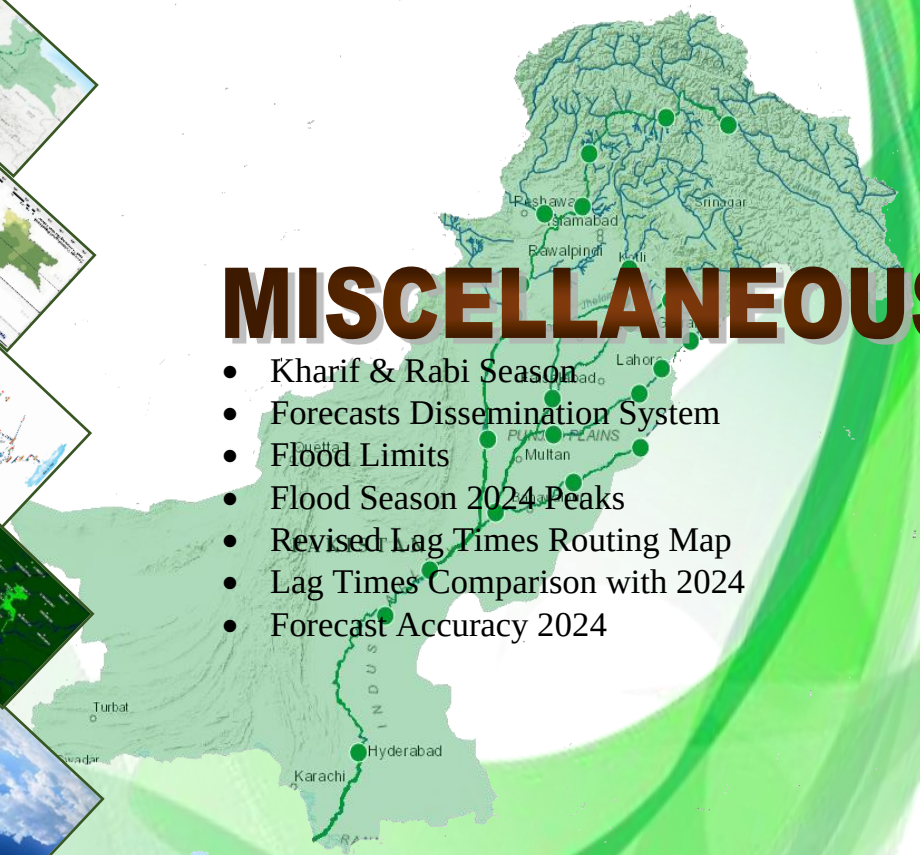

MISCELLANEOUS

- Kharif & Rabi Season
- Forecasts Dissemination System
- Flood Limits
- Flood Season 2024 Peaks
- Revised Lag Times Routing Map
- Lag Times Comparison with 2024
- Forecast Accuracy 2024

9 Kharif Season Water Availability (MAF) Forecast.

The water availability (in MAF) forecast on the basis of prevailing hydrometeorological conditions was issued on 26th March 2024 for River Indus at Tarbela & for River Jhelum at Mangla. A comparison of forecasted and observed volume (MAF) is shown below.

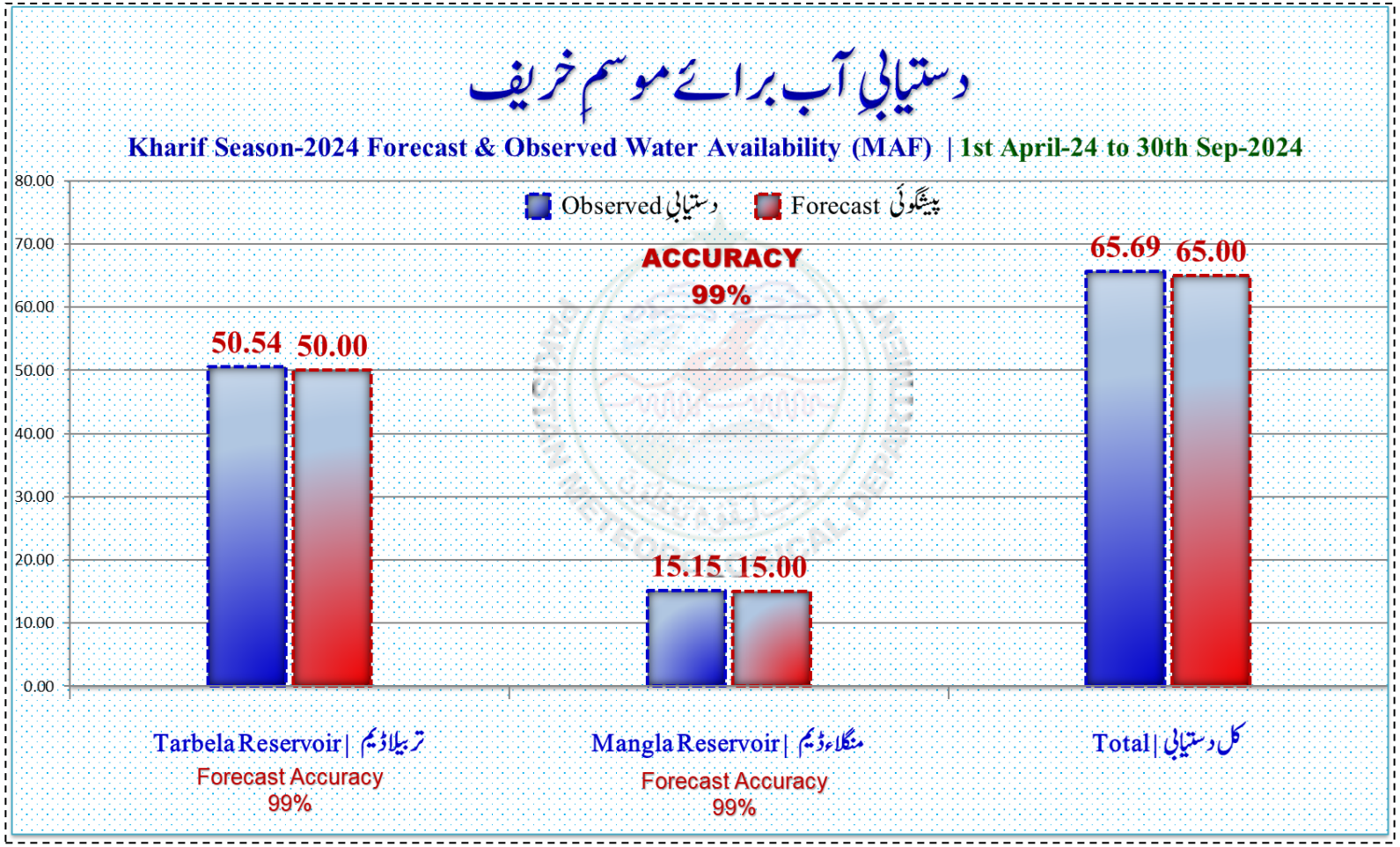

Fig (56) Kharif Season forecasted & Observed MAF (April-Sep-24).

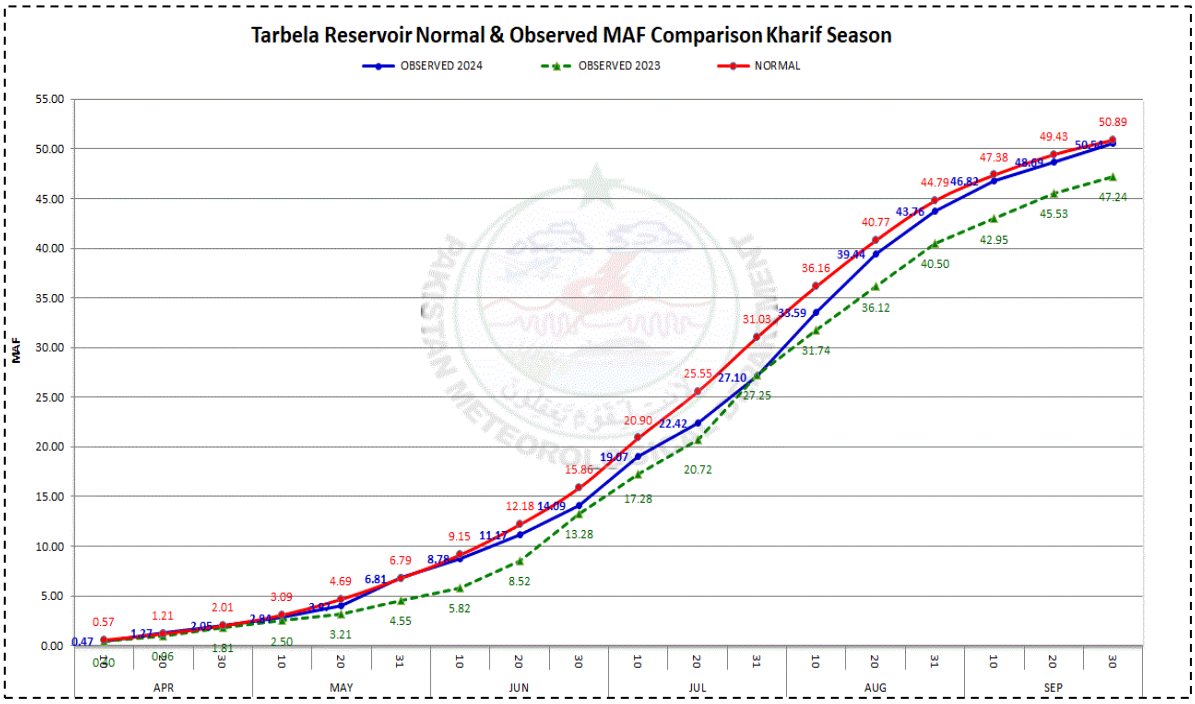

Fig (57) Kharif Season Tarbela Observed MAF (April-Sep-24)

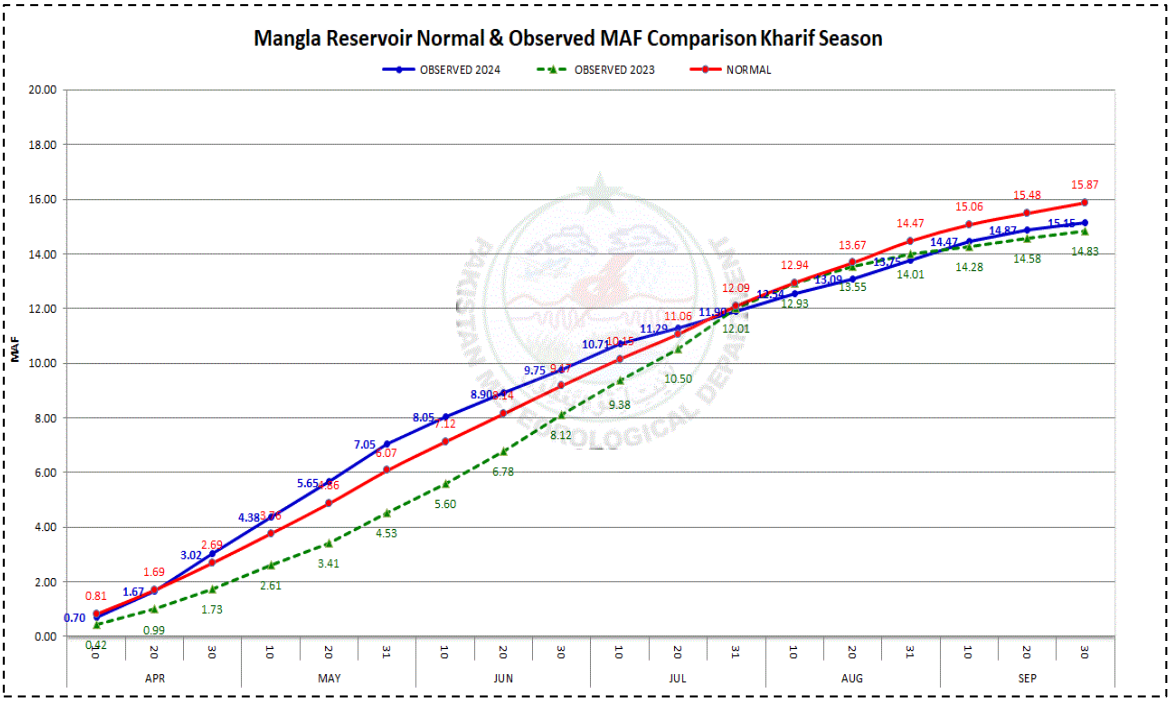

Fig (58) Kharif Season Mangla Observed MAF (April-Sep-24)

10 Rabi Season Water Availability (MAF) Forecast.

Similarly, the water availability forecast for Rabi season is issued on 26th September 2024 for River Indus at Tarbela & for River Jhelum at Mangla and is shown below.

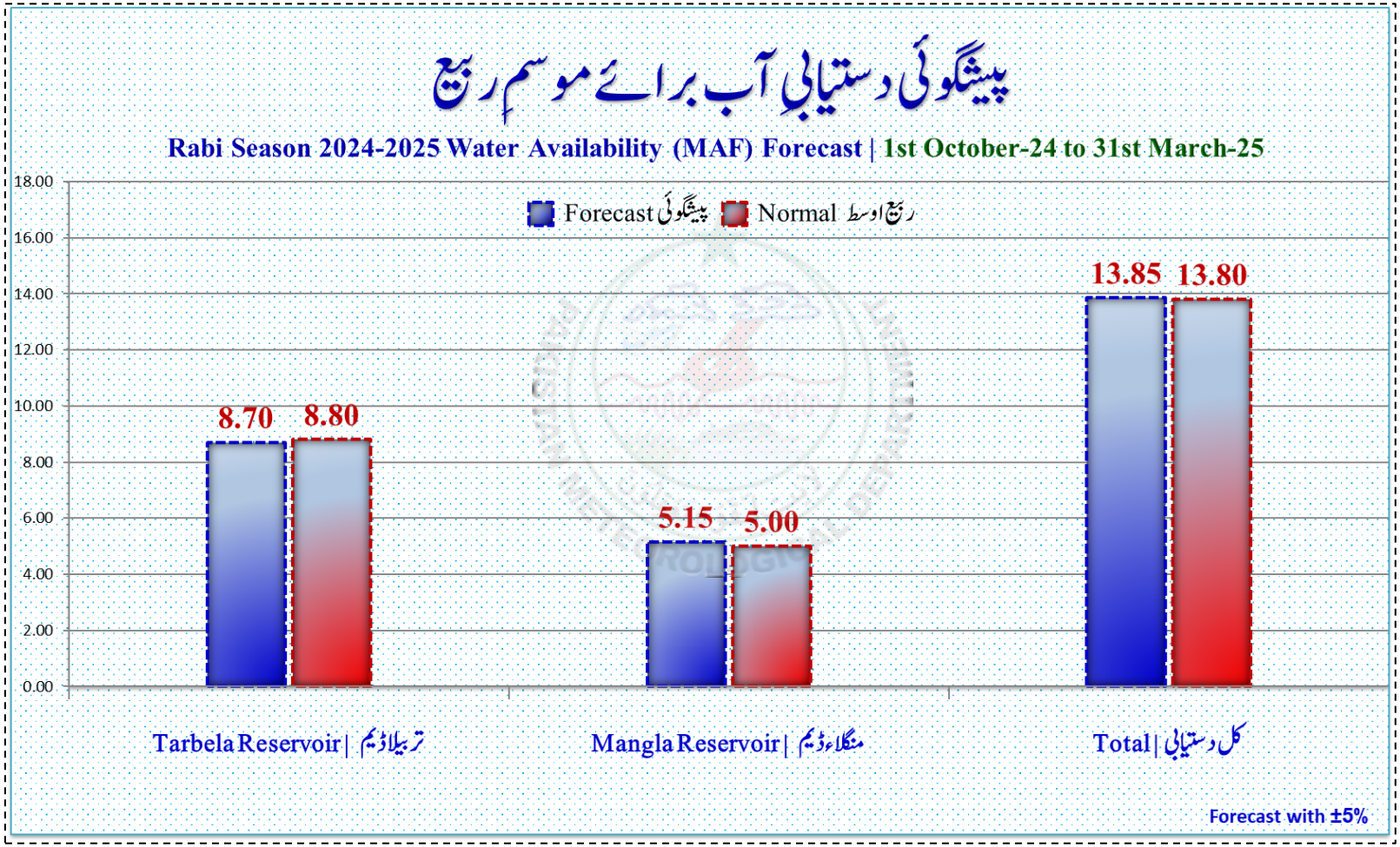

Fig (59) Rabi Season forecast MAF (Oct-2024 to March-2025)

11 Revised Lag Times (Maximum Observed Flood Peaks level) | Flood Routing Map

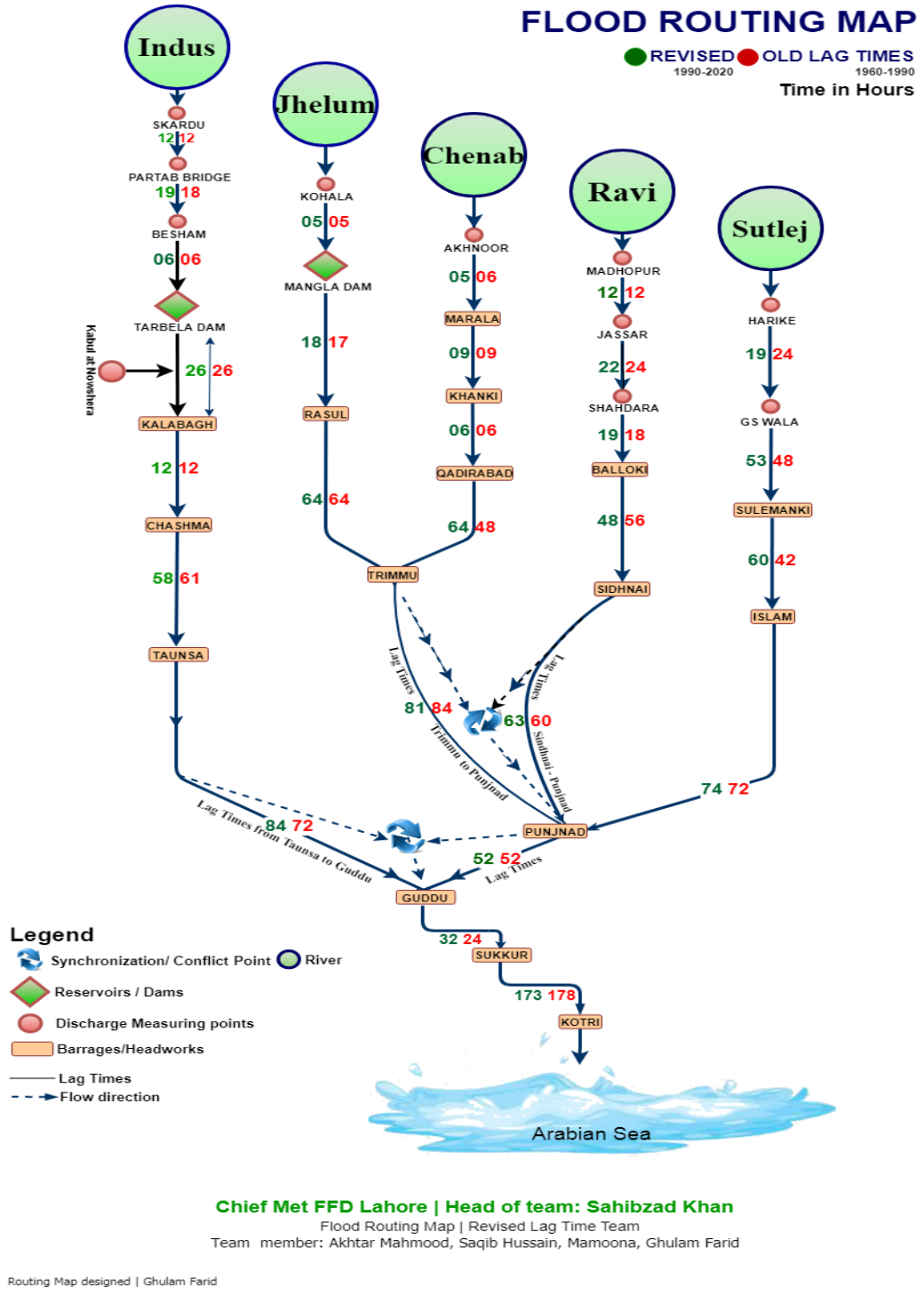

Fig (60) Revised lag Times

12 Extreme Events Flood Forecast Accuracy Season 2024

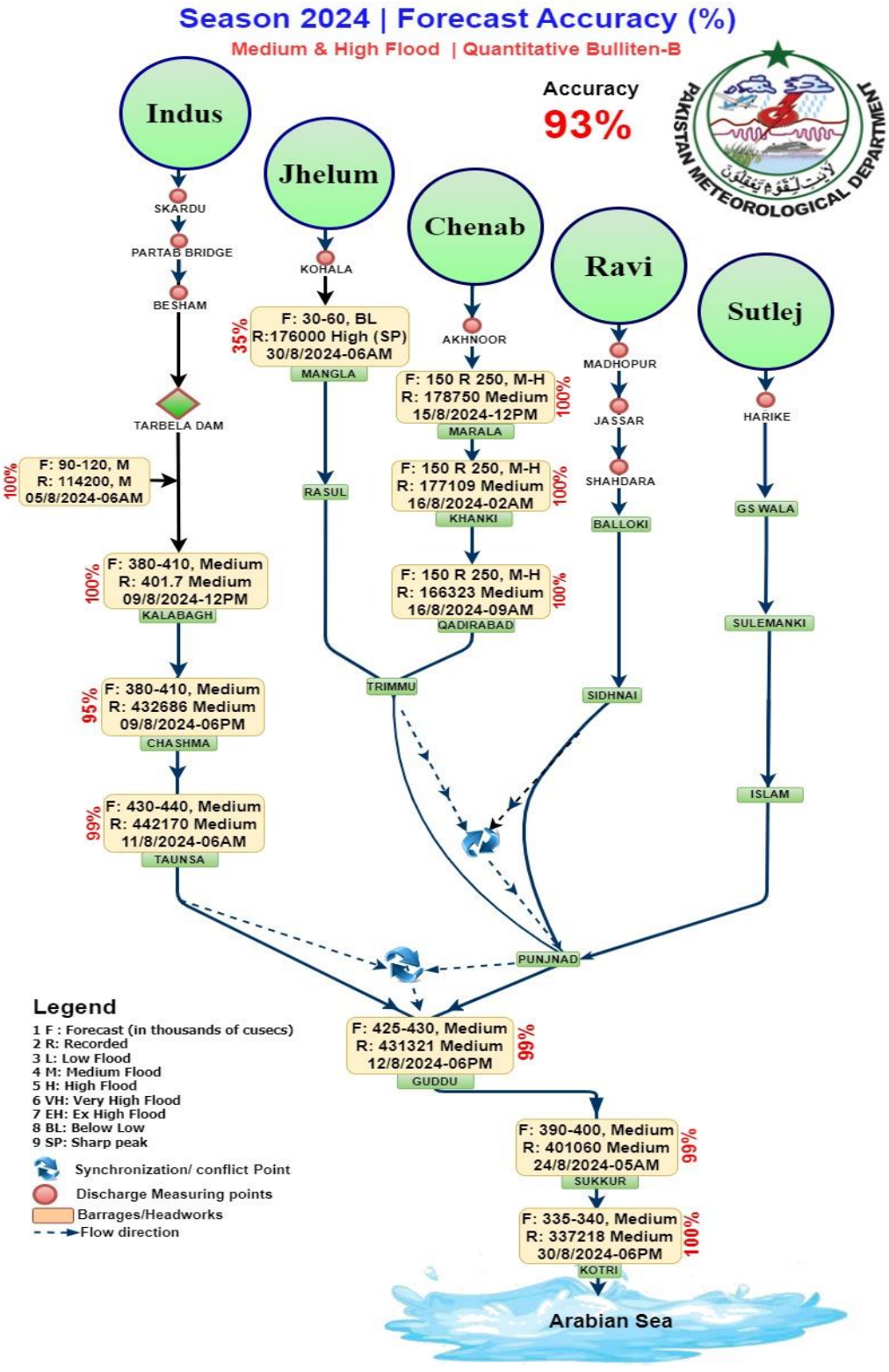

Fig (61) Flood Forecast Accuracy 2024

13 Maximum Flood Peaks Discharge (Cusecs) during Flood Season-2024.

Maximum Flood Peaks recorded during Flood Season-2024 is shown below

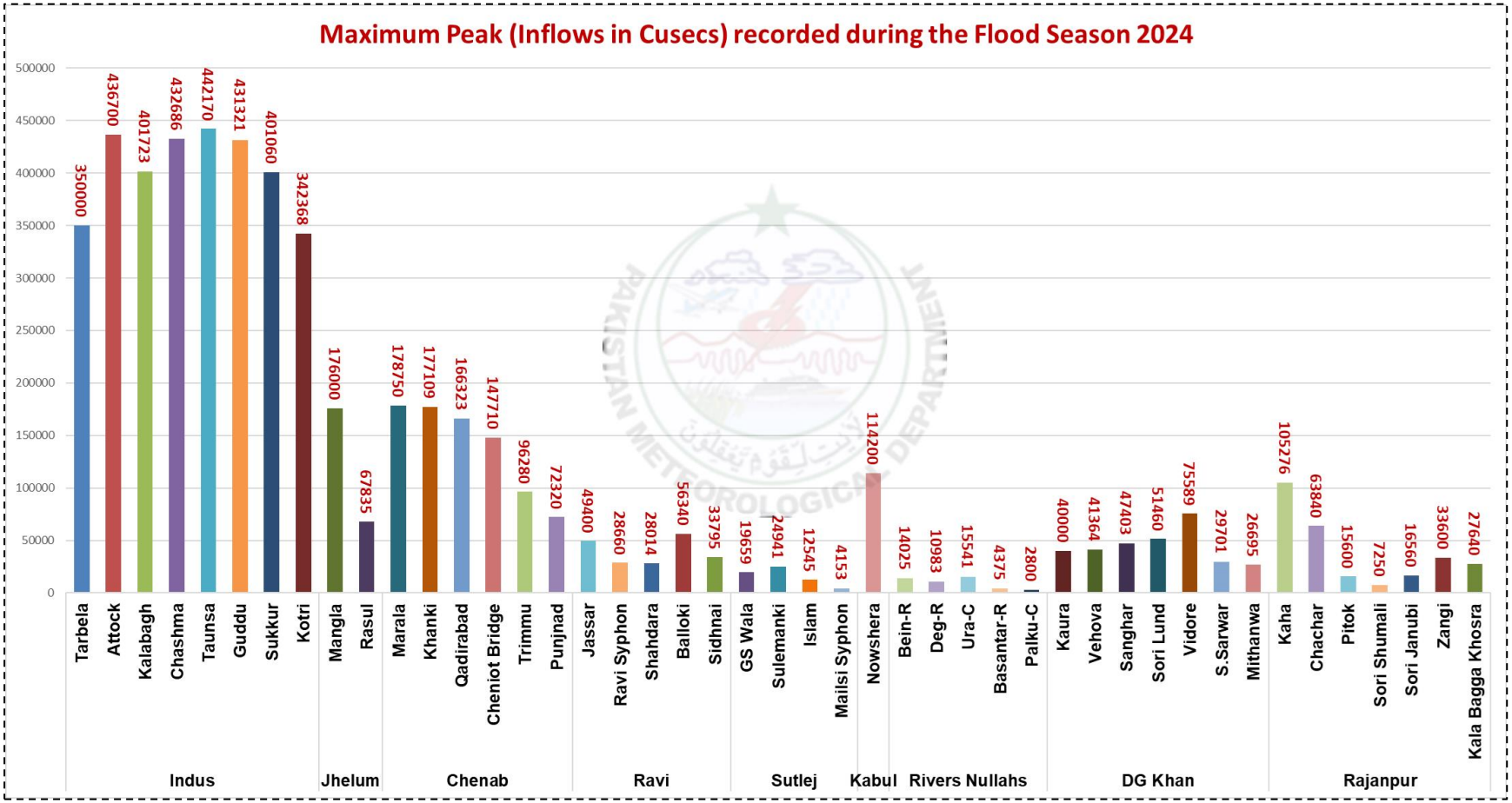

Fig (62) Maximum Observed Peaks 2024

14 Flood Forecast Dissemination

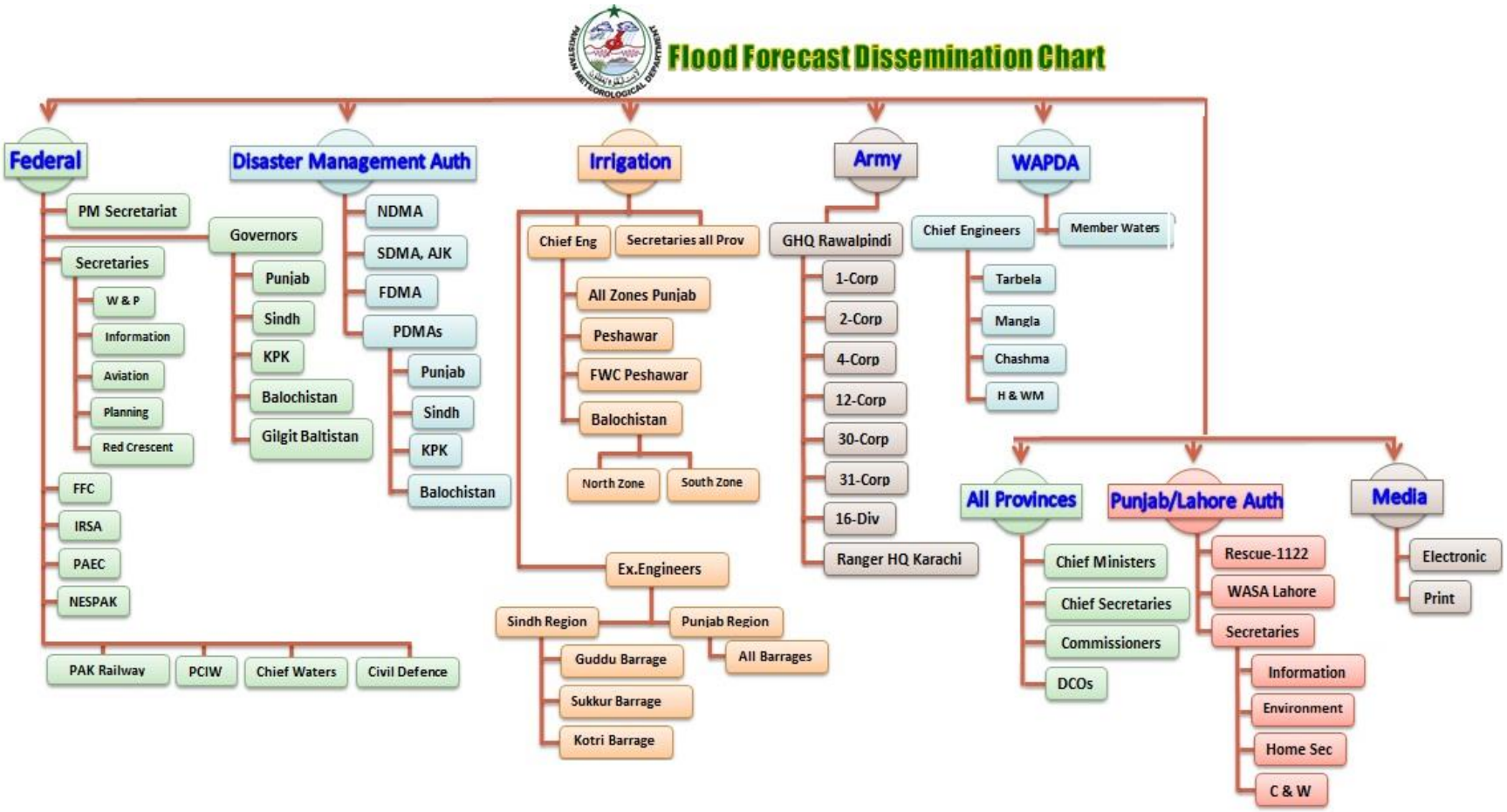

Fig (63) Flood Forecast Dissemination Chart

15 Flood limits (in thousands of cusecs)

River	Site	Design Capacity	Low	Med	High	V.high	Ex.high
Kabul	Nowshera	-	0.75	1.0	1.5	2.0	4.5
	Warsak	15.0	0.30	0.45	1.0	2.0	4.0
Indus	Tarbela	15.0	2.5	3.75	5.0	6.5	8.0
	Attock	-	2.5	3.75	5.0	6.5	8.0
	Kalabagh	9.5	2.5	3.75	5.0	6.5	8.0
	Chashma	9.5	2.5	3.75	5.0	6.5	8.0
	Taunsa	10.0	2.5	3.75	5.0	6.5	8.0
	Guddu	12.0	2.0	3.5	5.0	7.0	9.0
	Sukkur	9.0	2.0	3.5	5.0	7.0	9.0
	Kotri	8.5	2.0	3.0	4.5	6.5	8.0
Jhelum	Kohala	-	1.0	1.5	2.0	3.0	4.0
	Mangla	10.6	0.75	1.1	1.5	2.25	3.0
	Rasul	8.5	0.75	1.1	1.5	2.25	3.0
Chenab	Marala	11.0	1.0	1.5	2.0	4.0	6.0
	Khanki	8.0	1.0	1.5	2.0	4.0	6.0
	Qadirabad	8.07	1.0	1.5	2.0	4.0	6.0
	Trimmu	6.45	1.5	2.0	3.0	4.5	6.0
	Panjnad	7.0	1.5	2.0	3.0	4.5	6.0
Ravi	Jassar	2.75	0.5	0.75	1.0	1.5	2.0
	Ravi syphon	4.5	0.4	0.65	0.9	1.35	1.8
	Shahdra	2.5	0.4	0.65	0.9	1.35	1.8
	Balloki	2.25	0.4	0.65	0.9	1.35	1.8
	Sidhnai	1.5	0.3	0.46	0.6	0.9	1.3
Sutlej	Sulemanki	3.25	0.5	0.8	1.2	1.75	2.25
	Islam	3.0	0.5	0.8	1.2	1.75	2.25

Table 4: Rivers' major sites Flood Limits

16 Internship at Flood Forecasting Division Lahore

FFD Lahore offers an Internship program for the young students of different universities & colleges providing a hands-on opportunity to work in the field of Meteorology, Hydrology, Seismology, GIS and Weather Radar. They can learn how theory applies in the practical field and also provides a valuable experience which makes them a strong candidate in practical life. During the year 2024, FFD Lahore facilitated/provided the internships to around 160 students of different universities. The universities listed with FFD Lahore is as Under.

1. Kinnaird College for Women University Lahore
2. BUITEMS Quetta
3. Wuhan University China
4. Agricultural University of Faisalabad
5. University of Peshawar
6. Institute of Science and Technology Islamabad
7. University of Education Lahore
8. National University of Science and Technology Islamabad
9. Dr. AQ Khan Institute of Technology
10. Government College University Faislabad
11. Forman Christian College University Lahore
12. Government College University Lahore
13. Comsats Institute of Information Technology
14. National University of Computer and Emerging Sciences
15. University of Veterinary and Animal Sciences Lahore
16. Lahore College for Women University Lahore
17. The Superior University | College Lahore
18. University of Engineering and Technology Lahore
19. University of the Punjab Lahore
20. University of Central Punjab | UCP
21. University of Lahore Lahore
22. University of Management and Technology | UMT
23. Government Post Graduate College for Women Samanbad Lahore
24. Aspire Group of Colleges

Table 5: List of Universities

17 The Last Quantitative Flood Bulletin of Season 2024.

GOVERNMENT OF PAKISTAN
PAKISTAN METEOROLOGICAL DEPARTMENT
FLOOD FORECASTING DIVISION
46-JAIL ROAD LAHORE-54000

BULLETIN No. B-123/24

Dated: 15th October, 2024
Time: 10:40 hours (PST)

I: WEATHER/RAINFALL FORECAST FOR NEXT 24-HRS

RIVERS	Upper Catchments (Above Rim Stations)	Lower Catchments (Below Rim Stations)
INDUS	Mainly dry	Mainly dry (Rawalpindi Division)
JHELUM	-do-	-do- (Sargodha Division)
CHENAB	-do-	-do- (Gujranwala Division)
RAVI	-do-	-do- (Lahore Division)
SUTLEJ	-do-	-do- (Bahawalpur Division)

RESERVOIRS LEVEL
(FEET) at (0600 PST)

TARBELA
Current: 1535.67
Max. Conservation: 1550.00
Live Storage 85.90%

MANGLA
Current: 1202.55
Max Conservation: 1242.00
Live Storage 60.68%

II: QUANTITATIVE FLOOD FORECAST OF GAUGING STATIONS (IN THOUSANDS OF CUSECS)

RIVERS	Stations	Design Capacity	Actual Observations at 0600 PST		Quantitative Forecast for Next 24-hrs (Inflow)	Qualitative Forecasted Flood Level (Inflow)	Max Flood Peaks (In Thousands of Cusecs)		
			Inflow	Outflow			Historical		Flood Season 2024
INDUS	Tarbela	1500	38.0	33.7	35-40	Below Low	832.0	(2010)	350.0
	Kalabagh	950	45.9	41.3	No sig. change	-do-	950.0	(1942)	401.7
	Chashma	950	67.6	64.2	-do-	-do-	1038.9	(2010)	432.7
	Taunsa	1100	68.8	62.9	-do-	-do-	960.0	(2010)	442.2
	Guddu	1200	62.3	54.9	-do-	-do-	1199.7	(1976)	431.3
	Sukkur	1500	50.9	15.8	-do-	-do-	1166.6	(1986)	401.1
	Kotri	875	24.2	1.6	-do-	-do-	980.3	(1956)	342.4
KABUL	Nowshera	-	16.4	16.4	15-20	-do-	391.3	(1990)	114.2
JHELUM	Mangla	1060	7.0	32.5	07-09	-do-	1090.0	(1992)	176.0
	Rasul	850	31.3	11.9	No sig. change	-do-	952.2	(1992)	67.8
CHENAB	Marala	1100	10.6	3.5	8-12	-do-	1100.0	(1957)	178.8
	Khanki	1100	7.5	0.9	No sig. change	-do-	1086.5	(1959)	177.1
	Qadirabad	807	18.5	0.0	-do-	-do-	948.5	(1992)	163.2
	Trimmu	645	15.5	5.2	-do-	-do-	944.0	(1928)	96.3
	Punjnad	700	12.3	0.0	-do-	-do-	802.5	(1973)	72.3
RAVI	Jassar	275	1.7	1.7	-do-	-do-	680.0	(1955)	40.4
	Shahdara	250	1.3	1.3	-do-	-do-	576.0	(1988)	28.0
	Balloki	225	22.3	1.7	-do-	-do-	389.8	(1988)	56.3
	Sidhnai	150	10.4	0.0	-do-	-do-	330.2	(1988)	33.8
SUTLEJ	G.S. Wala	--	0.0	0.0	-do-	-do-	837.0	(1955)	19.7
	Sulemanki	325	14.8	2.5	-do-	-do-	598.9	(1955)	46.2
	Islam	300	3.0	0.6	-do-	-do-	492.6	(1955)	12.5

Isolated= 20 to 30% of area Scattered= 30 to 50% of area | Widespread= 90 to 100% of area R= Rising, F= Falling
Note: Concerned Departments may contact FFD, Lahore for rectification up-dation (if any)

(Shahid Abbas)
Chief Meteorologist
FFD Lahore

www.ffd.pmd.gov.pk | Email: ffdlhr@yahoo.com
Chief Meteorologist: 04299200208 & Duty Officer 24/7 hrs: 04299200139, 04299205367-70 and Fax:04299200209 & 5367

Fig (64) Flood Bulletin-B