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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

Preface

An efficient flood preparedness system should be seen in a holistic perspective, including the suite of monitoring, forecasting, warning, dissemination, and response. In an ideal system, an accurate forecast with adequate forecast lead time is translated into a reliable warning, which is broadly and effectively disseminated to the communities at risk, who in turn, take adequate loss-reducing actions.

Flood forecasting and warning are very important components of modern flood preparedness systems, in the category of non-structural flood protection measures, which may save lives and reduce material losses and human suffering. The system embraces detection of danger of occurrence of a flood-triggering situation, quantitative flood forecasting, construction of a warning message, issuing and dissemination of warning, response action, and finally post-audit, in order to learn and improve the system for future.

Flood warning has been present in human living memory for thousands of years - the Holy Books mention the oldest “early warning”, received by Noah from the God.

In order to detect the dangers of occurrence of a flood-triggering situation, a meteorological and hydrological monitoring system, possibly embracing manual, automatic, and remotely-sensed observations should be available. Time series of observed records of rainfall as well as radar based information and river stage are fed, in a real-time mode, to a mathematical model to obtained flood forecast. In other words, forecasting reqiures experts to convert the rainfall, present status of river, changes of moisture and snow cover, into a flood forecast. A forecast based flood alert and warning can be issued. A forecast expresses when, where, and how intense (flood magnitude: water discharge, inundated area, duration of flood) is likely to occur in the near future (hours, days, up to weeks ahead), how it will travel downstream and evolve, and what secondary effects it may cause. For small catchments, urban and flash floods, in steep and rapid mountain streams, a time lag between an intense precipitation and the destructive river flood peak may be very short. Observation of rising river water level and intense precipitation may be received too late for a flood forecasting; therefore, deployment of radar network and quantitative precipitation forecast is required in order to estimate the future river flow. In case of propagation of a flood wave in a large river, when high flows are already observed upstream, a hydrodynamic flood-routing model is being used, allowing visualization via GIS of the forthcoming inundation in downstream

cross-sections of the river. Propagation of a flood wave in a large river may take several weeks, allowing ample time for response to flood forecast.

Flood warning is timely information, based on a reliable forecast that high water level (or high river discharge) is expected to occur in a cross-section of interest at some defined future time and point, so that emergency actions, such as strengthening dikes or evacuation, can be undertaken. A warning should be issued sufficiently early before the peril, in order to allow adequate human preparations.

Pakistan has unique flood forecasting problems, which can be understood only if the meteorological causes of the floods are first understood. During summer, although monsoon is the dominating weather system, the westerly waves also continue to affect the country. Intensification of the monsoon weather system and northward recurving of the monsoon depressions is predominantly due to the westerly waves. Floods in Pakistan are mainly caused by the heavy monsoon rains during July to September.

FFD, since its establishment, is serving the nation by timely disseminating flood forecasts, warnings/alerts and creating awareness during each flood season. Issuance of Flood Report after the conclusion of flood season is a regular feature of the Flood Forecasting Division (FFD) Lahore, Pakistan Meteorological Department (PMD). This report gives a comprehensive overview of all the events occurred during the flood season. Flood report for the year 2020 has been prepared under the kind directives of Director General, Pakistan Meteorological Department. It contains all details regarding flood forecasting, tracks of monsoon lows, rainfall amount during wet spells, flood peaks, monthly and seasonal isohyetal maps, normal isopercental maps and flood limits. The flood forecast evaluation report is also added at the end.

Chief Meteorologist
Flood Forecasting Division
Lahore

1 Executive summary

- Quantitatively, the 2020 All Pakistan monsoon seasonal rainfall during 1 July to 30 September 2020 has been 198.9 mm against the long period average (LPA) of 140.9 mm.
- The seasonal percentage departure map for precipitation during the present Monsoon Season-2020 indicates 41 % more precipitation for whole of the country. Calculating on province wise the detail is given as below:

  Sindh 148 %, Balochistan 74%, Gilgit Baltistan 37%, Punjab 14% and Khyber Pakhtunkhwa 5% received above normal rainfall while Kashmir received -16% below normal rainfall.
- Four monsoon lows/Depressions originated during the present monsoon season-2020, three of these entered Pakistan, while one of them curved Northeast wards in India.
- Eleven rain-bearing spells occurred during the monsoon season 2020.
- One Exceptionally High Flood situation was observed in river Jhelum at Mangla Upstream while a High flood wave in river Chenab at Marala, Khanki, and Qadirabad and one peak of High flood in river Kabul at Nowshehra. Due to synchronization of flows from river Indus and Chenab a High flood situation arises at Guddu (upstream & downstream) and Sukkur (upstream).
- 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 2020 was up to the mark.

2 Tracks of Monsoon Lows during Monsoon Season-2020

During the monsoon season 2020 (15th June to 15th October) Four Monsoon Lows/Depressions were developed in the Bay of Bengal.

1st Monsoon Low:

1st Monsoon Low was developed over Northwest Bay of Bengal on 5th August 2020. Moving rapidly Westwards it was relocated over Western Madhya Pradesh on 06th august 2020, moving almost same course centered over southeast Sindh on 7th August 2020 from where it moved away westwards in Arabian Sea.

2nd Monsoon Low:

2nd Monsoon Low was also developed over Northwest Bay of Bengal on 14th August 2020. It took North-Northwesterly course and centered over southeast uttar Pradesh where it dissipated.

3rd Monsoon Low :

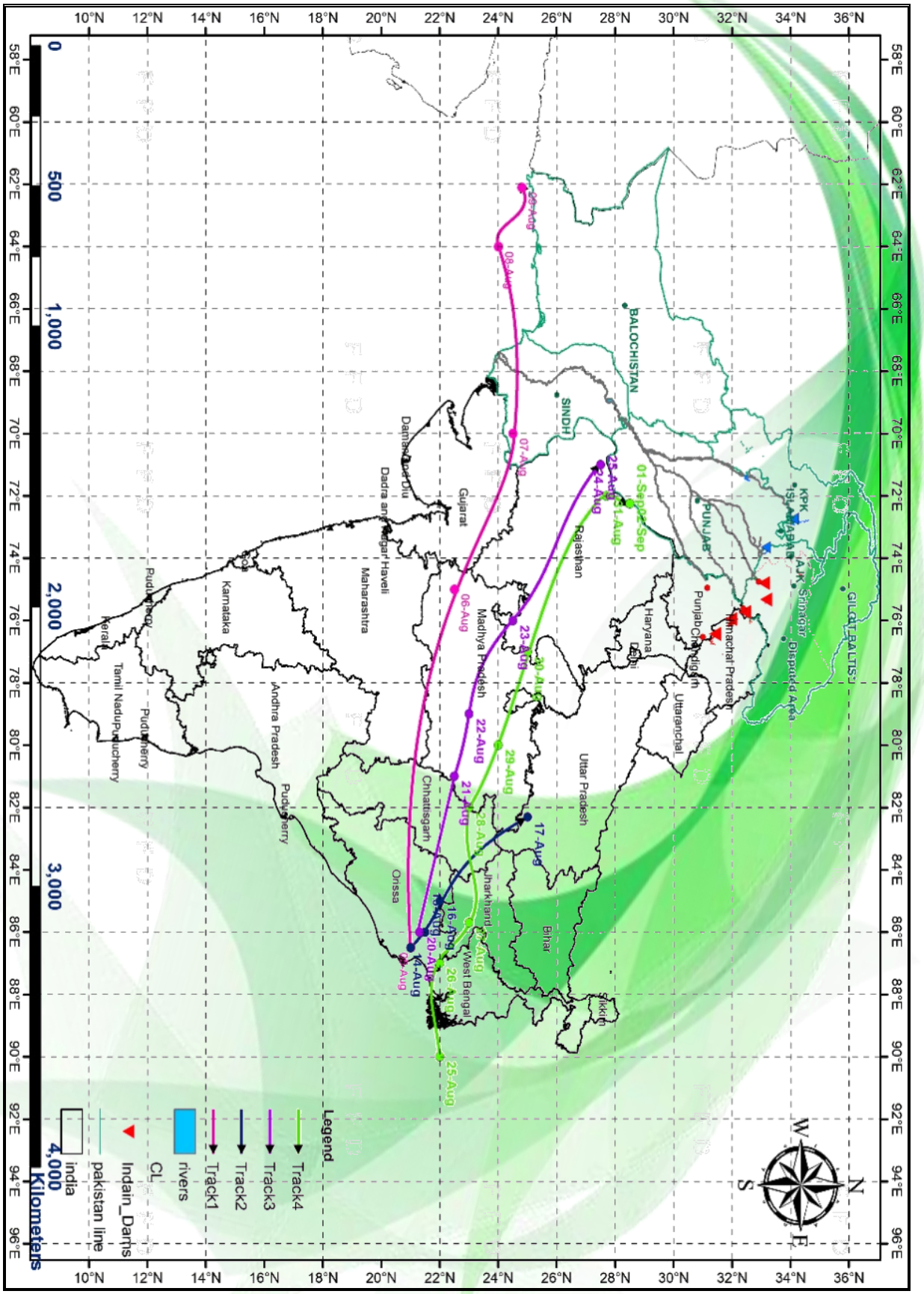
3rd Monsoon low was developed on 20th August 2020 over Northwest Bay of Bengal. It first moved west-northwestwards and reached Southwest Rajasthan on 23rd August 2020. Then it moved almost northwestwards and reached west Rajasthan and adjoining Pakistan on 24th August 2020 where it became insignificant after 25th August.

4th & final Monsoon Low:

4th and final Monsoon low was developed over North Bay of Bengal on 25th August 2020. After moving west-northwestwards, it reached Northwest Madhya Pradesh on 30th August-2020. Then it moved further North Northwestwards and located in the vicinity of the country near Bahawalpur division where it dissipated.

The paths followed by each low/depression are shown in figure 1.

Figure 1: Tracks of rain-producing monsoon system in 2020.



2.1 Significant hydro-meteorological events during the month of June 2020

Two rainfall spell was reported during the month of June 2020 over Pakistan. Generally flows in all the major rivers remained below Low flood level except two Low flood peaks one in river Kabul at Nowshehra and other in river Ravi at Balloki Upstream.

2.2 Meteorological events

No Monsoon low was developed over the Bay of Bengal during the month of June 2020. The rainfall mostly occurred across the country during the month of June 2020 was due to the accentuation of seasonal low over Balochistan and passing of a westerly wave to the north of the country.

2.3 1st wet spell of June 2020 (24th to 25th)

The first wet spell of June 2020 which remained active for two days was mainly due to the presence of a westerly trough accompanied by weak moist currents from the Arabian Sea. Figures 2 represents 500 hPa and 850 hPa geopotential height patterns along with 925 hPa wind flow during the spell. It indicates that most part of Pakistan is under the influence of the westerly wave. Southwesterly winds at 925 hPa are also present ensuring enough moisture supply from the Arabian Sea.

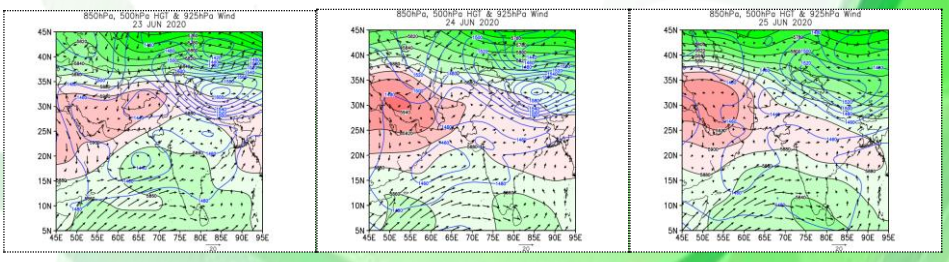


Figure 2: hPa geopotential Height & winds map June 2020 (24th-25th)

Figure 3 & 4 shows the spatial distribution of significant rainfall during this spell. Maximum rainfall of 60 mm occurred over Jhelum. Other maximum of more than 40 mm rainfall are located over Balakot, Besham & Mianwali. Province Sindh & Balochistan and some parts of South Punjab remained almost dry during the spell.

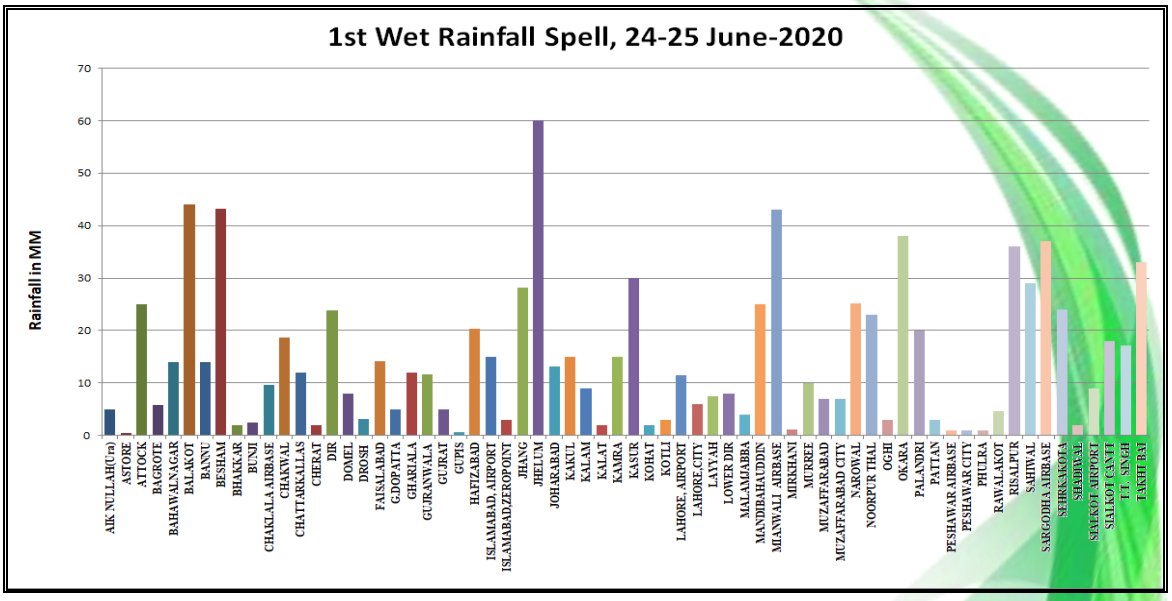


Figure 3: 01st Wet Spell of June 2020 (24th -25th)

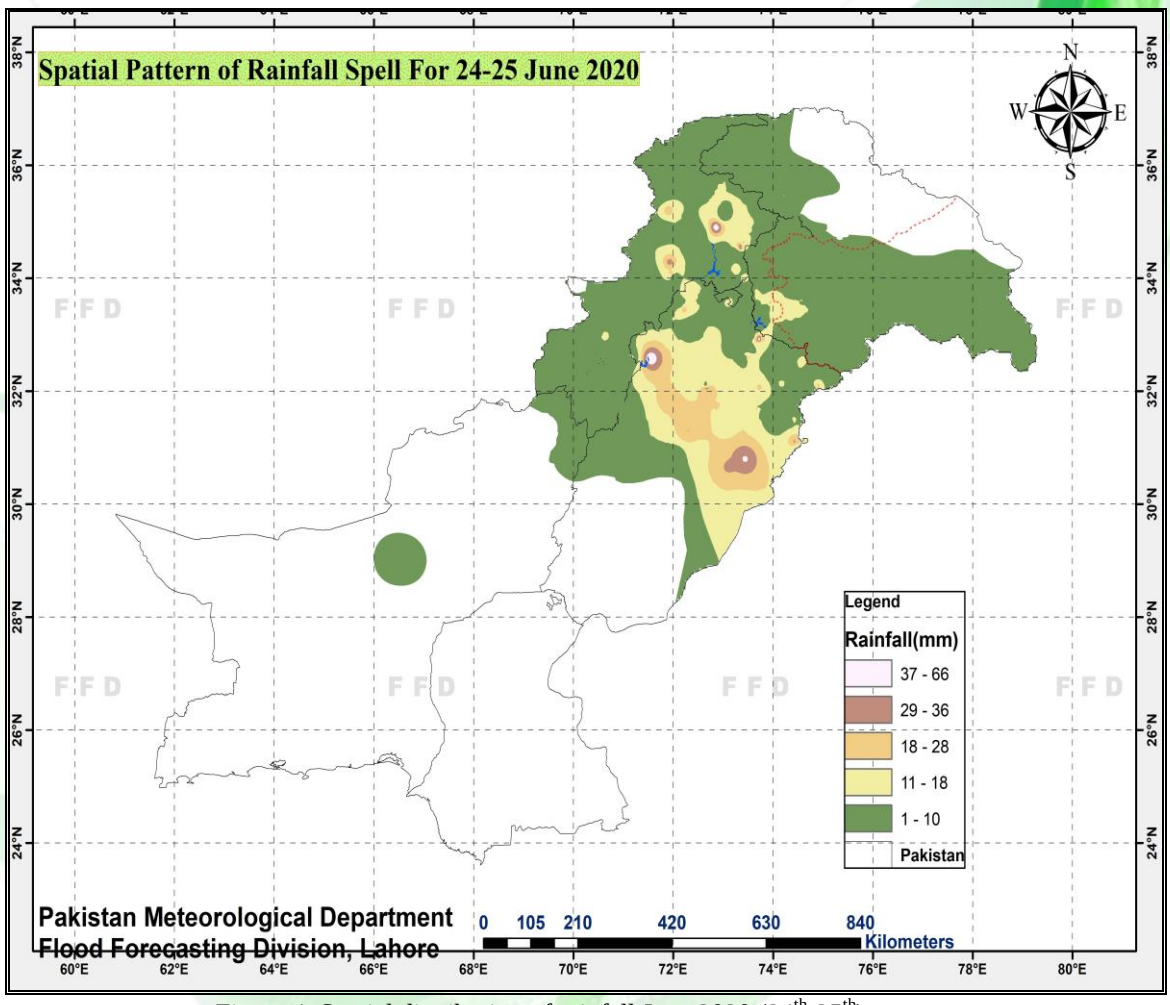
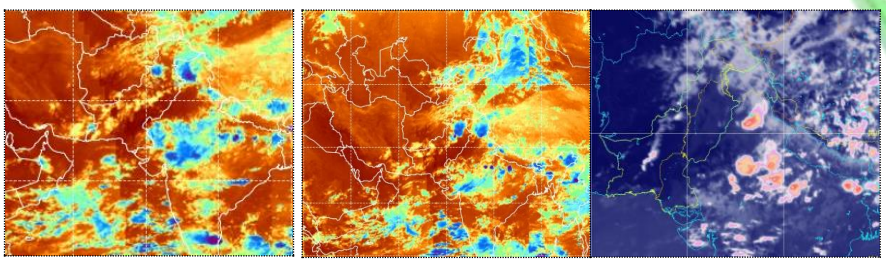


Figure 4: Spatial distribution of rainfall June 2020 (24th-25th)

Satellite/Radar images in figure 5 showing dense clouds over north Punjab, during the spell of 24th to 25th June-2020.



23-06-2020, 1800 UTC | 24-06-2020, 1200 UTC | 25-06-2020, 0900 UTC

Figure 5: Satellites Images of June 2020 (24th -25th)

2.4 2nd wet spell of June 2020 (29th to 30the)

The Second wet spell of June 2020 which remained active for two days was mainly due to the presence of a westerly trough accompanied by moist currents from the Arabian Sea .Figures 6 represents 500 hPa and 850 hPa geopotential height patterns along with 925 hPa wind flow during the spell. It indicates that most parts of Pakistan are under the influence of the westerly wave. Southwesterly winds at 925 hPa are also present ensuring moderate moisture supply from the Arabian Sea.

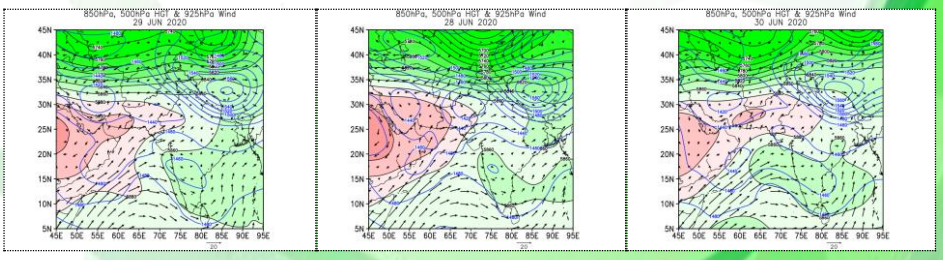


Figure 6: hPa Geopotential Height & winds map of June 2020 (29th-30th)

Figure 7 & 8 shows the spatial distribution of significant rainfall during this spell. Maximum rainfall of more than 60 mm occurred over Shadiwal in Gujranwala division. Other maxima of more than 35 mm rainfall are located over Faisalabad. Whole Sindh most parts of Balochistan and South Punjab remained dry during the spell.

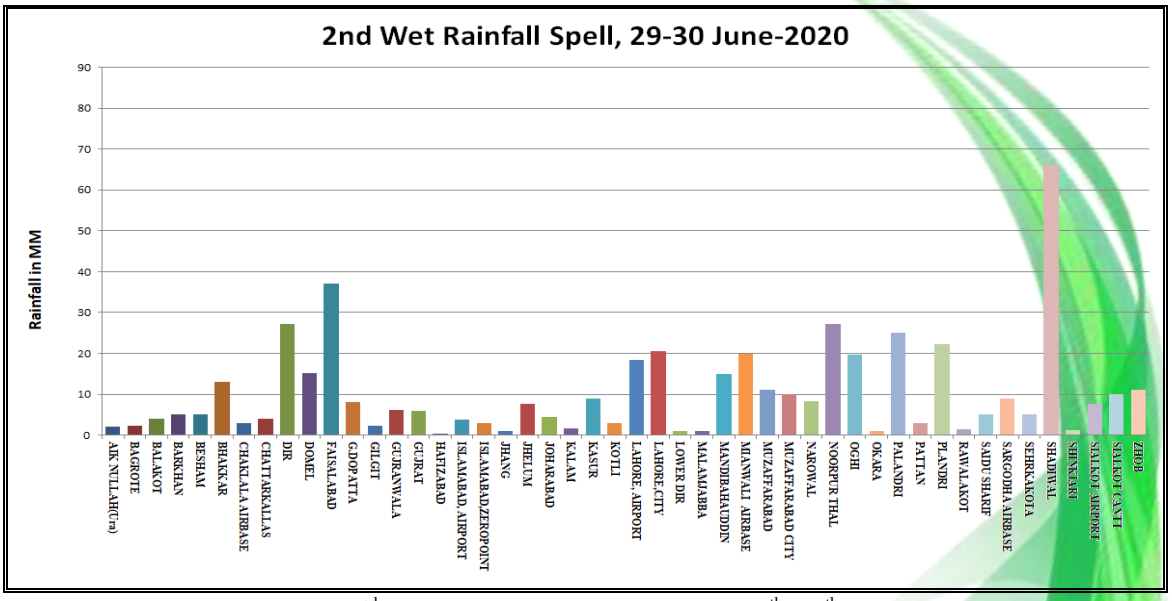


Figure 7: 02nd Wet Spell of Rainfall June 2020 (29th -30th)

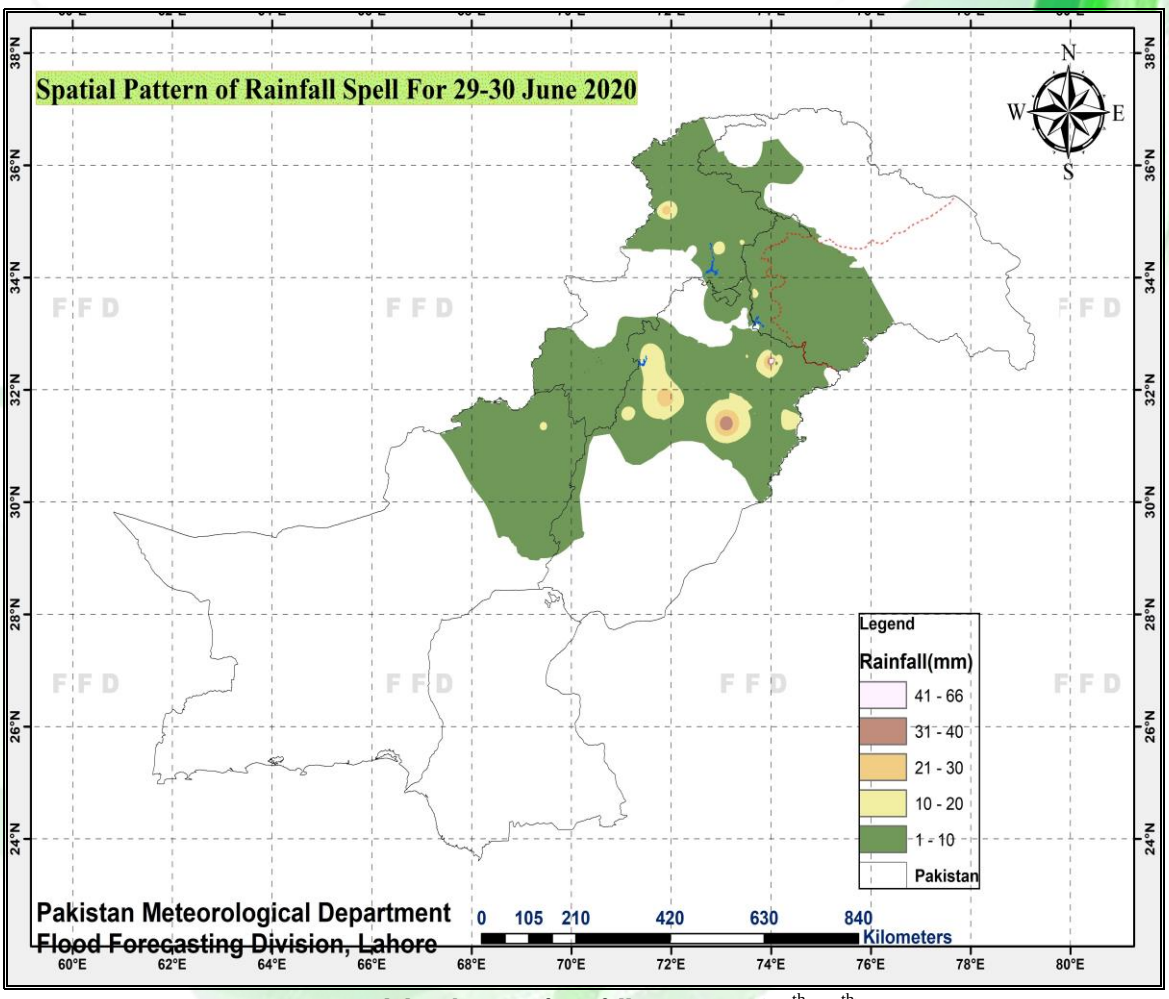


Figure 8: Spatial distribution of rainfall June 2020 (29th-30th)

Satellite/Radar images in figure 9 showing dense clouds over north Punjab, along with Khyber Pakhtunkhwa during the spell of 29th to 30th June-2020.

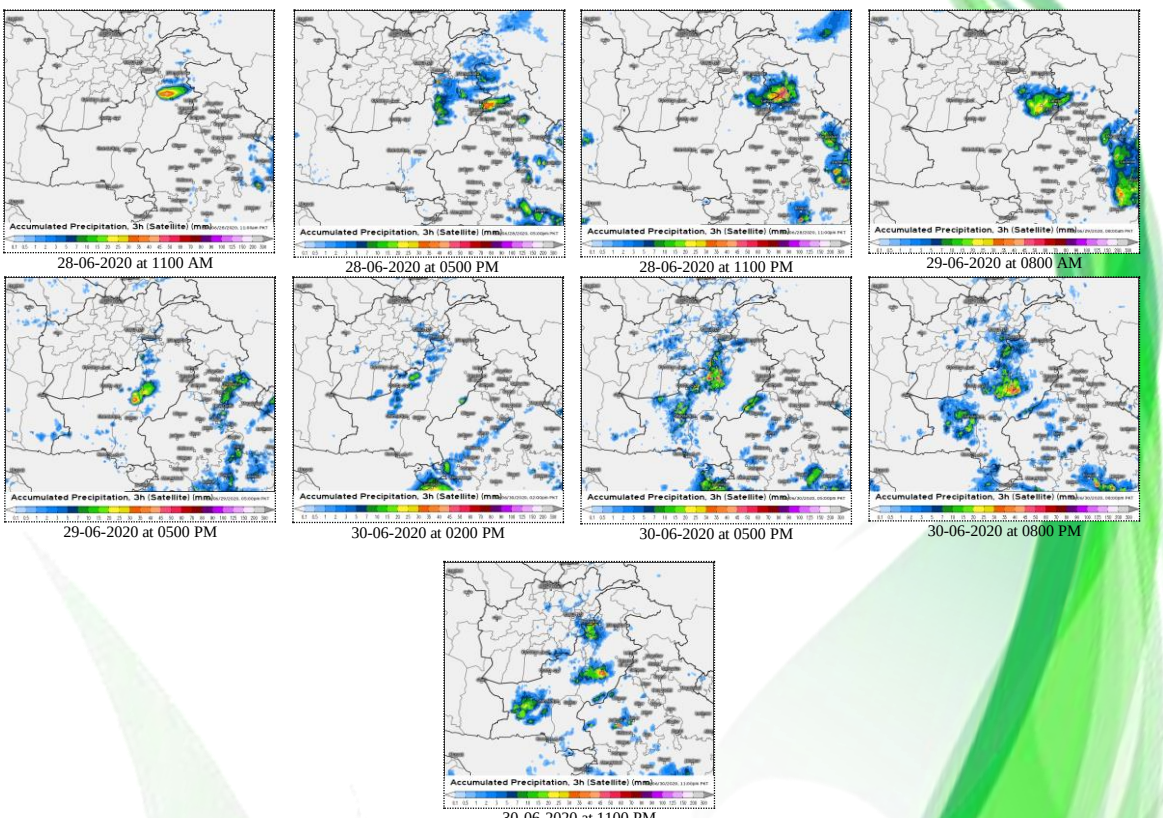


Figure 9: Satellites Images of June 2020 (29^{th}-30^{th}).

2.5 River position during June 2020

Flood peaks (thousands of Cusecs) recorded during June 2020 in different rivers at various points are given in Table 1.

Rivers/Site	Stations	Peaks Inflows	Date	Flood level
Kabul	Nowshehra	96700	24/06/2020	Low
Ravi	Balloki	40650	30/06/2020	Low

Table 1: Maximum Peaks recorded during the month of June 2020.

2.6 Hydrographs during Significant event of June 2020

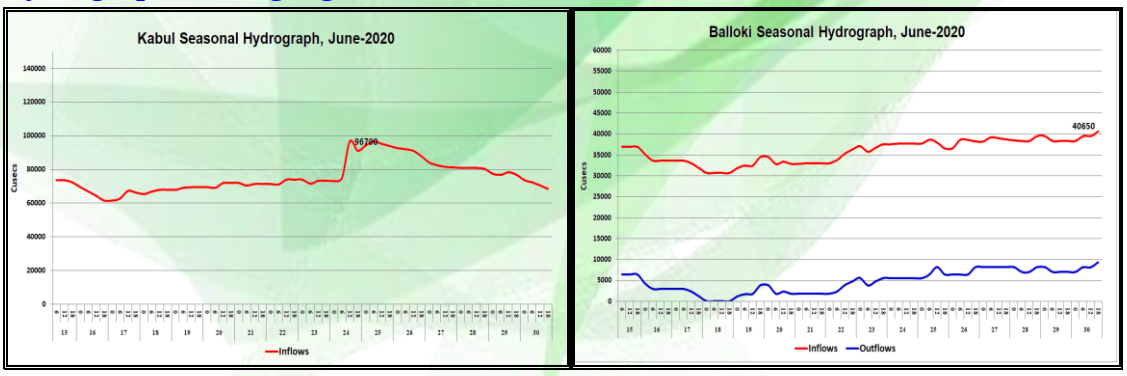


Figure 10: Hydrographs for the month of June 2020

2.7 Temporal Distribution during the month of June 2020

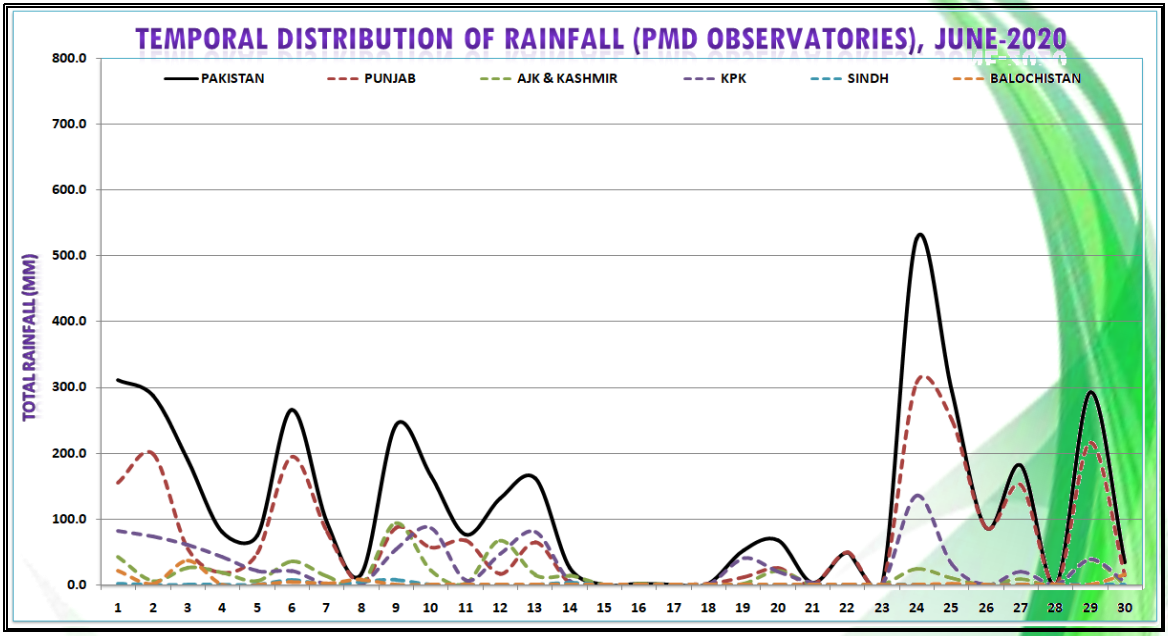


Figure 11: Temporal distribution of rainfall June 2020.

3 Significant hydro-meteorological events during the month of July 2020

Four significant rainfall spells occurred during the month of July 2020 however no High flood situation arises in any of the major rivers.

3.1 Meteorological events

The first spell which occurred from 05th to 07th July 2020 was the result of penetration of moderate moist currents from Arabian Sea, also due to the effect of westerly wave passing over northern parts of the country and the presence of well-marked low pressure area over Indian Gujarat. The second spell of July was observed from 12th to 13th July 2020. It was caused by the interaction of westerly wave passing over northern parts of the country and the moist influx from Arabian Sea. The third spell of the month of July was observed from 16th to 18th July 2020. It was also caused by moderate moist currents from Arabian Sea, presence of a westerly wave over the northern parts of the country and accentuated seasonal low over Balochistan along with upper air circulation over Indian Gujarat. The Fourth & Final spell of the month of July was observed from 26th to 27th July 2020. It was also caused by moderate moist currents from Bay of Bengal and Arabian Sea, presence of a westerly wave over the northern parts of the country,

presence of cyclonic circulation over East Arabian sea and seasonal low over Balochistan.

3.2 01st wet spell of July 2020 (05th to 07th)

The first wet spell of July 2020 which remained active for three days was mainly due to the presence of well-marked low pressure area over Indian Gujarat & trough westerly wave accompanied by moist currents from the Arabian Sea. Figure 12 represents 500 hPa and 850 hPa Geopotential height patterns along with 925 hPa wind flow during this spell. It indicates that many parts of Pakistan are under the influence of westerly wave, Southwesterly & Southeasterly winds at 925 hPa are also present ensuring enough moisture supply from the both Arabian Sea & Bay of Bengal.

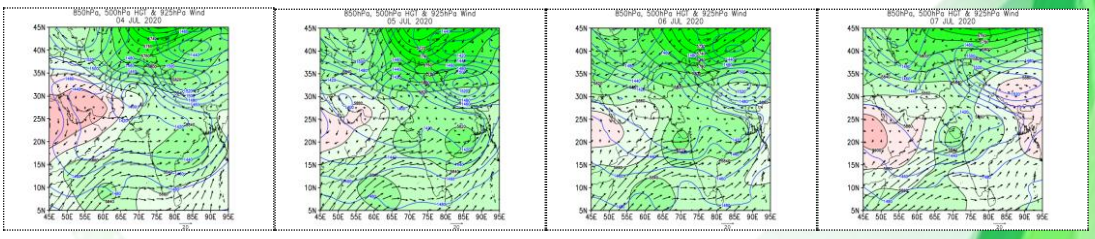


Figure 12: hPa Geopotential Height & winds map July 2020 (05th-07th)

Figure 13 & 14 indicates the spatial distribution of significant rainfall during the event which shows that moderate rainfall occurred over the most parts of Punjab. Light Rainfall is also reported from Khyber Pakhtunkhwa , Kashmir and Karachi division .

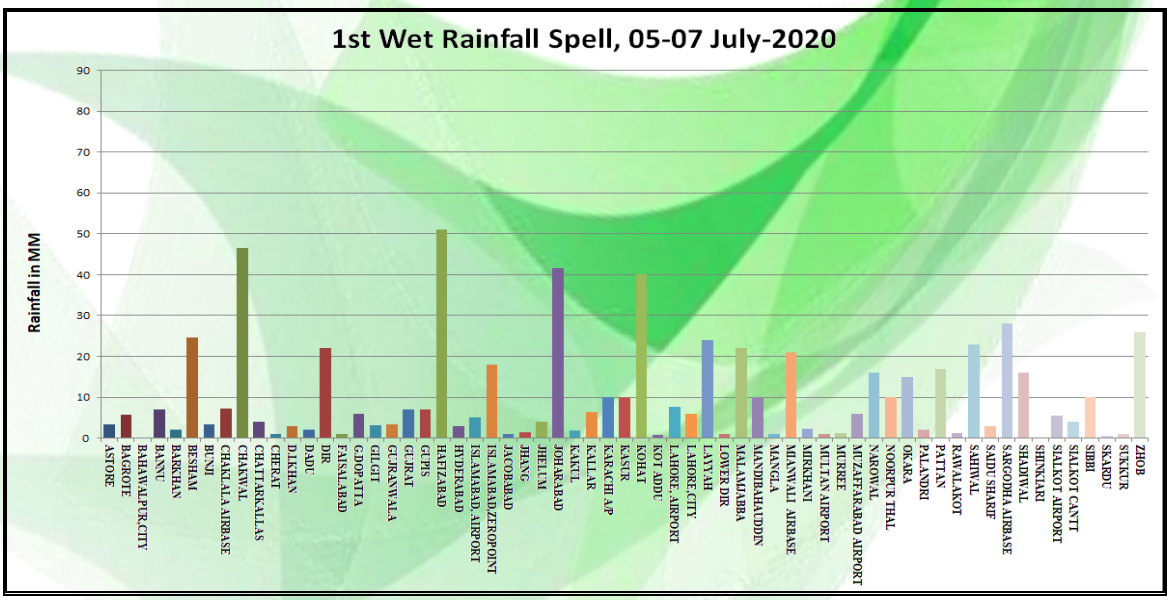


Figure 13: 1st Wet Spell Rainfall of July 2020 (05th-07th)

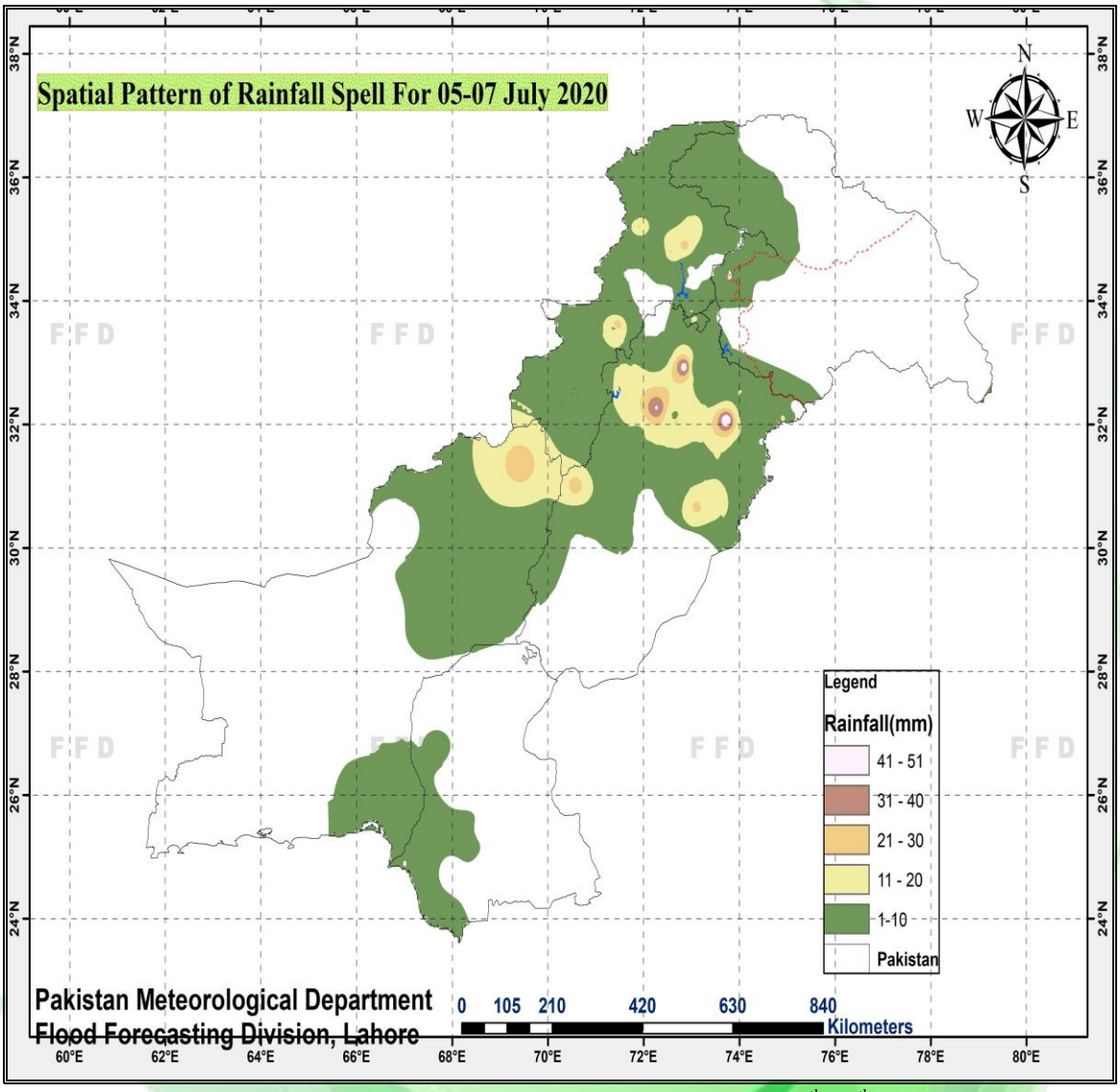
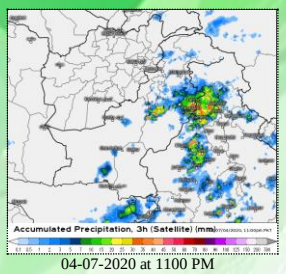


Figure 14: Spatial distribution of significant rainfall July 2020 (05th -07th)

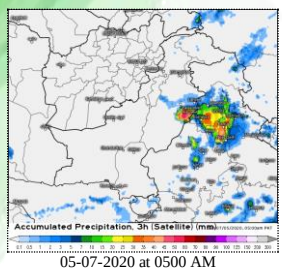
Figure 15 is showing rainfall/clouds remained over the Parts of the country during the spell.

04-07-2020 at 0500 PM

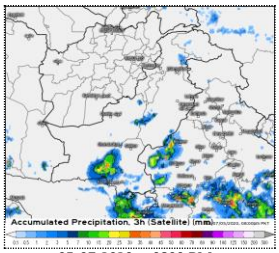
04-07-2020 at 0800 PM



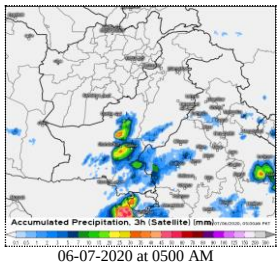
04-07-2020 at 1100 PM



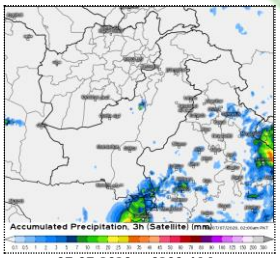
05-07-2020 at 0500 AM



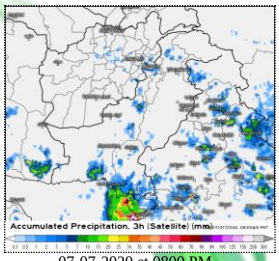
05-07-2020 at 0800 PM



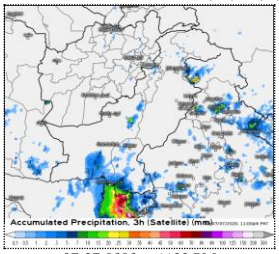
06-07-2020 at 0500 AM



07-07-2020 at 0200 AM



07-07-2020 at 0800 PM



07-07-2020 at 1100 PM

Figure 15: Satellites Images of July 2020 (04th -07th)

3.3 Rivers position due to first wet spell of July

No significant flood peak was observed during the period.

3.4 2nd wet spell of July 2020 (12th to 13th)

The second wet spell of July 2020 which remained active for two days was mainly due to the presence of a westerly trough accompanied by moist currents from the Arabian Sea. Figure 16 represents 500 hPa and 850 hPa Geopotential height patterns along with 925 hPa wind flow during this spell. It indicates that many parts of Pakistan are under the influence of westerly waves, Southwesterly winds at 925 hPa are also present ensuring enough moisture supply from the Arabian Sea.

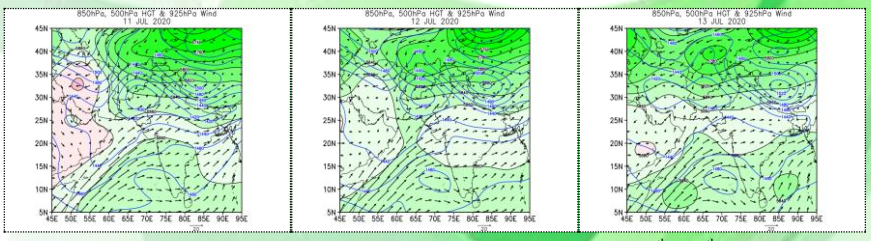


Figure 16: hPa Geopotential height & winds of July 2020 (12th - 13th)

Figure 17 & 18 indicates the spatial distribution of significant rainfall during the event which shows that maximum rainfall of more than 70 mm occurred over Faisalabad & Gujranwala Divisions. More than 50 mm rainfall was also observed over North Punjab at & North Sindh around Sukkur Division. Light rain also reported from Khyber Pakhtunkhwa , Kashmir and Gilgit Baltistan.

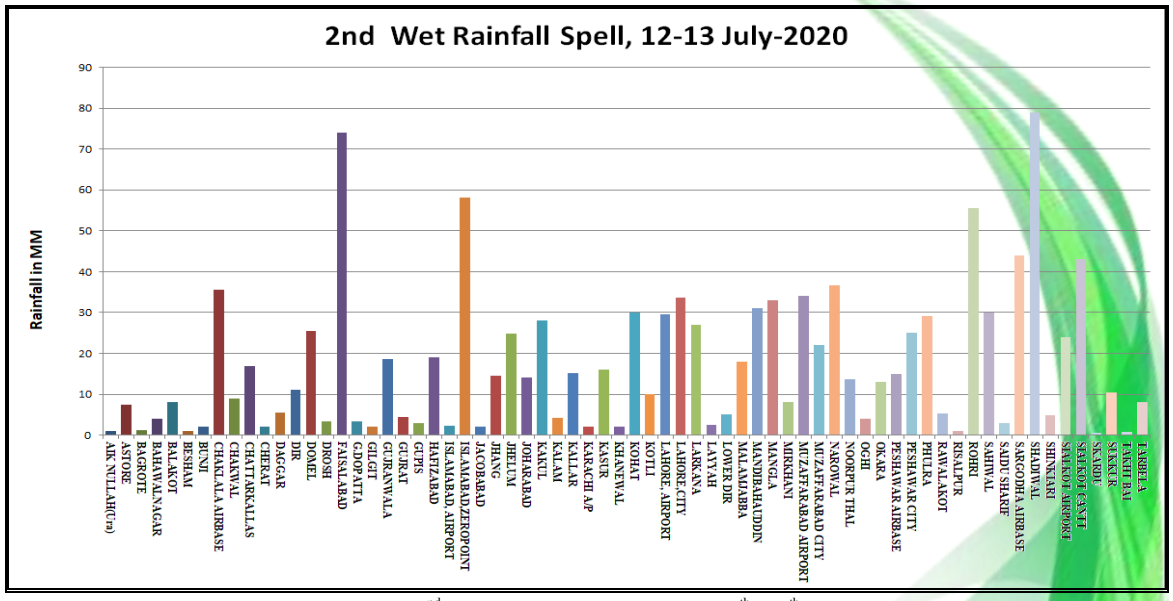


Figure 17: 2nd Wet spell rainfall of July 2020 (12th - 13th)

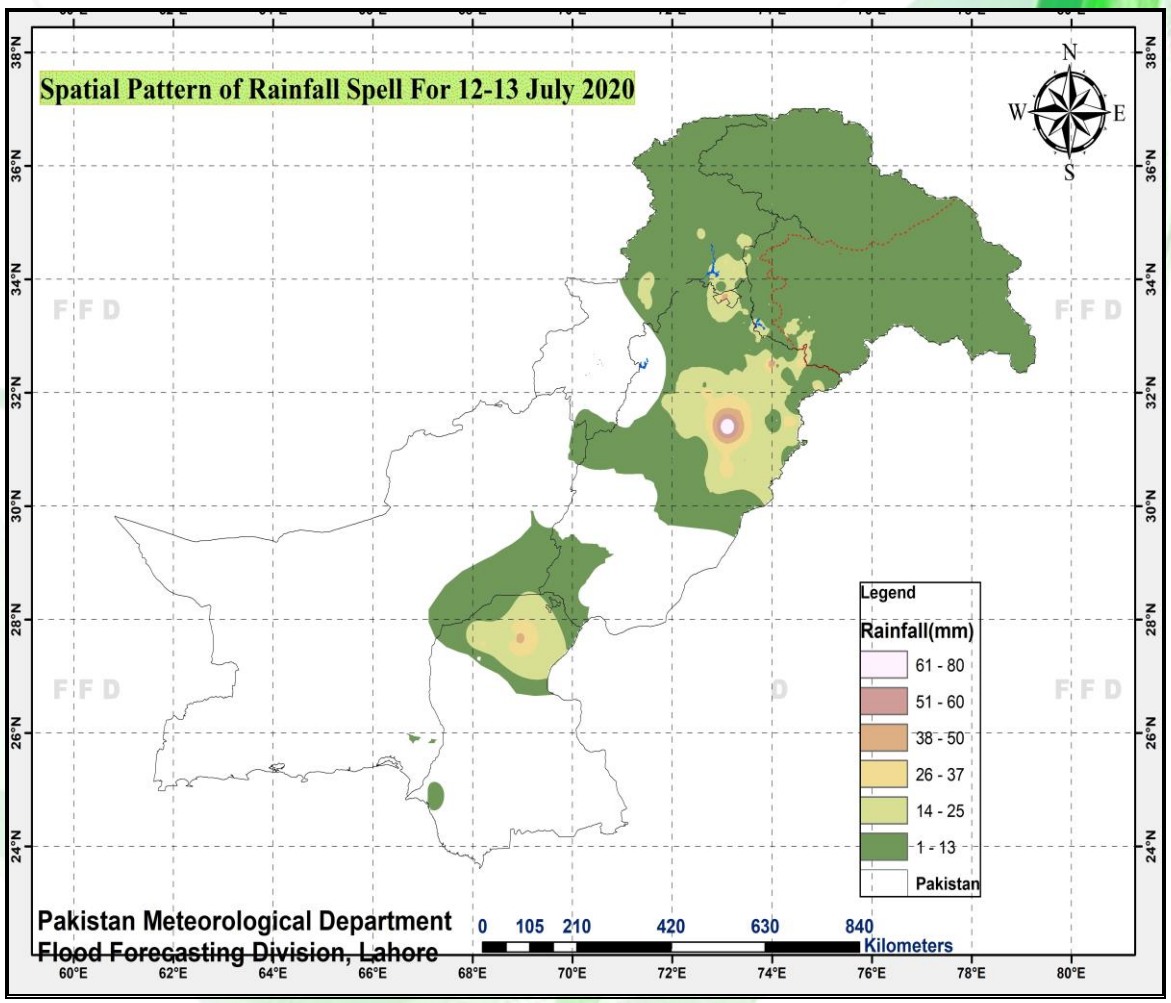
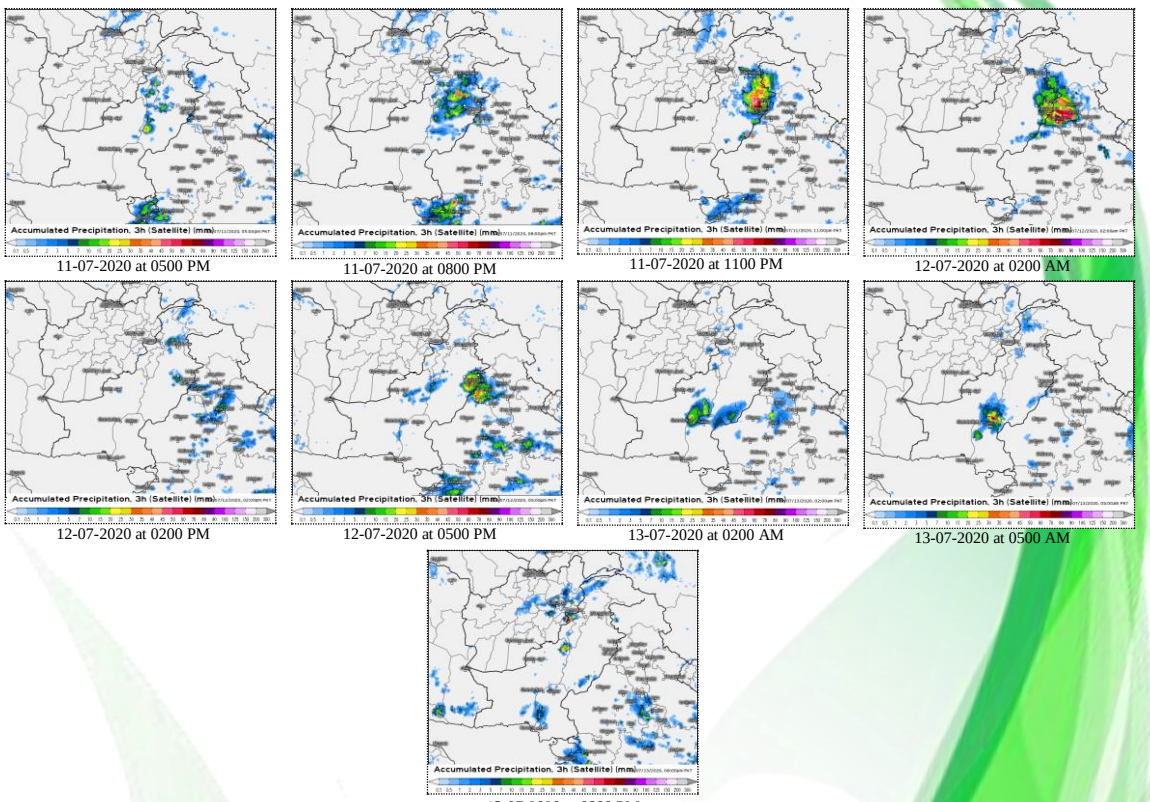


Figure 18: Spatial distribution of significant rainfall of July 2020 (12th -13th)

Figure 19 is showing rainfall/clouds over upper Punjab & upper Sindh during the period.



11-07-2020 at 0500 PM | 11-07-2020 at 0800 PM | 11-07-2020 at 1100 PM | 12-07-2020 at 0200 AM

12-07-2020 at 0200 PM | 12-07-2020 at 0500 PM | 13-07-2020 at 0200 AM | 13-07-2020 at 0500 AM

13-07-2020 at 0800 PM

Figure 19: Satellites Images of July 2020 (11th - 13th)

3.5 Rivers position due to second wet spell of July

No significant flood peak was observed during the period.

3.6 3rd wet spell of July 2020 (16th to 18th)

The third spell of July 2020 which was 5th of the flood season 2020 lasted for three days. It was mainly due to the passing of a westerly wave, accentuation of seasonal low, presence of upper air circulation and incursion of moist currents from Arabian Sea as shown in Figure 20. Overall trend of 925 hPa winds caused rainfall in areas shown in figure:

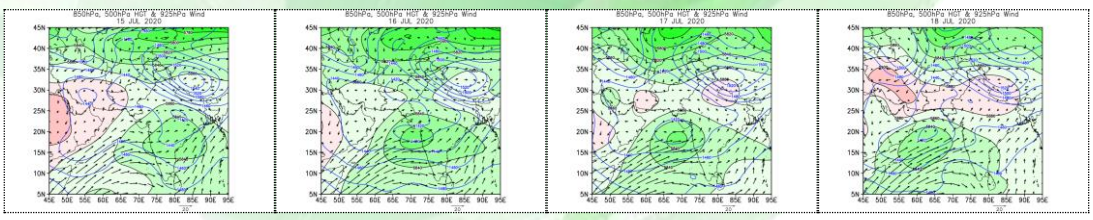


Figure 20: hPa Geopotential Height & winds map of July 2020 (16th -18th)

Figure 21 & 22 indicates the spatial distribution of significant rainfall during the event which shows that maximum rainfall of more than 50 mm occurred over Southeast sindh around Mithi. Another maximum of rainfall more than 45 mm was observed over Bhakkar and Daggar. Light rainfall was also observed over the parts of the country shown in figures.

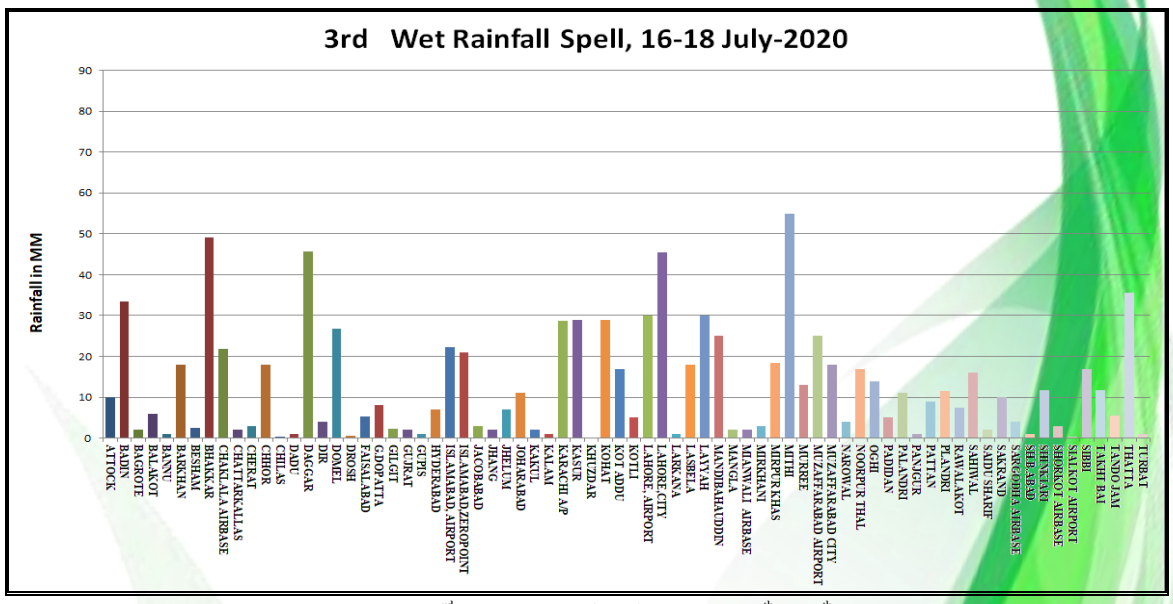


Figure 21: 3rd Wet Spell Rainfall of July 2020 (16th to 18th)

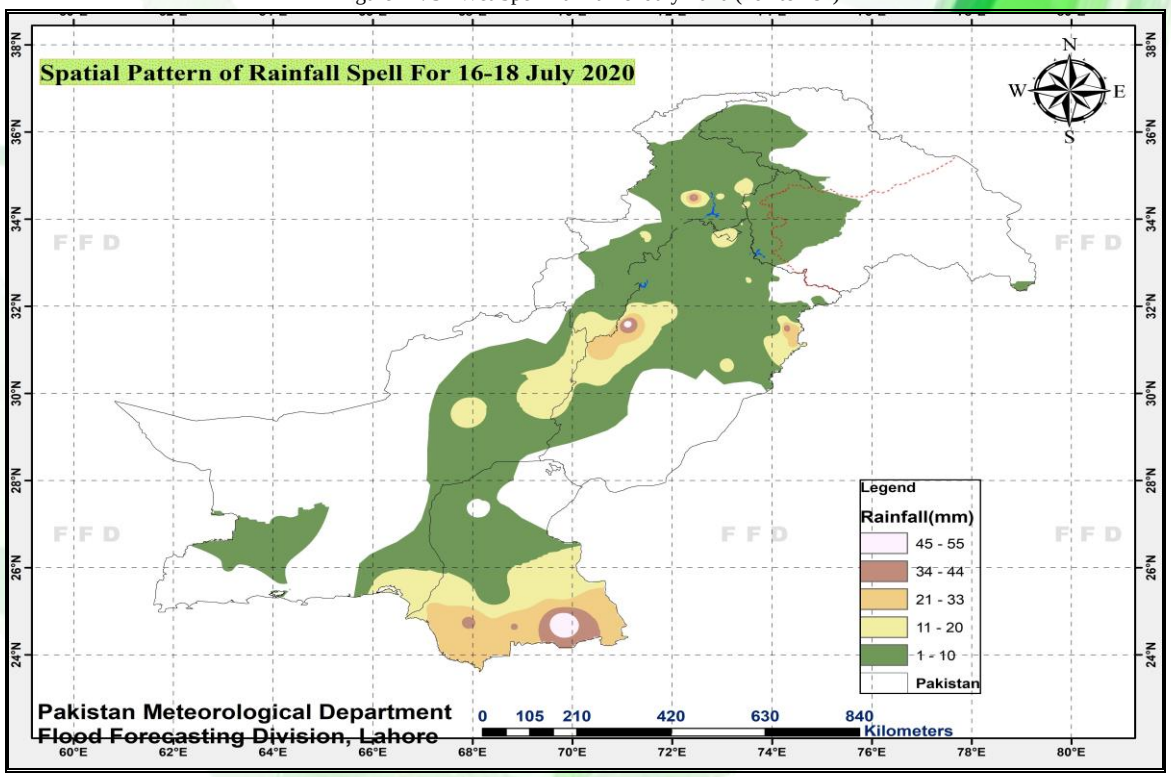


Figure 22: Spatial distribution of significant rainfall of July 2020 (16th -18th)

Figure 23 is showing clouds over South eastern Sindh & scattered clouds over different parts of the country during the spell.

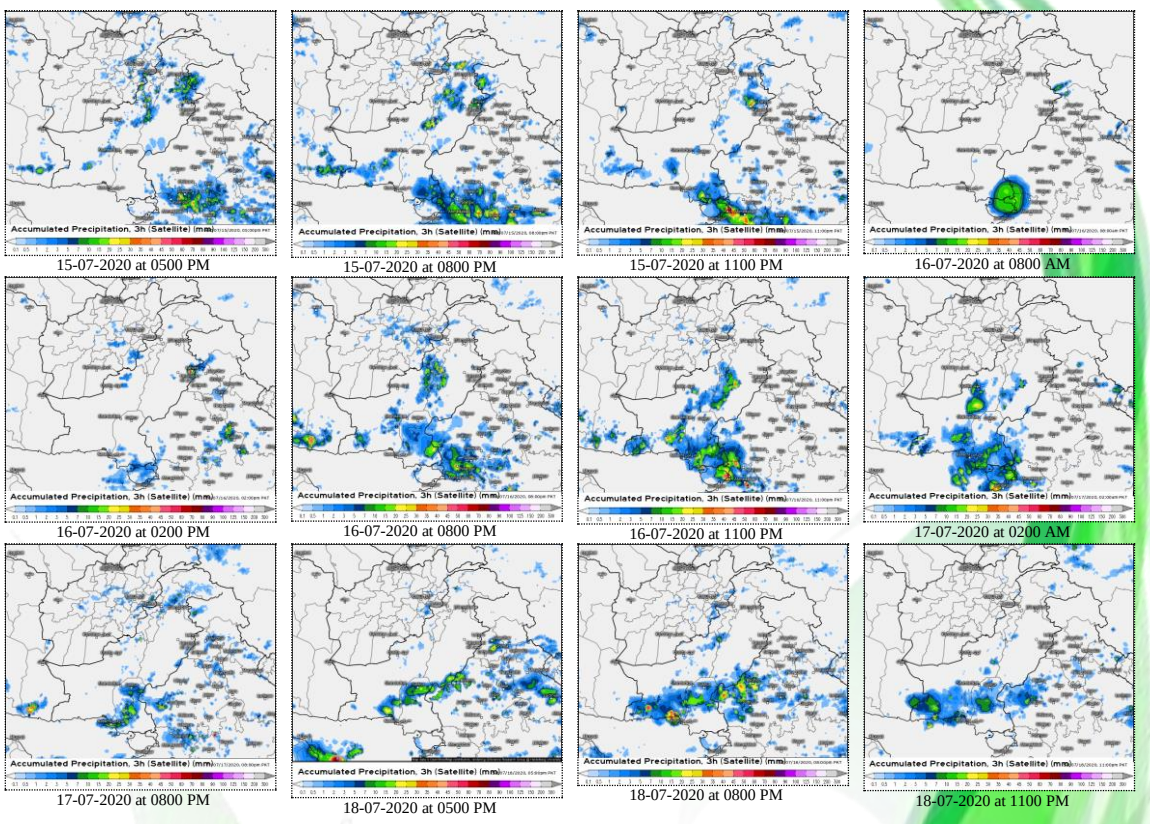


Figure 23: Spatial distribution of significant rainfall July 2020 (16^{th}-18^{th})

3.7 River position due to the third wet spell of July

All the major rivers remained in the state of their normal flows during the period

3.8 4^{th} Wet spell of July 2020 (26^{th} to 27^{th})

The fourth spell of July 2020 which was 6^{th} of the flood season 2020, lasted for two days. It was mainly due to the passing of a westerly wave, cyclonic circulation over East central Arabian Sea, accentuation of seasonal low and incursion of moist currents from Arabian Sea as well as Bay of Bengal as shown in Figure 24.

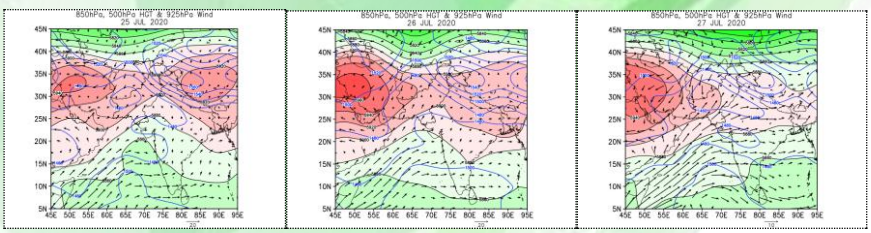


Figure 24: hPa Geopotential Height & hPa winds map July 2020 (26^{th}-27^{th})

Figure 25 & 26 indicates the spatial distribution of significant rainfall during the event which shows that maximum rainfall of more than 90 mm occurred over north Punjab around Chaklala. Another maximum of rainfall of 50 mm was observed over South Sindh at Karachi.

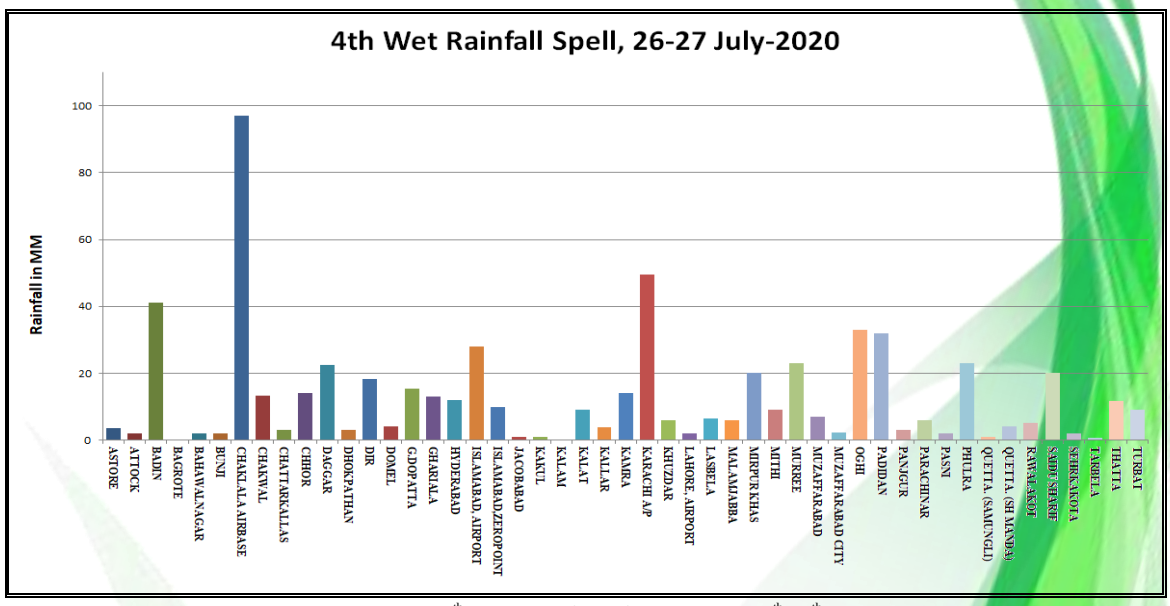


Figure 25: 4th Wet Spell of Rainfall July 2020 (26th-27th)

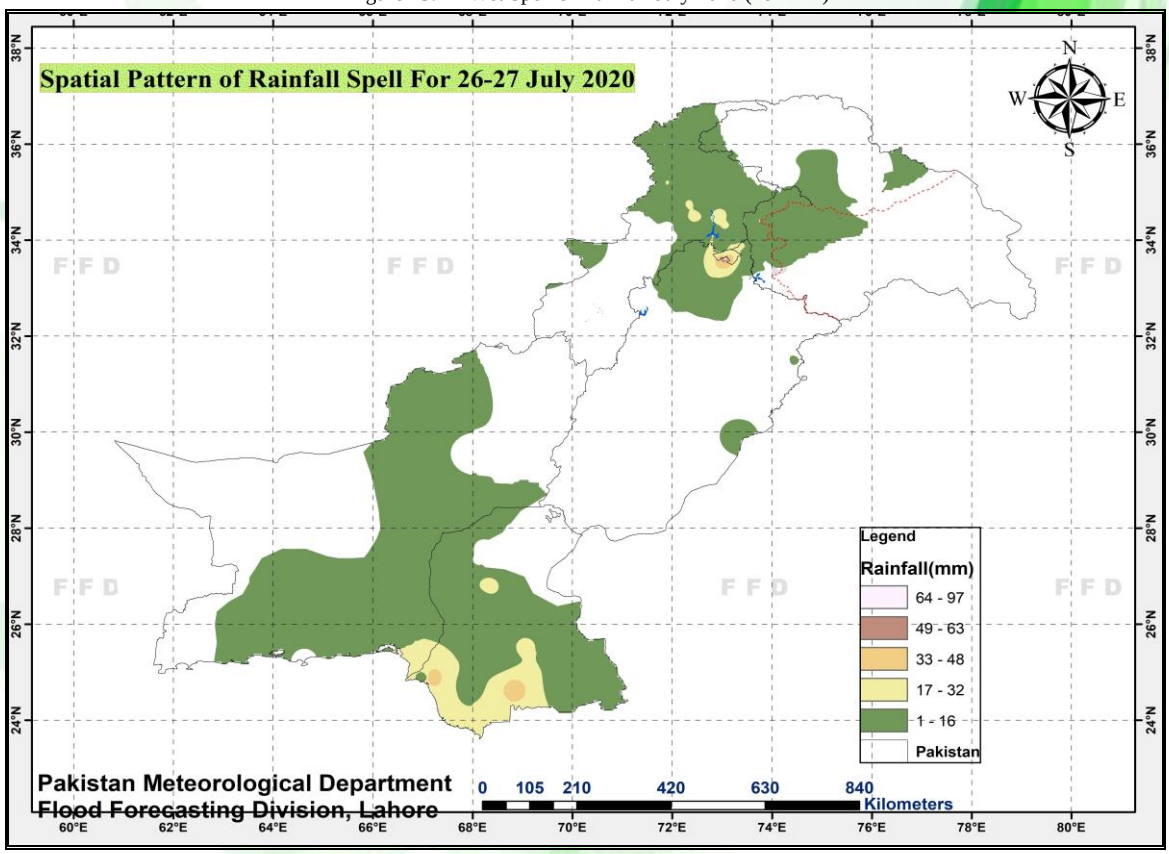
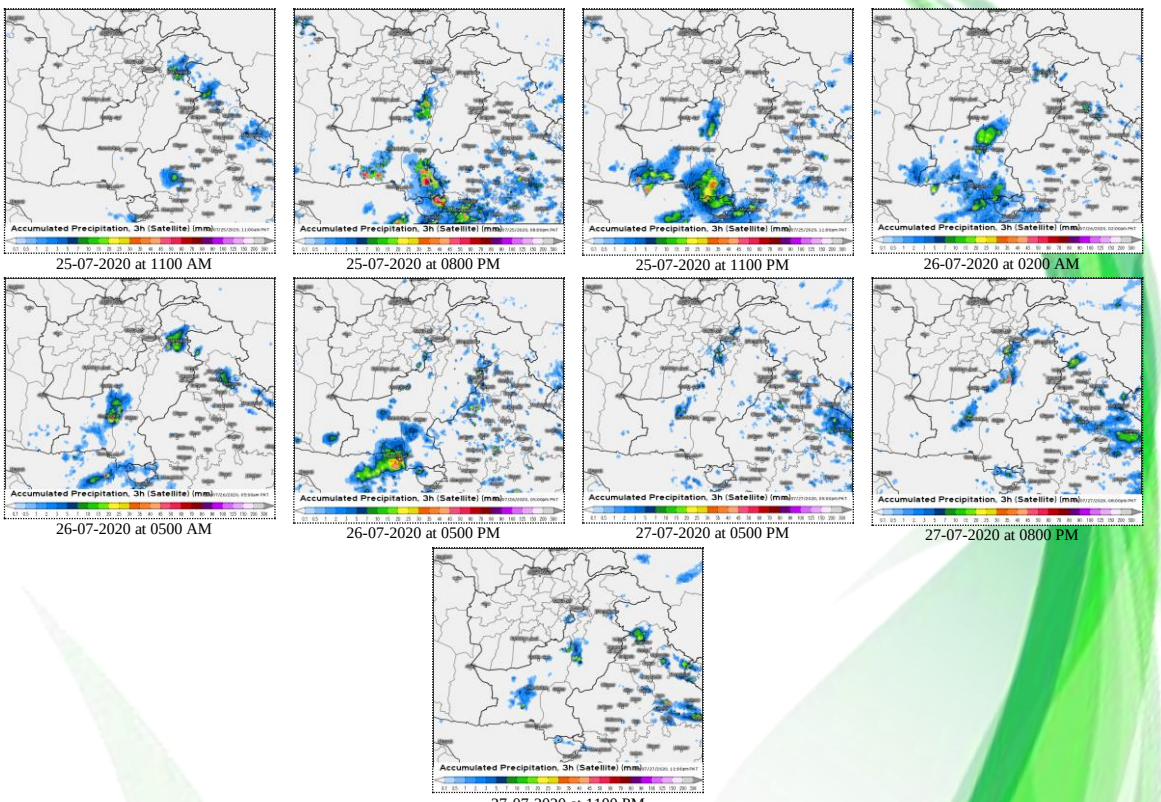


Figure 26: Spatial distribution of significant rainfall July 2020 (26th-27th)

Figure 27 is showing clouds distribution over the country during the spell.



25-07-2020 at 1100 AM | 25-07-2020 at 0800 PM | 25-07-2020 at 1100 PM | 26-07-2020 at 0200 AM
26-07-2020 at 0500 AM | 26-07-2020 at 0500 PM | 27-07-2020 at 0500 PM | 27-07-2020 at 0800 PM
27-07-2020 at 1100 PM

Figure 27: Satellites Images of July 2020 (26^{th}-27^{th})

3.9 River position due to the Fourth wet spell of July

All the major rivers remained in the state of their normal flows during the period.

3.10 River position during July 2020

Flood peaks (thousands of cusecs) recorded during July 2020 in different rivers at various points are shown in table 02.

Rivers/Site	Stations	Peaks Inflows	Date	Flood level
Jhelum	Mangla	107000	21/07/2020	Low

Table 2: Maximum peaks recorded during July 2020.

3.11 Hydrographs during Significant event of July 2020

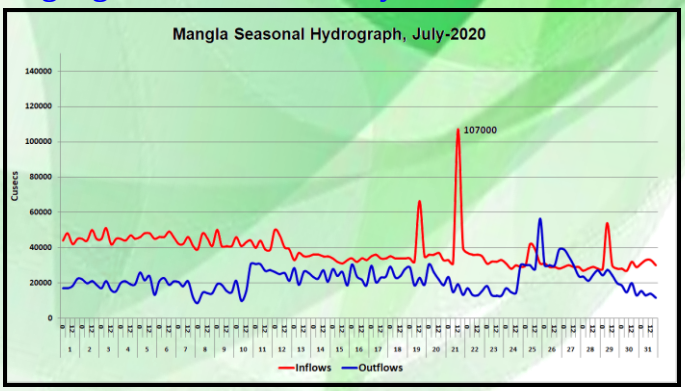


Figure 28: Hydrographs for the month of July 2020.

3.12 The spatial pattern of rainfall during the month of July 2020

Isohyetal map of July 2020 indicates that two maxima rainfall more than 220 mm one lies over kasur in Northeast Punjab & other over Chaklala in north Punjab. Other Maximum rainfall of more than 150 mm occur over Faisalabad ,Jhelum ,Lahore ,Sargodha ,Gujranwala, in Punjab over Balakot in Khyber Pakhtunkhwa and over Kotli in Kashmir. More than 100 mm are also observed over Murree, Nurpurthal, Sahiwal, Sialkot in Punjab, Kohat & Malam Jabba in Khyber Pakhtunkhwa. The spatial distribution of rainfall map of July 2020 is shown in figure 29 & 30.

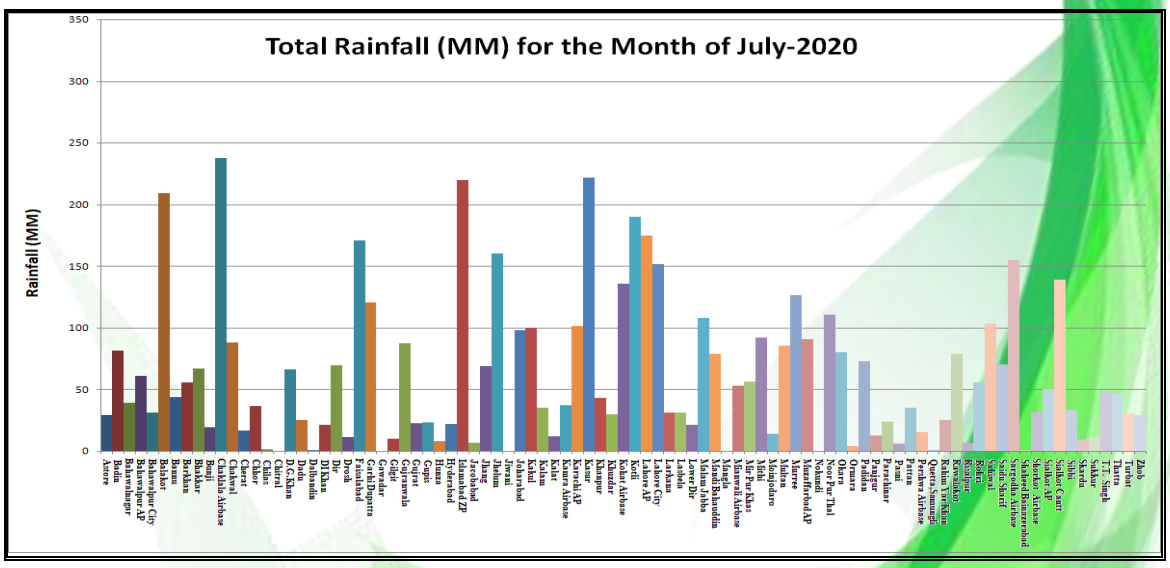


Figure 29: Total Rainfall for the month of July 2020.

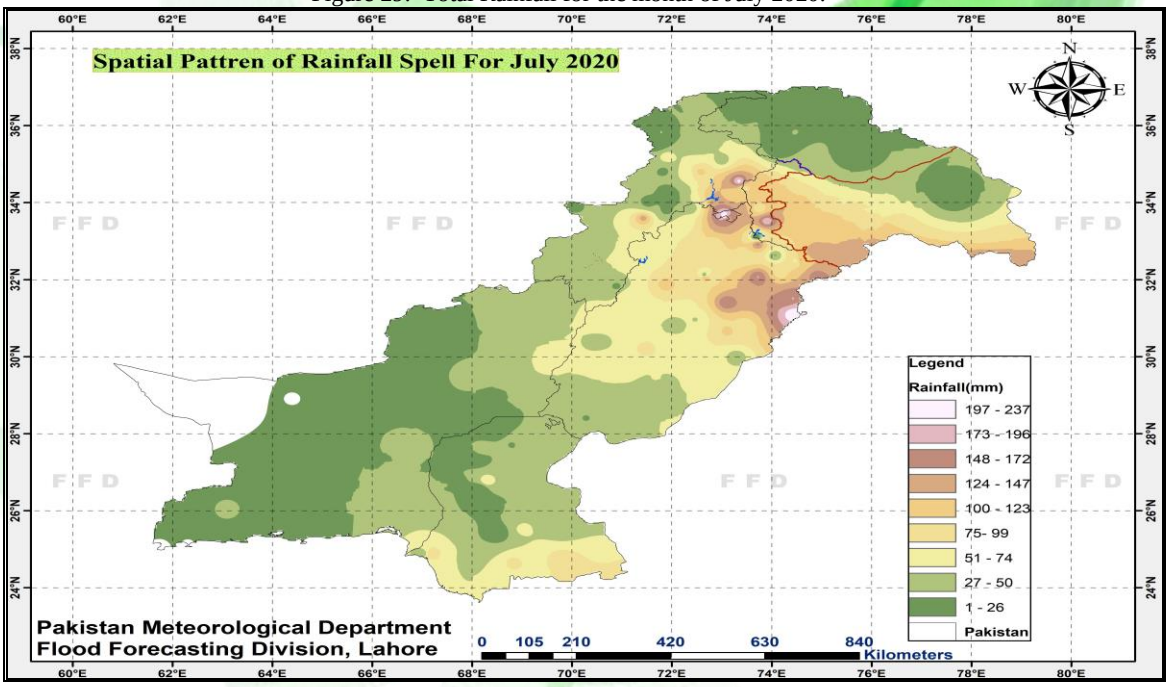


Figure 30: Spatial distribution rainfall map of July 2020.

3.13 Percentage Anomaly during the month of July 2020

Percentage Anomaly map for the month of July 2020 indicates that Most parts of the country received below normal rainfall. However Faisalabad, Multan ,Sargodha Kohat ,Karachi, Shaheed Benazirabad and Makran divisions received above normal rainfall. Percentage Anomaly map of July 2020 is shown in Figure 31 & 32.

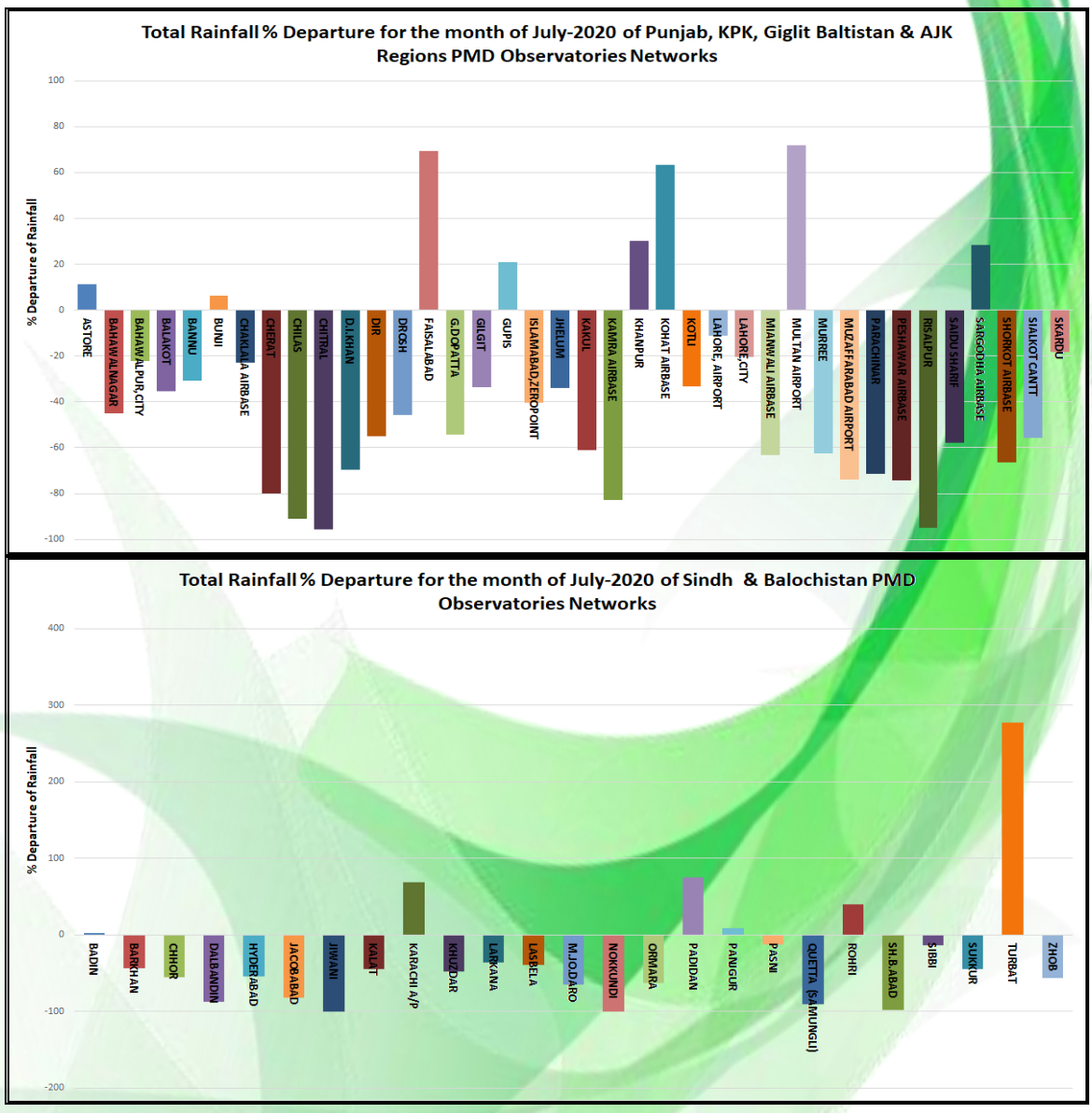


Figure 31: Rainfall % Departure for of July 2020.

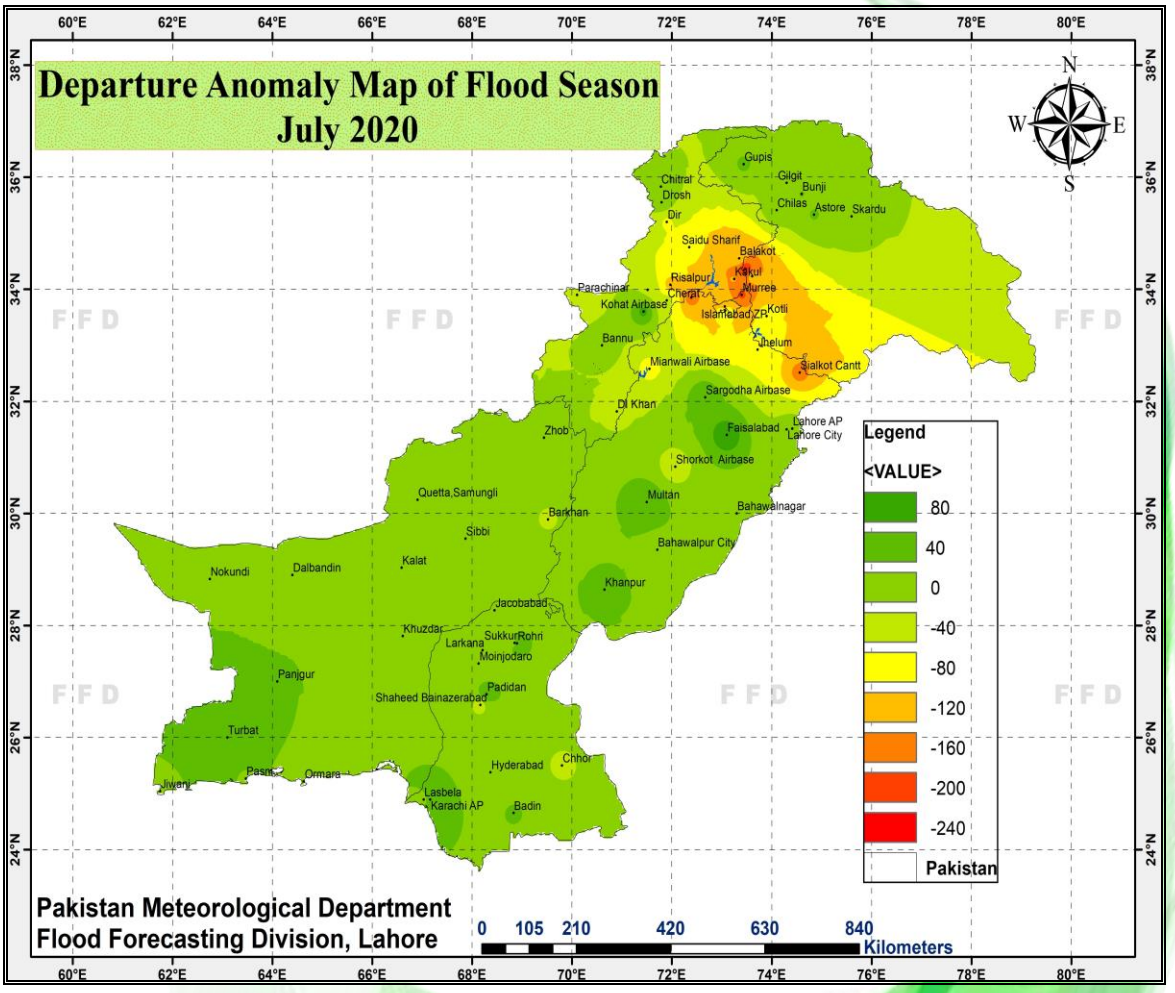


Figure 32: Percentage Anomaly rainfall map of July 2020.

3.14 Temporal Distribution during the month of July 2020

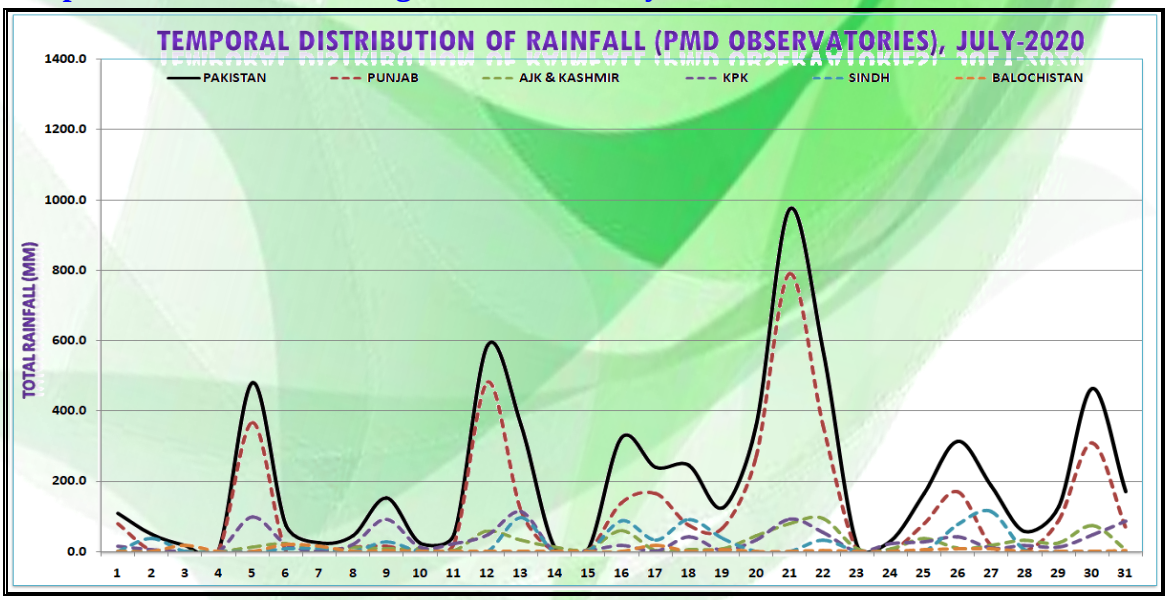


Figure 33: Temporal distribution of rainfall July 2020.

4 Significant hydro-meteorological events during the month of August 2020

Three rainy spells occurred during the month of August 2020..

4.1 Meteorological events

The first spell continued from 08th to 11th August 2020. This spell was caused by the presence of well marked low over Southeast Sindh, cyclonic circulation over south Gujarat (India), strong trough of westerly wave over northern parts of Afghanistan and moderate to strong moist currents from the Arabian Sea as well as from Bay of Bengal. The second wet spell of August was observed from 20th to 22nd August 2020. This spell was caused by the interaction of westerly wave over northern parts of the country and strong moist currents from the Arabian Sea and Bay of Bengal up to 5000 feet. The third wet spell of August was observed from 25th to 28th August 2020. This spell was caused by the Monsoon Low over Rajasthan and adjoining areas, trough of westerly wave over northern parts of the country along with moderate moist currents from the Arabian Sea. The Fourth & final wet spell of August was observed from 31st August to 02nd September 2020. This spell was caused by monsoon Low over Bahawalpur division, the trough of westerly wave over northern parts of the country along with moderate moist currents from the Arabian Sea.

4.2 1st wet spell of August 2020 (08th to 11th)

The rainfall during the first spell of August occurred from 08th to 11th August 2020. Moderate to Heavy rainfall was observed during this spell over the upper catchments of river Indus and Jhelum along with Sindh, coastal Balochistan , north and northeast Punjab. Atmospheric conditions during this wet spell are shown in figure 34.

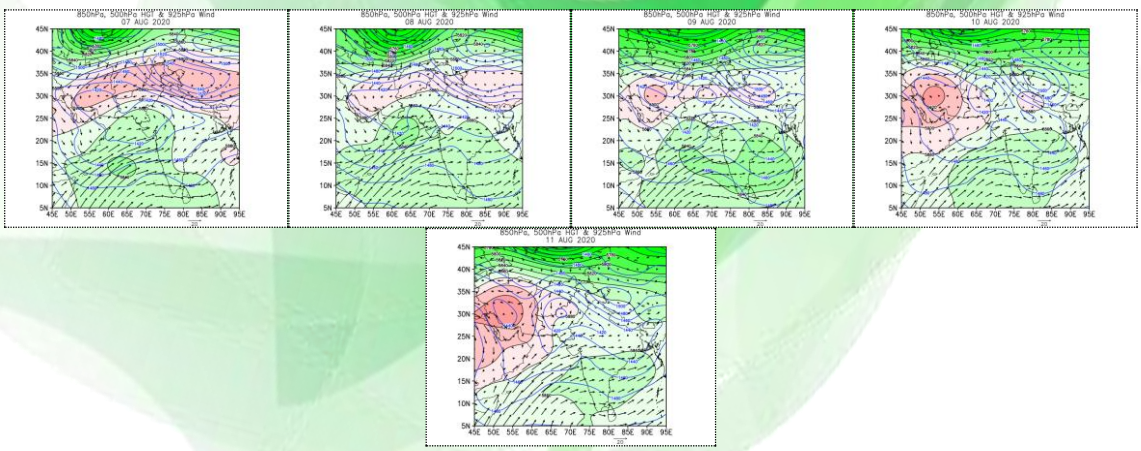


Figure 34: hPa geopotential height & hPa winds map August (07th-11th)

Satellite images in figure 35 are showing dense clouds over Punjab, Lower Khyber Pakhtunkhwa & Kashmir. Light clouds are also present over South Sindh & East Balochistan.

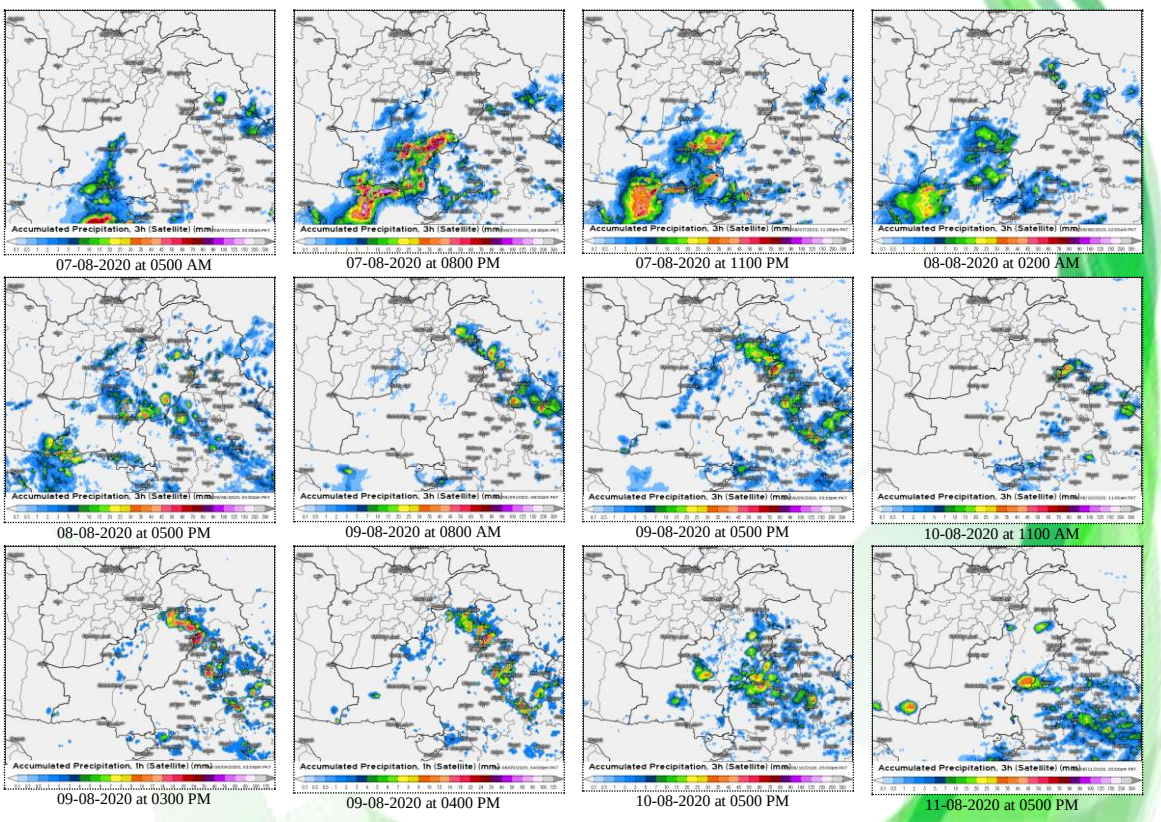


Figure 35: Satellites Images of August 2020 (08^{th} to 11^{th})

Figure 36 & 37, Isohyetal map and spatial distribution of 07^{th} to 11^{th} August 2020 indicates that one maxima of rainfall more than 150 mm lies over Khyber Pakhtunkhwa around Balakot and adjoining Kashmir. Another two maximum of rainfall of more than 100 mm one lies over northeast Punjab in Lahore Division and other over coastal Balochistan at Ormara. Scattered rains of more than 50 mm were also observed over the parts of the country as shown below.

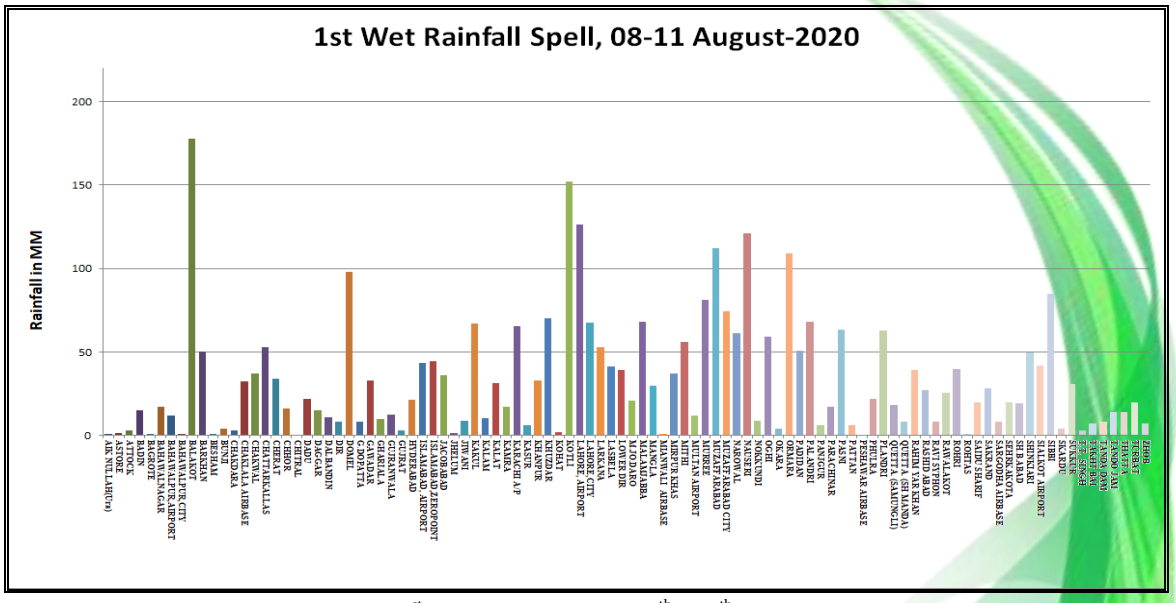


Figure 36: 1st Wet spell Rainfall of 08th – 11th August-2020.

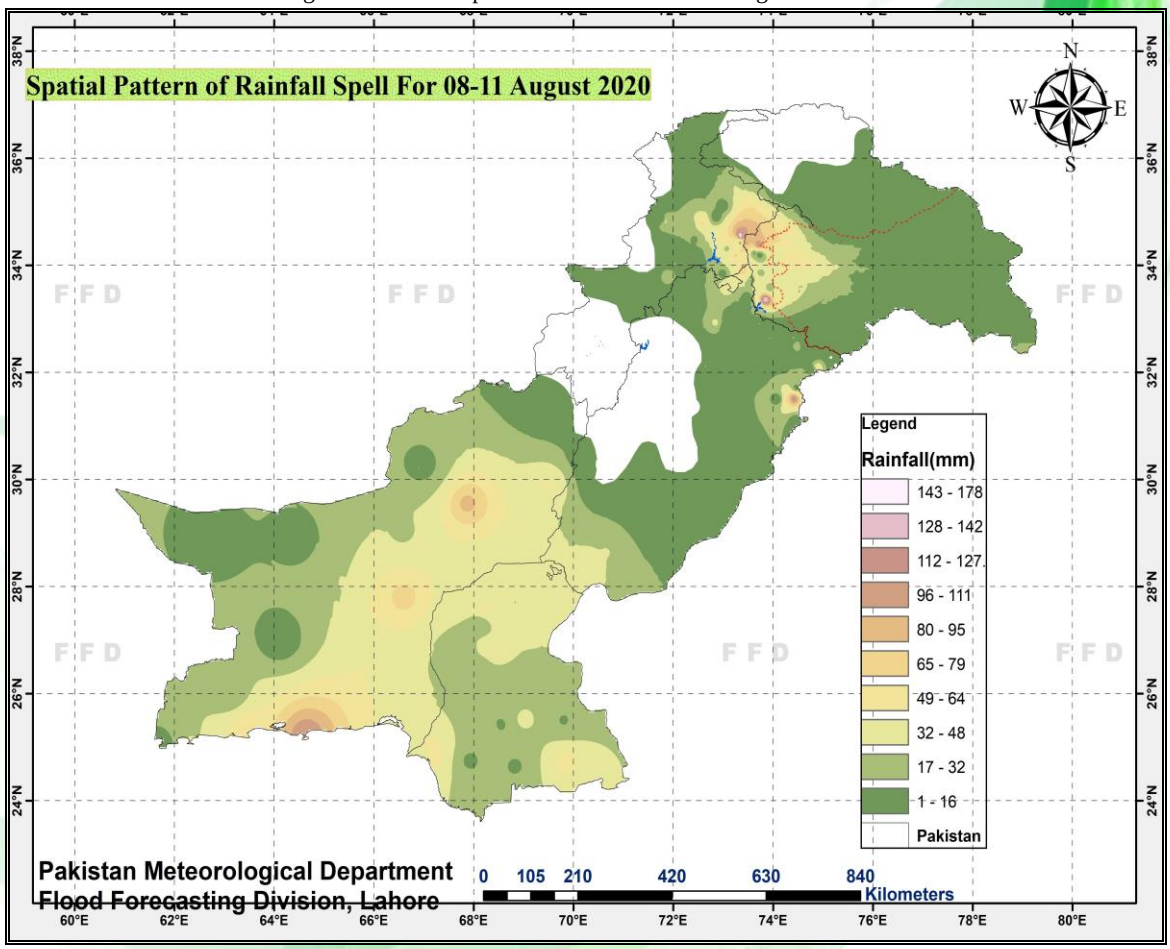


Figure 37: Spatial distribution of significant rainfall August 2020 (08th -11th)

4.3 Rivers position during the first spell of August-2020

Because of long dry conditions over the upper catchments of all the major rivers no significant rise recoded in any of the major rivers

4.4 2nd wet spell of August 2020 (20th to 22nd)

Rainfall of moderate-intensity with isolated heavy falls was recorded over central Punjab. Catchments of all the major rivers received no significant rain during the spell. Figure 38 represents the atmospheric conditions during this wet spell. This spell was caused by the interaction of westerly wave over northern parts of the country and strong moist currents from the Arabian Sea and Bay of Bengal up to 5000 feet.

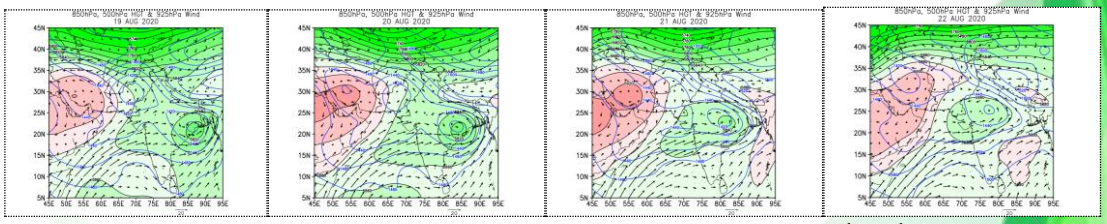


Figure 38: hPa Geopotential height & hPa winds map of August 2020 (20th-22nd)

Figure 39 & 40 shows the spatial distribution of significant rainfall of more than 100 mm recorded over central Punjab around Faisalabad Jhang, Hafizabad and Lahore. Scattered Rainfall also recorded as shown in Figure:

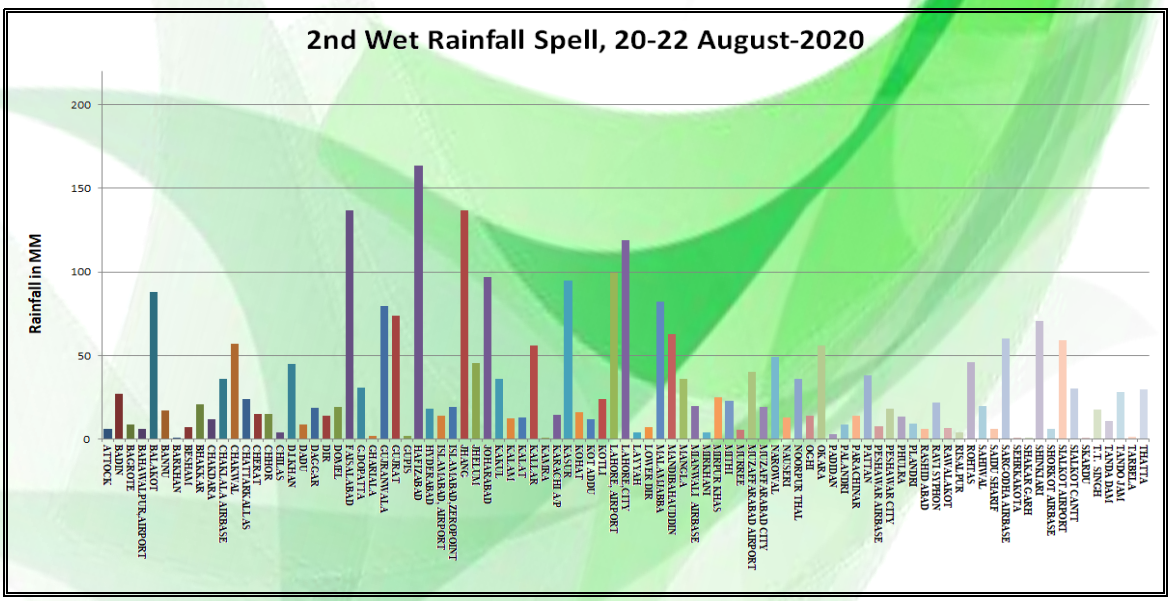


Figure 39: 2nd Wet Spell Rainfall of 20th to 22nd August 2020.

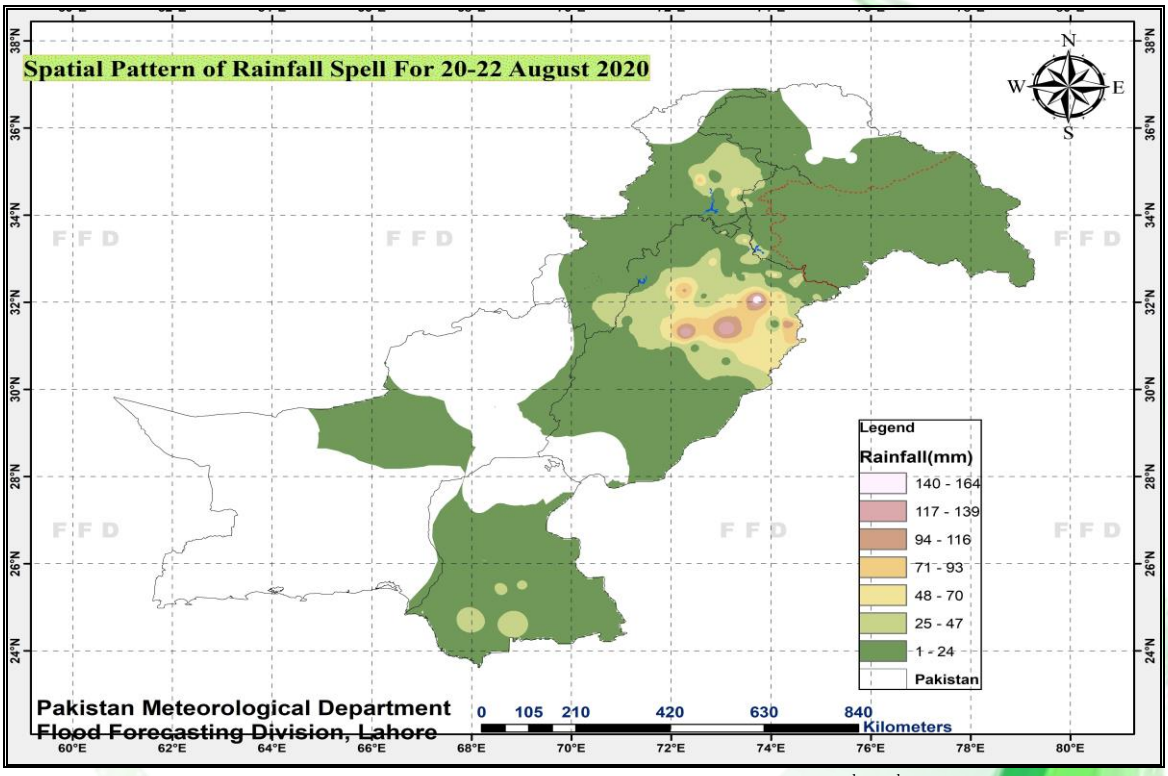


Figure 40: Spatial distribution of significant rainfall August 2020 (20th-22th)

Satellite/Radar images in figure 41 showing dense clouds over central Punjab.

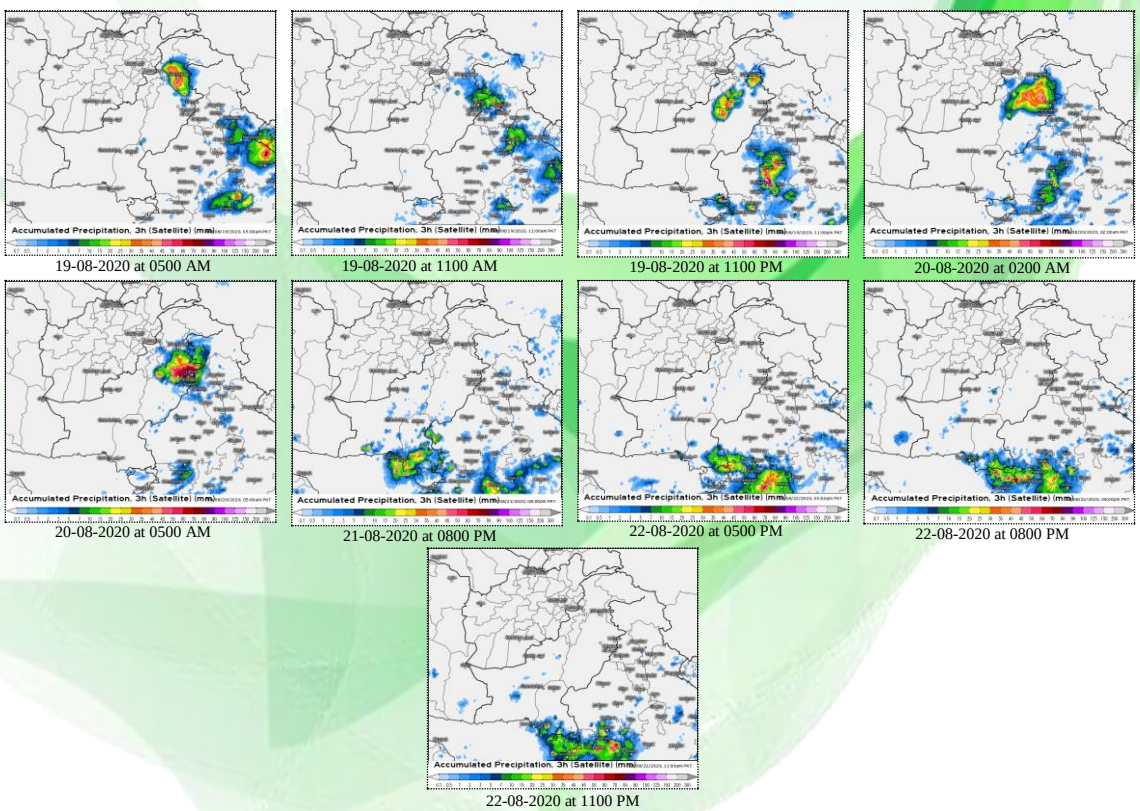


Figure 41: Satellites Images of August 2020 (20th-22nd)

4.5 Rivers position during the second spell of August-2020

Due to no significant rain over the upper catchments of all the major rivers no flood situation arises at any site of the major rivers.

4.6 3rd wet spell of August 2020 (25th to 28th)

This was the most significant wet spell of the flood season 2020 which cause Rainfall of Heavy to Very heavy intensity over the upper catchments of rivers Jhelum, Chenab along with Sindh. Figure 42 represents the atmospheric conditions during this wet spell. This spell was caused by the Monsoon Low over Rajasthan and adjoining areas, trough of westerly wave over northern parts of the country along with moderate moist currents from the Arabian Sea and the influx of southwesterly currents at 925 hPa.

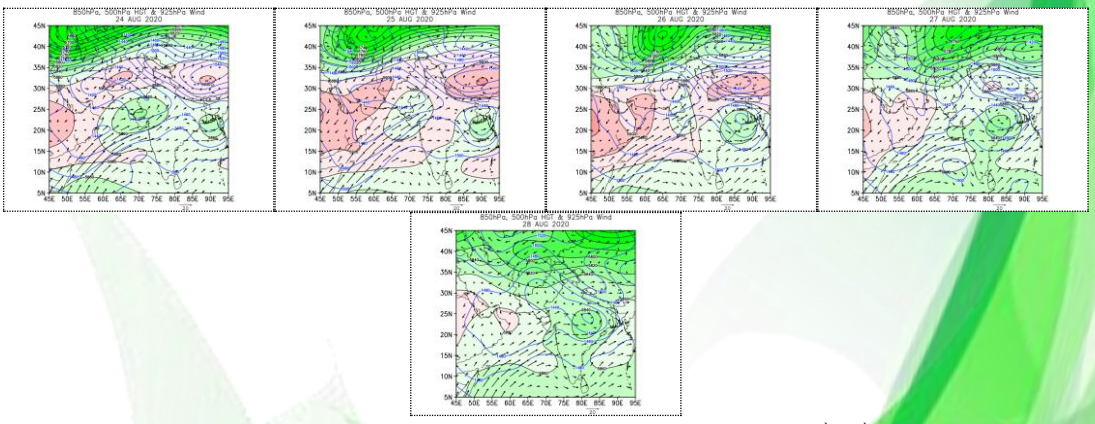


Figure 42: hPa Geopotential height & hPa winds map August 2020 (25th-28th)

Figure 43 & 44 shows the spatial distribution of significant rainfall of more than 300 mm recorded over Kashmir around Kotli and rainfall of more than 200 mm was also recorded over Sindh, Northeast Punjab around Sialkot, over Kashmir around Palandri. More than 100 mm rainfall also recorded at scattered places of the country as shown in figure below.

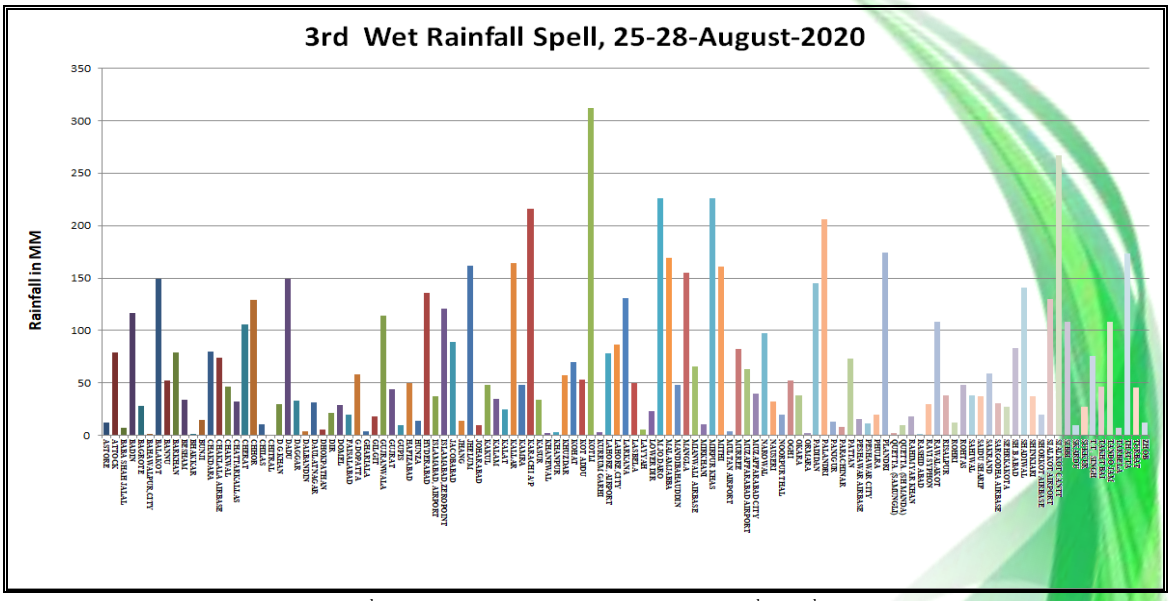


Figure 43: 3rd Wet Spell Rainfall of August 2020 (25th - 28th)

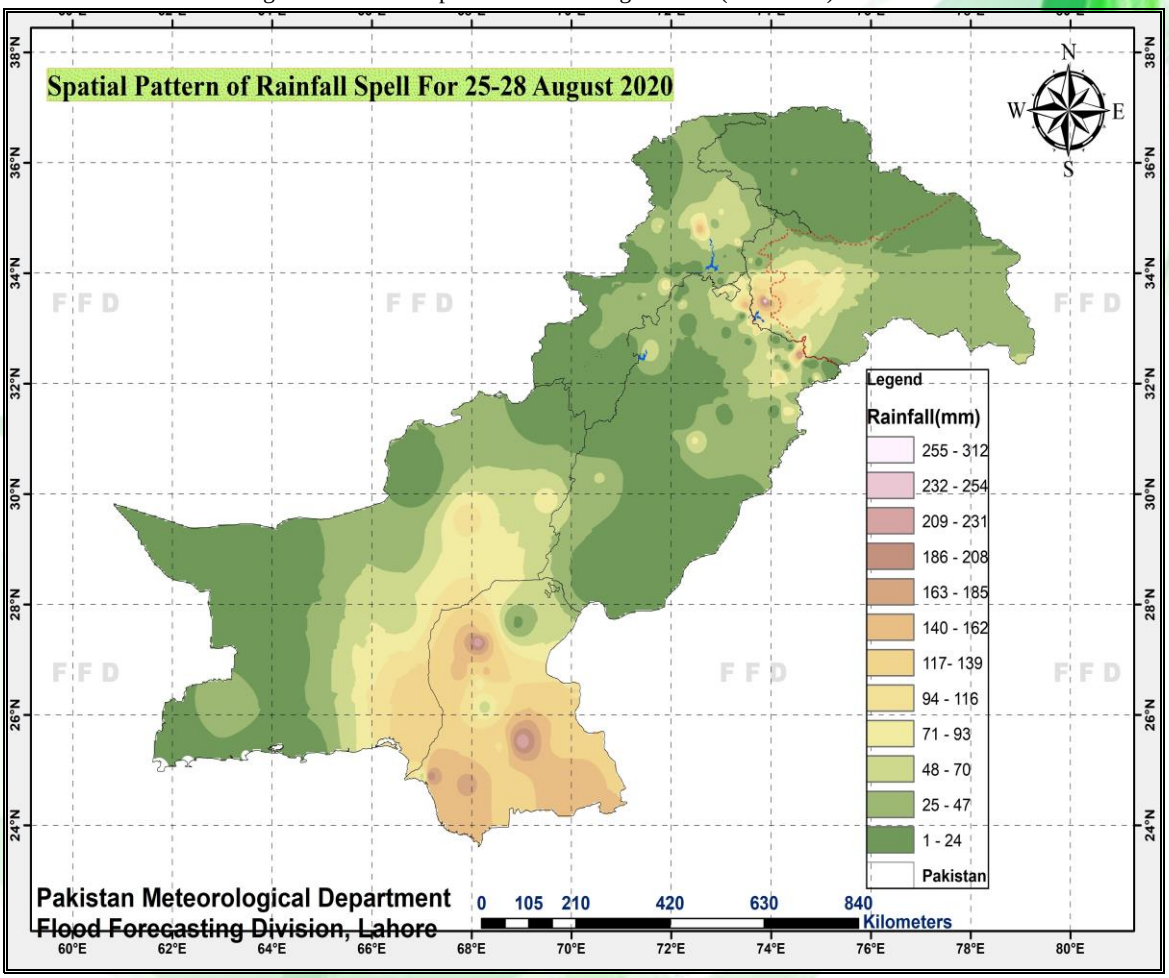


Figure 44: Spatial distribution of significant rainfall August 2020 (25th-28th)

The satellite image in figure 45 is showing clouds cover over Kashmir ,Northeast Punjab and Sindh. Scattered clouds are also visible over Coastal & Eastern Balochistan.

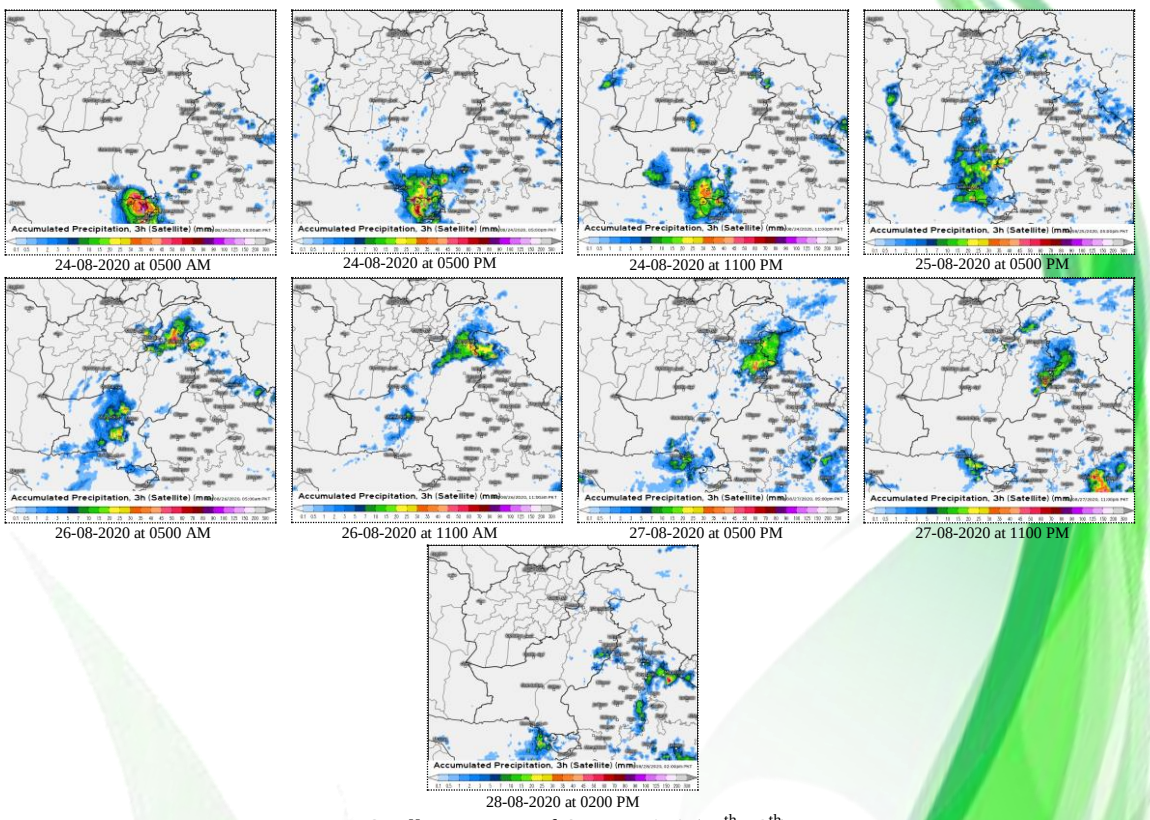


Figure 45: Satellites Images of August 2020 (25th-28th)

4.7 Rivers position during the third spell of August-2020

Exceptionally High flood situation was recorded during the spell over the upstream Mangla and High flood situation also observed in River Chenab at Marala, Khanki and Qadirabad.

4.8 Spatial distribution of rainfall during the month of August 2020

The precipitation during the month of August is shown in figure 46 & 47 which indicates that monsoon activity remained active over North &Northeast Punjab and Kashmir And Southeast Sindh. One center of maximum rainfall exceeding 500 mm is located one at Kotli and other at Sialkot. While another maxima of 400 mm is located around Southeast Sindh at Mithi.

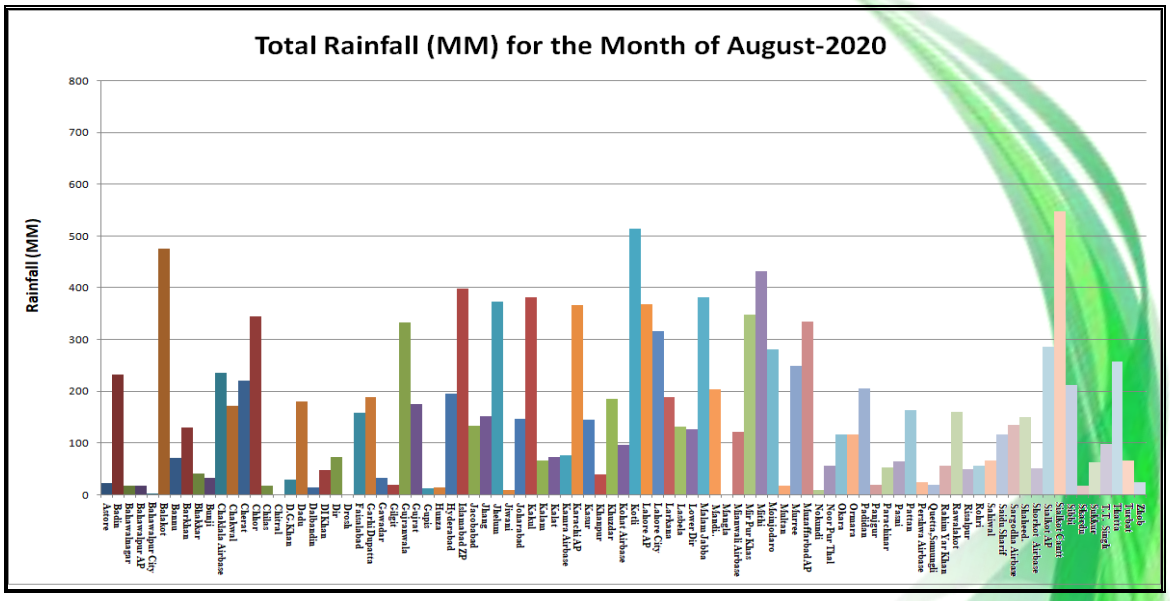


Figure 46: Total Rainfall for the month of August 2020.

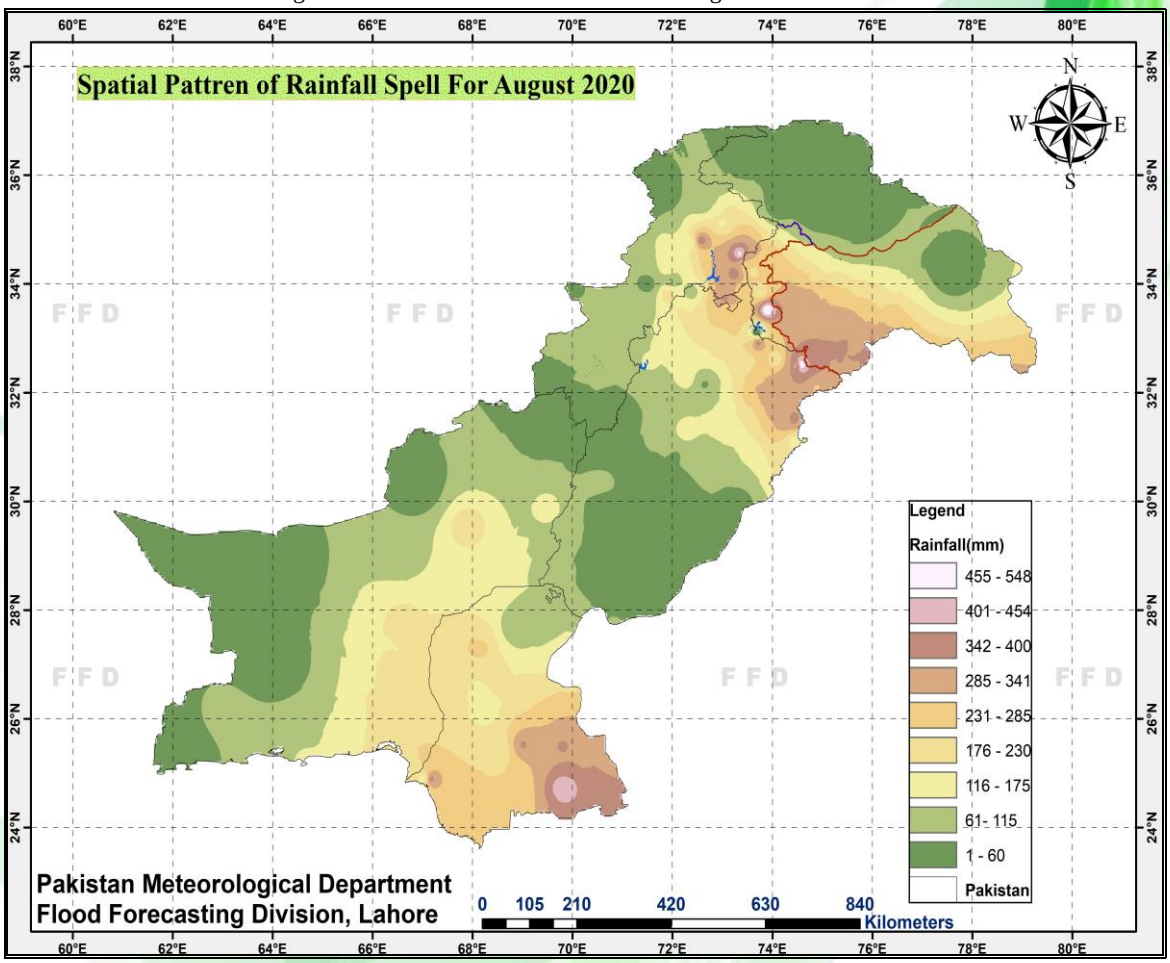


Figure 47: Spatial distribution of significant rainfall map of August 2020.

4.9 Percentage Anomaly during the month of August 2020

Percentage Anomaly map for the month of August 2020 indicates that most parts of Sindh & Balochistan, northeast Punjab received above normal Rainfall while most parts of Khyber Pakhtunkhwa & South Punjab received below normal rainfall. Percentage Anomaly map of August 2020 is shown in Figure 48 & 49.

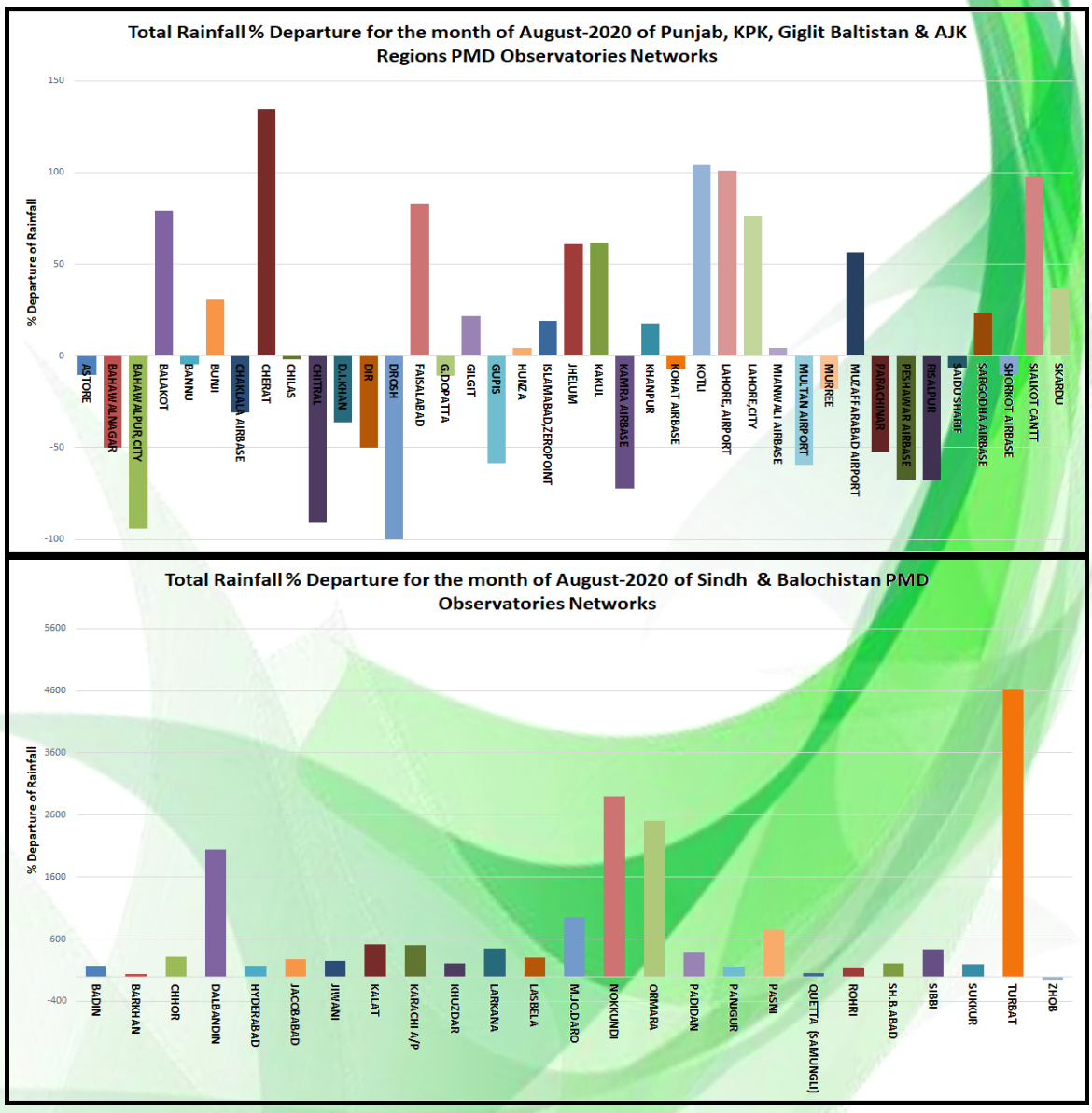


Figure 48: Rainfall % Departure for August 2020.

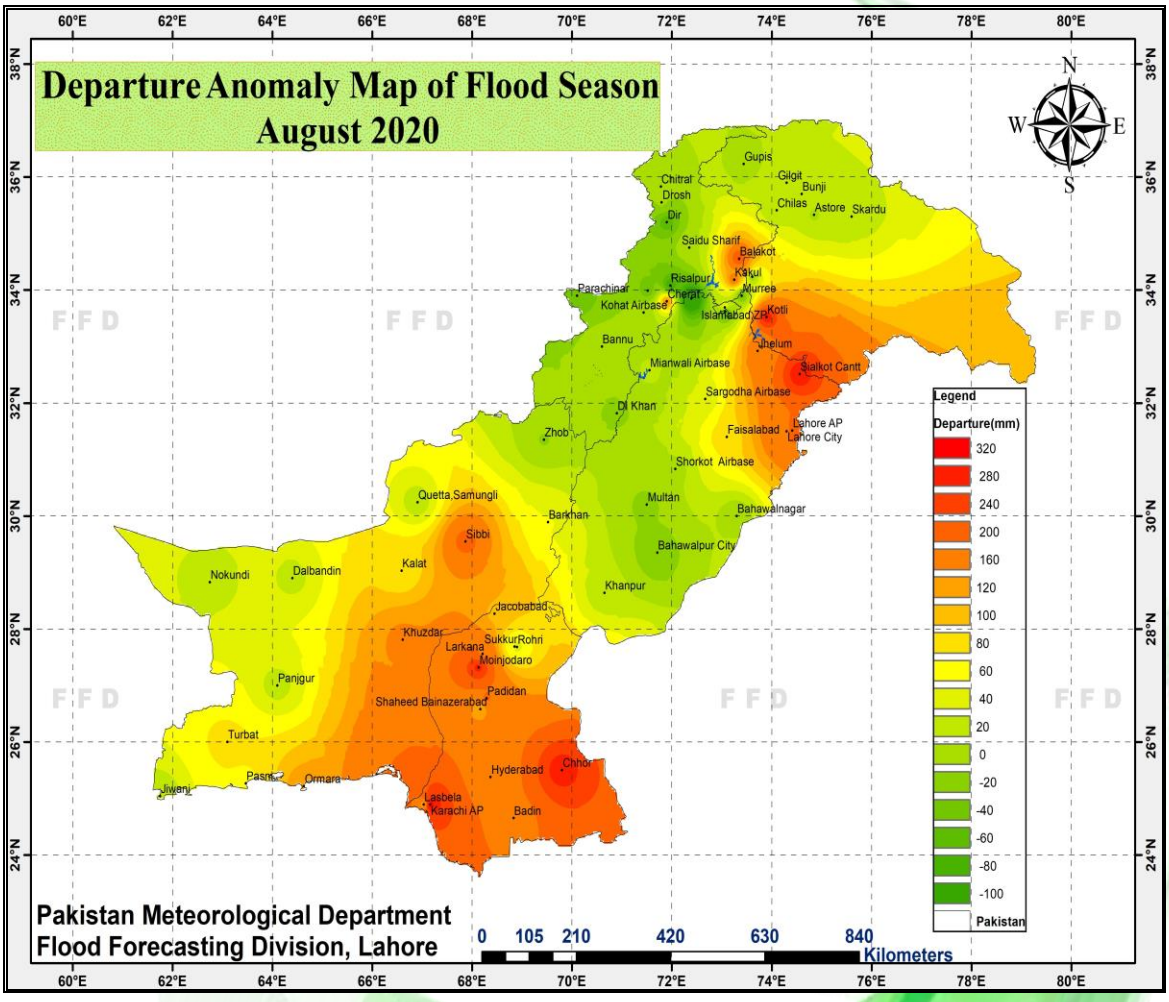


Figure 49: Percentage Anomaly rainfall map of August 2020.

4.10 Temporal Distribution during the month of August 2020

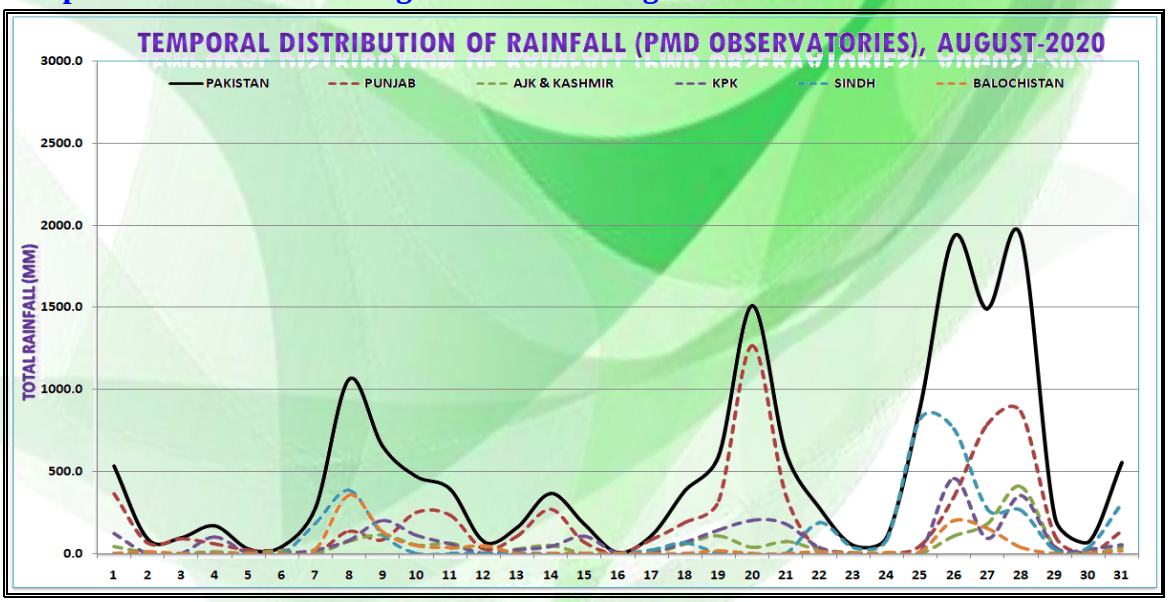


Figure 50: Temporal distribution of rainfall during August 2020.

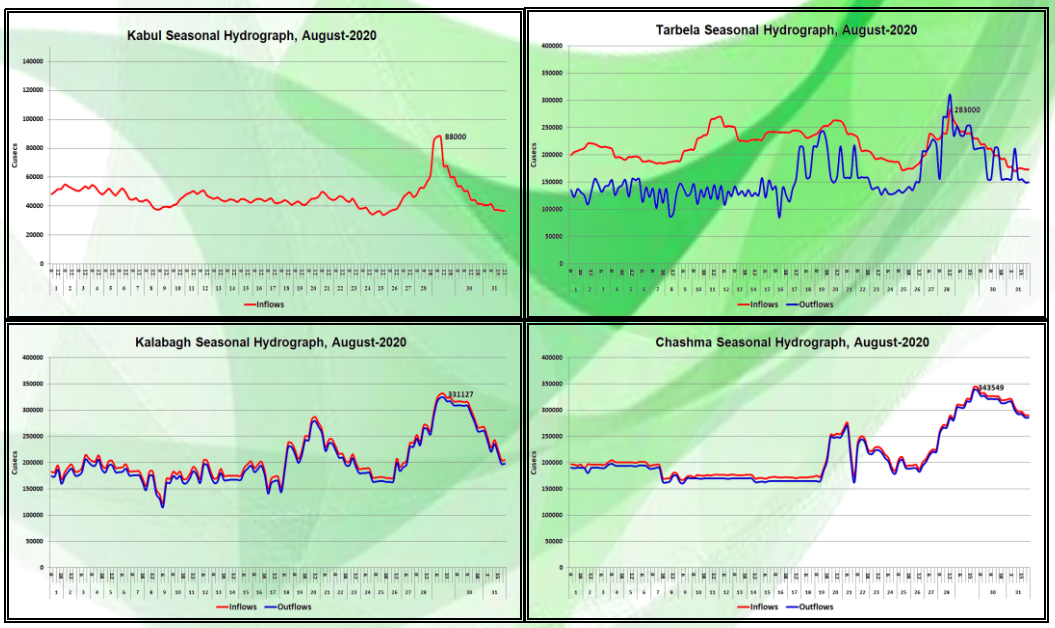
4.11 Rivers position during the month of August-2020

Flood peaks recorded during August 2020 are shown in table 3.

Rivers/Site	Stations	Peaks Inflows	Date	Flood level
Kabul	Nowshehra	88000	29/08/2020	Low
Indus	Tarbela	283000	28/08/2020	Low
Indus	Kalabagh	331127	29/08/2020	Low
Indus	Chashma	343549	29/08/2020	Low
Indus	Taunsa	368246	31/08/2020	Low
Indus	Guddu	256489	31/08/2020	Low
Indus	Sukkur	214340	27/08/2020	Low
Jhelum	Mangla	415000	27/08/2020	Ex.High
Jhelum	Rasul	127000	28/08/2020	Medium
Chenab	Marala	303884	28/08/2020	High
Chenab	Khanki	292093	28/08/2020	High
Chenab	Qadirabad	284000	28/08/2020	High
Chenab	Trimmu	200527	31/08/2020	Medium
Ravi	Balloki	63250	29/08/2020	Low
Ravi	Sidhnai	33036	31/08/2020	Low
Sutlej	GS Wala	2000	29/08/2020	

Table 3: Maximum peaks recorded during August 2020.

4.12 Hydrographs observed during the month of August 2020 are shown in figure 53



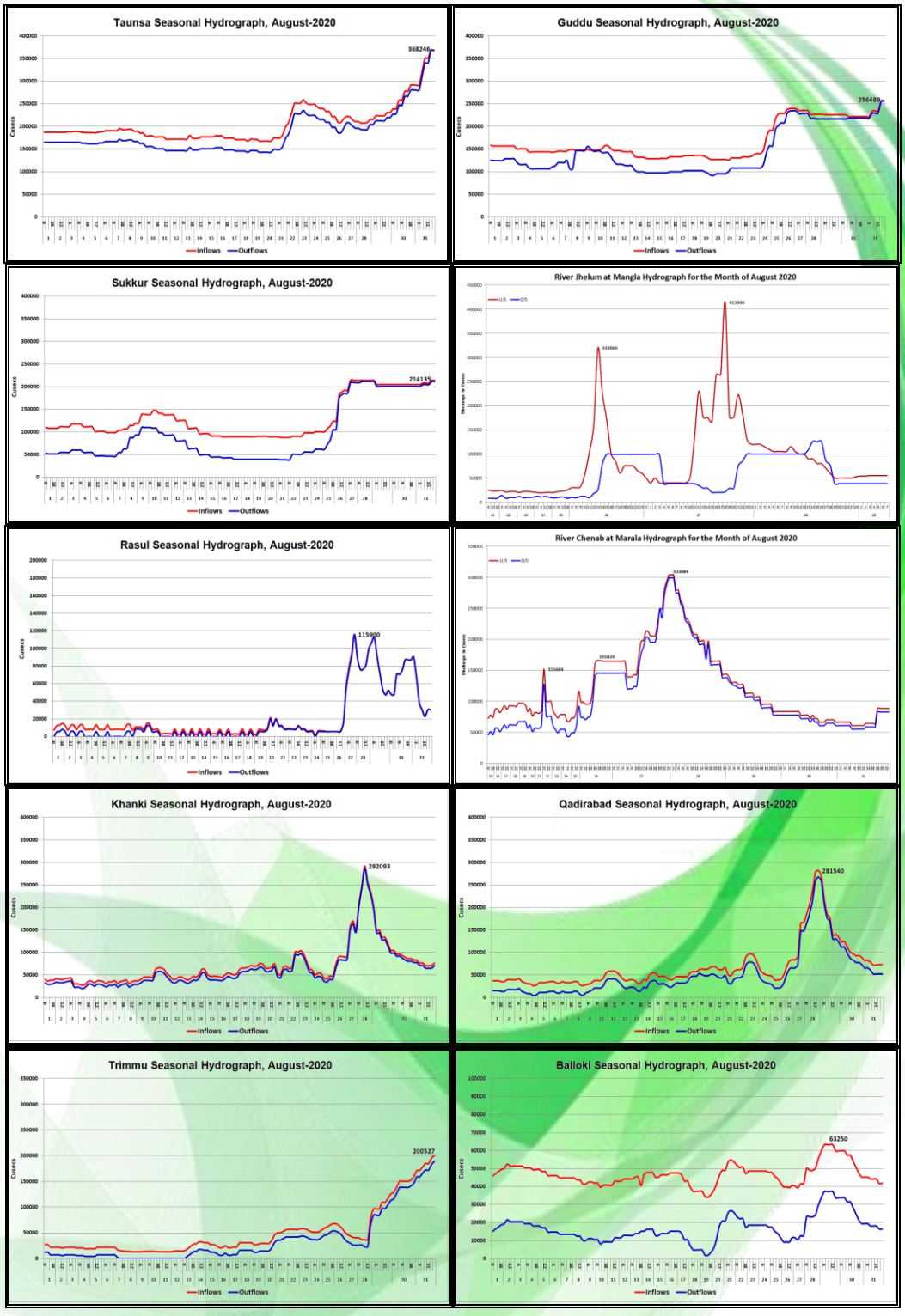


Figure 51: Hydrographs for the month of August-2020.

5 Significant hydro-meteorological events during the month of September 2020

During the month of September, no monsoon low was developed over Bay of Bengal which affects the country, however two wet spells were recorded during the month.

5.1 1st wet spell of September 2020 (31st August to 02nd September)

This spell occurred from 31st to 02nd September 2020. During this event moderate to heavy rainfall was reported from Sargodha and Hazara divisions, light to moderate rain also recorded from scattered places of the country. This situation was created by the presence of a westerly wave over north of Pakistan, interacting with the sufficient moisture available as shown in Figure 52.

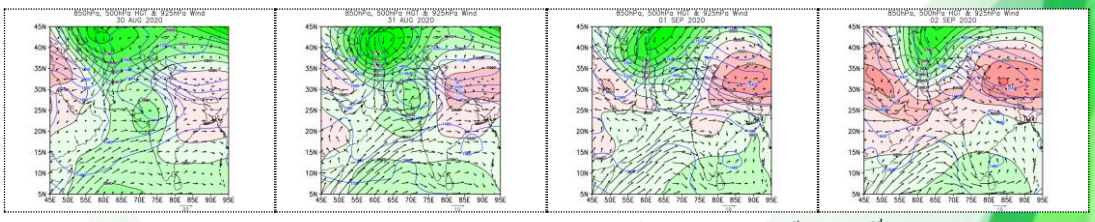


Figure 52: hPa geopotential height & hPa winds map of August 2020 (31st Aug 02nd Sep)

Figure 53 & 54 shows the spatial distribution of significant rainfall round about 200 mm recorded over Mandi Bahauddin & other maxima centre of rainfall more than 40 mm observed around Joharabad, Noorpur thal, Malamjabba, & Oghi along with moderate rainfall at scattered places over the country.

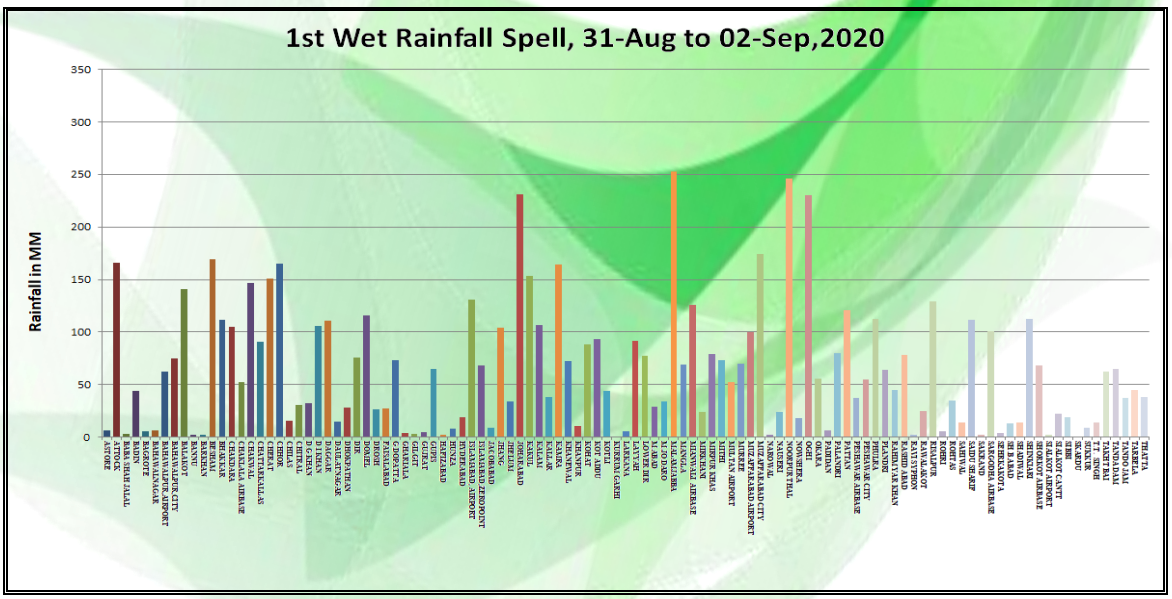


Figure 53: 1st Wet Spell of Rainfall 31st Aug to 02nd Sep 2020.

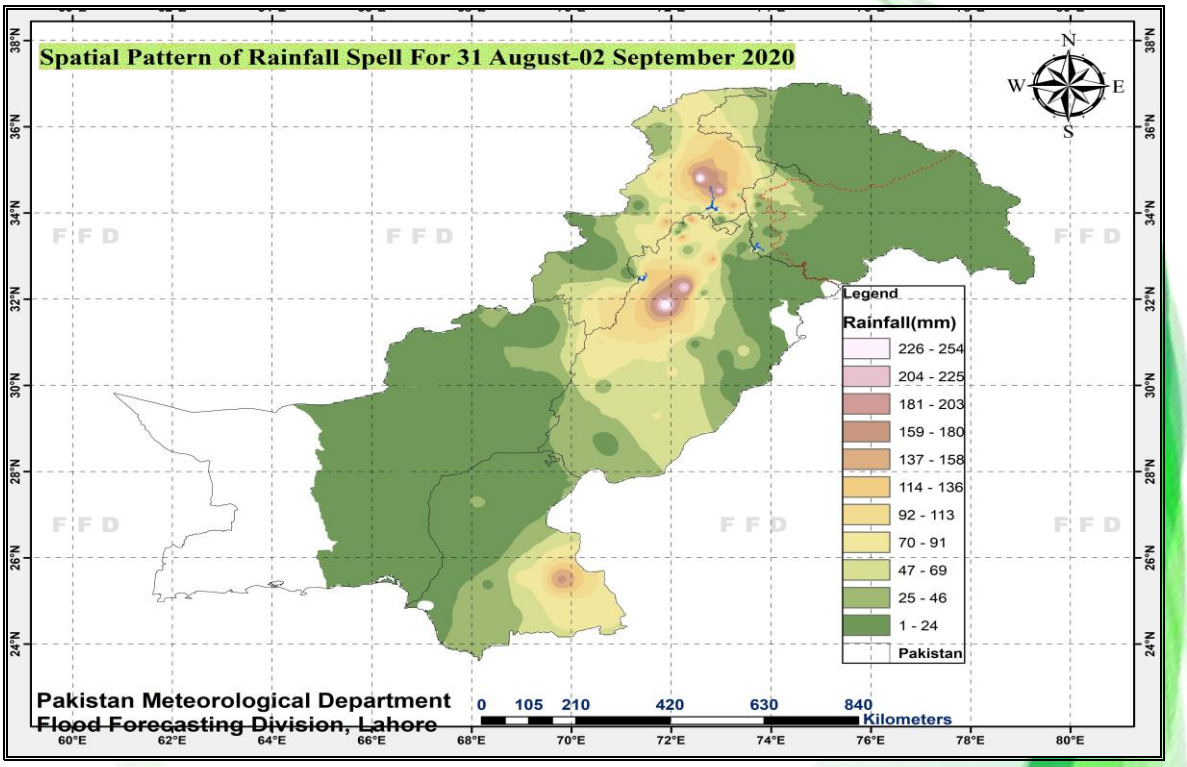
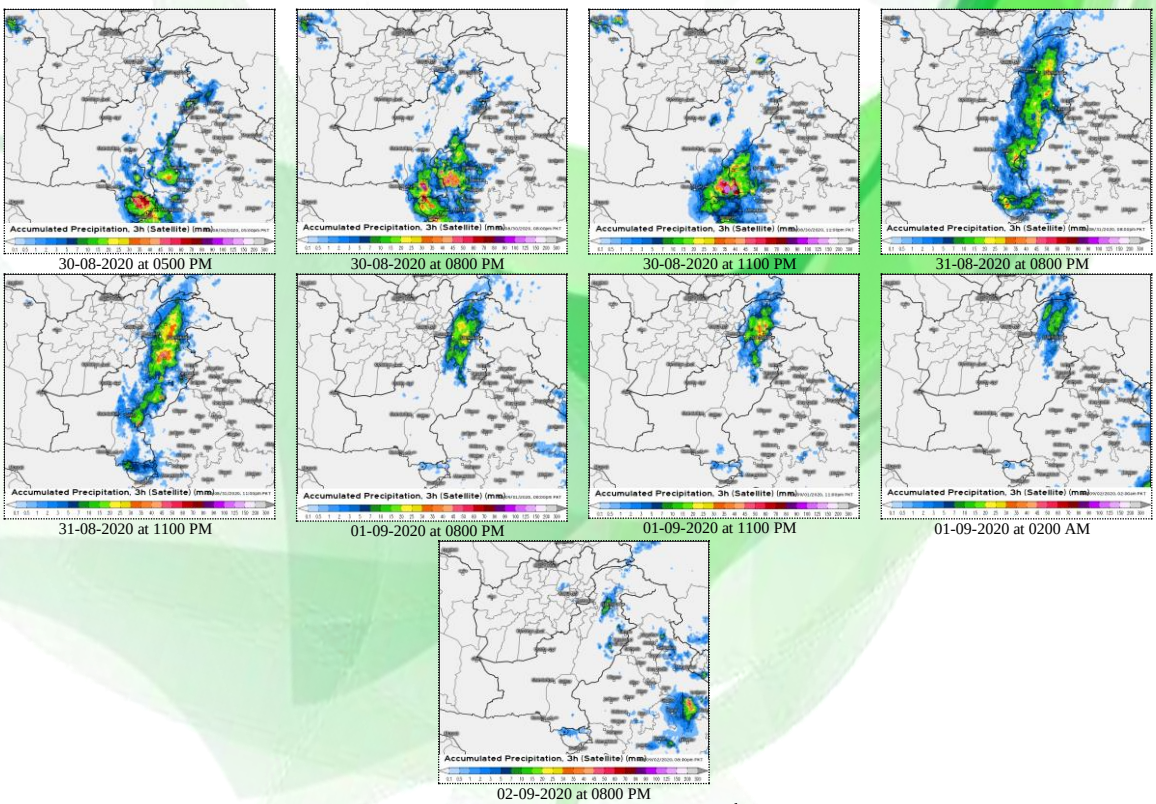


Figure 54: Spatial distribution of significant rainfall of 31st Aug to 02nd Sep-20.

The satellite image in figure 55 shows moderate clouds over North Punjab, Southeast Sindh and Kashmir.



30-08-2020 at 0500 PM | 30-08-2020 at 0800 PM | 30-08-2020 at 1100 PM | 31-08-2020 at 0800 PM

31-08-2020 at 1100 PM | 01-09-2020 at 0800 PM | 01-09-2020 at 1100 PM | 01-09-2020 at 0200 AM

02-09-2020 at 0800 PM

Figure 55: Satellites Images of 31st Aug to 02nd Sep-20

5.2 Rivers position during the first spell of September-2020

Due to Heavy rainfall, the Medium to high level flood was observed as shown in the table 4.

Rivers/Site	Stations	Peaks Inflows	Date	Flood level
Indus	Taunsa	368246	31/08/2020	Low
Indus	Guddu	256489	31/08/2020	Low
Chenab	Trimmu	200527	31/08/2020	Medium
Ravi	Sidhnai	33036	31/08/2020	Low
Chenab	Trimmu	206077	1/9/2020	Medium
Ravi	Sidhnai	32900	1/9/2020	Low
Kabul	Nowshehra	151000	2/9/2020	High
Indus	Tarbela	384000	2/9/2020	Medium

Table 4: Maximum peaks recorded during July 2020.

5.3 2nd wet spell of September 2020 (04th to 05th)

The second rainy spell occurred from 4th to 5th September 2020 was the last spell of the flood season 2020. During this event light to moderate rainfall was reported from Islamabad, Lahore and Bahawalpur Divisions and Muzaffarabad in Kashmir. This situation occurred by the interaction of a westerly wave over the north of Pakistan with the sufficient moisture available as shown in Figure 56.

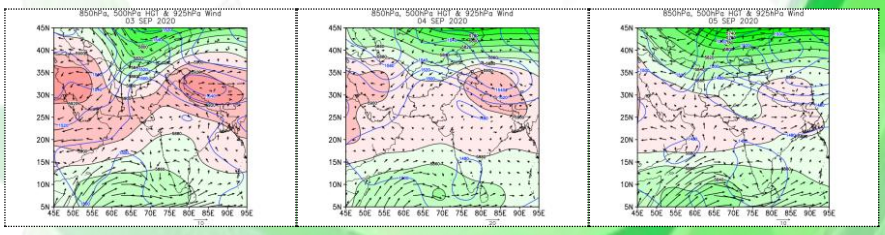


Figure 56: hPa geopotential height & hPa winds map of Sep-2020 (04h-05th)

Figure 57 & 58 shows the spatial distribution of significant rainfall of more than 100 mm recorded over Islamabad & Lahore divisions. Another two maximum of more than 70 mm rainfall was observed over Bahawalpur & Mirpur khas districts.

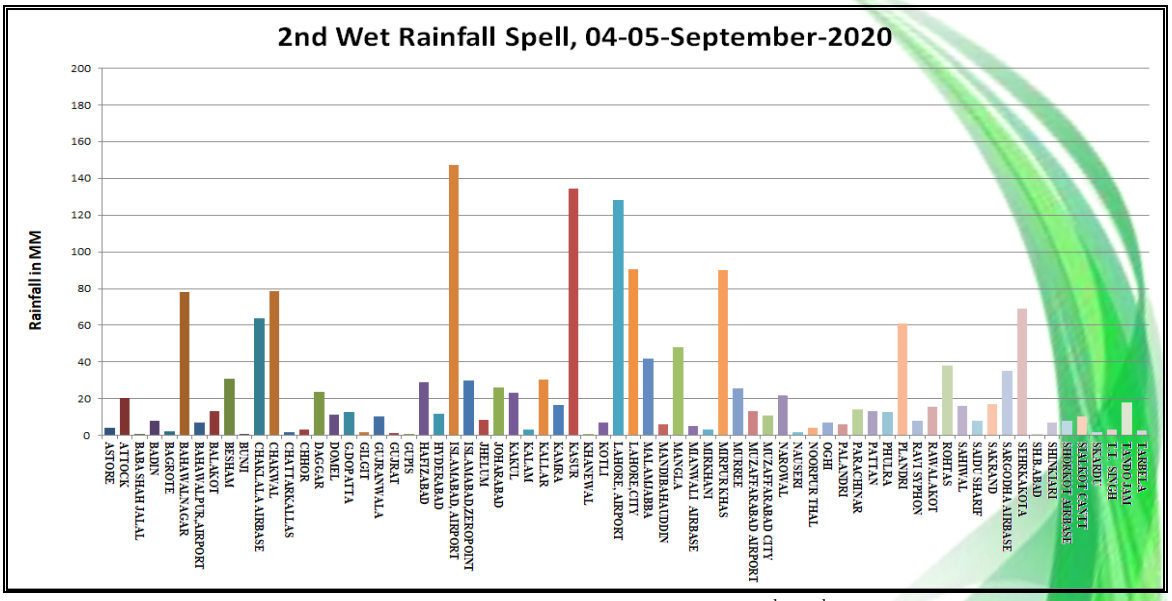


Figure 57: 02nd Wet Spell Rainfall of Sep-2020 (04th-05th)

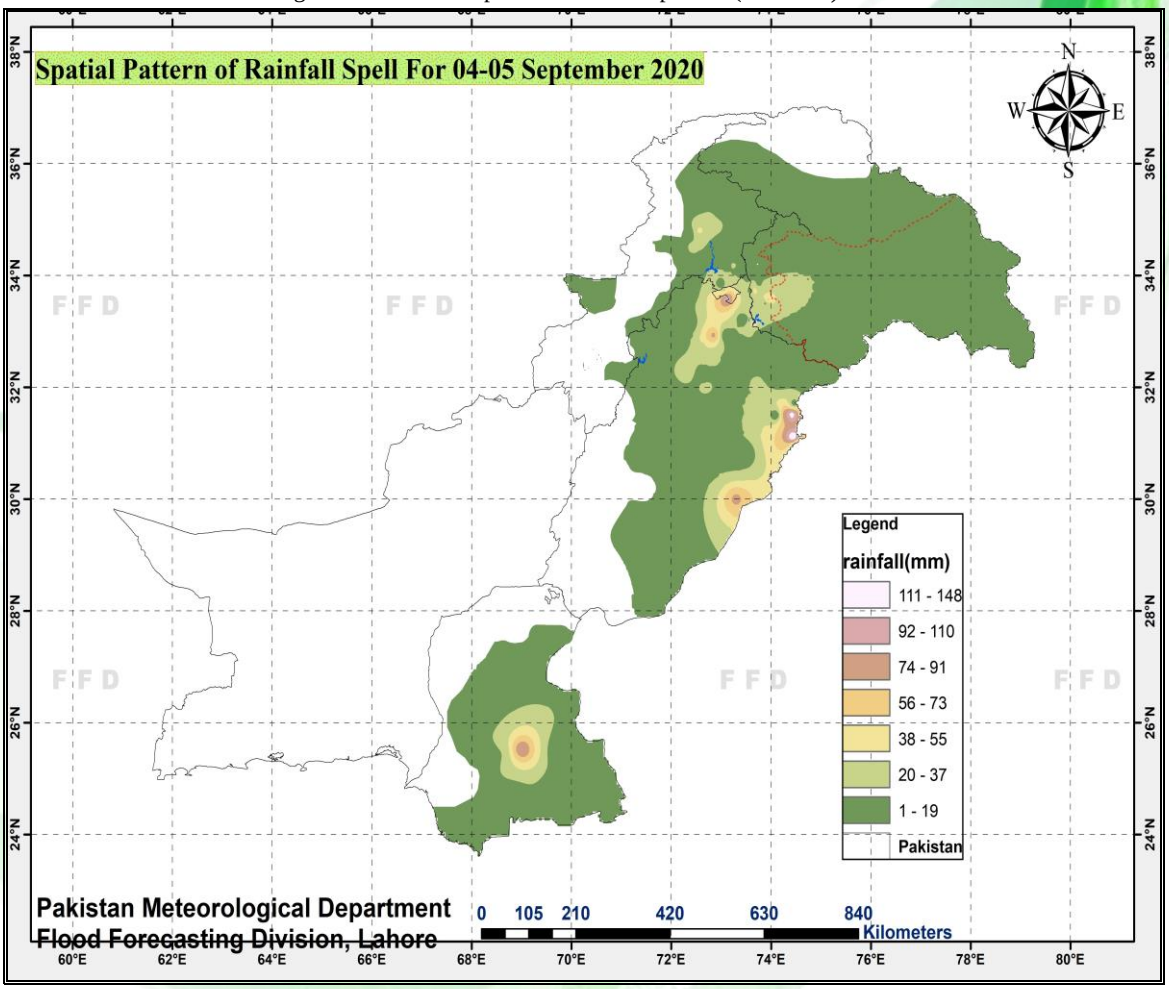


Figure 58: Spatial distribution of significant rainfall map of 04th to 05th September 2020.

Satellite images in figure 59 show moderate clouds over Punjab, Kashmir & Southeast Sindh.

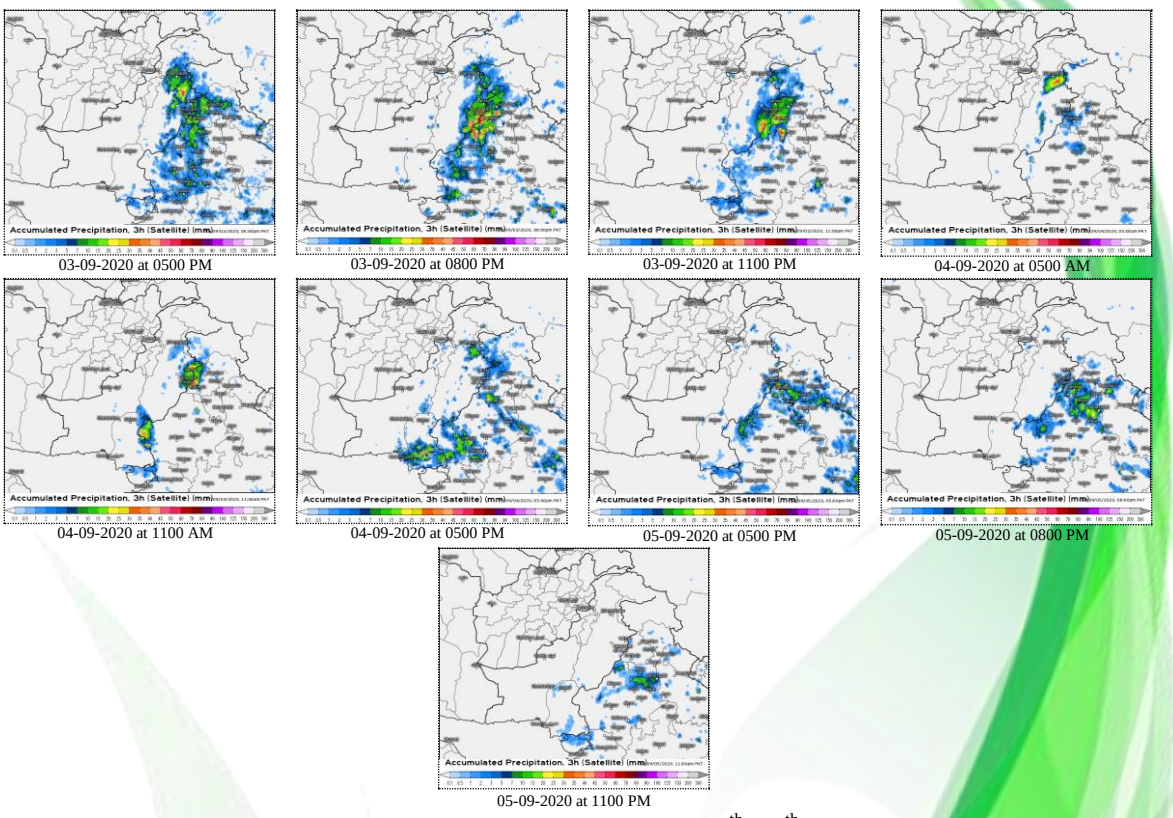


Figure 59: Satellites Images of Sep-2020 (04th -05th)

5.4 Rivers position during the second spell of September-2020

Flood peak observed during the spell in major rivers shown in the table 5.

Rivers/Site	Stations	Peaks Inflows	Date	Flood level
Ravi	Balloki	43450	5/9/2020	Low

Table 5: Maximum peaks recorded during the 02nd Spell of Sep 2020

5.5 Rivers position during the month of September-2020

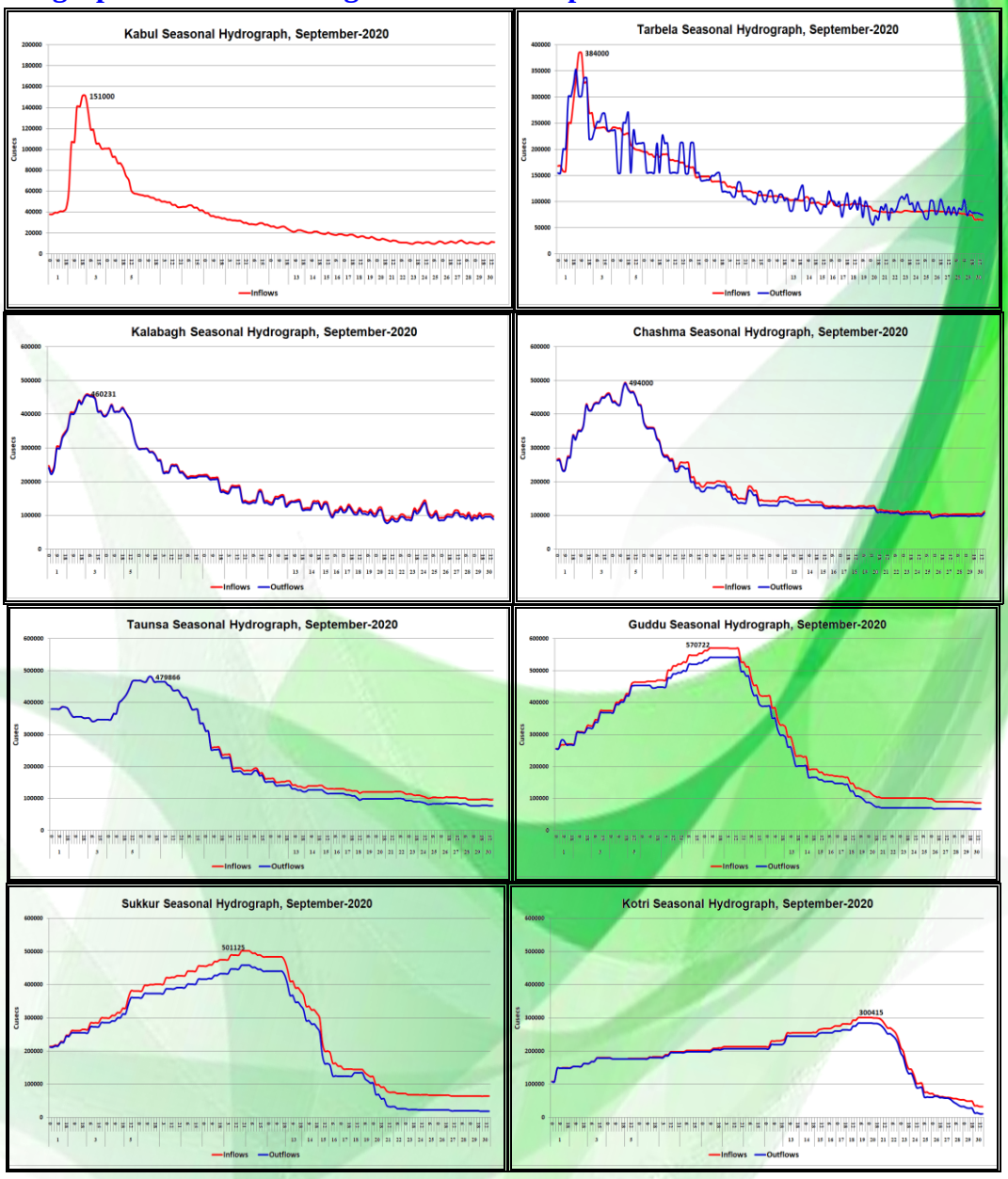
Flood peaks recorded during September 2020 are shown in Table 6

Rivers/Site	Stations	Peaks Inflows	Date	Flood level
Kabul	Nowshehra	151000	2/9/2020	High
Indus	Tarbela	384000	2/9/2020	Medium
Indus	Kalabagh	460231	3/9/2020	Medium
Indus	Chashma	494000	3/9/2020	Medium
Indus	Taunsa	479866	6/9/2020	Medium
Indus	Guddu	570722	9/9/2020	High
Indus	Sukkur	501125	10/9/2020	High
Indus	Kotri	300595	20/09/2020	Medium
Jhelum	Mangla	115000	7/9/2020	Medium

Jhelum	Rasul	83100	3/9/2020	Low
Chenab	Trimmu	206077	1/9/2020	Medium
Ravi	Balloki	43450	5/9/2020	Low
Ravi	Sidhnai	32900	1/9/2020	Low
Sutlej	GS Wala	1014	7/9/2020	

Table 6: Maximum peaks recorded during September 2020

5.6 Hydrographs recorded during the month of September 2020 are as below



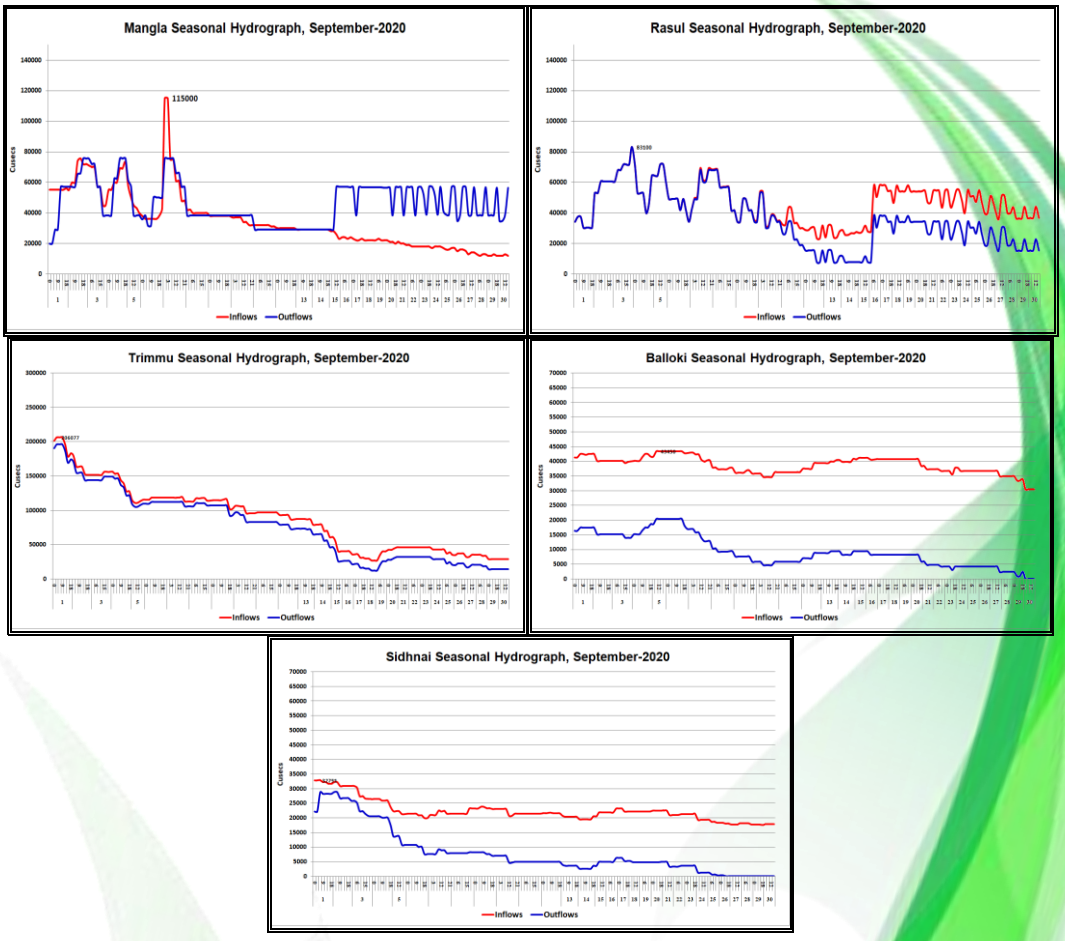


Figure 60: Hydrographs for the month of September-2020.

5.7 Spatial distribution of rainfall during the month of September 2020

The precipitation during the month of August is shown in figure 61 & 62, it indicates monsoon activity remained over North & Northeast Punjab and Kashmir along with Southeast Sindh. One center of maximum rainfall exceeding 225 mm is located at Indian Gujarat while more than 120 mm recorded at Mithi in Southeast Sindh. More than 210 mm of rainfall was also observed at Islamabad. While maxima of above 100 mm are located around Kashmir & Northeast Punjab. West Balochistan remained dry during the month.

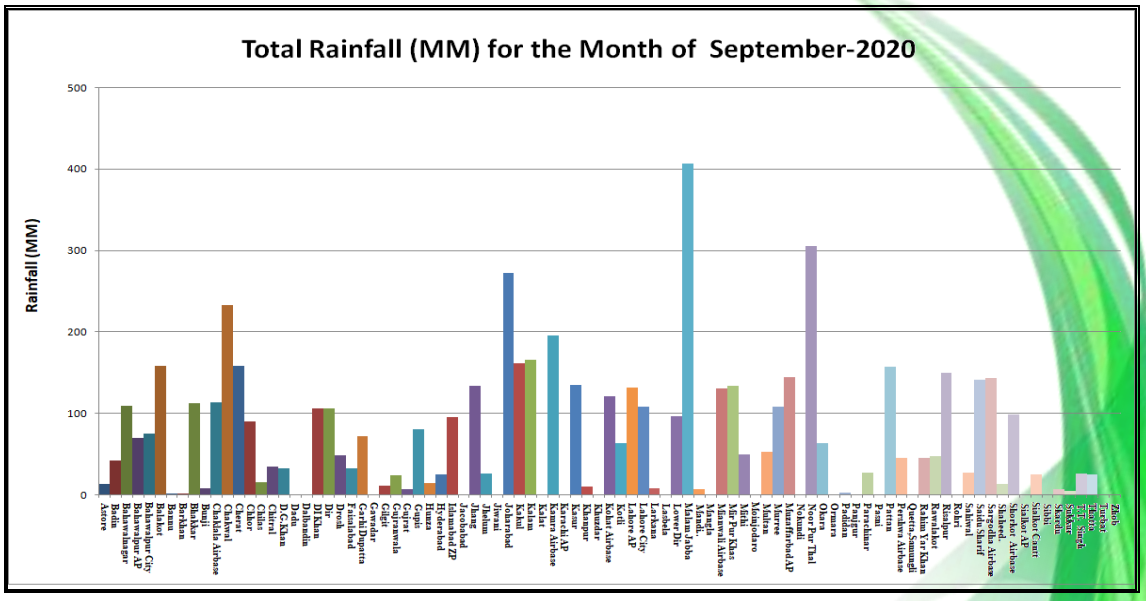


Figure 61: Total Rainfall for the month of September 2020.

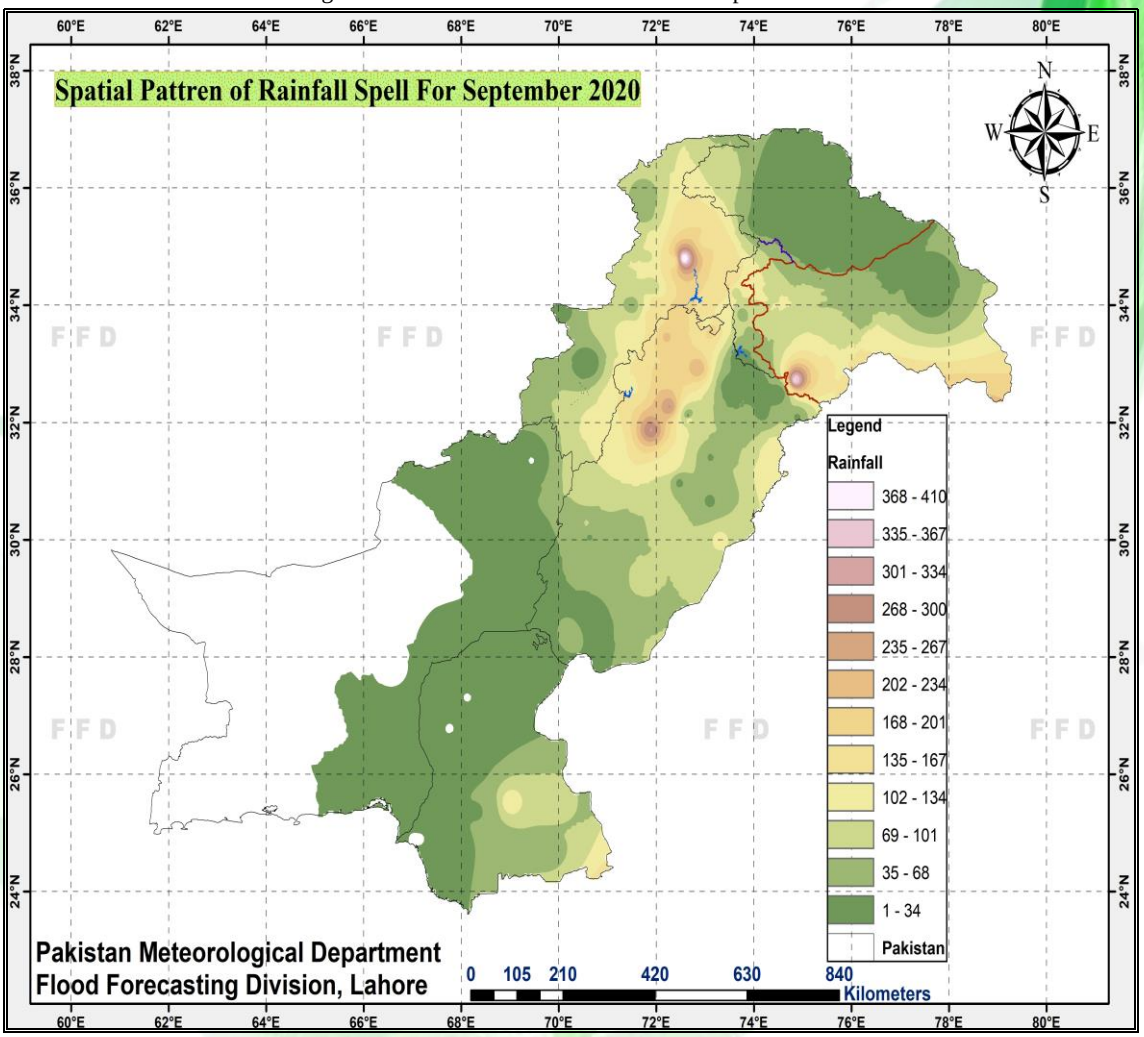


Figure 62: Spatial distribution of significant rainfall of September 2020.

5.8 Percentage Anomaly during the month of September 2020

Percentage Anomaly map for the month of September 2020 indicates that Sindh received above normal Rainfall. Significantly above Normal rainfall received in south Punjab .Below normal rainfall recorded in Kashmir .Percentage Anomaly map of August 2020 is shown in Figure 63 & 64.

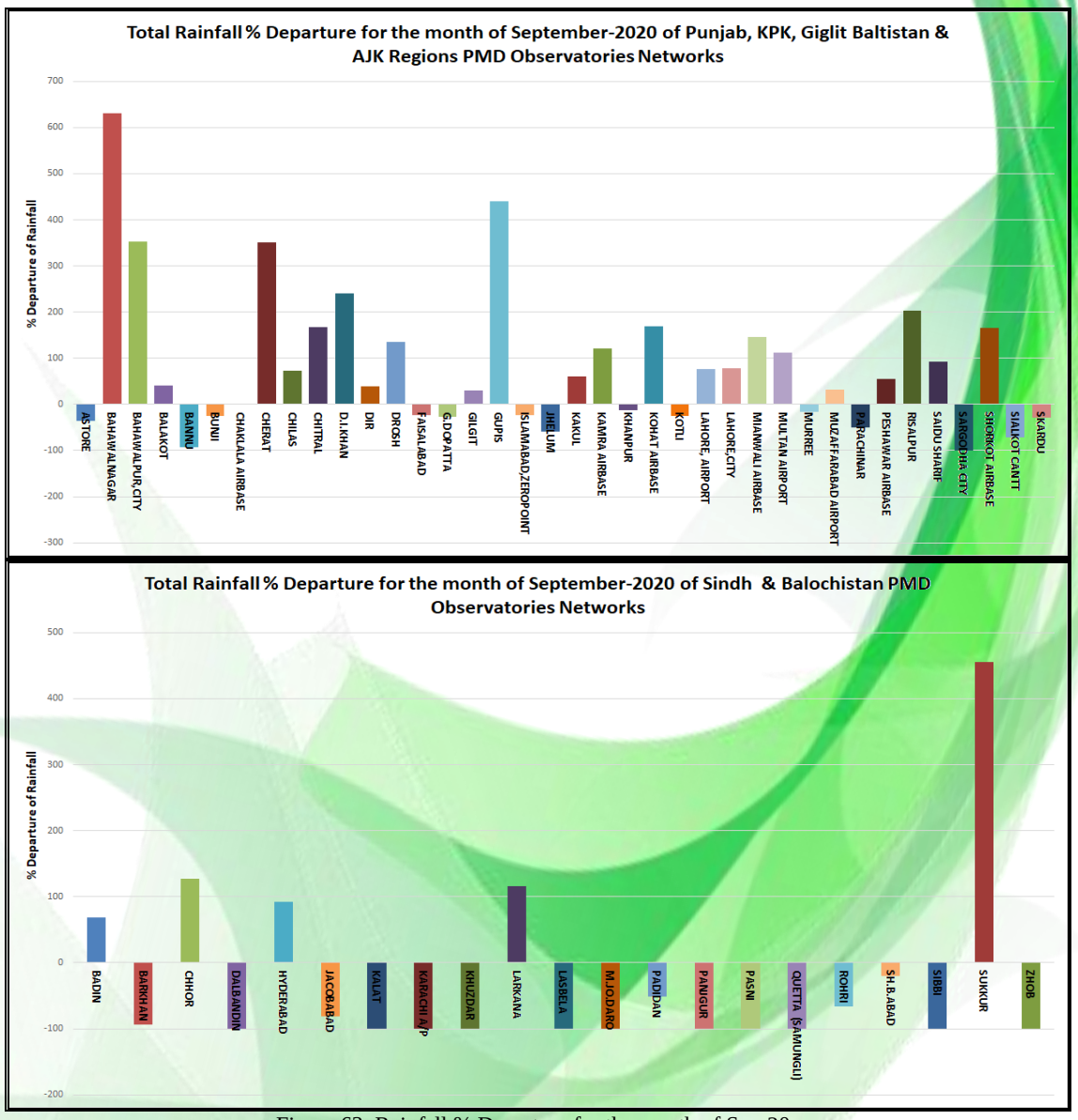


Figure 63: Rainfall % Departure for the month of Sep-20.

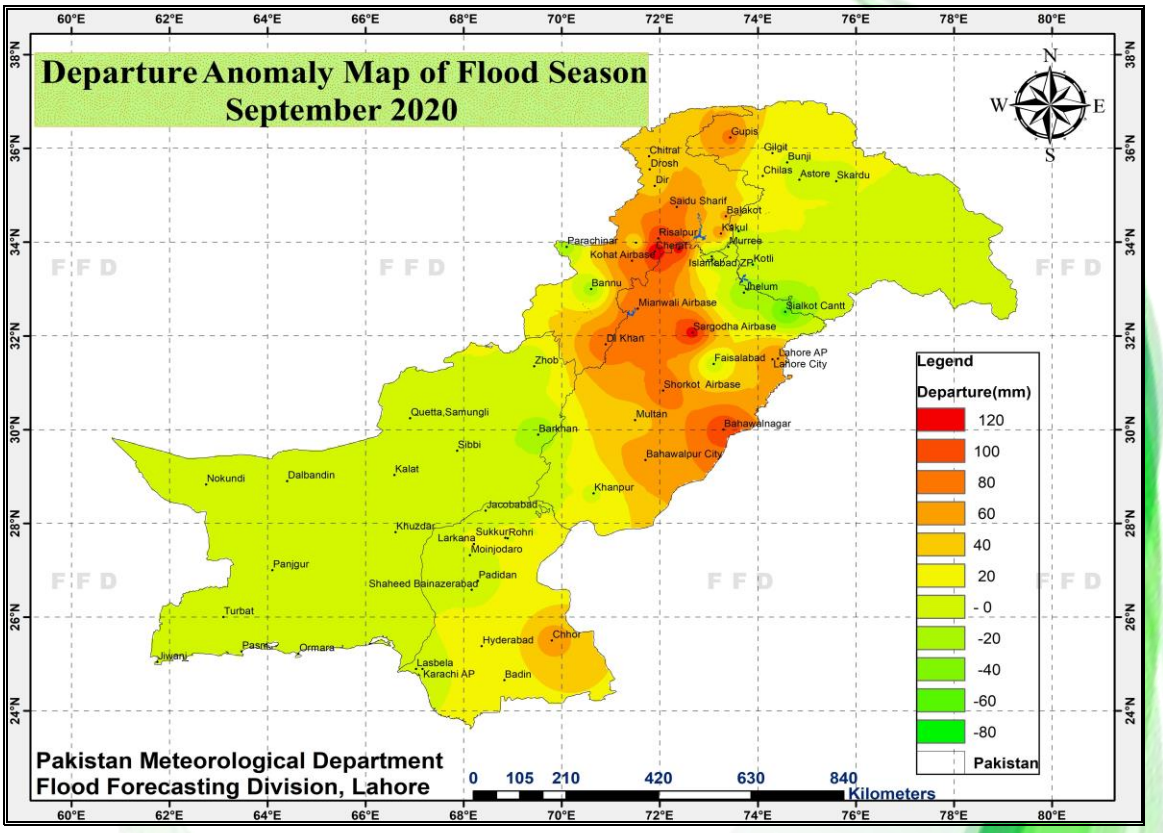


Figure 64: Departure Anomaly rainfall map of September 2020.

5.9 Temporal Distribution during the month of September 2020

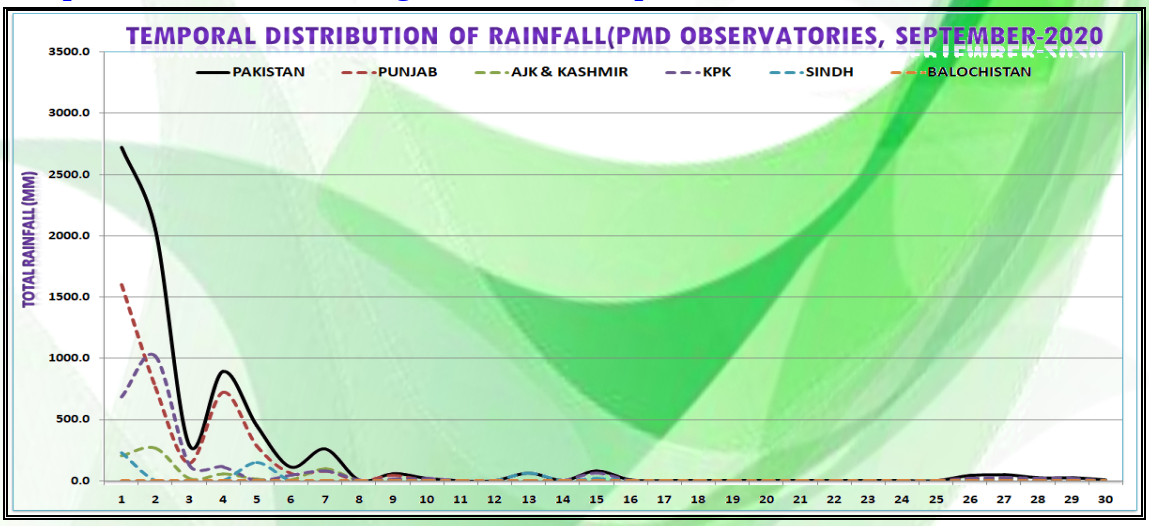


Figure 65: Temporal distribution of rainfall during September 2020.

6 Seasonal rainfall pattern July to September 2020

Seasonal rainfall distribution during the season is shown in figure 66 & 67. Region of maximum precipitation (more than 800 mm) is located over Balakot and Malamjabba in Khyber Pakhtunkhwa. Another center of extreme rainfall of more than 700 mm is

located over Islamabad, Kotli (Kashmir) and Sialkot. Mirpur khas and Mithi in Sindh received more than 500 mm during the season. Lowest Rainfall recorded over northwest Balochistan during flood season.

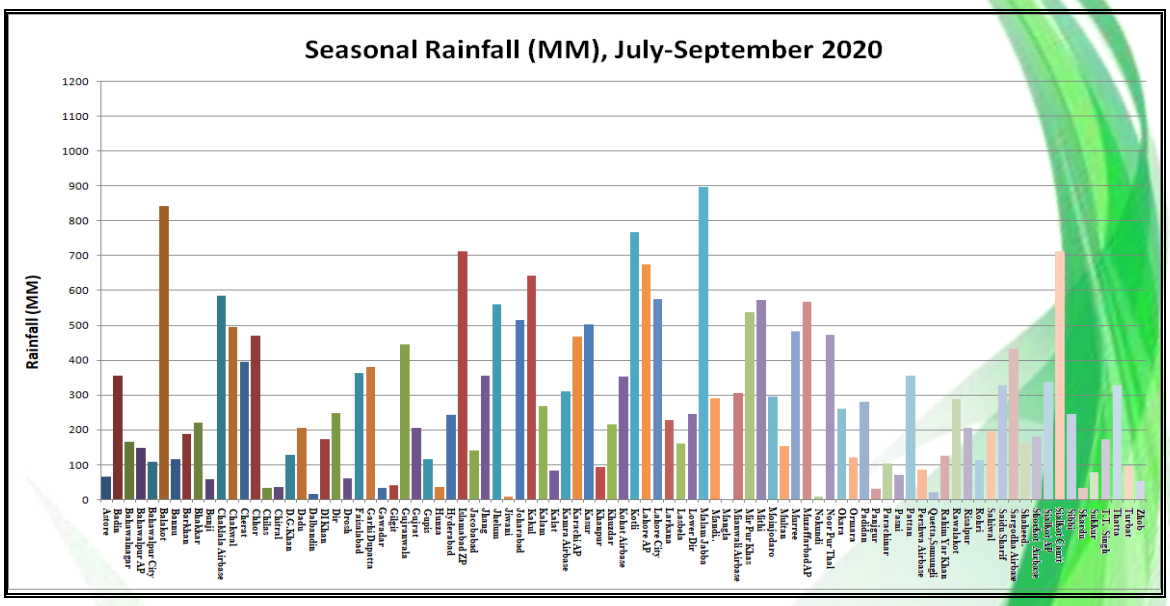


Figure 66: Seasonal total Rainfall July- September 2020.

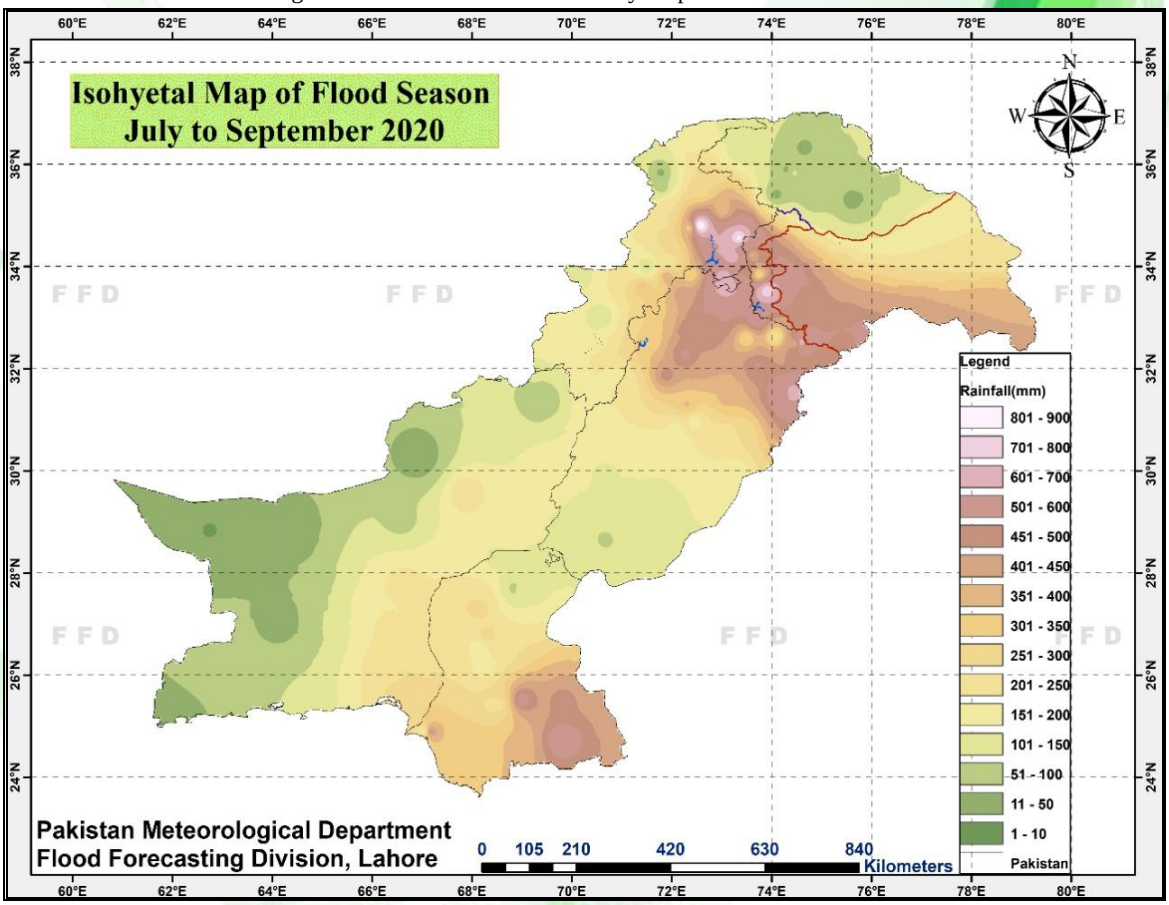


Figure 67: Spatial distribution of significant rainfall map of July-Sep-20.

6.1 Percentage Anomaly during the Season July-September 2020

Percentage Anomaly map for the months of July-September 2020 indicates that Sindh, and Balochistan(Except Northeast Balochistan), Lahore & Sargodha divisions received above normal Rainfall while parts of Khyber Pakhtunkhwa, Gilgit Baltistan & Kashmir received below normal rainfall. Percentage Anomaly map of July-September 2020 is shown in Figure 68 & 69.

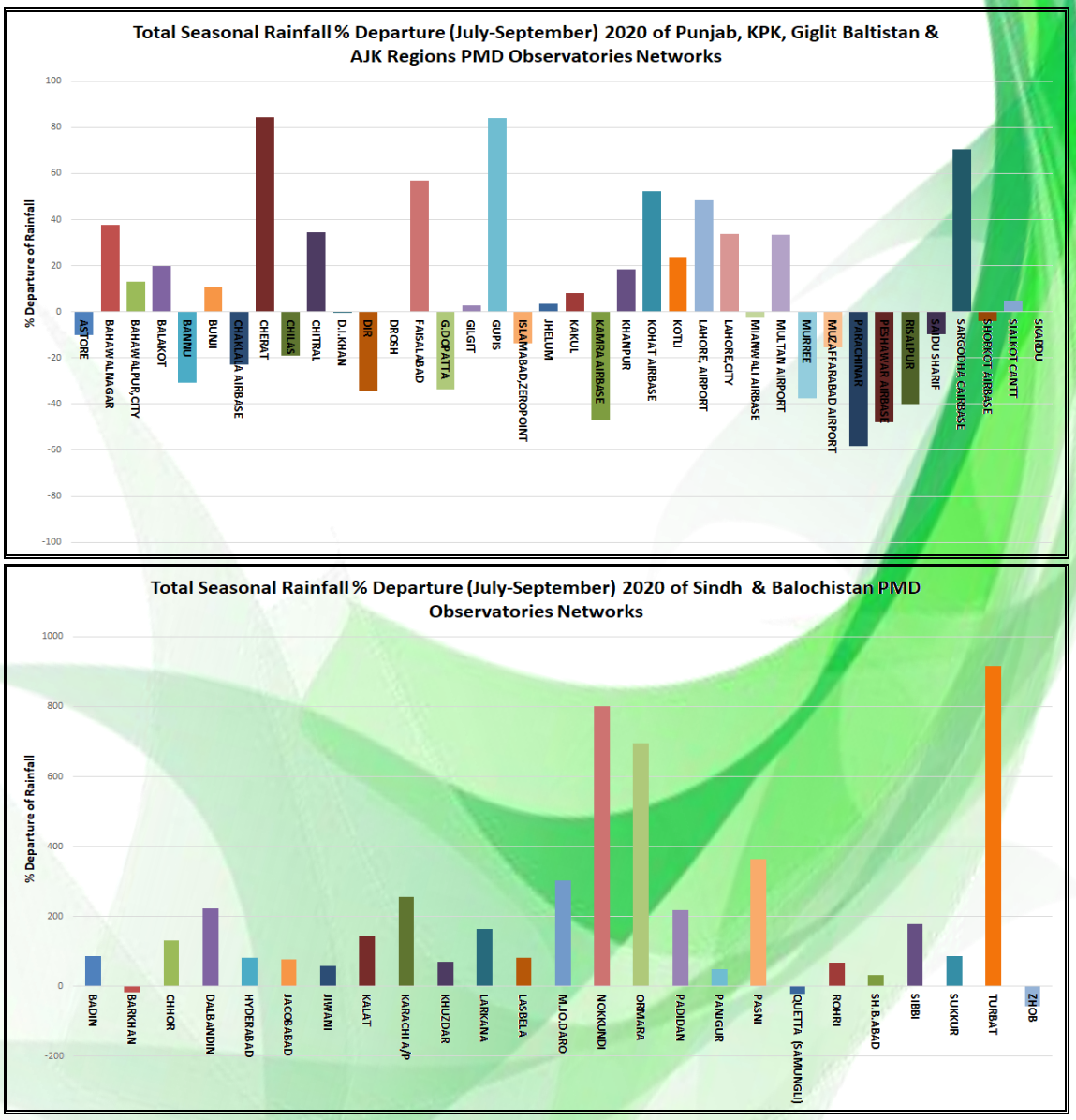


Figure 68: Seasonal Rainfall % departure for July- Sep-20

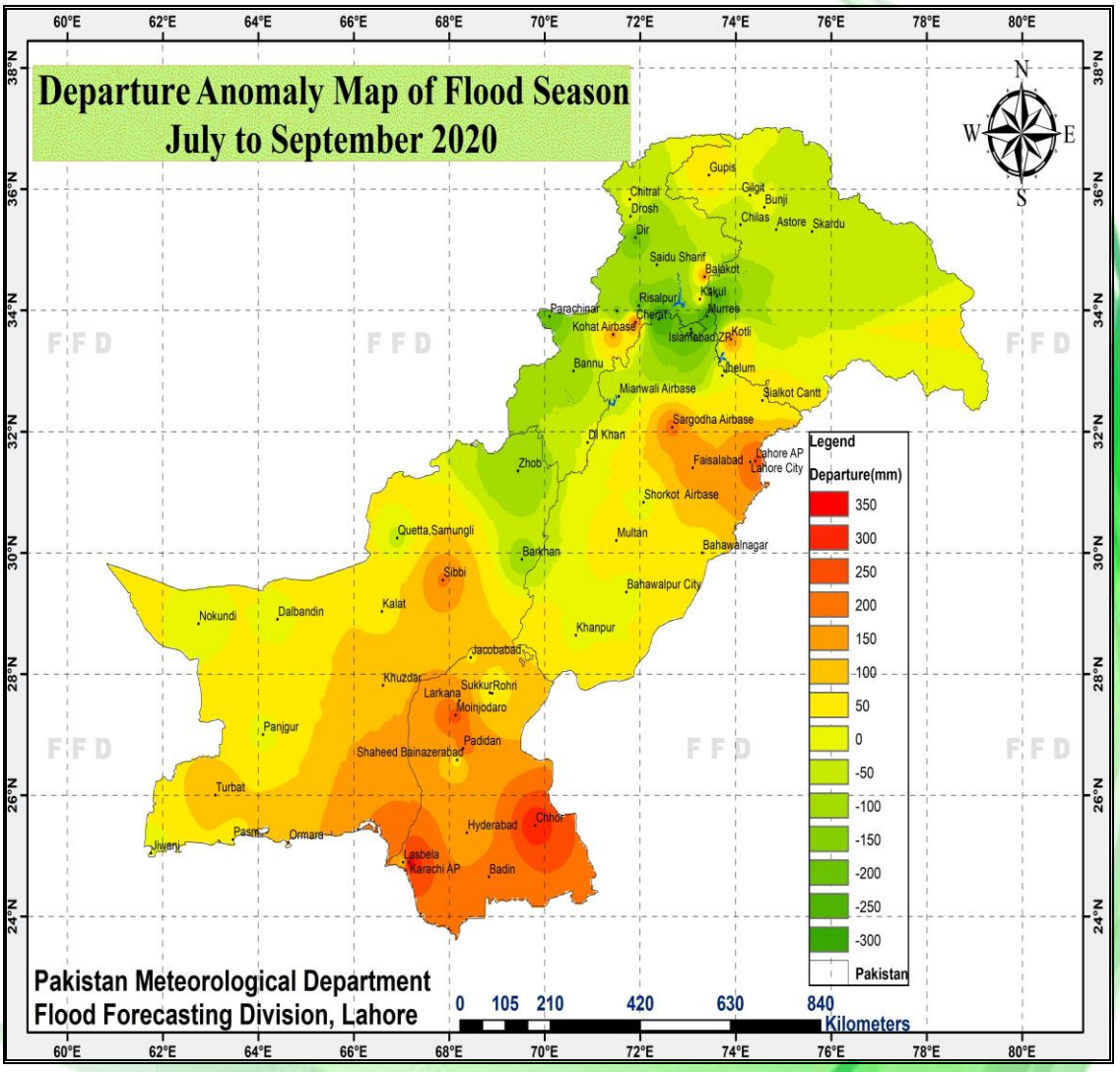


Figure 69: Departure Anomaly rainfall map for Season July-Sep-20.

7 Seasonal area weighted precipitation from July-September 2020.

- During the monsoon season (1-Jul to 30-Sep) 2020, country recorded 41% above normal rainfall. On regional scale; GB, Balochistan, Sindh & Punjab recorded above normal rainfall whereas KP & AJK recorded close and below to normal rainfall respectively.
- In September, country (+89) as well as provinces except Balochistan recorded more than average rainfall.
- In the month of August 2020, country recorded 112% above normal rainfall.

All the provinces recorded above normal rainfall but Balochistan, Sindh & GB recorded exceptionally high rainfall in the month.

- In July 2020, Pakistan as whole, recorded 34% below normal rainfall. On regional scale, all provinces except GB recorded below average rainfall.

  On provincial scale, above-normal rainfall was observed over Sindh, Punjab & normal over Kashmir, Balochistan & Khyber Pakhtunkhwa map as shown in figures 70.

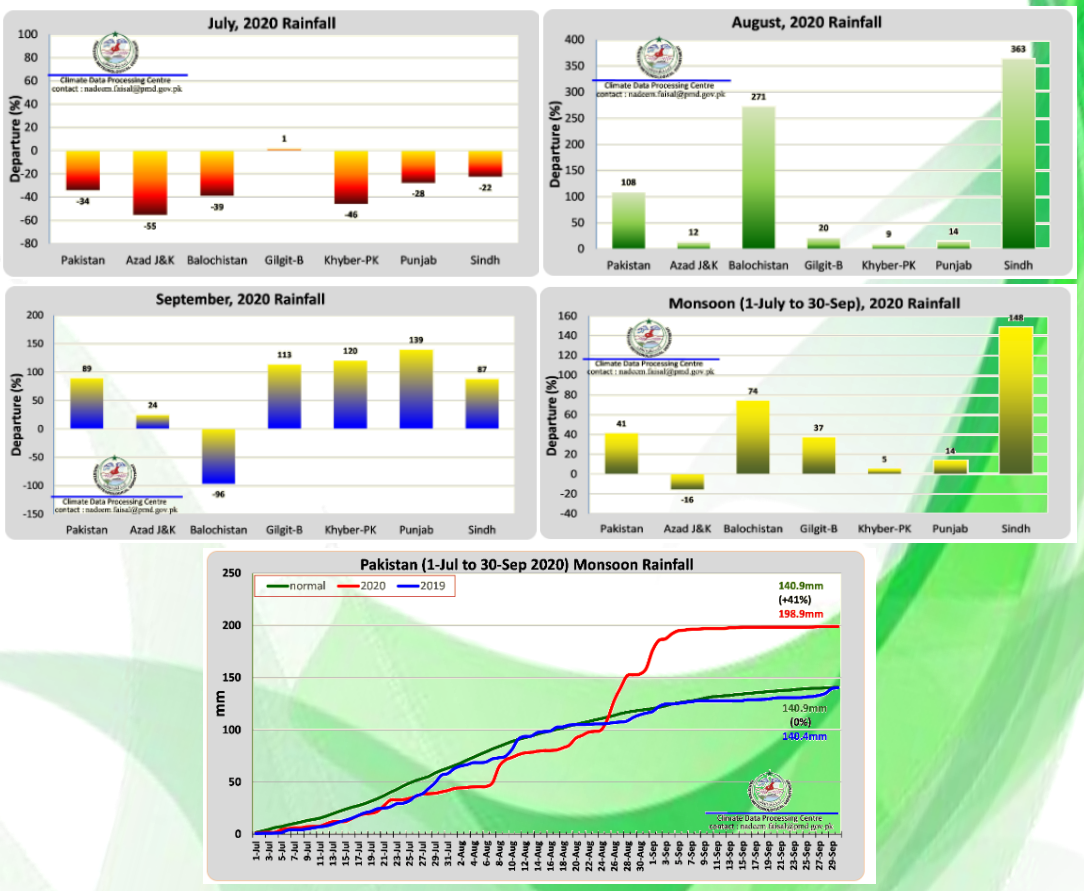


Figure 70: Monsoon July-Sept (JAS) 2020 rainfall.

Source: CDPC Karachi

8 Kharif & Rabi Seasons forecast

The water availability (MAF) forecast & observed for Kharif season was issued on 01st April 2020 for Tarbela at River Indus & for Mangla at River Jhelum. A comparison of forecasted and observed volume (MAF) is shown in fig 71.

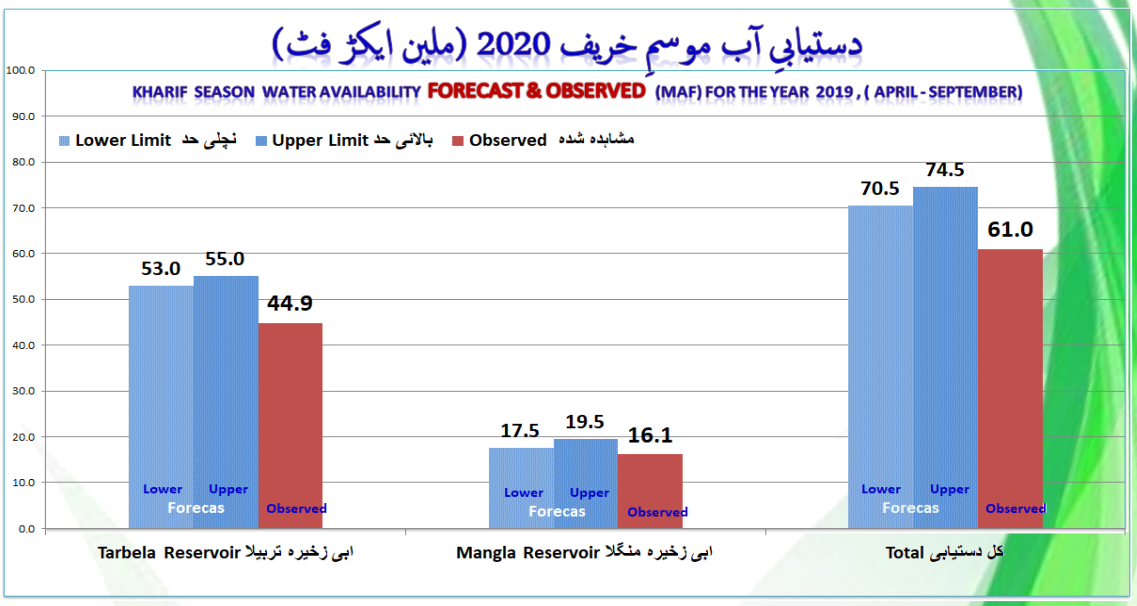


Figure 71: Kharif Season forecast & Observed MAF (April-Sep-20).

Similarly the water availability (MAF) forecast for Rabi season was issued on 04th September 2020 for Tarbela at River Indus & for Mangla at River Jhelum. A comparison of forecasted and observed volume (MAF) is shown in fig 72.

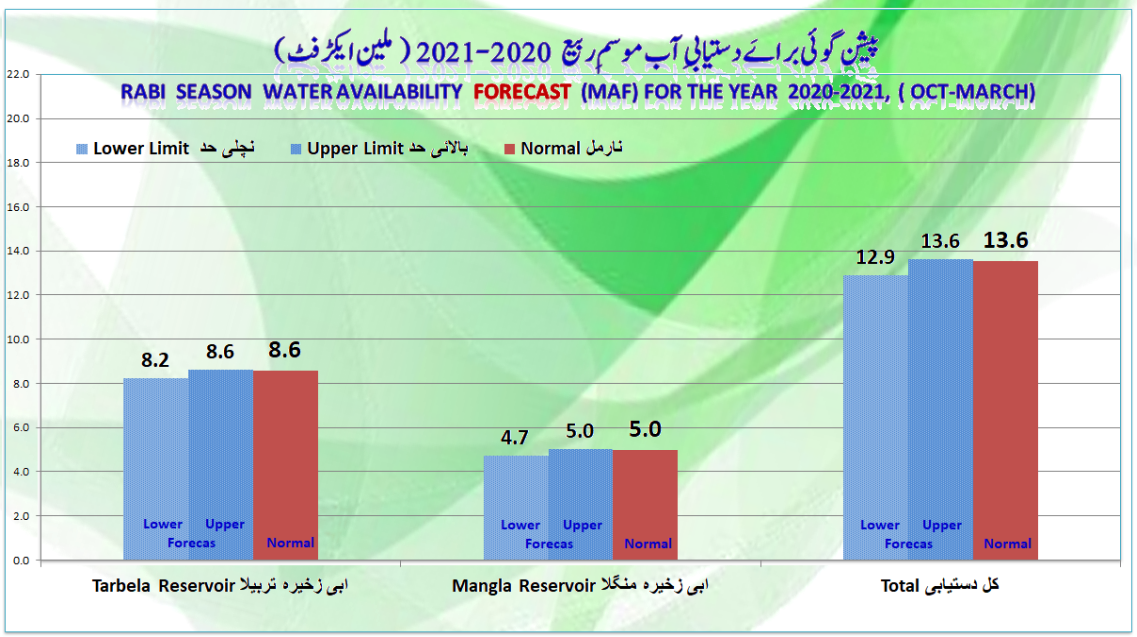


Figure 72: Kharif Season forecast & Observed MAF (April-Sep-20).

9 Flood forecast evaluation report

The Flood Forecast evaluation report for 2020 for all categories of floods is given in table 7.

Rivers	Stations	Forecast		Observed	
		Forecasted (U/S) Flood Level	Date	Observed (U/S) Flood Level	Date
Kabul	Nowshera	Low	24-06-2020	Low	24-06-2020
Indus	Tarbela	Low	28-08-2020	Low	28-08-2020
Indus	Kalabagh	Low	28-08-2020	Low	29-08-2020
Indus	Chashma	Low	29-08-2020	Low	29-08-2020
Indus	Taunsa	Low	31-08-2020	Low	31-08-2020
Indus	Guddu	Low	31-08-2020	Low	31-08-2020
Indus	Sukkur	Low	26-08-2020	Low	27-08-2020
Jhelum	Mangla	Ex. High (Cat-I Warning)	26-08-2020	Ex.High	27-08-2020
Jhelum	Rasul	Low	25-08-2020	Medium	28-08-2020
Chenab	Marala	High (Warning)	26-08-2020	High	28-08-2020
Chenab	Khanki	High (Warning)	26-08-2020	High	28-08-2020
Chenab	Qadirabad	High (Warning)	26-08-2020	High	28-08-2020
Chenab	Trimmu	Medium	31-08-2020	Medium	31-08-2020
Kabul	Nowshera	High	31-08-2020	High	02-09-2020
Indus	Tarbela	Medium (Warning)	01-09-2020	Medium	02-09-2020
Indus	Kalabagh	Medium	02-09-2020	Medium	03-09-2020
Indus	Chashma	Medium	02-09-2020	Medium	03-09-2020
Indus	Taunsa	Medium	05-09-2020	Medium	06-09-2020
Indus	Guddu	High (Warning)	04-09-2020	High	09-09-2020
Indus	Sukkur	High (Warning)	04-09-2020	High	10-09-2020
Indus	Kotri	Medium	19-09-2020	Medium	20-09-2020
Jhelum	Mangla	Medium(info FMC through Phone)	07-09-2020	Medium	07-09-2020

Table 7: Flood forecast evaluation table

10 Achievements

1. Flood forecasting division Lahore predicted the category-I flood situation well in advance in river Jhelum upstream Mangla which was quite helpful for the dam authorities to manage flood wave properly in river Jhelum. Mangla Authorities thanked with the remarks that we are highly thankful for FFD support and guidance. Your kind self office initial assessment of regulated Category-1 Flood was very right well before time of occurrence. Your office's initial assessment was a peak of 440000 cusecs which was quite accurate.
2. Accurate predictions (warnings & significant forecasts) of Flood wave in river Indus and Chenab and their synchronization at Guddu and Sukkur.
3. DG PDMA apprised the PMD website, as the best in the region.
4. Mangla additional Chief Engineer cordially appreciate and feelings obliged for cooperation/prompt response of FFD for providing early category –wise flood Forecast for Mangla before flood season
5. Time Lags basis on 1960-1990 revised by FFD Lahore on the basis of data 1990-2020.

11 Flow chart of daily routine work at FFD Lahore

The website (http://ffd.pmd.gov.pk/cp/ffd.php is maintained by FFD Lahore and is updated regularly. This is a source of real-time information to all the stakeholders, concerned authorities, organizations and individuals.

FFD work flow chart

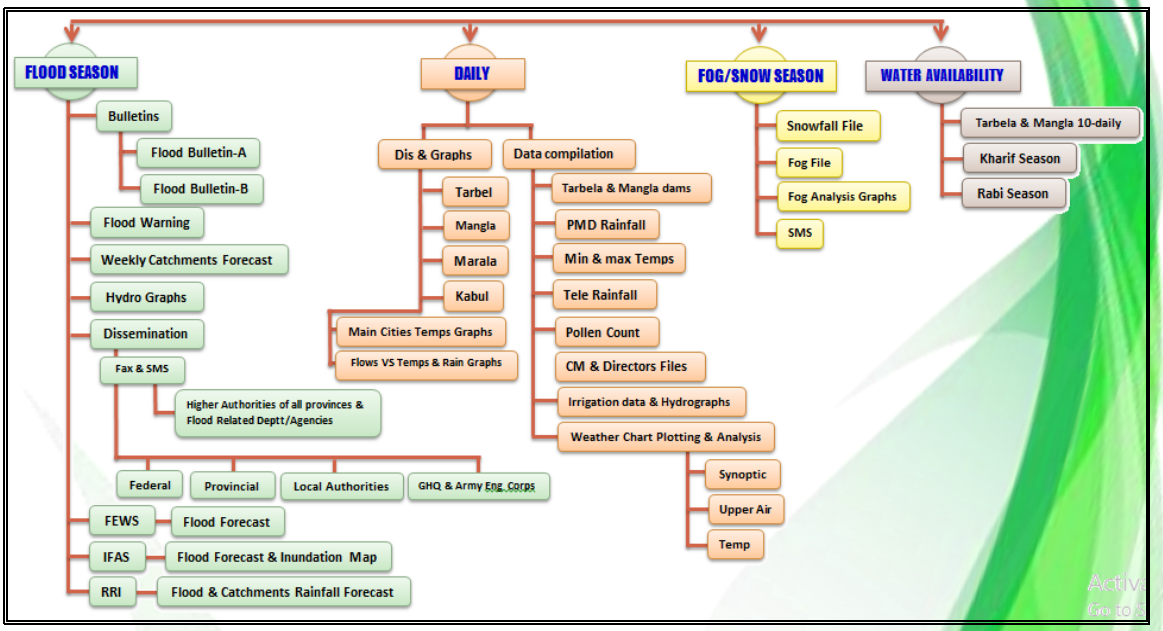


Figure 73: FFD Lahore work flow chart.

Sr#	Work	Time Interval
1	Flood Bulletins A & B	Updated daily
2	Weekly Catchment Forecast	Updated daily
3	Flood Warning	When required
4	Inundation Map	When required
5	FEWS Model Forecast	Twice a day & when required
6	IFAS Model Forecast	Updated daily & when required
7	RRI Model Forecast	Updated daily & when required
8	Hydrographs	Hourly & six-hourly basis
9	Discharge file (Tarbela & Mangla Dams)	Updated daily
10	Discharges Graphs (Tarbela, Mangla, Marala & Kabul)	Updated daily
11	Flows VS Temps & Rain Graphs	Updated daily
12	PMD Rainfall data	Updated daily
13	Temperatures data	Updated daily
14	Main Cities Temperature Graphs	Updated daily
15	WAPDA Telemetric Rainfall	Updated daily
16	MAF Forecast (Tarbela & Mangla Dams)	10-day basis
17	Kharif MAF Forecast (Tarbela & Mangla Dams)	Six monthly basis
18	Rabi MAF Forecast (Tarbela & Mangla Dams)	Six monthly basis
19	Pollen Count for Lahore City	Updated daily
20	Fax	Daily & when required
21	SMS	Hourly & six hourly basis & when required

12 Flood Forecast Dissemination

Dissemination of flood forecasts and warnings is an important part of flood mitigation. Flood information is communicated on daily basis by using different modes of communication i.e phone, fax and cellular networks. Electronic versions of daily flood forecasts are also available to different agencies and organizations. This is also made a part of FFD web page. To ensure that flood forecast is disseminated to the right person at the right time, contact numbers are also collected and verified during pre-flood season.

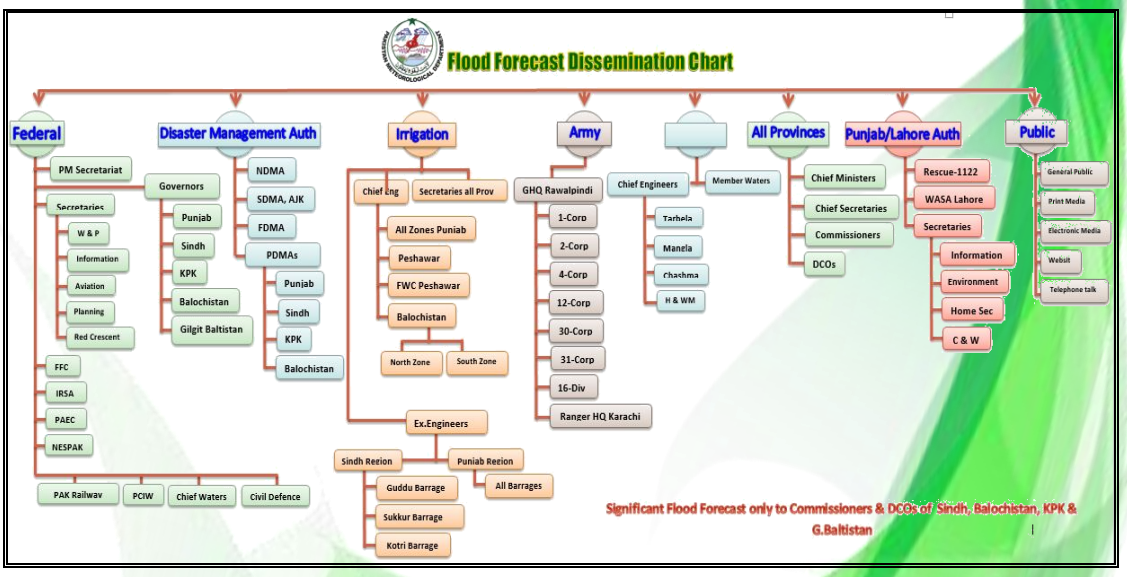


Figure 74: Flood report dissemination chart

13 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. The chart of internee students during 2020 is shown in table 8.

More detail for internees can be followed on this link:

University/College		Students
	Punjab University Lahore	02
	Lahore College for Women University, Lahore	40
	University of Agricultural, Faisalabad	08
	University of Veterinary &Animal Sciences, Lahore	01
	Govt College University Lahore	09
	Govt College University Faisalabad	01
	Aspire College Lahore	02
	The Superior College Lahore	04

Table 8: List of internees

14 Monsoon Season 2020 Damages/Losses

No of Deaths, Injured Persons and Houses Damaged during the Flood 2020 are shown in table 9.

Provinces / Regions	Deaths				Injured			
	M	F	C	T	M	F	C	T
ICT	*	*	*	*	*	*	*	*
Balochistan	7	3	11	21	14	1	2	17
Khyber Pakhtunkhwa	37	24	55	116	52	22	27	101
Punjab	104	*	*	104	175	*	*	175
Sindh	80	33	32	145	94	1	1	96
AJ & K	2	2	8	12	4	5	*	9
Gilgit Baltistan	5	*	6	11	4	*	*	4
Total	235	62	112	409	343	29	30	402

Table 9: Flood forecast evaluation table

.

Source: NDMA Islamabad

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 10: Flood limits

16 Flood Routing Time Lag

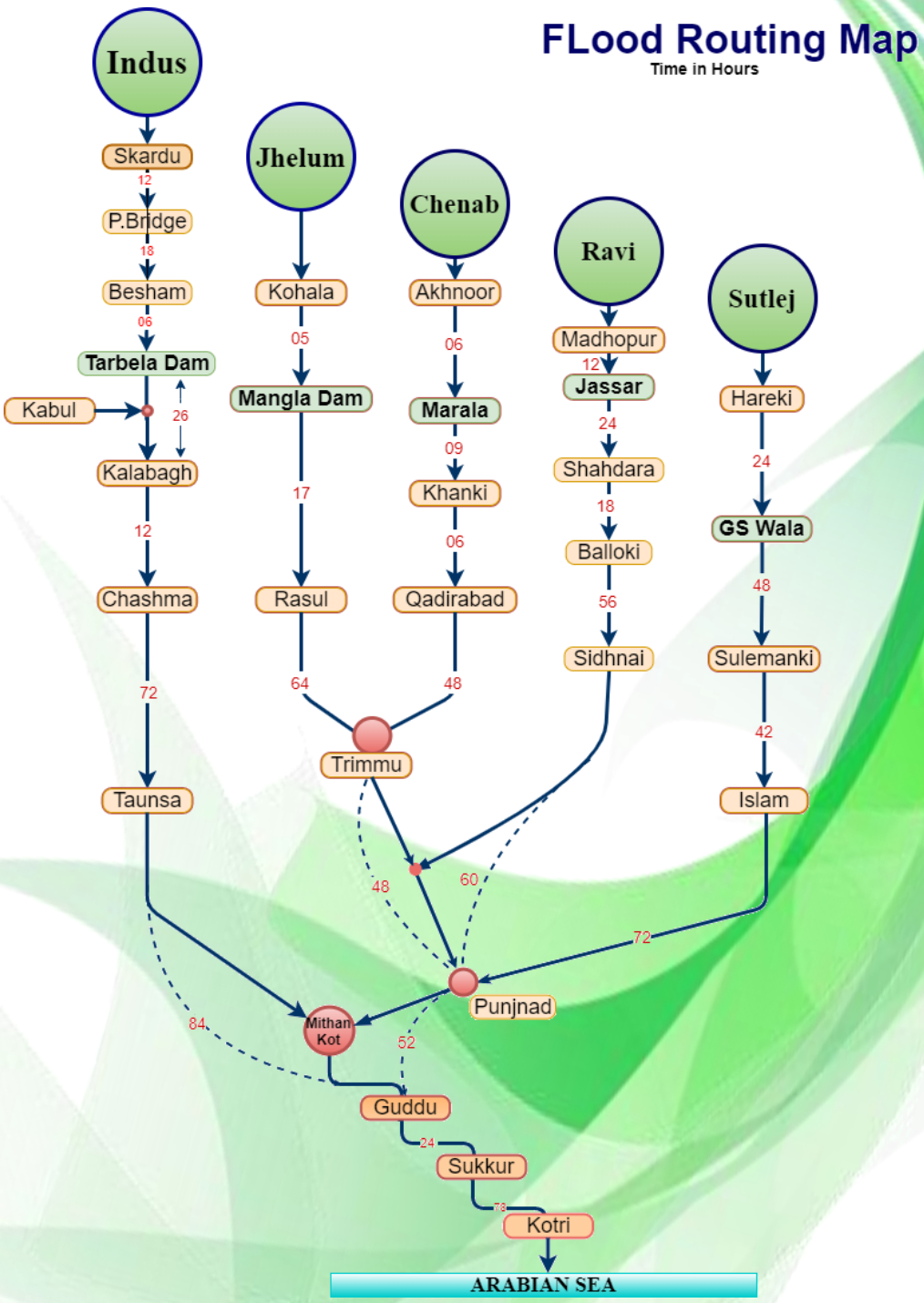
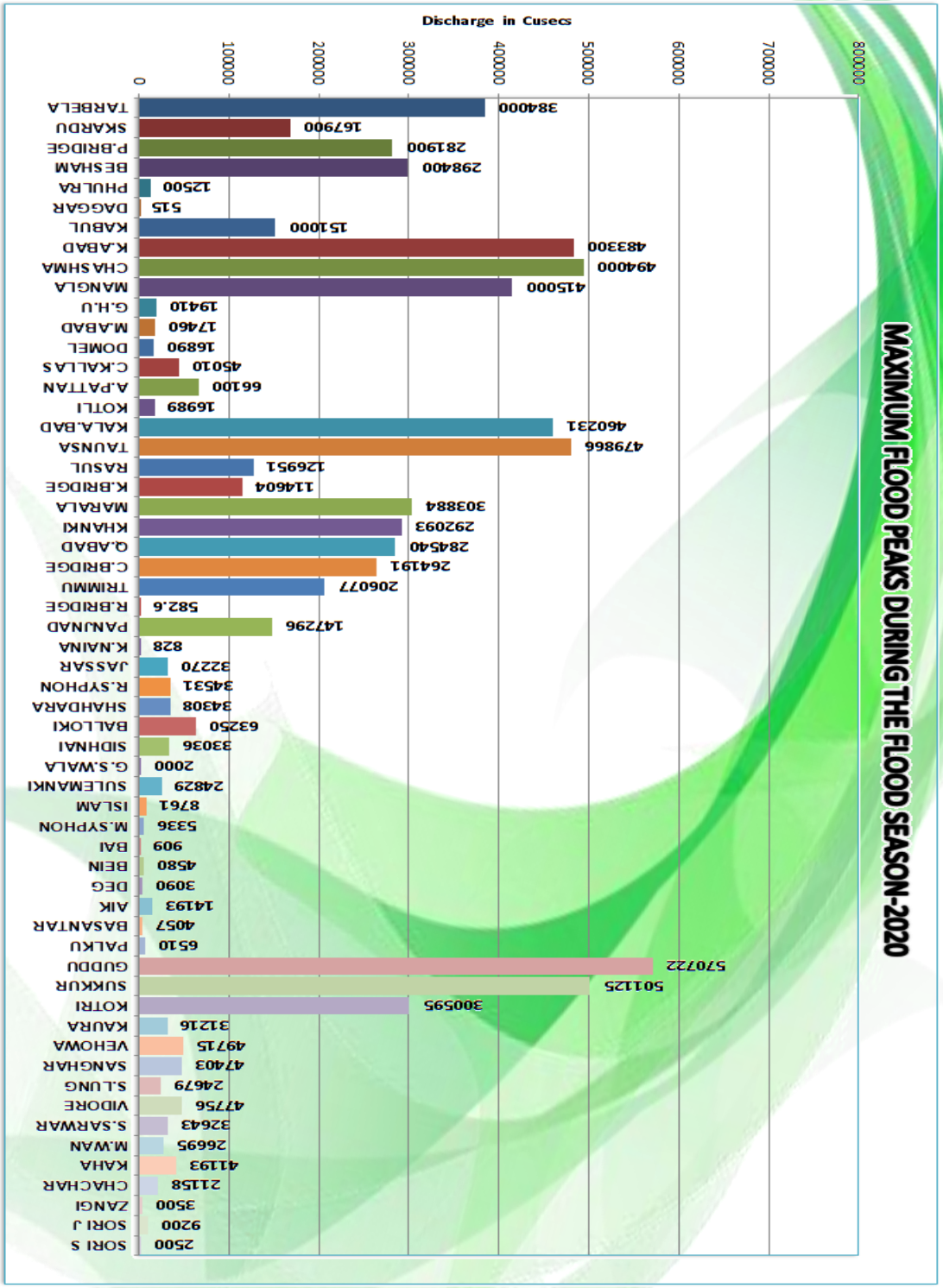


Figure 75: Time Lag

17 Maximum Flood Peaks Discharge during Flood Season-2020.

Maximum Flood Peaks recorded during Flood Season-2020 is shown below

Figure 76: Maximum flood peaks recorded during the season 2020



18 Facilities Provided By FFD Lahore during the Flood Season

- Flood Forecasting Division Lahore provides semi-furnished accommodation facilities to the Police Tele Communication officers & officials in the office premises.
- Flood Forecasting Division Lahore has provided space & facilities to the Environmental Protection Department (EPD), Punjab to install their instruments to monitor air quality of Lahore.
- Sports facilities were also provided to the flood relating agencies working in FFD during the flood season.
- Flood Forecasting Division Lahore also provided facilities to media for live coverage regarding Flood/Weather events.