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List of Acronyms

- AJK — Azad Jammu & Kashmir
- CDPC — Climate Data Processing Centre
- DCOs — District Coordination Officers
- 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 Authorities
- PCIW — Pakistan Commissioner for Indus Waters
- PDMAs — Provincial Disaster Management Authority
- PMD — Pakistan Meteorological Department
- SDMA — State Disaster Management Authority
- WAPDA — Water and Power Development Authority
- XEN — Executive Engineer

Preface

Water is vital for life. No animal or plant can survive without it. The crop will not grow without supply of adequate water. Yet the same water causes havoc and becomes a terror in the form of floods when the rivers overflow from their banks due to excessive rains in their catchment generating disastrous floods which cause heavy destruction to life and property. Countries irrigated by an efficient river system are blessed in many ways. These rivers not only help agriculture but they provide a cheap and efficient transport system for the development of internal trade. Land divides, seas unite, but these waterways bring a lot of misery to the people of Pakistan by causing devastating seasonal floods in the rivers Sutlej, Ravi, Chenab, Jhelum, Indus and Kabul almost every rainy season. It brings untold sufferings to the people living in flood plains. Millions are rendered homeless. Men and cattle die in large numbers and the damage to property including standing crops is incalculable. Besides, floods affect the health of the locality and increase the incidences of cholera, typhoid and other water-borne diseases. These floods may be due to two natural causes. First, the melting of glaciers on the mountains resulting in enormous volume of water much in excess of rivers capacities, Secondly, heavy rains on the mountains again excess of water supply. In either case, the excess water overflows the embankments and submerges the low-lying plains. Higher release from dams leads to inundation. Natural disasters cannot be controlled by human being .These cannot be stopped but can be mitigated up to some extent. Properties loss is amendable by analyzing the prevailing atmospheric conditions on micro scale, future possible variability in it and then possible accurate forecast .The timely dissemination of the flood information to the concerned authorities, media and public contributes a lot in minimizing the losses due to floods.

The Flood Forecasting Division Lahore (FFD), since its establishment is serving the nation by issuing flood forecasts during each flood season (15^{th} June -15^{th} October). FFD, as usual monitored flood season 2015 carefully through its Hydro-Meteorological bulletins, Warnings / Advisories and then informing different Government agencies, press and electronic media, in order to minimize mass destruction. The compilation of flood report after each flood season is a regular feature observed by FFD Lahore. Flood report for the year 2015 has been prepared under the kind guidance and instructions of Director General, Pakistan Meteorological Department. It contains all the details pertaining to flood forecasting

like monsoon low's tracks, rainfall during wet spells, flood peaks, monthly and seasonal isohyetal maps, normal isopercental maps, flood limits and flood evaluation report. FFD Lahore besides its conventional practice of forecasting is introducing flood forecast through different models. Recently, beside other models a new flood routing and inundation model IFAS has been run on experimental basis. The foreign trained FFD experts are on the job to customize the model on local condition. The inundation results produced so far by the model are encouraging and helpful in briefing the flood mitigating agencies to minimize the flood looses in the country. Although the model is confined to Indus River only, yet its extension to the Eastern Rivers is in the offing.

Chief Meteorologist
Flood Forecasting Division
Lahore

1 Executive summary

- Monsoon during 2015 was more active over South Punjab and central Khyber Pakhtunkhwa. Seasonal percentage departure map for precipitation during the present monsoon season indicates 27% above normal precipitation for whole of Pakistan. Khyber Pakhtunkhwa, Punjab, Gilgit-Baltistan and Sindh received 37%, 55%, 116%, 4% above normal rainfall respectively while Kashmir and Balochistan received 2% and 30% below normal rainfall respectively.
- Three monsoon lows originated during the present monsoon season, two of them affected Pakistan.
- Nine rain bearing spells occurred during the monsoon season 2015.
- Four High Flood waves with synchronizing of flow from river Kabul and Soan were observed in River Indus.
- The base flow in river Indus remained above normal during July and August 2015. This was mainly due to the increase in mean minimum temperatures over the catchment of River Indus.
- The supply of hydro-meteorological data from WAPDA, Punjab and Sindh irrigation departments & Pakistan Commissioner for Indus Water (PCIW) remained satisfactory.
- All the concerned federal and provincial authorities, general public, along with print and electronic media were kept in touch about the prevailing weather/flood conditions through phone, fax & other electronic sources.
- A website (http://ffd.pmd.gov.pk/cp/floodpage.htm) maintained by FFD Lahore was updated regularly. This was a source of real time information to all the concerned authorities, organizations and individuals.
- Twenty four significant flood forecasts /warnings were issued by FFD during monsoon season 2015, whenever the weather/flood situation demanded.
- Overall accuracy of forecast issued by FFD during the Season 2015 has been calculated as 93%.

2 Tracks of Lows during monsoon season 2015

During the monsoon season 2015 (15th June to 15th October) three monsoon lows/depressions developed over Bay of Bengal. **1st** Monsoon Low developed in West Bay of Bengal on 9th July, 2015. After moving West Northwest wards it was relocated over east Madhya Pradesh on 11th July, 2015. From here it moved rapidly North Northwest wards and reached Uttarakhand on 13th July, 2015 where it dissipated without affecting the country. **2nd** Monsoon Low was developed on 19th July, 2015 over East Uttar Pradesh. First it moved Southwest wards and reached North Madhya Pradesh on 23rd July, 2015. From here it moved slowly West wards and finally it moved North wards and dissipated over Northwest Rajasthan and adjoining areas of Pakistan on 30th July, 2015. Parts of Sindh received rainfall due to it. **3rd** and final Monsoon Low developed over Bay of Bengal on 14th September, 2015. After moving west northwest wards it reached Gujarat on 20th September, 2015. From here it moved quickly North wards and dissipated on 22nd September, 2015 near Himachal Pradesh & adjoining areas of Azad Jammu and Kashmir.

The path followed by each low/depression is shown in figure 1.

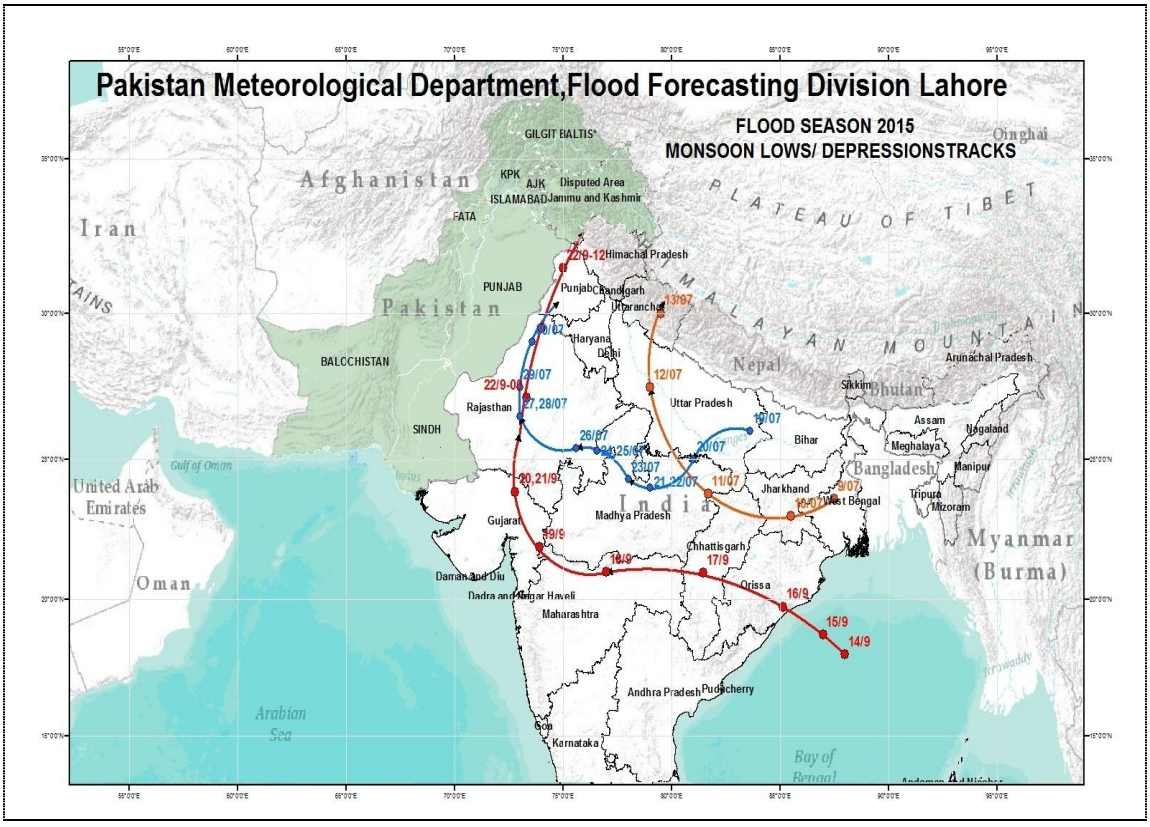


Figure 1: Monsoon tracks 2015.

3 Significant hydro-meteorological events during the month of June 2015

Only one significant rainfall spell was reported during the month of June 2015.

3.1 Meteorological events

No monsoonal low developed over Bay of Bengal during the month of June 2015. The rainfall mostly occurred across the country during the month was due to the accentuation of seasonal low over Baluchistan and westerly wave in the North of the country.

Wet spells in each of the months are explained by using the weather charts in the subsequent sections. In each of these charts shaded portion represents 500 hPa patterns, 850 hPa values are shown by blue contour lines while wind vectors represent 925 hPa winds. NCEP-NCAR reanalysis dataset is used to draw these charts.

3.2 Wet spell of June 2015 (23rd to 25th June 2015)

The only wet spell of June 2015 which remained active for three days was mainly due to the presence of the westerly trough accompanied by moist current from Arabian Sea. Figure 2 represents 500 hPa and 850 hPa geopotential height patterns along with 925 hPa wind flow during this 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 enough moisture supply from the Arabian Sea. Figure 3 represents the temporal distribution of rainfall during the month of June. Figure 4 shows spatial pattern of significant rainfall during this spell which shows that maximum rainfall more than 120 mm occurred over Bahawalpur division.

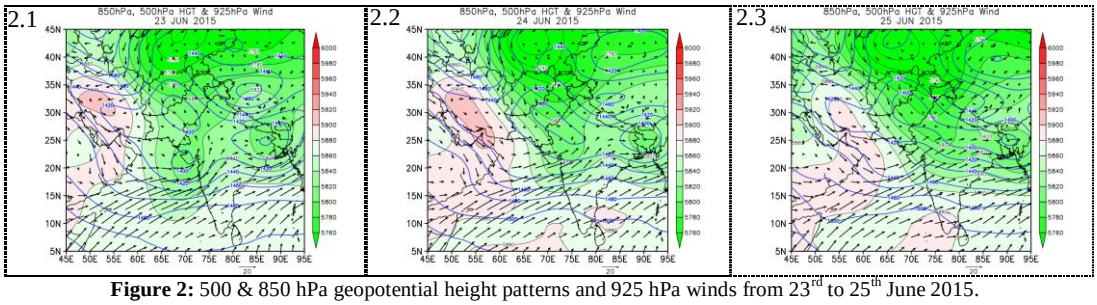


Figure 2: 500 & 850 hPa geopotential height patterns and 925 hPa winds from 23rd to 25th June 2015.

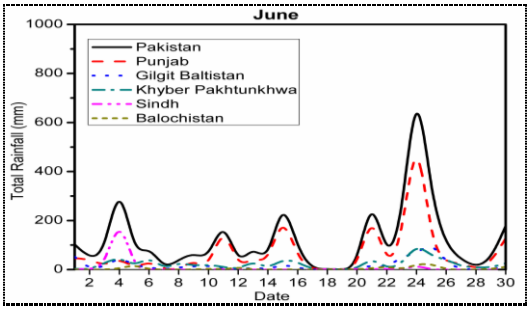


Figure 3: Temporal distribution of rainfall June 2015.

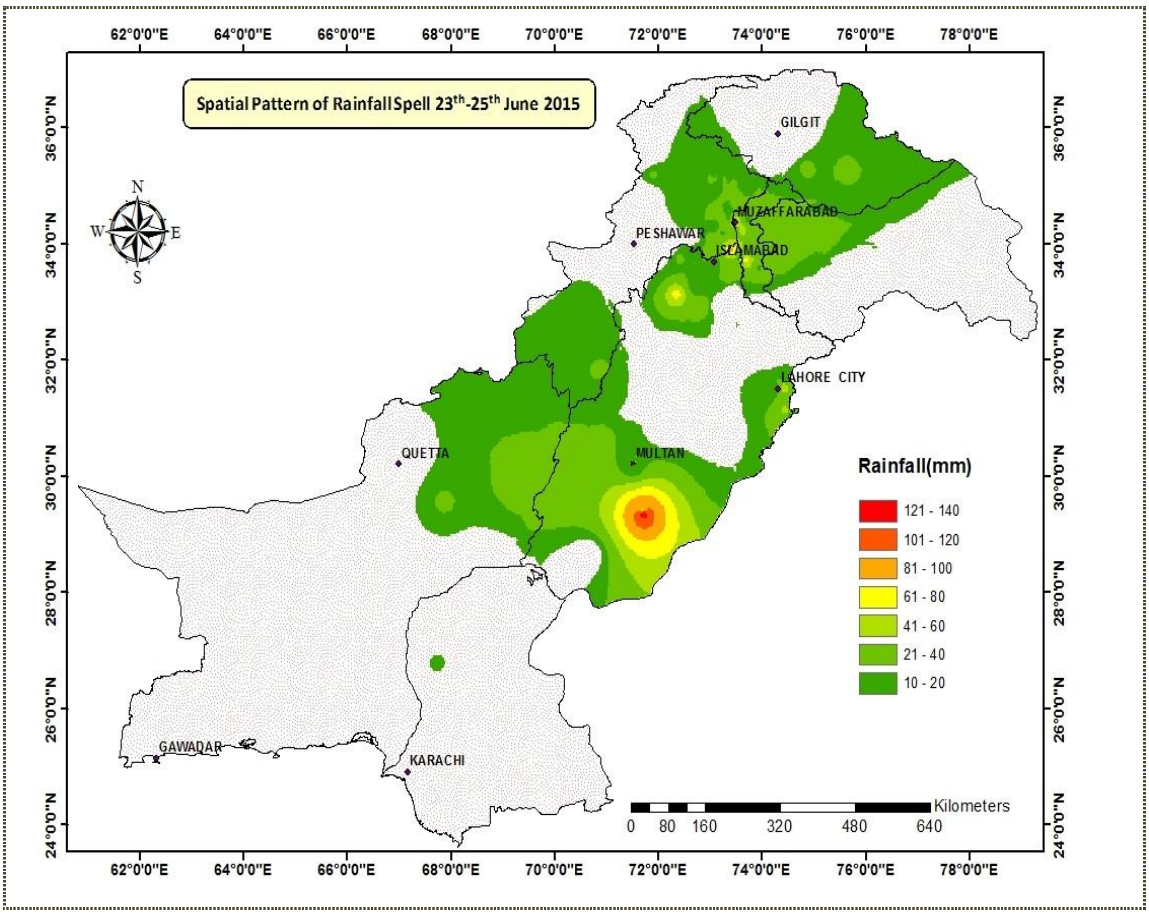


Figure 4: Significant rainfall 23rd-25th June.

3.3 Position of rivers during June 2015

Flood peaks recorded during June, 2015 are shown below.

Date	Rivers	Stations	Peaks inflows (cusecs)	Flood level
25/6/2015	Jhelum	Mangla	149000	Medium
22/6/2015	Kabul	Nowshera	93300	Medium

3.4 Hydrographs during June, 2015

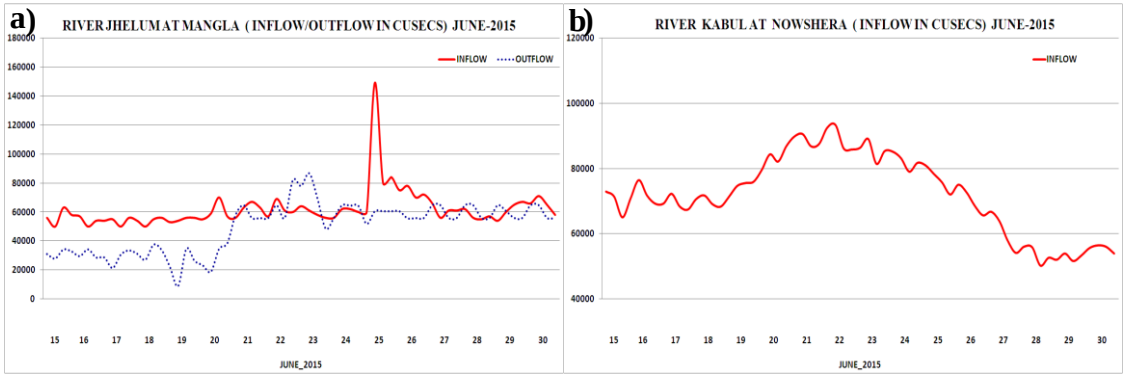


Figure 5: Hydrographs for the month of June, a) Mangla, b) Kabul.

4 Significant hydro-meteorological events during the month of July 2015

Four significant rainfall spells occurred during the month of July 2015.

4.1 Meteorological events

First spell occurred from 6th to 8th July 2015 was the result of the penetration of moist current from Arabian Sea into sub mountainous areas of Punjab & Kashmir under the effect of westerly wave passing over the Northern parts of the country and accentuation of seasonal low into a well marked low. The second spell of July observed during 10th to 12th July, 2015 was caused due to the interaction of westerly wave passing over the Northern parts of the country and the moist influx from Arabian Sea. Third spell of the Month of July was observed from 17th to 25th July, 2015. It was also caused due to interaction of westerly wave and strong moist current from Arabian Sea and Bay of Bengal. Fourth and final spell was observed from 27th to 30th July. It was caused due to interaction of Monsoon Low, westerly wave, moist current from both the sources and seasonal low.

4.2 First wet Spell of July 2015 (6th to 8th July 2015)

The first spell of July 2015 which was 2nd of the flood season 2015 lasted for 3 days. It was mainly due to the passage of westerly wave, accentuation of seasonal low and incursion of moist current from Arabian Sea. Figure 6.1 represents an accentuated seasonal low on 6th July, present over northern parts of Balochistan and its adjoining areas. Figures 6.1 and 6.2 show the influence of a westerly trough over Pakistan on 6th and 7th of July. An overall southwesterly trend of 925 hPa winds during the three days can also be witnessed in these charts. This all resulted to produce significant rainfall in Kashmir and parts of Punjab. Spatial distribution of significant rainfall during the spell is shown in figure 7 which shows that maximum rainfall more than 120 mm observed in Kashmir around Palandri.

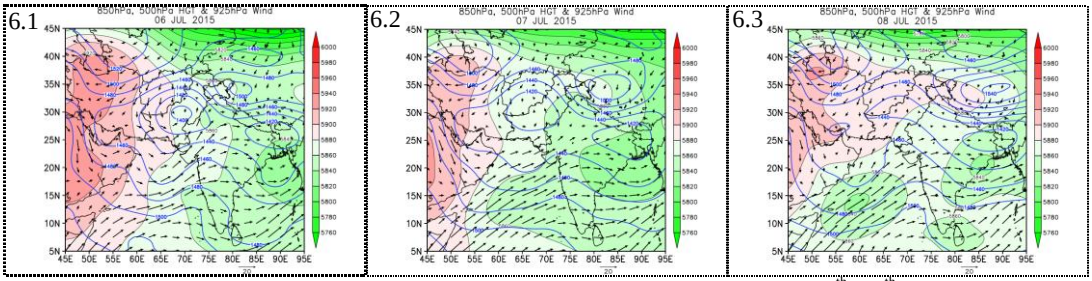


Figure 6: 500 & 850 hPa geopotential height patterns and 925 hPa winds from 06th to 8th July 2015.

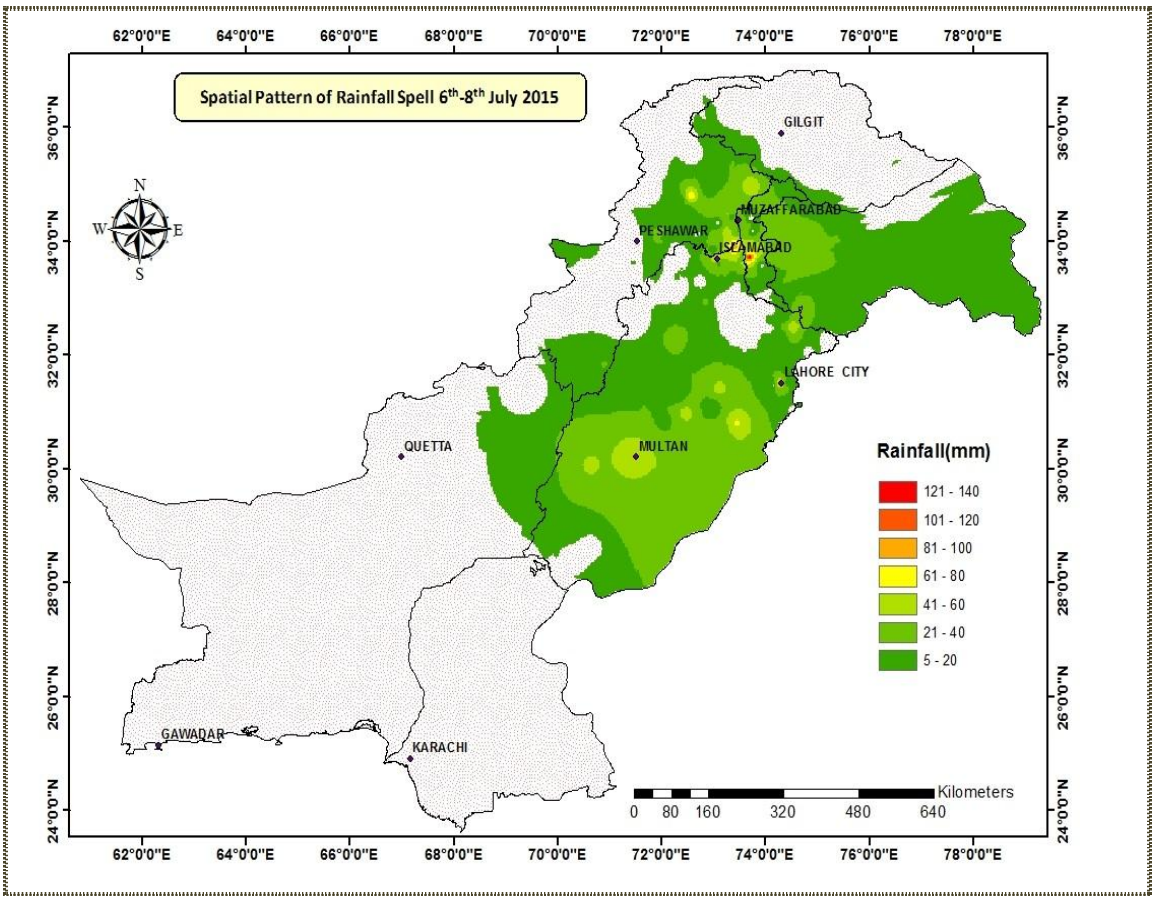


Figure 7: Significant rainfall 06th-08th July 2015.

4.3 Position of rivers due to first wet spell of July

River Kabul at Nowshera remained in state of medium flood during the period while river Indus at Tarbela, river Jhelum at Mangla and river Chenab at Marala, Khanki & Qadirabad attained Low flood level due to this rainfall spell.

4.4 Second wet spell of July 2015 (10th to 12th July 2015)

This spell also lasted for three days. Moderate to heavy rainfall was recorded at scattered places over Kashmir, while of moderate intensity over Punjab. Figures 8.1 to 8.3 represent the geopotential heights at 500 hPa, 850 hPa and winds at 925 hPa during this wet spell. It shows strong southwesterly currents at 925 hPa entering in most parts of Pakistan while on 11th July moist currents from Bay of Bengal also started entering in parts of Pakistan. This was due to the formation of another low pressure area over central India. Westerly trough is also seen influencing most parts of the country. This produced rainfall in most parts of Punjab and Kashmir. Spatial rainfall pattern during the spell is shown in figure 9 which shows maximum rainfall more than 130 mm recorded in Kashmir around Palandri .

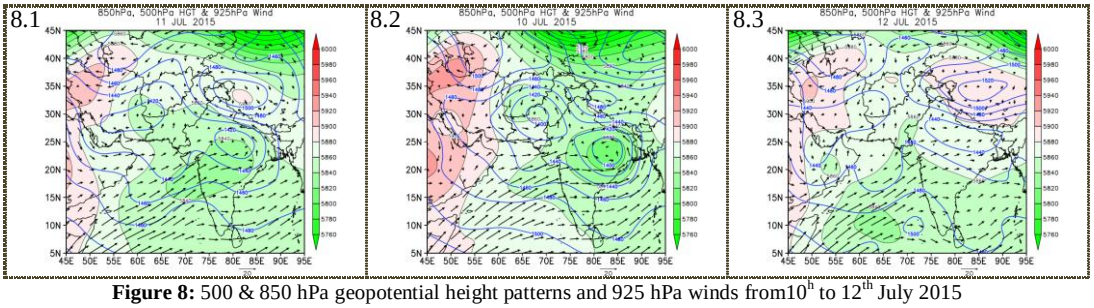


Figure 8: 500 & 850 hPa geopotential height patterns and 925 hPa winds from10^{h} to 12th July 2015

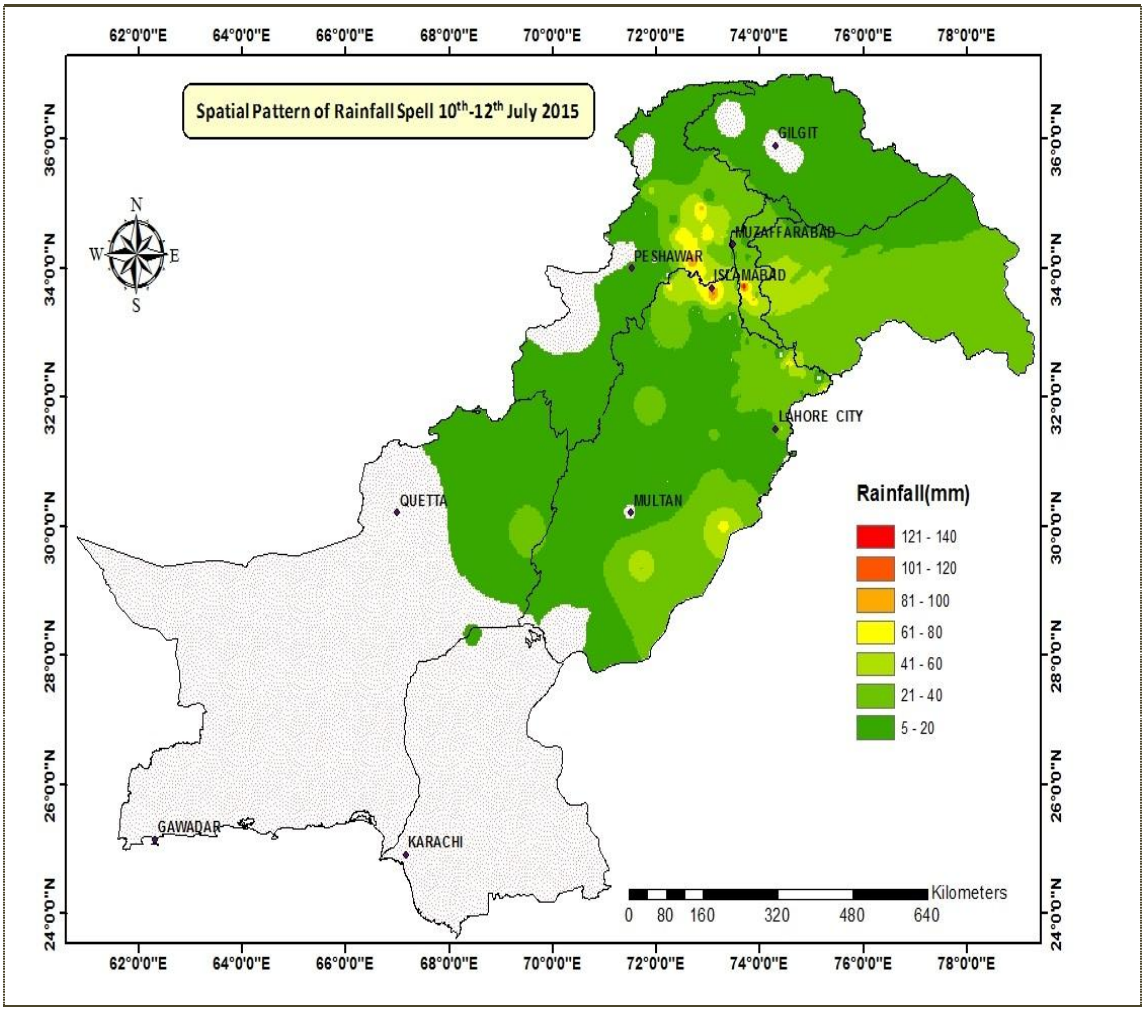


Figure 9: Significant rainfall of July 2015 (10-12 July).

4.5 Position of rivers due to second wet spell of July

River Jhelum at Mangla and river Chenab at Marala, Khanki & Qadirabad, river Kabul at Nowshera & river Indus at Chashma attained the Medium flood level due to this rainy spell while Low flood was recorded in river Indus at Tarbela and Kalabagh. All the other major rivers remained below Low flood level.

4.6 Third wet Spell of July 2015 (17th to 25th July 2015)

This was a long spell; it lasted for almost nine days. The rainfall of heavy to very heavy intensity was recorded over north & northeast Punjab and Kashmir along with upper

catchments of river Indus. Atmospheric conditions for 18th of July are shown in figure 10. Strong southwesterly incursion at 925 hPa and the presence of a westerly wave produced heavy rainfall during this period. Formation of another low pressure over eastern India on 19th July and its subsequent westward movement was another cause of heavy rainfall during this spell. Spatial distribution of significant rainfall during this spell is shown in figure 11 which indicates maximum rainfall more than 300 mm around Islamabad.

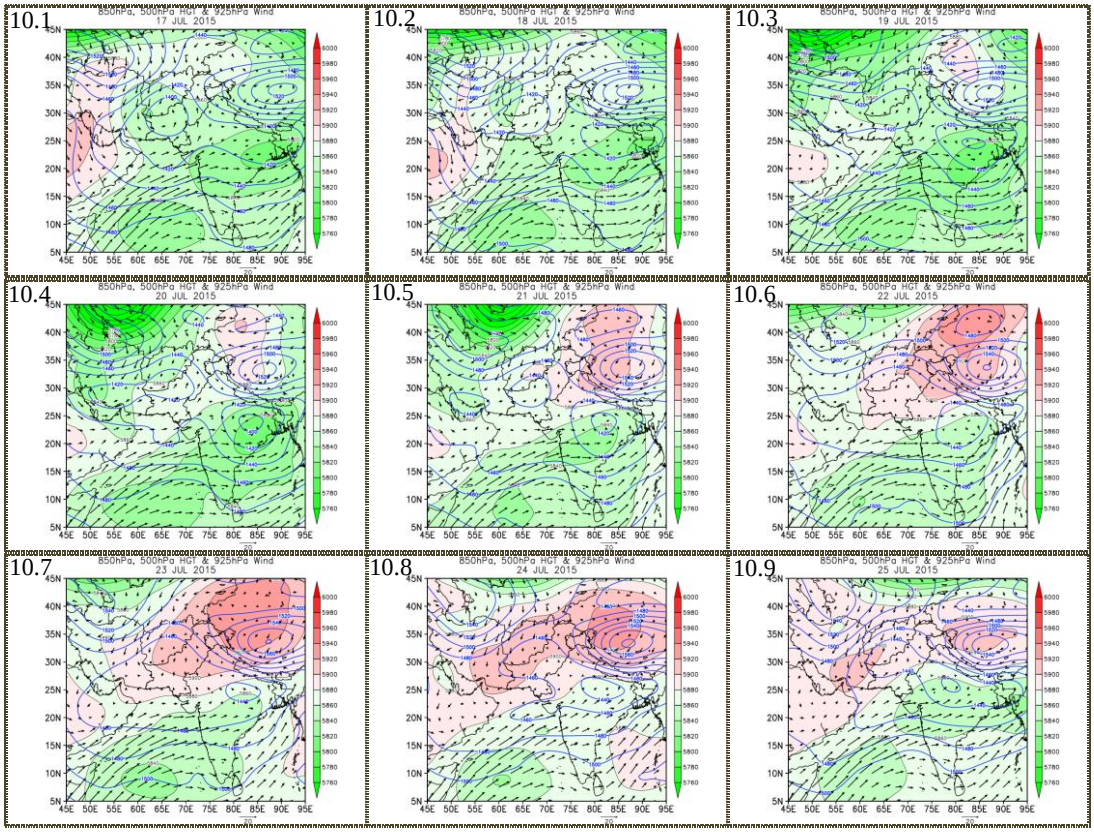


Figure 10: 500 & 850 hPa geopotential height patterns and 925 hPa winds from 17th to 25h July 2015.

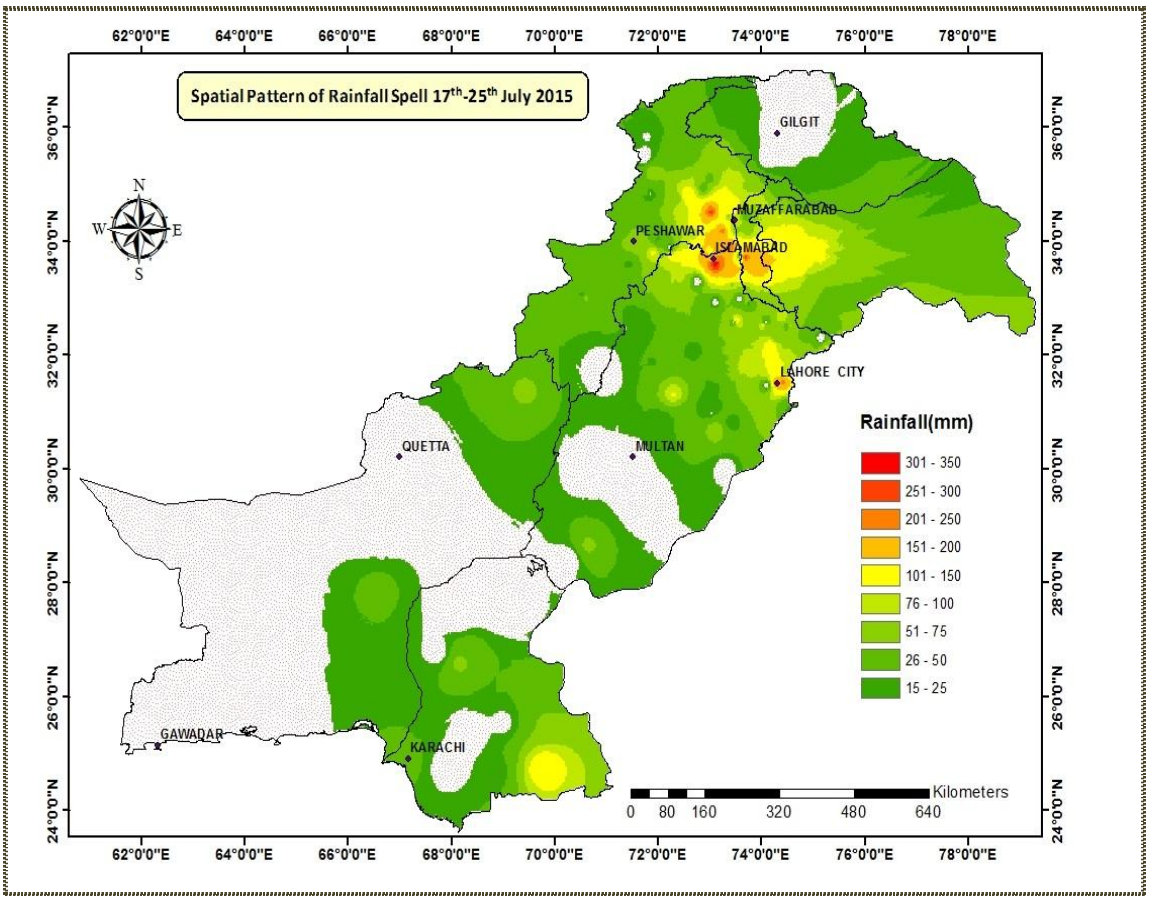


Figure 11: Significant rainfall of July 2015 (17-25 July).

4.7 Position of rivers due to third wet spell

River Indus at Chashma and river Jhelum at Mangla attained High flood level. River Indus at Tarbela and Kalabagh, River Kabul at Nowshera and river Ravi at Balloki recorded Medium Flood level. Low flood was observed in river Chenab at Marala, Khanki, and Qadirabad along with river Ravi at Sidhnai.

4.8 Fourth wet spell of July 2015 (27th to 30th July 2015)

This spell remained active for four days. Figure 12 represents geopotential height situations at 500 hPa and 850 hPa along with wind directions at 925 hPa during this wet spell. A well marked low pressure is present over Indian Gujarat and adjoining areas of Sindh. Wind pattern at 925 hPa shows a strong southwesterly flow. Moisture from the Arabian Sea got interacted with a westerly wave, which remained

almost stagnant in the western parts of the country. The movement of the westerly wave was hindered by the westward movement of the subtropical high. This situation which resulted in the warm moist air interacting with cold dry air from the north resulted in heavy rainfall over parts of Sindh and Southern Punjab. Presence of westerly trough also

produced rainfall in Kashmir and adjoining areas. Figure 13 shows the spatial distribution of this rainfall spell which indicates the maximum rainfall more than 225 mm recorded in Southeast Sindh . While figure 14 represents the temporal distribution of rainfall over the month of July.

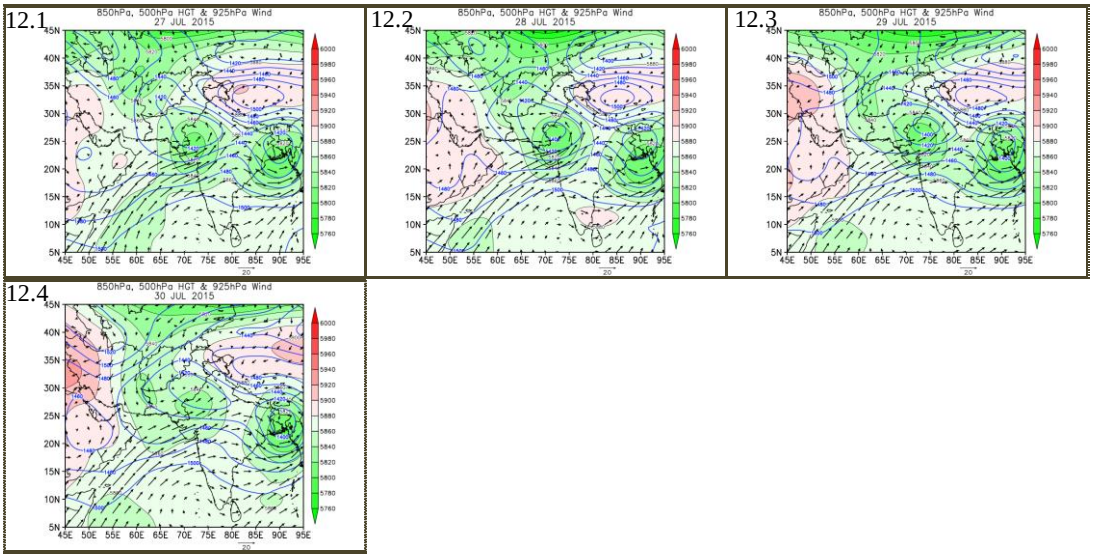


Figure 12: 500 & 850 hPa geopotential height patterns and 925 hPa winds from 27th to 30th July 2015.

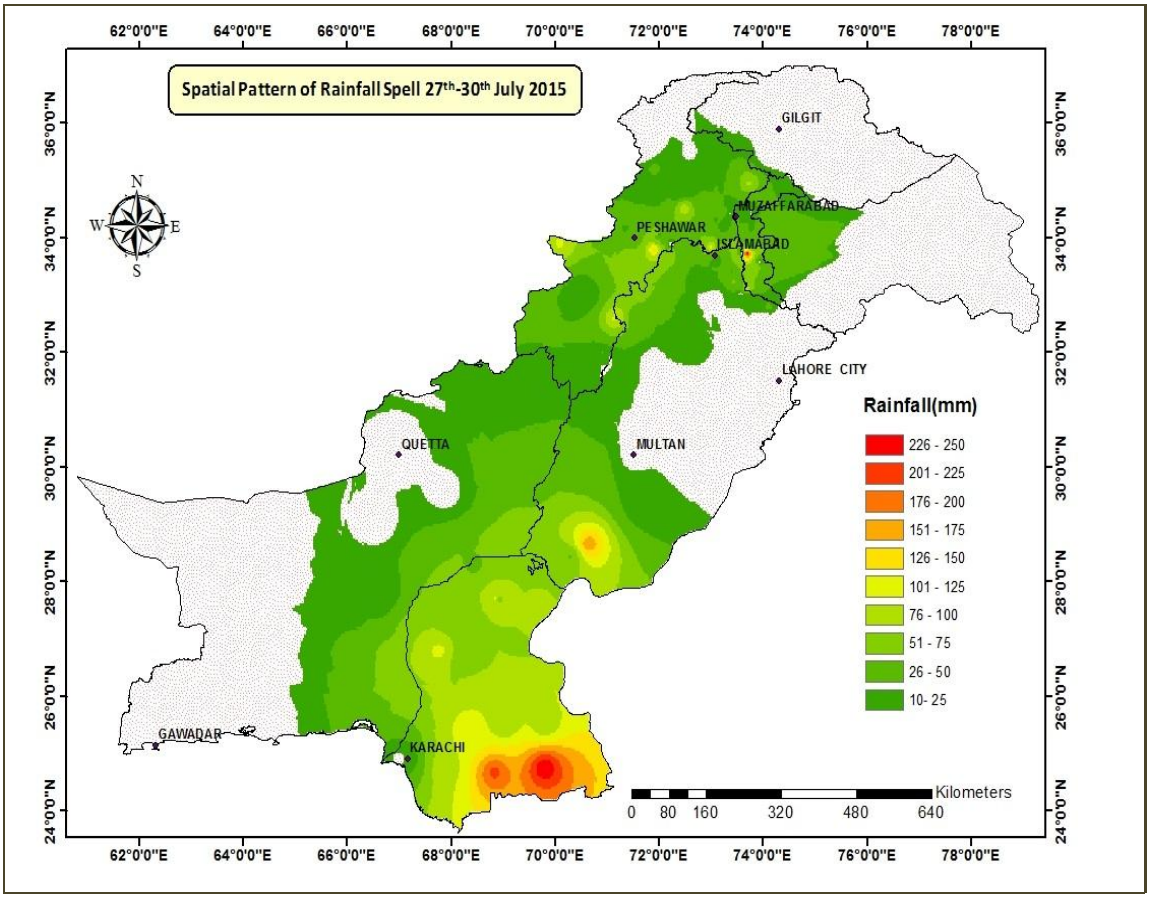


Figure 13: Significant rainfall of July 2015 (27-30 July).

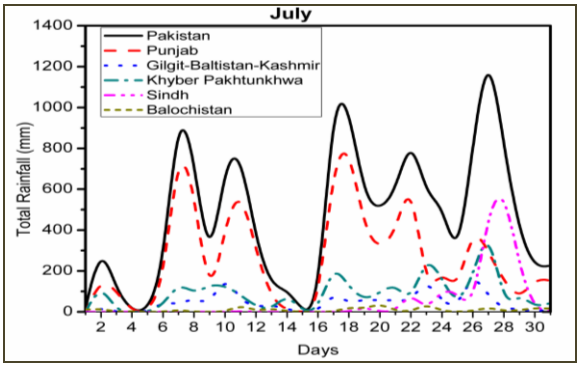


Figure 14: Temporal distribution of rainfall during July 2015.

4.9 Position of rivers due to fourth spell

River Indus at Guddu attained Very High Flood level. River Indus at Kalabagh, Chashma, Taunsa and Sukkur attained High Flood level. Medium Flood level also was recorded in river Indus at Tarbela, River Kabul at Nowshera and river Jhelum at Rasul.

4.10 Spatial pattern of rainfall during the month of July 2015

Isohyetal map of July 2015 indicates that one maxima of rainfall (more than 500 mm) lies over Islamabad & adjoining areas and another maximum rainfall of more than 350 mm lies over Southeast Sindh as shown in figure 15.

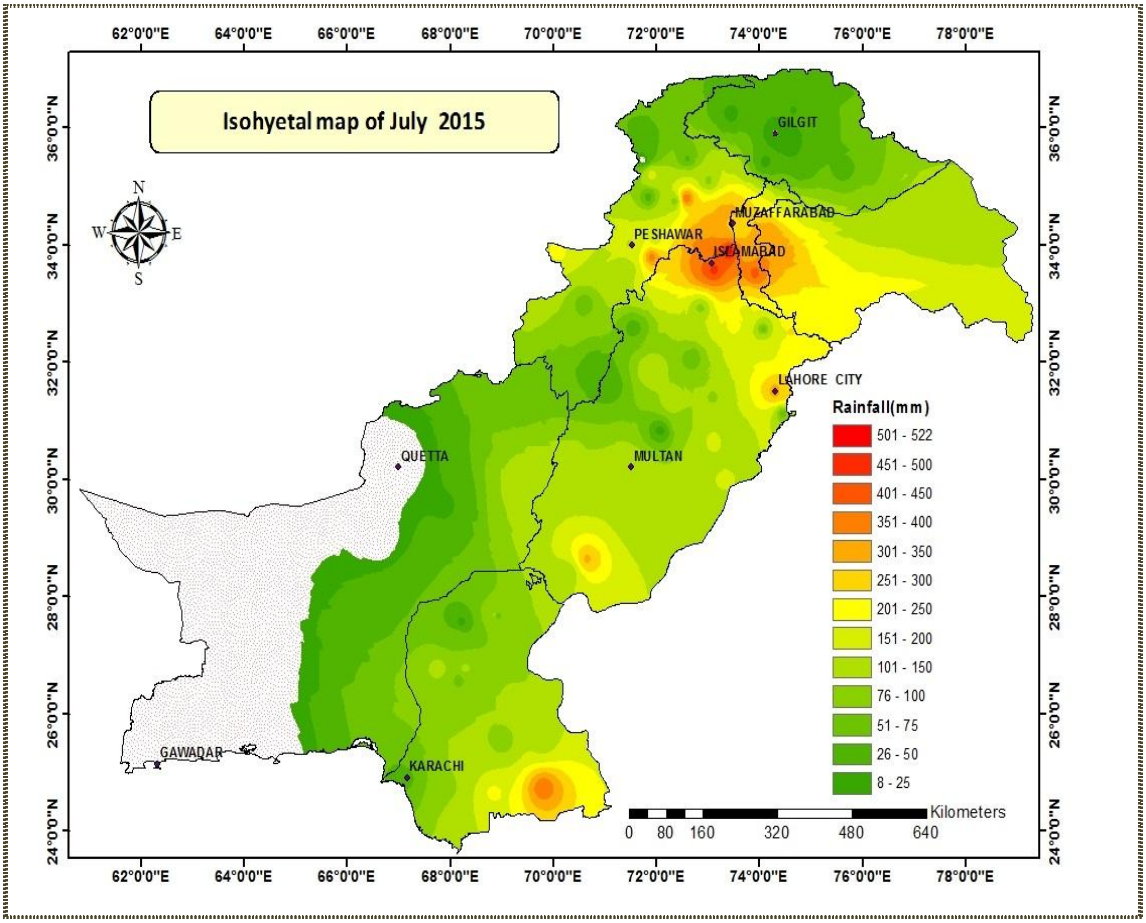
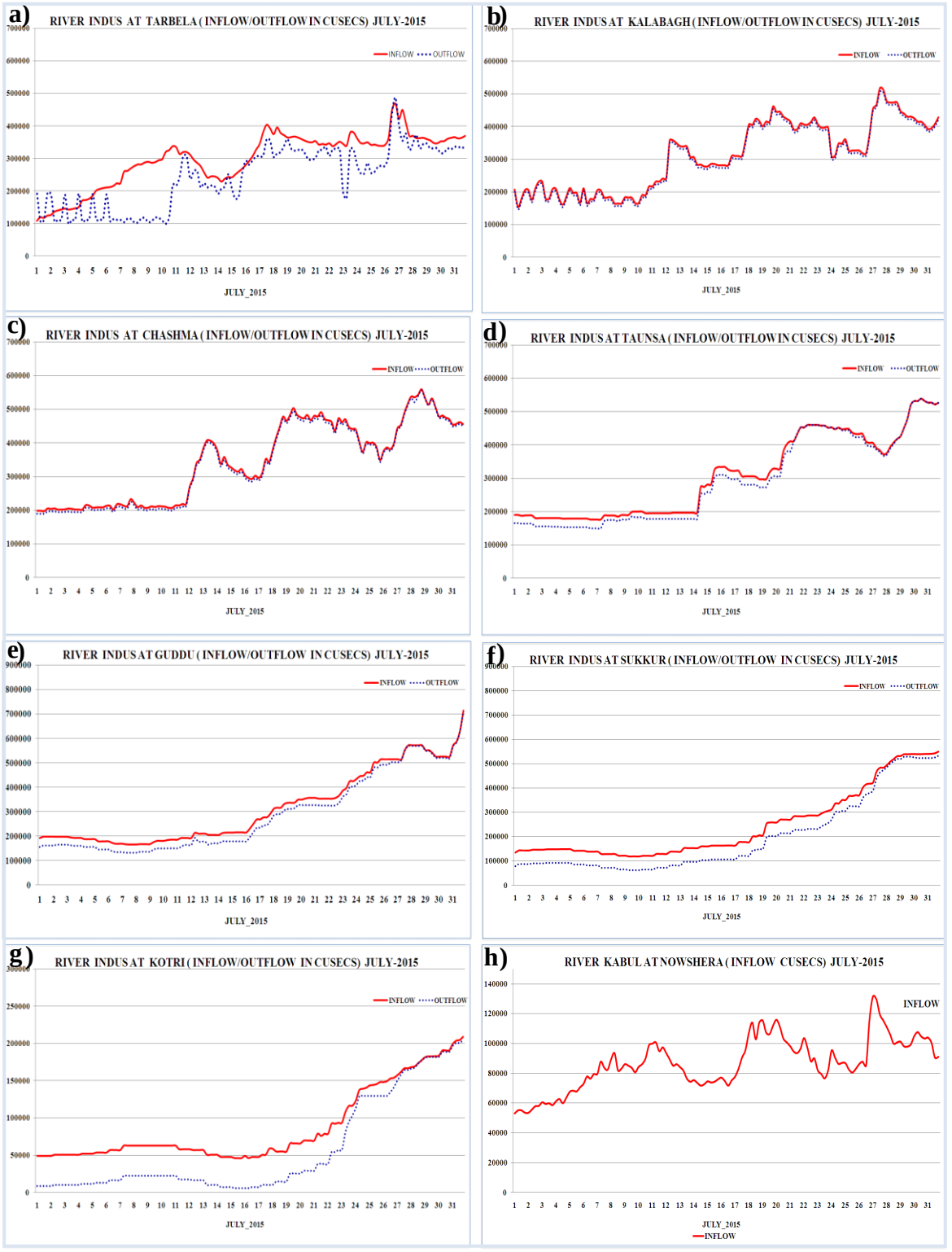


Figure 15: Isohyetal map of July 2015.

4.11 Position of rivers during the month of July 2015

Date	Rivers	Stations	Peaks inflows (cusecs)	Flood level
10/7/2015	Indus	Tarbela	338000	Low
17/7/2015	Indus	Tarbela	404000	Medium
23/7/2015	Indus	Tarbela	380000	Medium
26/7/2015	Indus	Tarbela	490000	Medium
11/7/2015	Kabul	Nowshera	100700	Medium
20/7/2015	Kabul	Nowshera	115900	Medium
27/7/2015	Kabul	Nowshera	133500	Medium
12/7/2015	Indus	Kalabagh	358036	Low
19/7/2015	Indus	Kalabagh	461665	Medium
27/7/2015	Indus	Kalabagh	517167	High
13/7/2015	Indus	Chashma	412793	Medium
19/7/2015	Indus	Chashma	502808	High
28/7/2015	Indus	Chashma	589090	High
16/7/2015	Indus	Taunsa	333752	Low
22/7/2015	Indus	Taunsa	459732	Medium
30/7/2015	Indus	Taunsa	539677	High
20/7/2015	Indus	Guddu	356243	Medium
27/7/2015	Indus	Guddu	570768	High
31/7/2015	Indus	Guddu	722862	V. High
21/7/2015	Indus	Sukkur	283212	Low
29/7/2015	Indus	Sukkur	539025	High
31/7/2015	Indus	Kotri	308721	Low
09/7/2015	Chenab	Marala	159315	Medium
12/7/2015	Chenab	Marala	183431	Medium
17/7/2015	Chenab	Marala	148610	Low
26/7/2015	Chenab	Marala	145300	Low
09/7/2015	Chenab	Khanki	132978	Low
13/7/2015	Chenab	Khanki	157535	Medium
17/7/2015	Chenab	Khanki	119100	Low
10/7/2015	Chenab	Qadirabad	138491	Low
11/7/2015	Chenab	Qadirabad	146723	Low
18/7/2015	Chenab	Qadirabad	125886	Medium
29/7/2015	Chenab	Trimmu	150865	Low
06/7/2015	Jhelum	Mangla	98000	Low
10/7/2015	Jhelum	Mangla	149000	Medium
21/7/2015	Jhelum	Mangla	196000	High
23/7/2015	Jhelum	Mangla	146000	Medium
24/7/2015	Jhelum	Mangla	148000	Medium
26/7/2015	Jhelum	Mangla	176000	High
28/7/2015	Jhelum	Mangla	132000	Medium
27/7/2015	Jhelum	Rasul	110101	Medium
19/7/2015	Ravi	Balloki	67180	Medium

4.12 Hydrographs recorded during the month of July 2015 are as below



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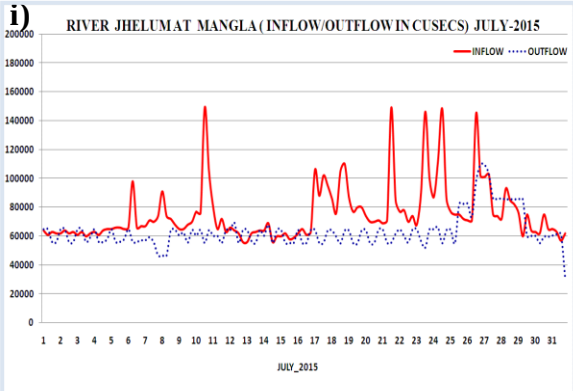
RIVER JHELUM AT MANGLA (INFLOW/OUTFLOW IN CUSECS) JULY-2015
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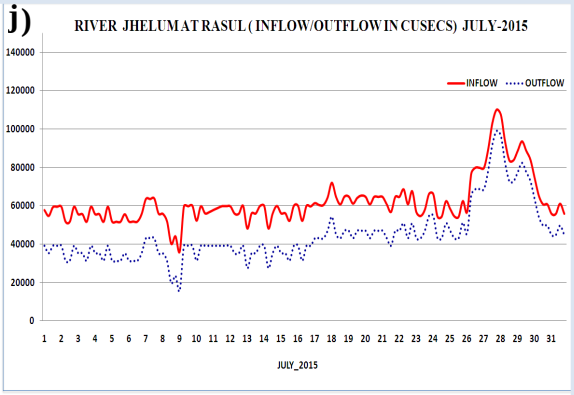
RIVER JHELUM AT RASUL (INFLOW/OUTFLOW IN CUSECS) JULY-2015
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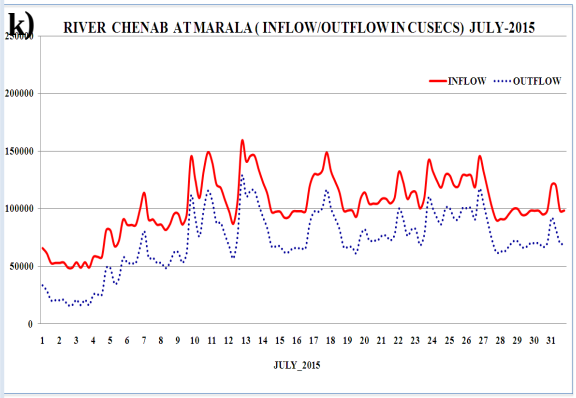
RIVER CHENAB AT MARALA (INFLOW/OUTFLOW IN CUSECS) JULY-2015
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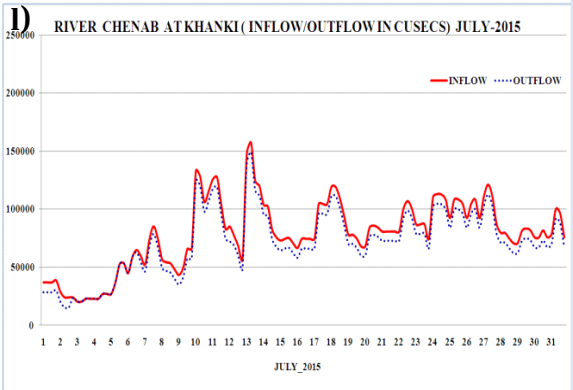
RIVER CHENAB AT KHANKI (INFLOW/OUTFLOW IN CUSECS) JULY-2015
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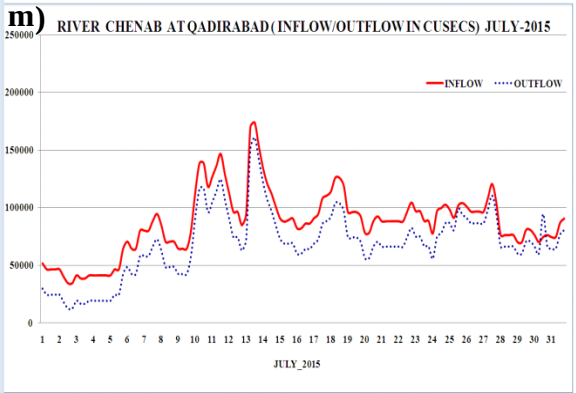
RIVER CHENAB AT QADIRABAD (INFLOW/OUTFLOW IN CUSECS) JULY-2015
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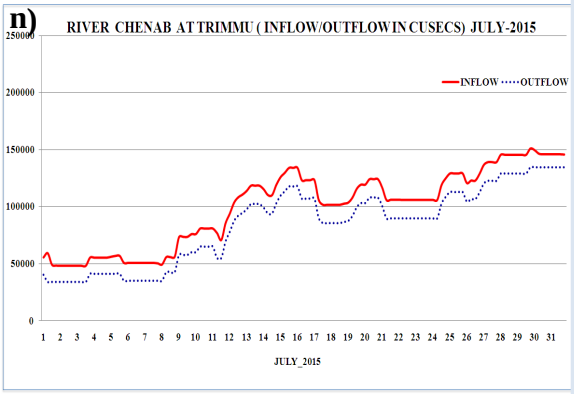
RIVER CHENAB AT TRIMMU (INFLOW/OUTFLOW IN CUSECS) JULY-2015
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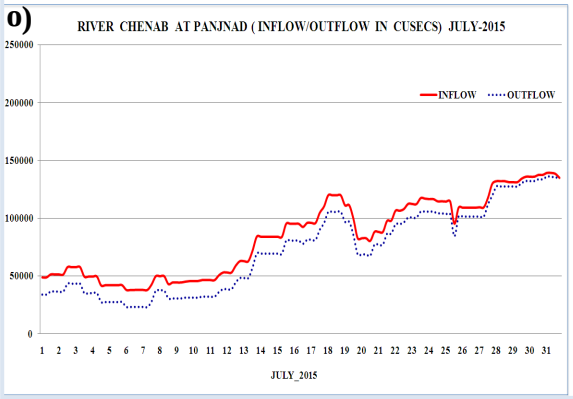
RIVER CHENAB AT PANJNAD (INFLOW/OUTFLOW IN CUSECS) JULY-2015
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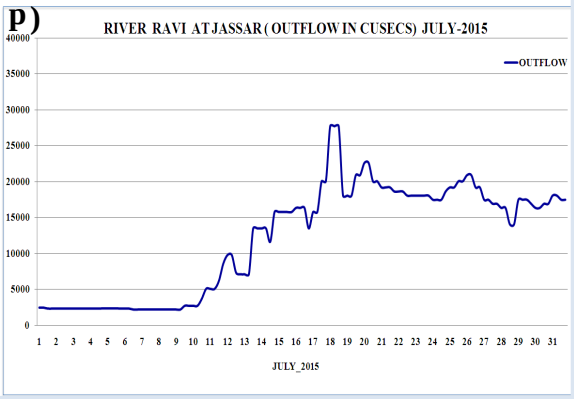

RIVER RAVI AT JASSAR (OUTFLOW IN CUSECS) JULY-2015
OUTFLOW
JULY_2015

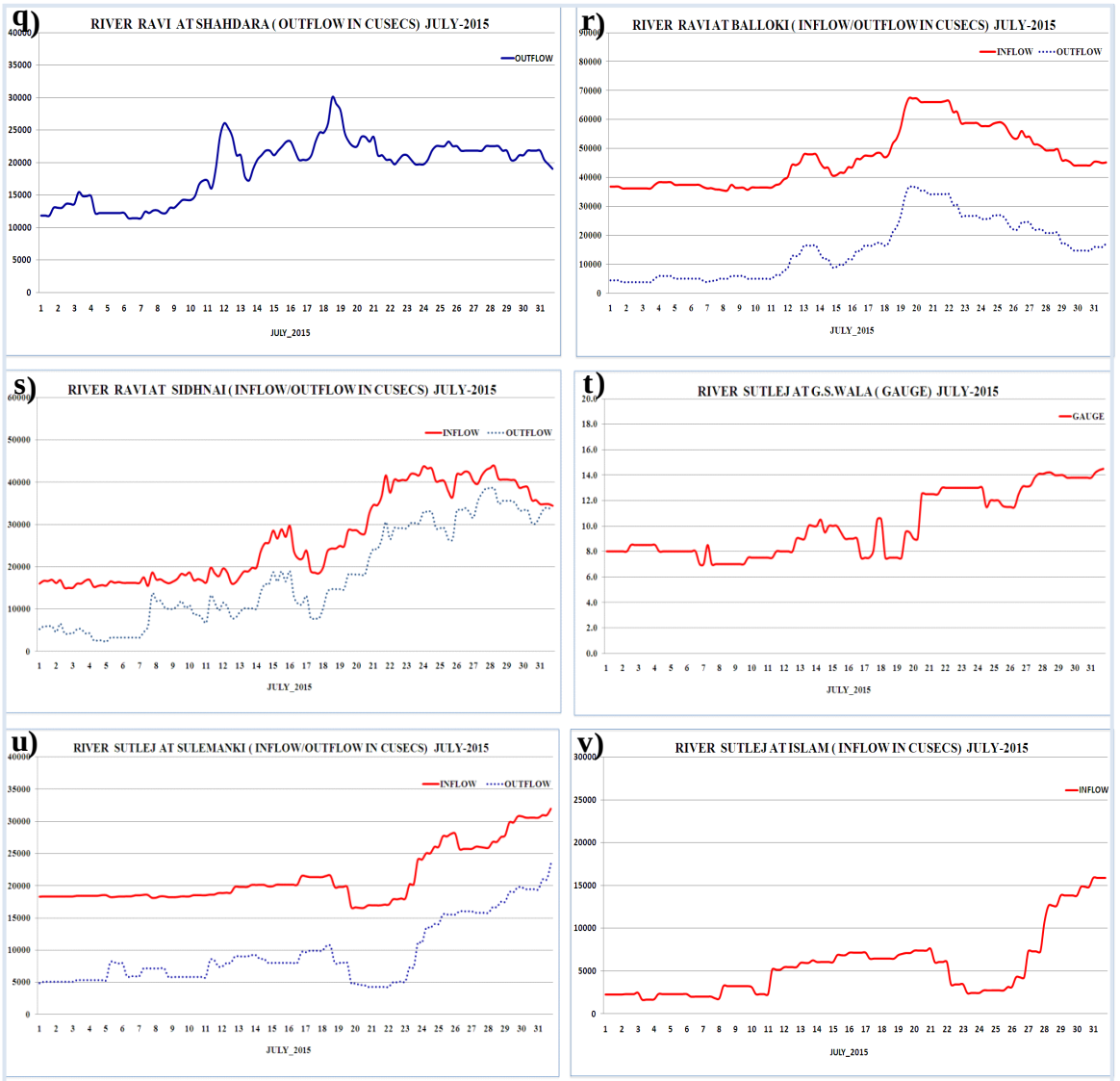


Figure 16: Hydrographs for the month of July, River Indus at, a) Tarbela, b) Kalabagh, c) Chashma, d) Taunsa, e) Guddu, f) Sukkur, g) Kotri, River Kabul at, h) Nowshera, River Jhelum at, i) Mangla j) Rasul, River Chenab at, k) Marala, l) Khanki, m) Qadriabad, n) Trimmu, o)Panjnad, River Ravi at, p) Jassar, q) Shahdra, r) Balloki, s) Sidhnai , River Sutlej at, t) G. S. Wala, u) Sulemanki and v) Islam.

5 Significant hydro-meteorological events during the month of August 2015

5.1 Meteorological events

Three rainy spells occurred during the month of August. First spell occurred from 1st to 3rd August 2015. This spell was caused by the interaction of a trough of westerly wave with the presence of monsoon low over Bahawalpur division and moist current from the Arabian Sea and Bay of Bengal. Second wet spell of the August was observed from 10th to 14th August 2015. This spell was caused by the interaction of a seasonal low and moist current from the Arabian Sea. Third spell occurred from 21st to 23rd August 2015.

This spell was caused by passage of westerly wave along with accentuation of seasonal low.

5.2 First wet spell of August (01st to 3rd August 2015)

The rainfall during the first spell of August which was 6th of the season occurred during 1st to 3rd August 2015. Heavy to very heavy rainfall was observed in this spell over Mianwali. Moderate to heavy rain was observed in Khyber Pakhtunkhwa and Kashmir. Atmospheric conditions during this wet spell are shown in figure 17. It shows a deep westerly trough at 500 hPa and strong southwesterly flow at lower level. The presence of the deep westerly trough was the main reason for the accentuation of the seasonal low, present over central parts of the country. Figure 18 gives the spatial distribution of significant rainfall during the present spell.

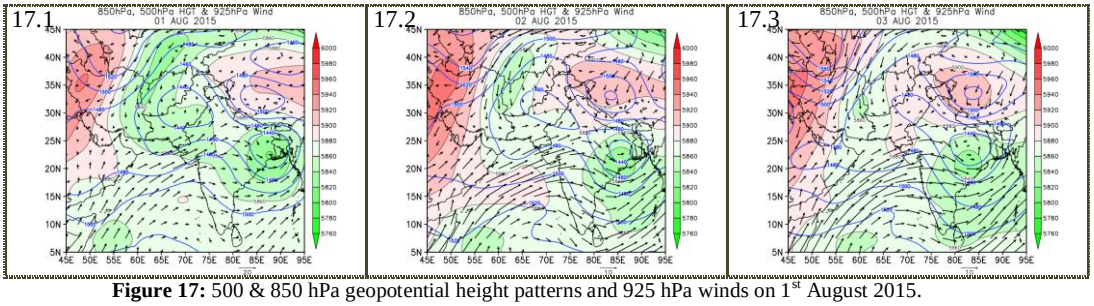


Figure 17: 500 & 850 hPa geopotential height patterns and 925 hPa winds on 1st August 2015.

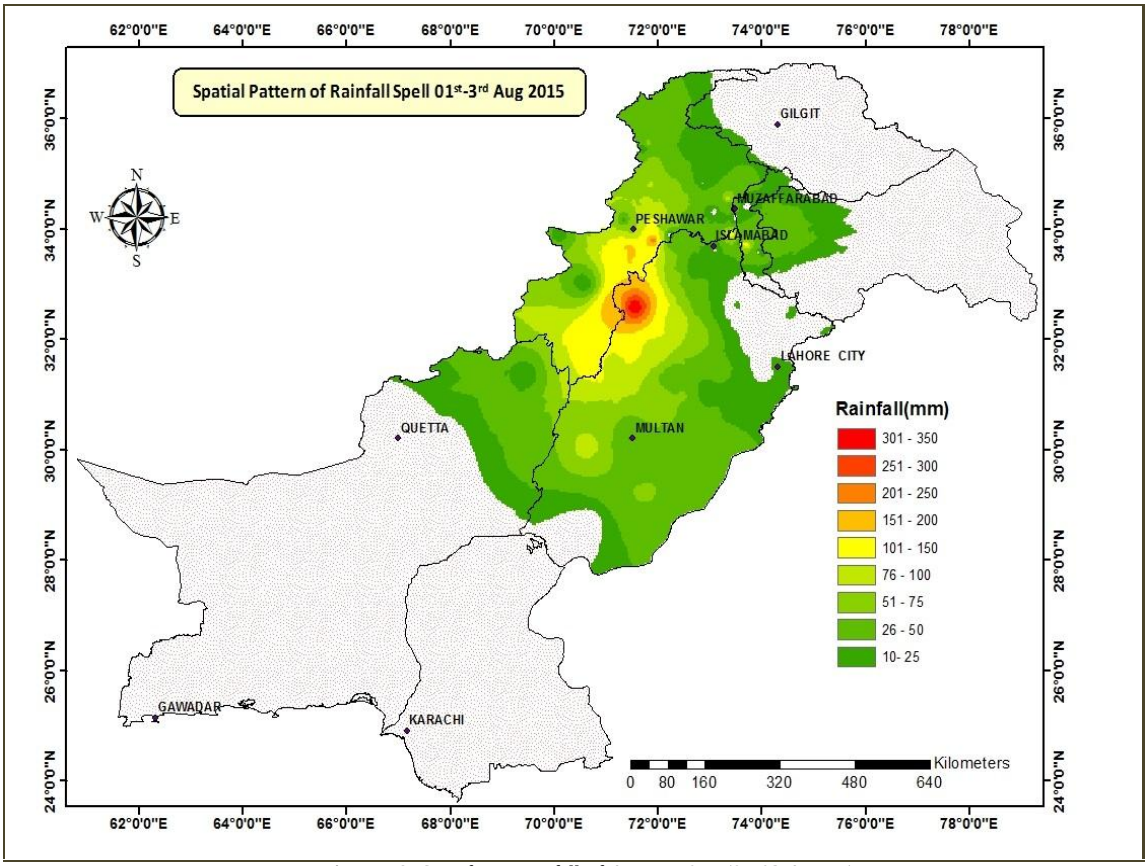


Figure 18: Significant rainfall of August 2015 (01-03 August).

5.3 Position of rivers during first spell of August

Due to this spell river Kabul at Nowshera attained a High flood situation while High flood situation was also observed in river Indus at Kalabagh, Chashma and Taunsa. Medium Flood situation was also recorded in river Jhelum at Mangla.

5.4 Second wet spell of August (10th to 14th August 2015)

Rainfall of moderate intensity was recorded over North and Northeast Punjab and Kashmir. Figure 19 represents the atmospheric conditions during this wet spell. This wet spell was caused by a westerly trough affecting upper parts of the country and the influx of southwesterly currents at 925 hPa. The westward movement of monsoonal low, present of central India, in latter days of the spell also contributed towards the enhanced rainfall during this spell. Figure 20 shows the spatial distribution of significant rainfall and more than 90 mm recorded over Jhelum.

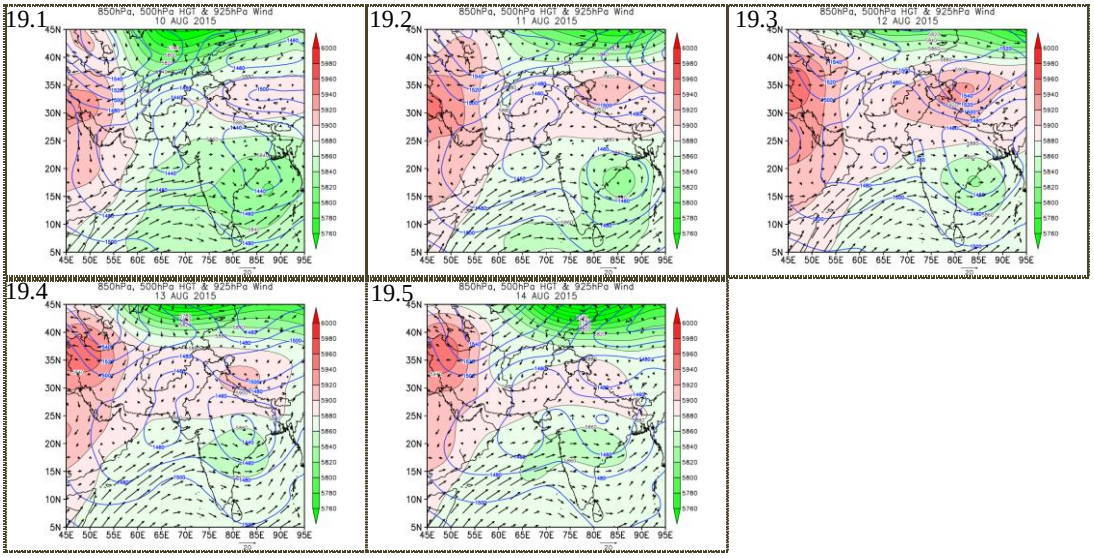


Figure 19: 500 & 850 hPa geopotential height patterns and 925 hPa winds on 10th August 2015.

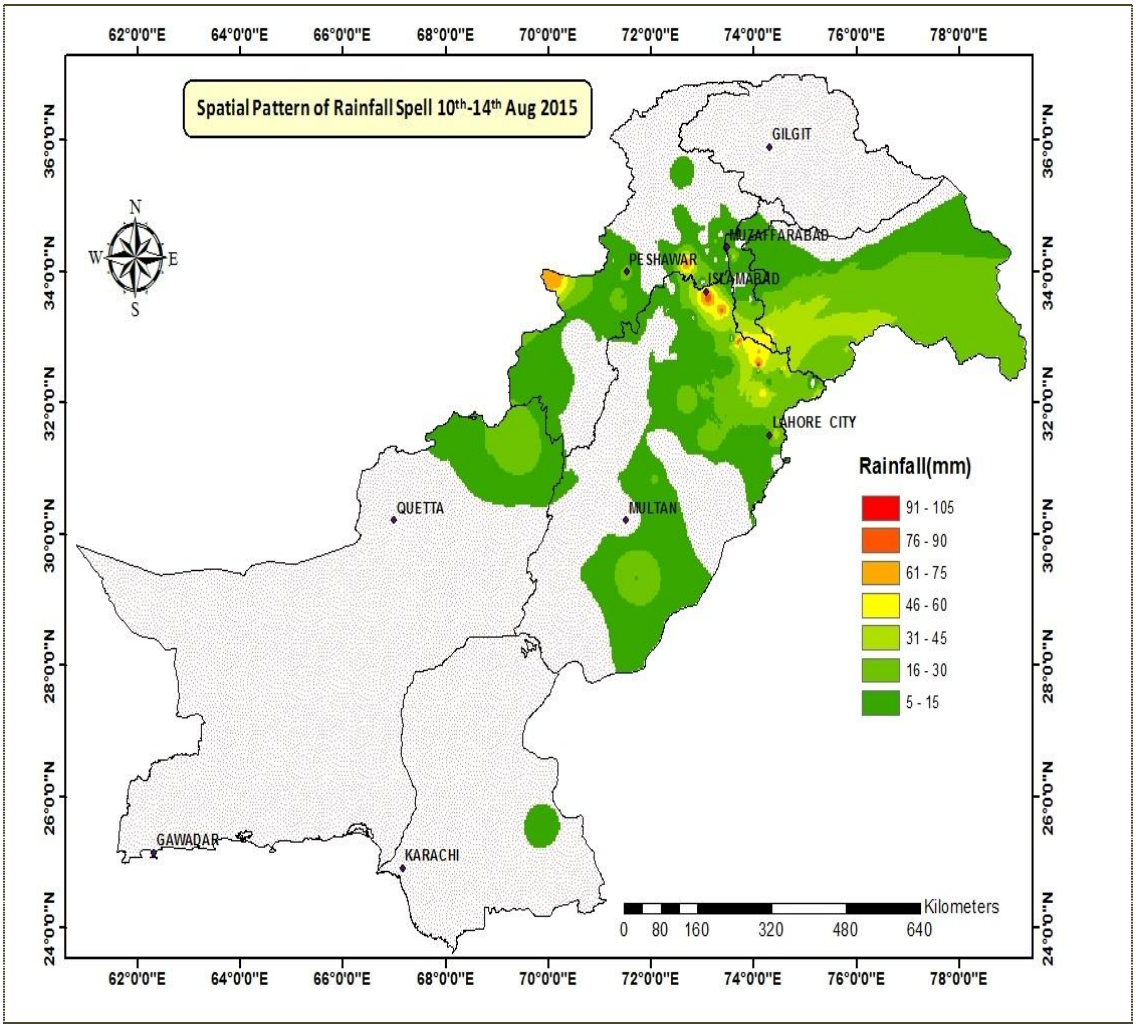


Figure 20: Significant rainfall of August 2015 (10-14 August).

5.5 Position of rivers during the second spell of August

During this spell, High flood situation upstream was recorded in river Jhelum at Mangla.

5.6 Third wet spell of August (21st to 23rd August 2015)

Third spell in August was caused due to passage of westerly wave along with accentuation of seasonal low. Figure 21 shows this situation with a strong southwesterly flow at lower level. Warm moist air from the Arabian Sea interacted with cold dry air producing significant rainfall in Lahore, Peshawar and Islamabad. Spatial distribution of rainfall during the spell is shown in figure 22.

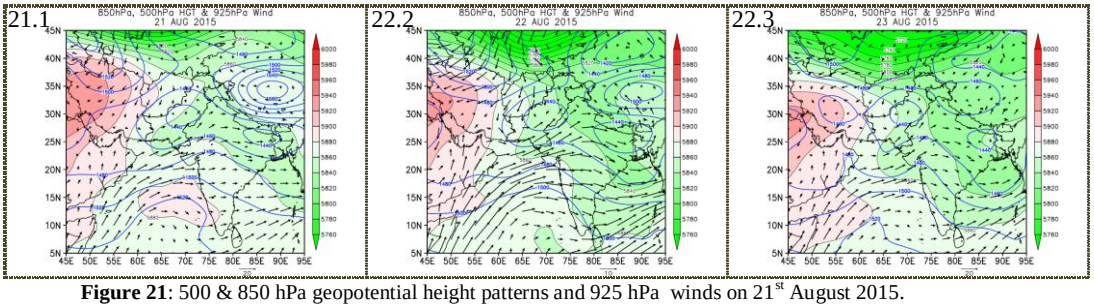


Figure 21: 500 & 850 hPa geopotential height patterns and 925 hPa winds on 21st August 2015.

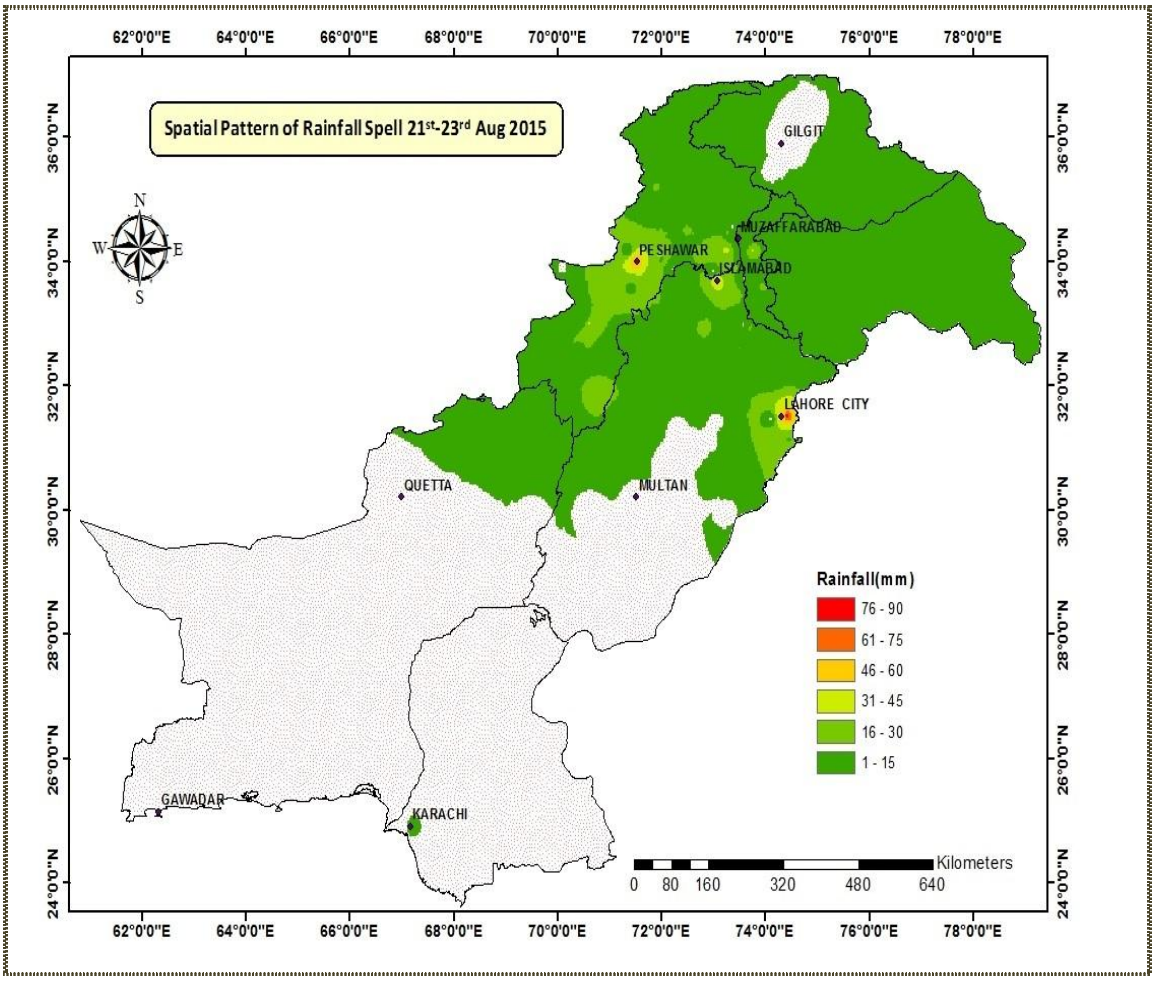


Figure 22: Significant rainfall of August 2015 (21-23 August).

5.7 Position of rivers during the Spell

No significant flood situation was observed in all the major rivers.

5.8 Spatial pattern of rainfall during the month of August 2015

The monthly isohyetal pattern during the month of August shown in figure 23 indicates normal monsoon activity over most parts of the country. Rainfall maxima exceeding 300 mm in the month of August, 2015 was located around Mianwali while another maxima

of slightly of less than 300 mm was found around Cherat. Figure 24 shows the temporal distribution of rainfall during the month of August.

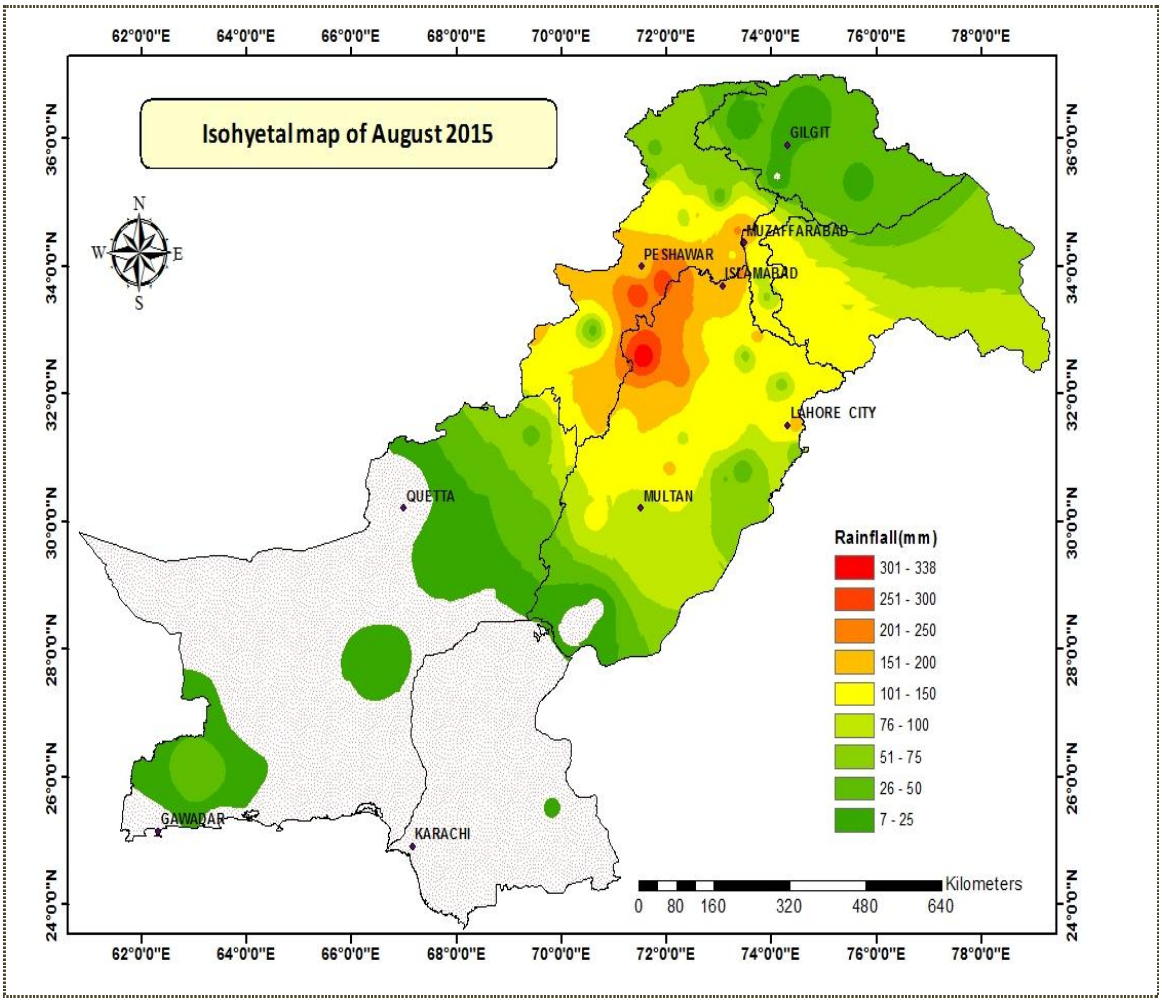


Figure 23: Isohyetal map of August 2015.

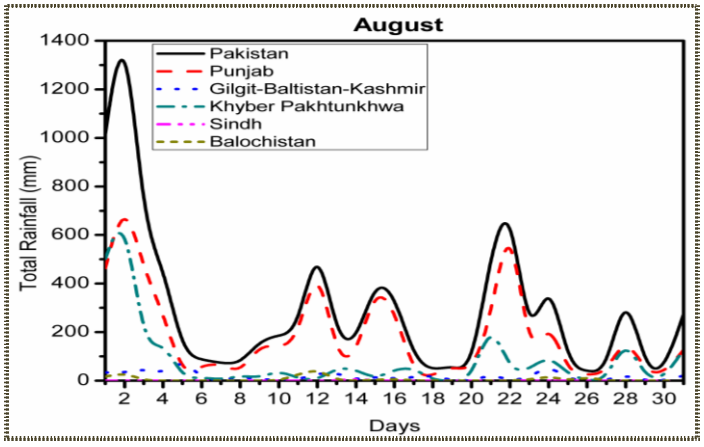


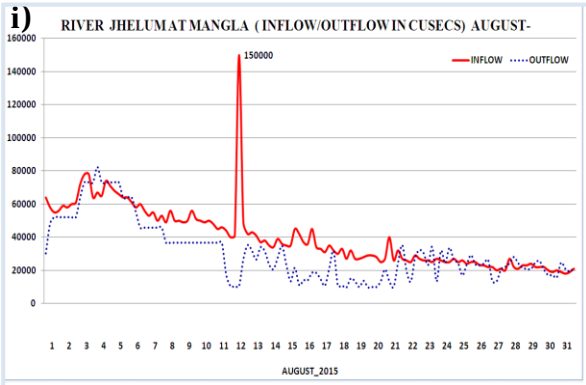
Figure 24: Temporal distribution of rainfall during August 2015.

5.9 Position of rivers during the month

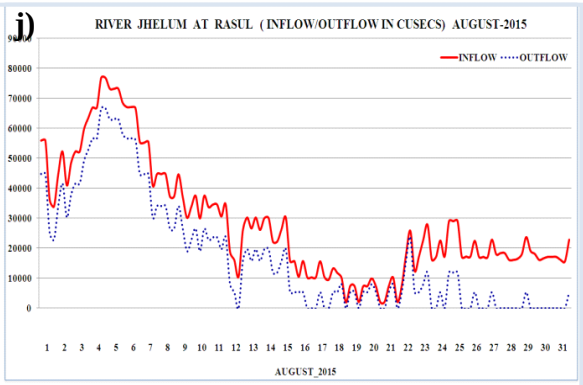
Date	River	Stations	Up-stream (cusecs)	Level
2/8/2015	Indus	Tarbela	381000	Medium
06/8/2015	Indus	Tarbela	421000	Medium
02/8/2015	Indus	Kalabagh	533098	High
07/8/2015	Indus	Kalabagh	484275	Medium
03/8/2015	Indus	Chashma	638652	High
08/8/2015	Indus	Chashma	540630	High
05/8/2015	Indus	Taunsa	604714	High
10/8/2015	Indus	Taunsa	522175	High
3/8/2015	Indus	Guddu	754005	V. High
8/8/2015	Indus	Guddu	725324	V. High
4/8/2015	Indus	Sukkur	707256	V. High
09/8/2015	Indus	Sukkur	698385	High
17/8/2015	Indus	Kotri	634919	High
02/8/2015	Kabul	Nowshera	165800	High
09/8/2015	Chenab	Marala	146450	Low
9/8/2015	Chenab	Khanki	132885	Low
10/8/2015	Chenab	Marala	118210	Low
3/8/2015	Jhelum	Mangla	79000	Low
12/8/2015	Jhelum	Mangla	150000	High
10/8/2015	Jhelum	Rasul	76862	Low

5.10 Hydrographs observed during the month of August 2015 are as under

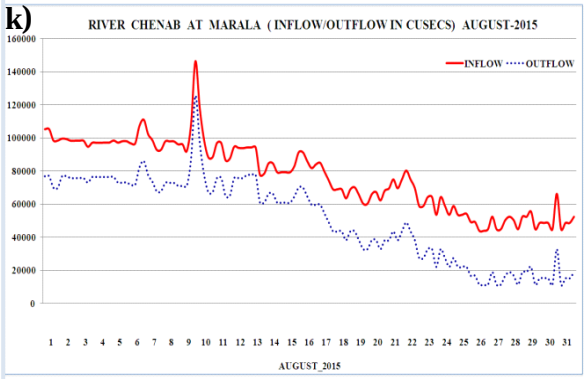
i)


RIVER JHELUM AT MANGLA (INFLOW/OUTFLOW IN CUSECS) AUGUST-
INFLOW
OUTFLOW
150000
AUGUST_2015

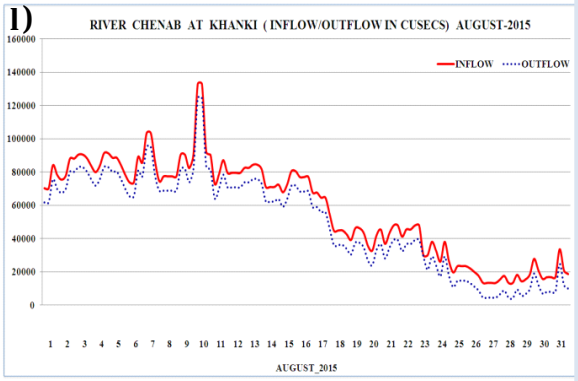
j)


RIVER JHELUM AT RASUL (INFLOW/OUTFLOW IN CUSECS) AUGUST-2015
INFLOW
OUTFLOW
AUGUST_2015

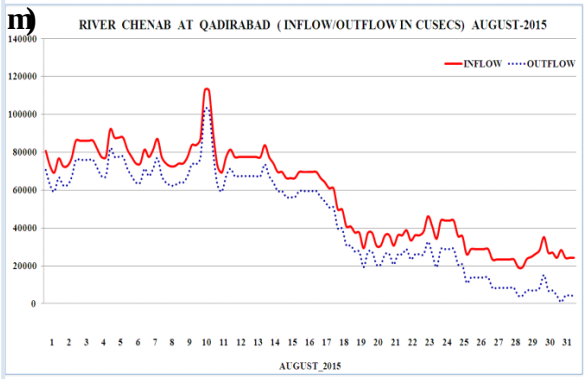
k)


RIVER CHENAB AT MARALA (INFLOW/OUTFLOW IN CUSECS) AUGUST-2015
INFLOW
OUTFLOW
AUGUST_2015

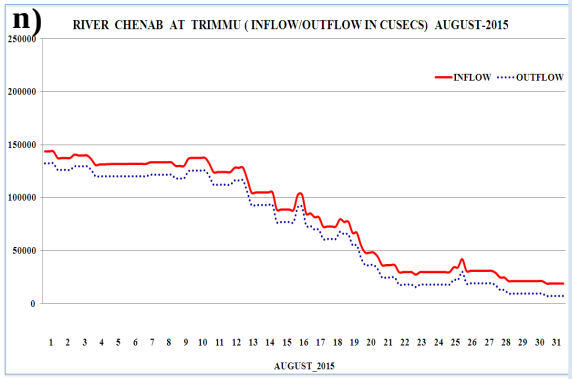
l)


RIVER CHENAB AT KHANKI (INFLOW/OUTFLOW IN CUSECS) AUGUST-2015
INFLOW
OUTFLOW
AUGUST_2015

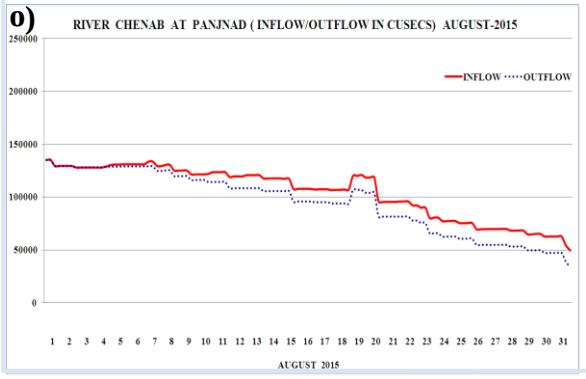
m)


RIVER CHENAB AT QADIRABAD (INFLOW/OUTFLOW IN CUSECS) AUGUST-2015
INFLOW
OUTFLOW
AUGUST_2015

n)


RIVER CHENAB AT TRIMMU (INFLOW/OUTFLOW IN CUSECS) AUGUST-2015
INFLOW
OUTFLOW
AUGUST_2015

o)


RIVER CHENAB AT PANJNAD (INFLOW/OUTFLOW IN CUSECS) AUGUST-2015
INFLOW
OUTFLOW
AUGUST_2015

p)

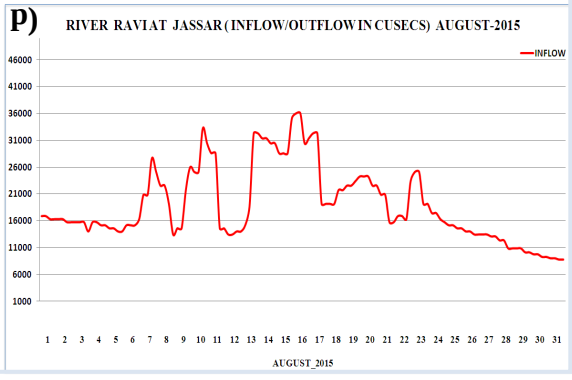

RIVER RAVI AT JASSAR (INFLOW/OUTFLOW IN CUSECS) AUGUST-2015
INFLOW
AUGUST_2015

Figure 25: Hydrographs for the month of August, River Indus at, a) Tarbela, b) Kalabagh, c) Chashma, d) Taunsa, e) Guddu, f) Sukkur, g) Kotri, River Kabul at, h) Nowshera, River Jhelum at, i) Mangla j) Rasul, River Chenab at, k) Marala, l) Khanki, m) Qadriabad, n) Trimmu, o) Panjnad, River Ravi at, p) Jassar, q) Shahdra, r) Balloki, s) Sidhnai, River Sutlej at, t) G. S. Wala, u) Sulemanki and v) Islam.

6 Significant hydro-meteorological events during the month of September 2015

Only one monsoon low developed during the month of September over Bay of Bengal on 14th of the month. After moving west northwestward it reached over Gujarat on 19th and then moved north-northeast wards and finally dissipated over Kashmir on 23rd.

6.1 First wet spell of September (20th to 27th September 2015)

The only rainy spell of September occurred during 20th to 27th September 2015. During this period heavy rainfall was reported from North & Northeast Punjab and Kashmir. This situation was raised by the presence of the monsoonal low. This weather system was developed over Bay of Bengal in the mid of September which shown in figure 26. It after reaching the Indian state of Gujarat and Rajasthan tracked northeast wards along the eastern boundary of Pakistan finally dissipated in Kashmir. As the weather system moved northeast wards the direct moisture feeding from the Arabian Sea was cut off by 23rd September. This was accompanied by the presence of strong westerly wave over most parts of Pakistan. This strong westerly wave pushed the subtropical high eastwards. During the rainy period a jet stream at 300 hPa was extending from the northwestern borders of Pakistan to the upper parts of the country. This can be witnessed in figure 27. The northeast ward movement of the monsoonal weather system caused heavy rainfall in parts of Punjab and Kashmir. Figure 28 shows the spatial distribution of this rainfall spell.

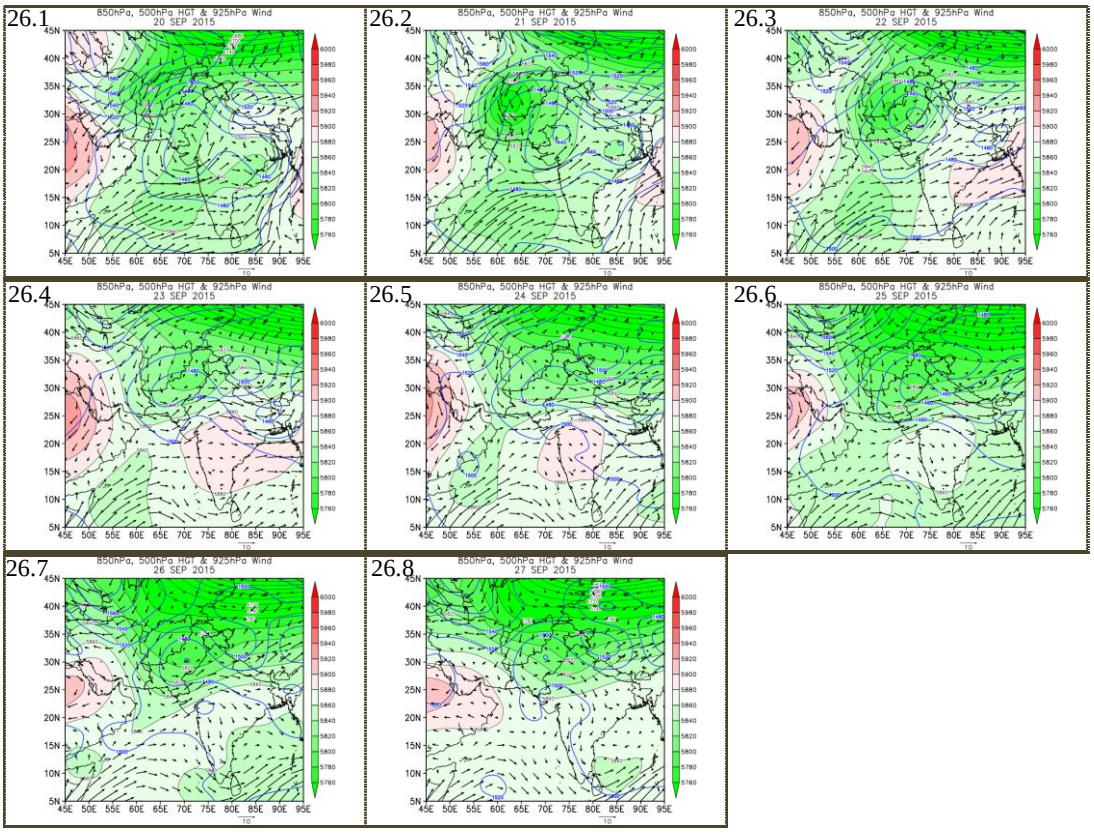


Figure 26: 500 & 850 hPa geopotential height patterns and 925 hPa winds on 20th September 2015.

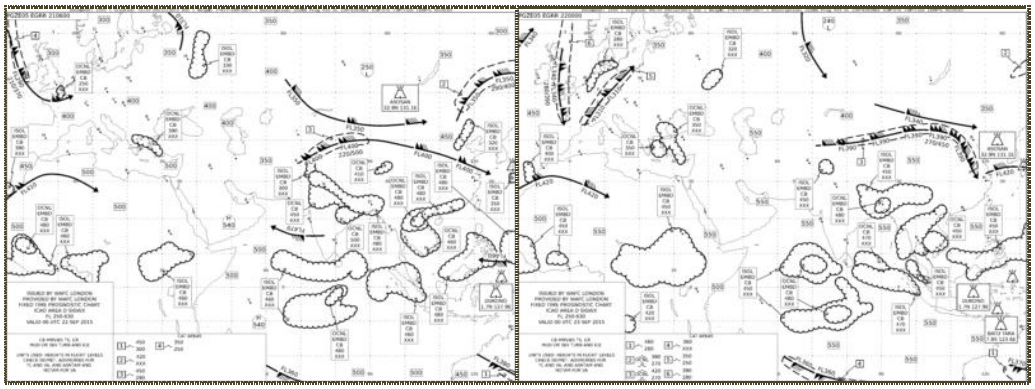


Figure 27: 300 hPa jet stream on 22nd & 23rd September-2015

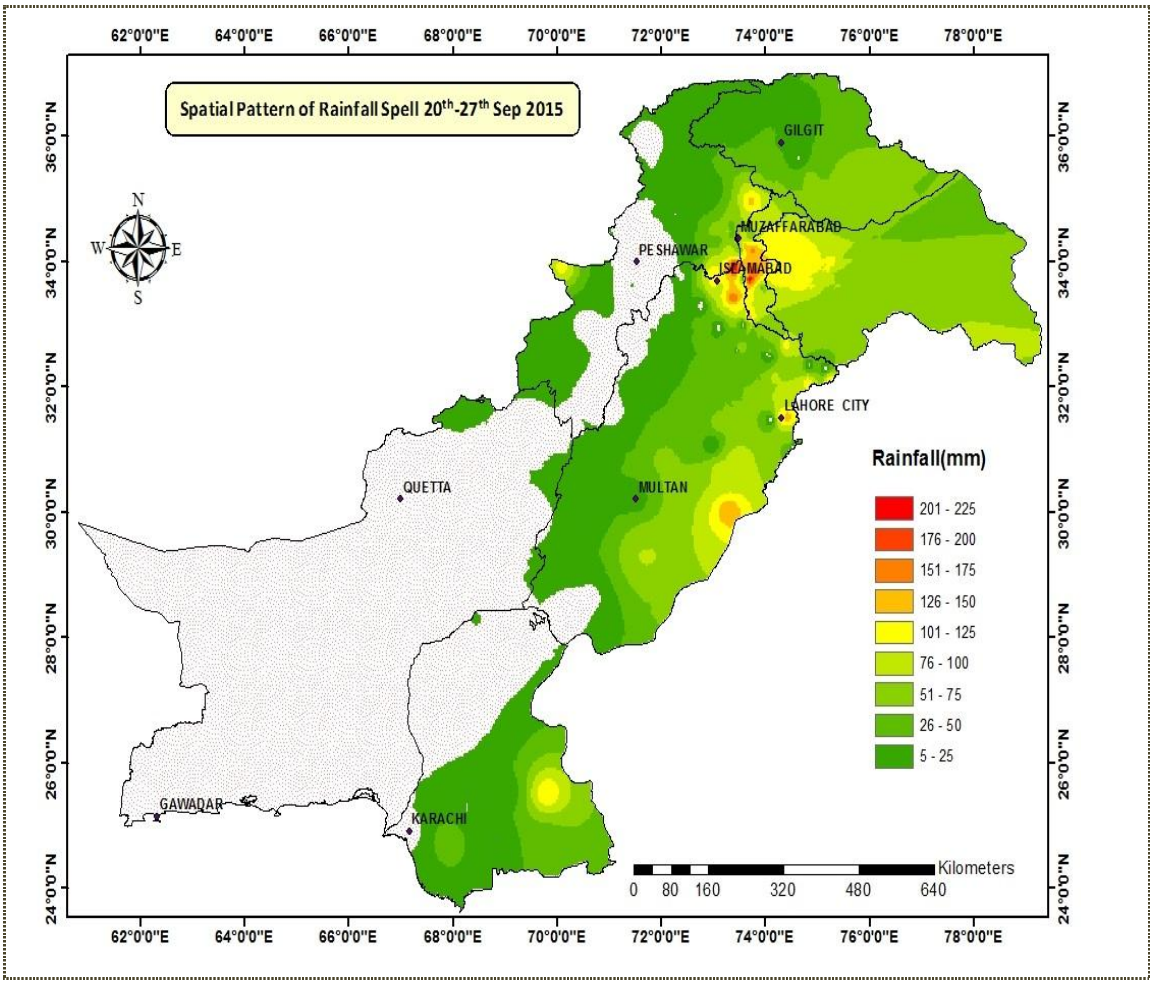


Figure 28: Significant rainfall of September 2015 (20-27 September).

6.2 Satellite Images of 22nd September 2015:

Cloud mass monitored by satellite during the spell is shown in figure 29. It shows a center of deep convection developing along the north eastern border of Pakistan at 1045 UTC of 22nd September 2015. While northern parts of the country are covered by thick sheet of perceptible clouds. Center of convective clouds grew to its maximum by 1415 UTC and then gradually begin to subside.

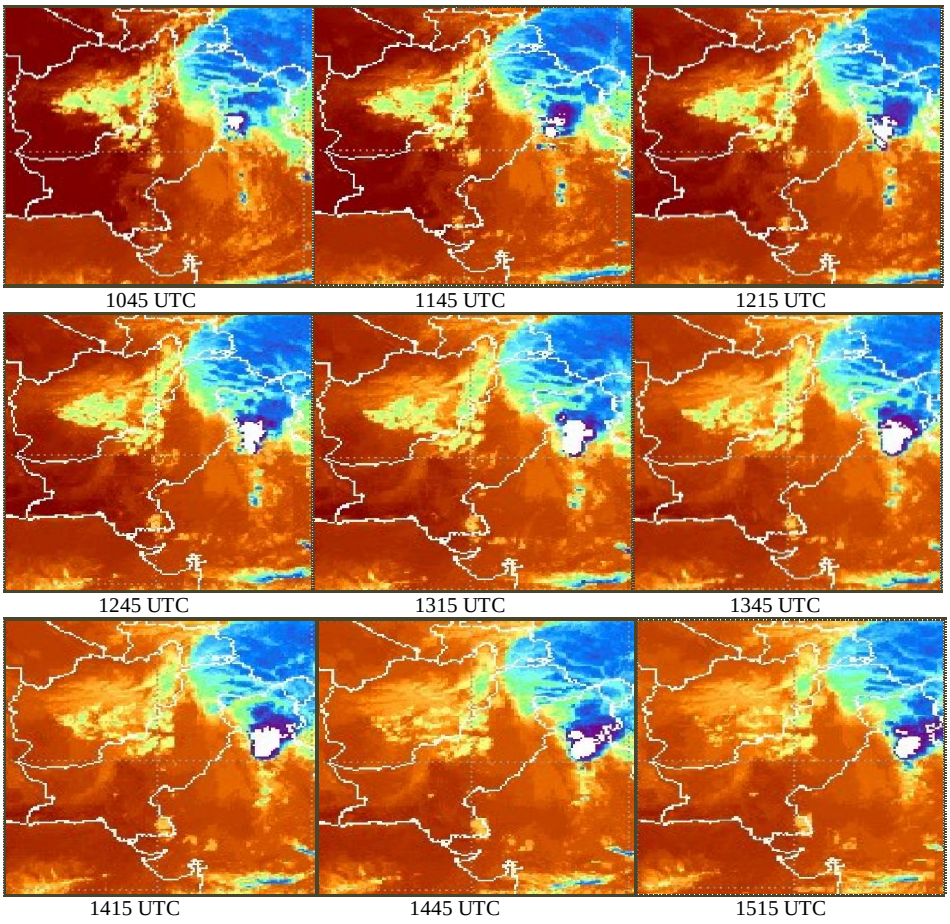


Figure 29: Satellite Images of 22nd Sep 2015.

6.3 Position of rivers during the month of September

Due to this spell river Jhelum at Mangla (upstream) attained High flood level. Medium flood level was recorded in river Chenab at Marala, Khanki and Qadirabad and in river Ravi at Balloki. Low flood level was also recorded in river Ravi at Jassar and Sidhnai.

6.4 Spatial pattern of rainfall during the month of September 2015

A rainfall maximum of more than 240 mm was located around North Punjab near Murree as shown in figure 30.

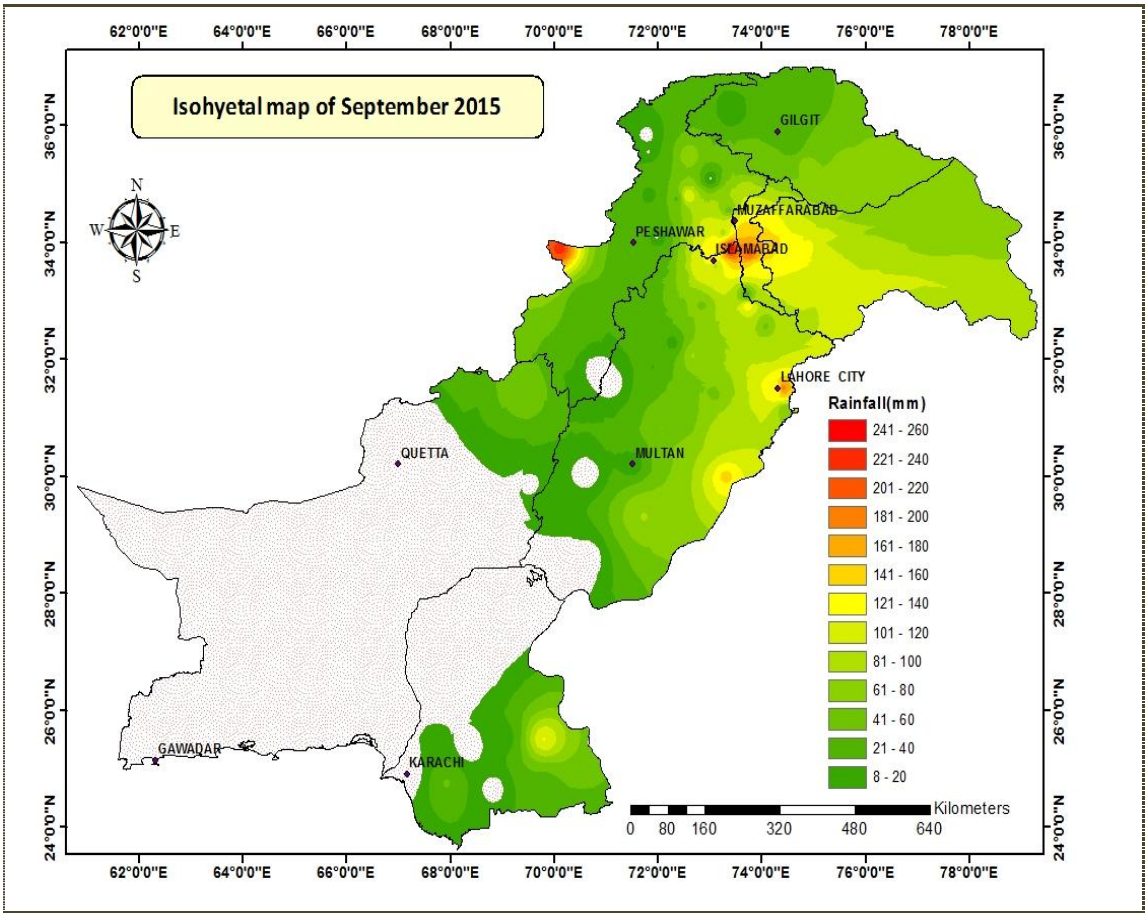


Figure 30: **Isohyetal map of September 2015.**

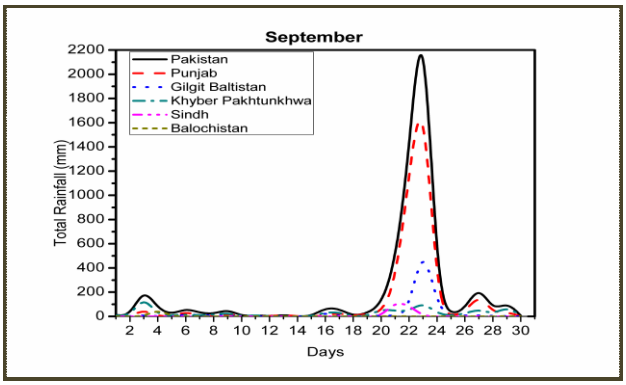


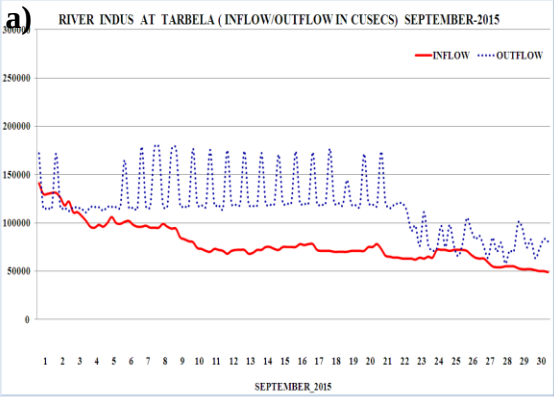
Figure 31: Temporal distribution of rainfall during September 2015 (20-27 September).

6.5 Position of rivers during the month of September

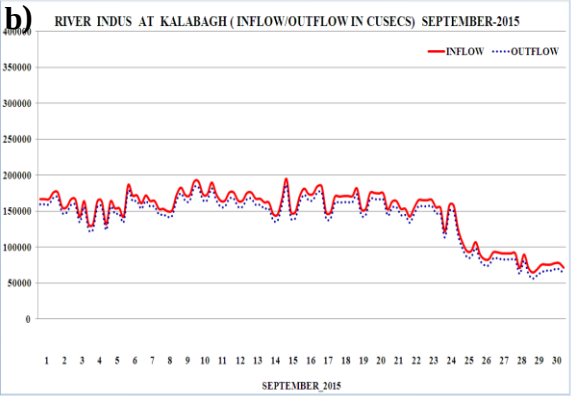
Date	River	Stations	Up-stream (Cusecs)	Level
23/09/2015	Chenab	Marala	180749	Medium
23/09/2015	Chenab	Khanki	154211	Medium
24/09/2015	Chenab	Qadirabad	166140	Medium
23/09/2015	Jhelum	Mangla	172000	High
24/09/2015	Ravi	Jassar	62652	Low
24/09/2015	Ravi	Balloki	73740	Medium
27/09/2015	Ravi	Sidhnai	44370	Low

6.6 Hydrographs observed during the month of September 2015 are as under

a)



b)



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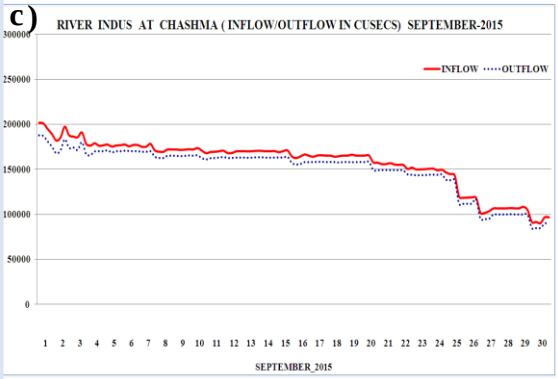

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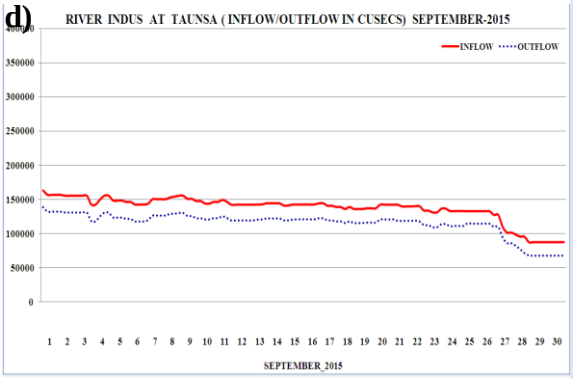

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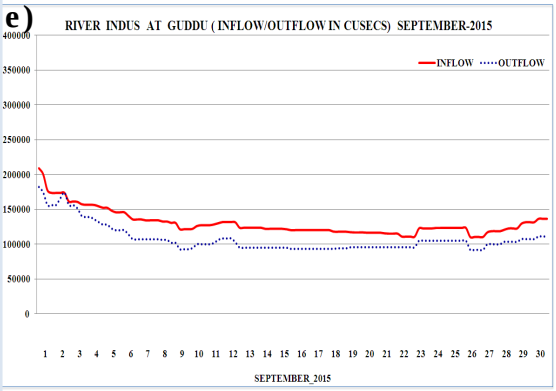
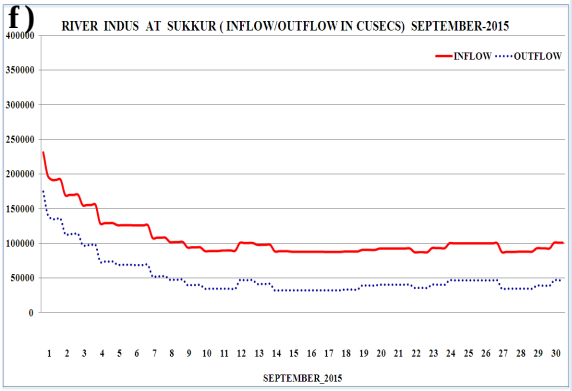


f)



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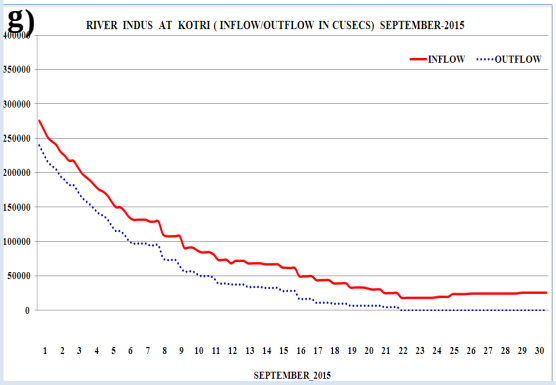

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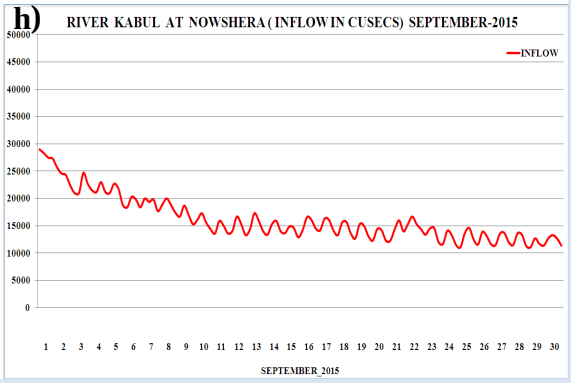
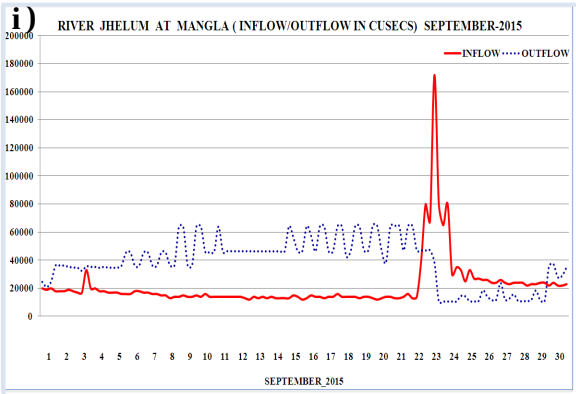
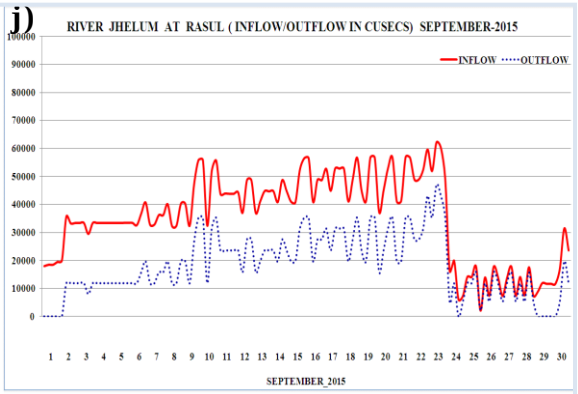


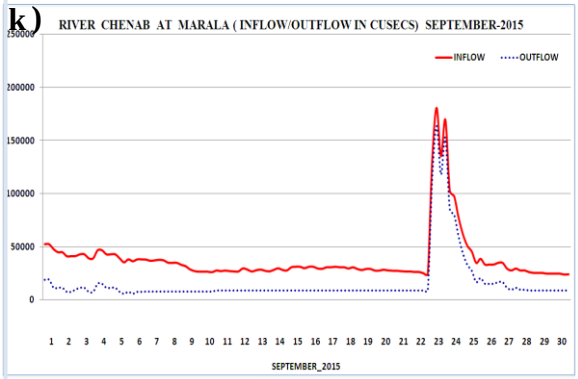
i)


RIVER JHELUM AT MANGLA (INFLOW/OUTFLOW IN CUSECS) SEPTEMBER-2015
INFLOW
OUTFLOW
SEPTEMBER_2015

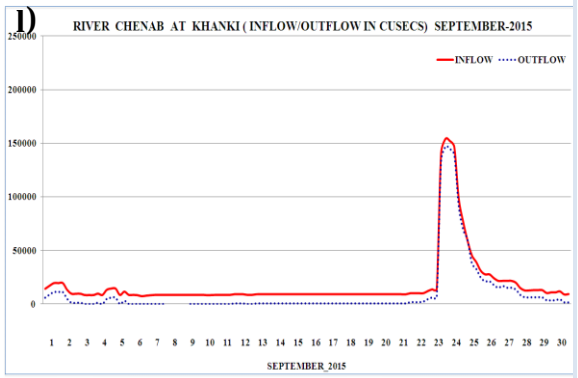
j)


RIVER JHELUM AT RASUL (INFLOW/OUTFLOW IN CUSECS) SEPTEMBER-2015
INFLOW
OUTFLOW
SEPTEMBER_2015

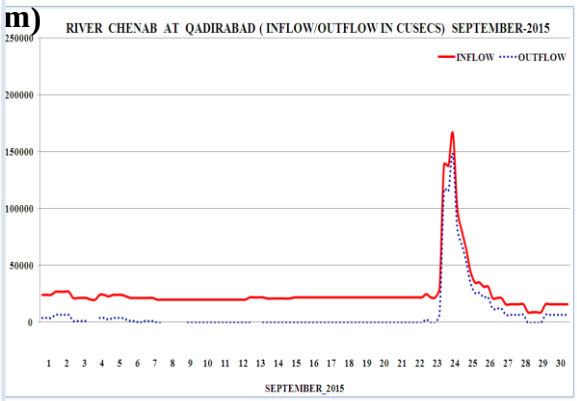
k)


RIVER CHENAB AT MARALA (INFLOW/OUTFLOW IN CUSECS) SEPTEMBER-2015
INFLOW
OUTFLOW
SEPTEMBER_2015

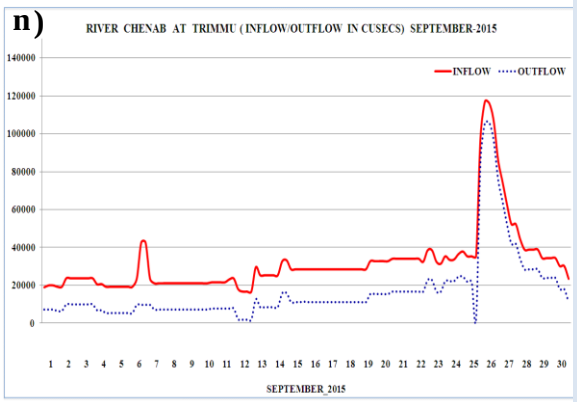
l)


RIVER CHENAB AT KHANKI (INFLOW/OUTFLOW IN CUSECS) SEPTEMBER-2015
INFLOW
OUTFLOW
SEPTEMBER_2015

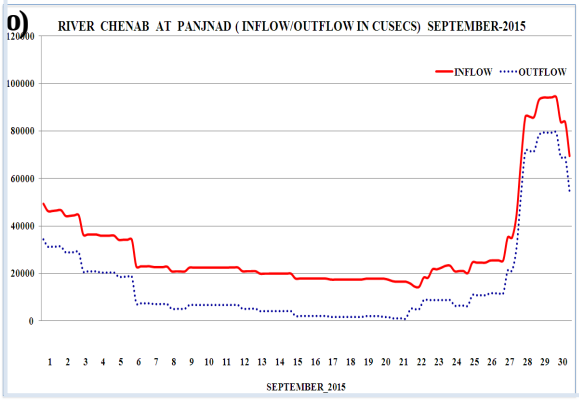
m)


RIVER CHENAB AT QADIRABAD (INFLOW/OUTFLOW IN CUSECS) SEPTEMBER-2015
INFLOW
OUTFLOW
SEPTEMBER_2015

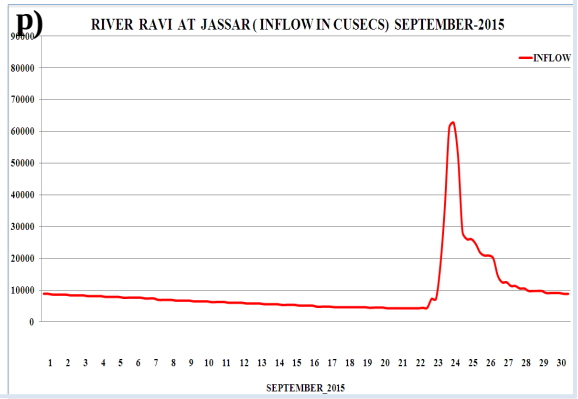
n)


RIVER CHENAB AT TRIMMU (INFLOW/OUTFLOW IN CUSECS) SEPTEMBER-2015
INFLOW
OUTFLOW
SEPTEMBER_2015

o)


RIVER CHENAB AT PANJNAD (INFLOW/OUTFLOW IN CUSECS) SEPTEMBER-2015
INFLOW
OUTFLOW
SEPTEMBER_2015

p)


RIVER RAVI AT JASSAR (INFLOW IN CUSECS) SEPTEMBER-2015
INFLOW
SEPTEMBER_2015

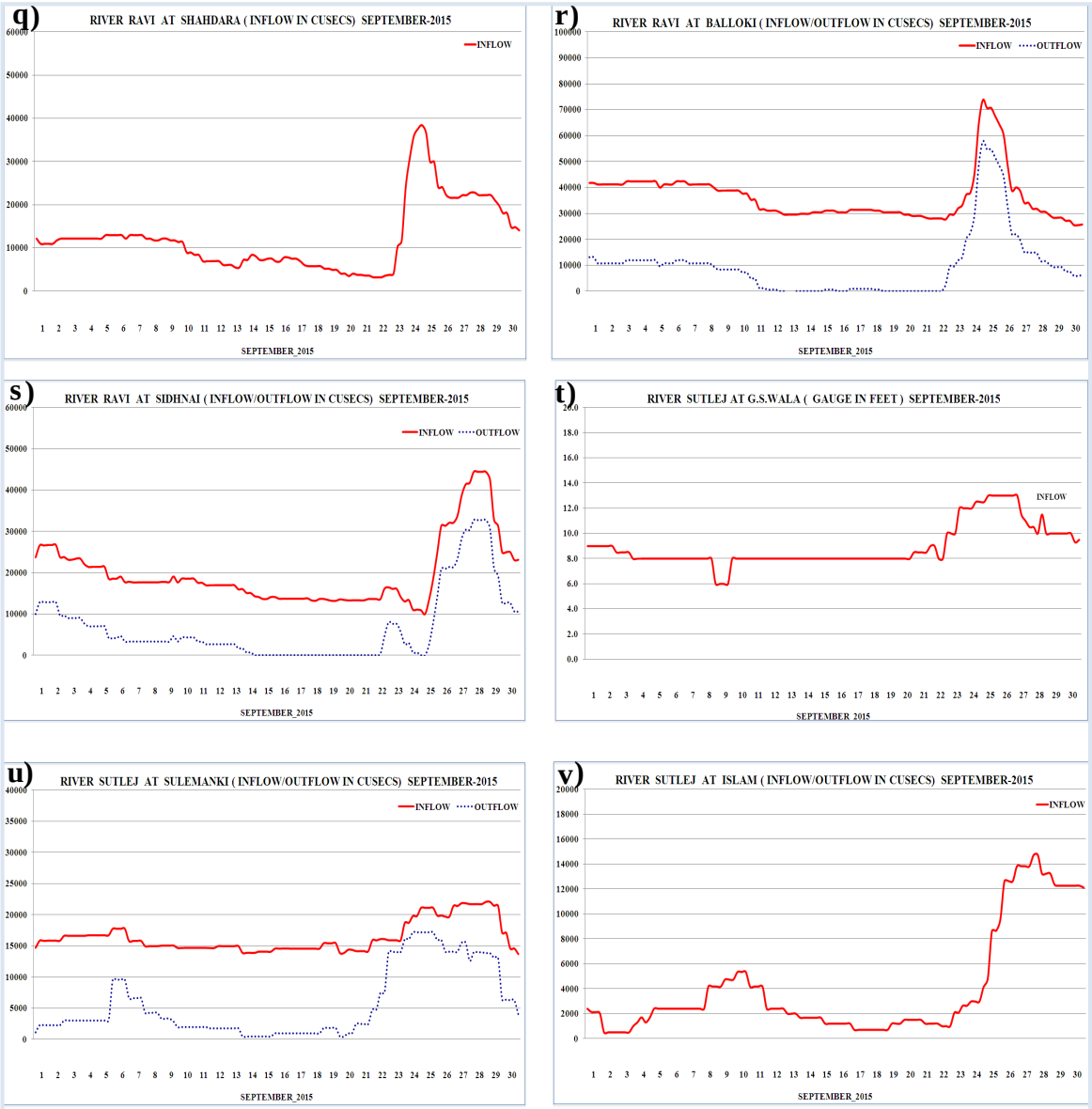


Figure 32: Hydrographs for the month of September, River Indus at, a) Tarbela, b) Kalabagh, c) Chashma, d) Taunsa, e) Guddu, f) Sukkur, g) Kotri, River Kabul at, h) Nowshera, River Jhelum at, i) Mangla j) Rasul, River Chenab at, k) Marala, l) Khanki, m) Qadriabad, n) Trimmu, o)Panjnad, River Ravi at, p) Jassar, q) Shahdra, r) Balloki, s) Sidhnai, River Sutlej at, t) G. S. Wala, u) Sulemanki and v) Islam.

7 Significant impact of snowmelt on flows in River Indus

Most significant flood peaks of Flood Season 2015 in River Indus were due to the increase in mean minimum temperature over the upper catchment of River Indus (Bunji, Hunza, Astore, Skardu, Chitral, Dir & Saidusharif) during July and August. Under these

conditions base flow remained above normal .These higher base flows synchronized with flows from Kabul and Soan Rivers along with flows from Kurram River.

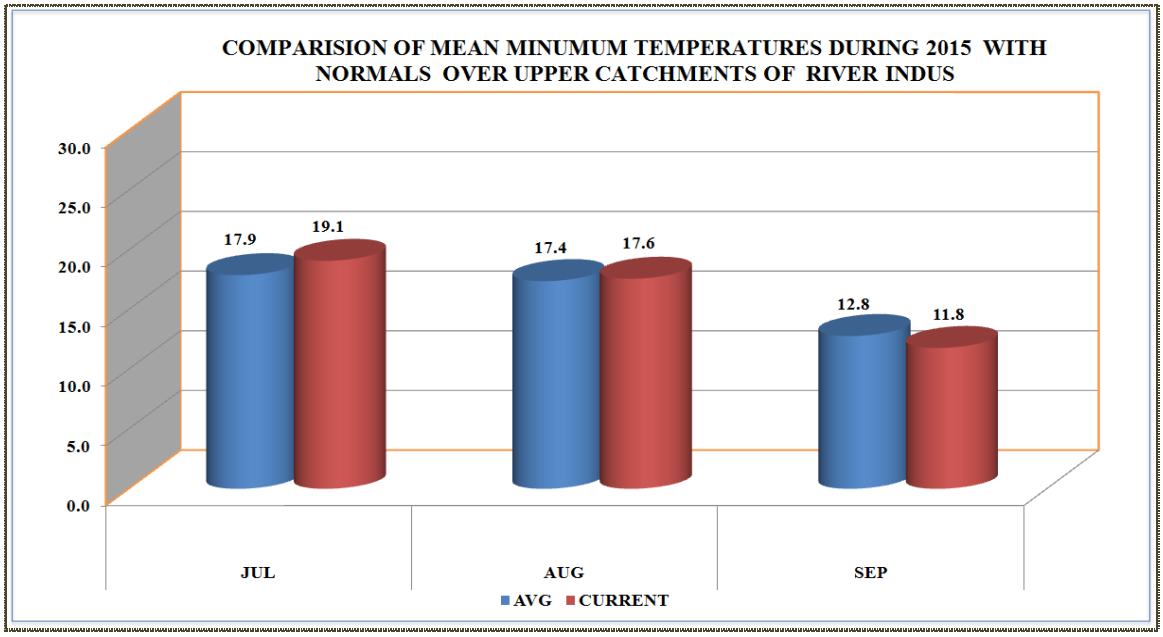


Figure 33: River Indus catchment minimum temperature comparison (July-August).

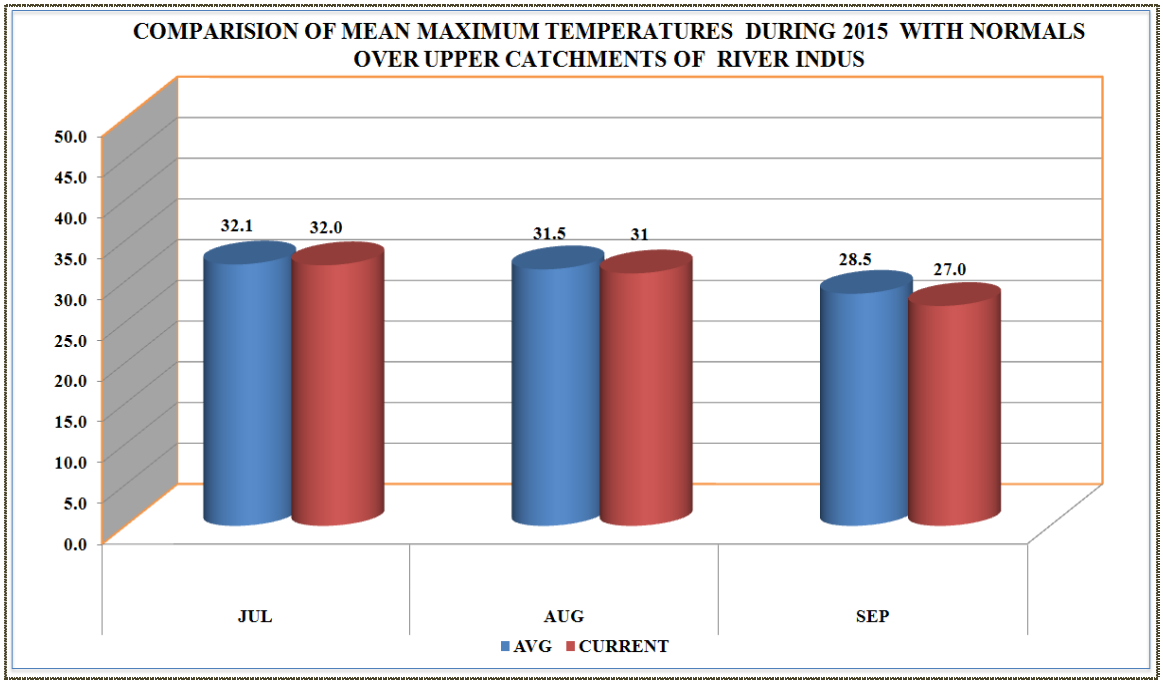


Figure 34: River Indus catchment maximum temperature comparison (July-August).

8 Seasonal rainfall pattern July to September 2015

Seasonal rainfall pattern during the season is shown in figure 34. Region of maximum precipitation (more than 900 mm) is located over Murree in North Punjab; West Balochistan remained almost dry during the season.

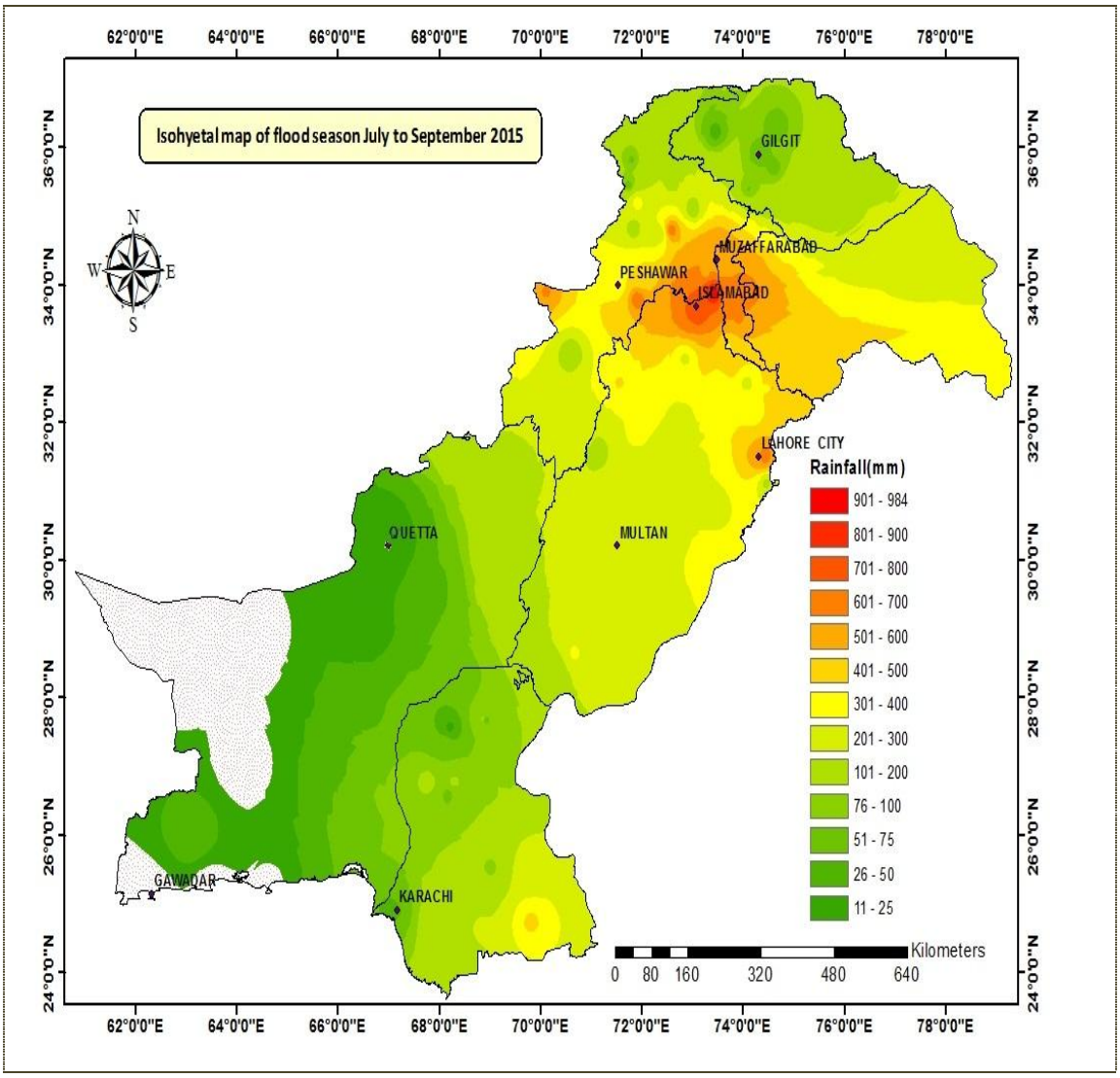


Figure 35: Seasonal isohyetal map (July-September-2015).

9 Seasonal area weighted precipitation from July-September 2015

The seasonal percentage departure precipitation map obtained from Climate Data Processing Centre (CDPC) of Pakistan Meteorological Department for monsoon 2015 indicates 27% more than normal precipitation on all Pakistan basis scattering it at provincial level it is observed that Khyber Pakhtunkhwa, Punjab, Gilgit Baltistan and Sindh received 37%, 55%, 116% and 4% respectively above normal rainfall while Kashmir received relatively less rainfall where precipitation remained 2% below normal

and Balochistan received 30% below normal rainfall as shown figure 36.Isopercental map of rainfall also prepared which is shown in figure 37.

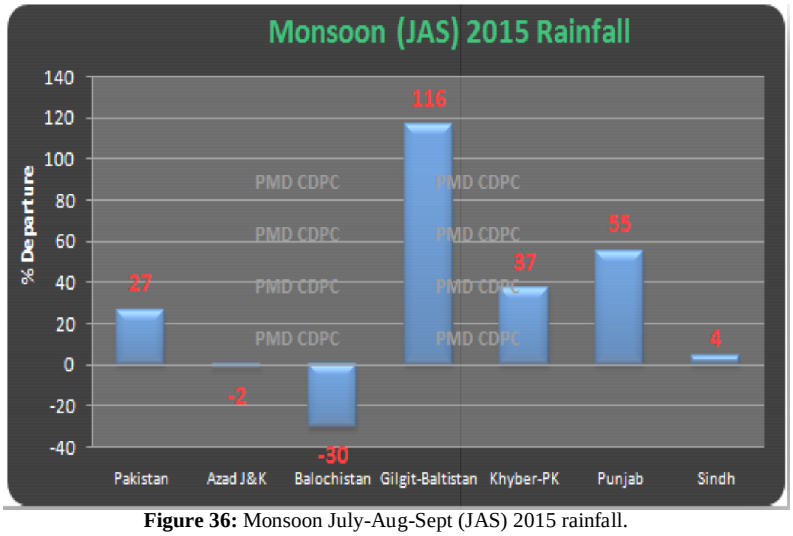


Figure 36: Monsoon July-Aug-Sept (JAS) 2015 rainfall.

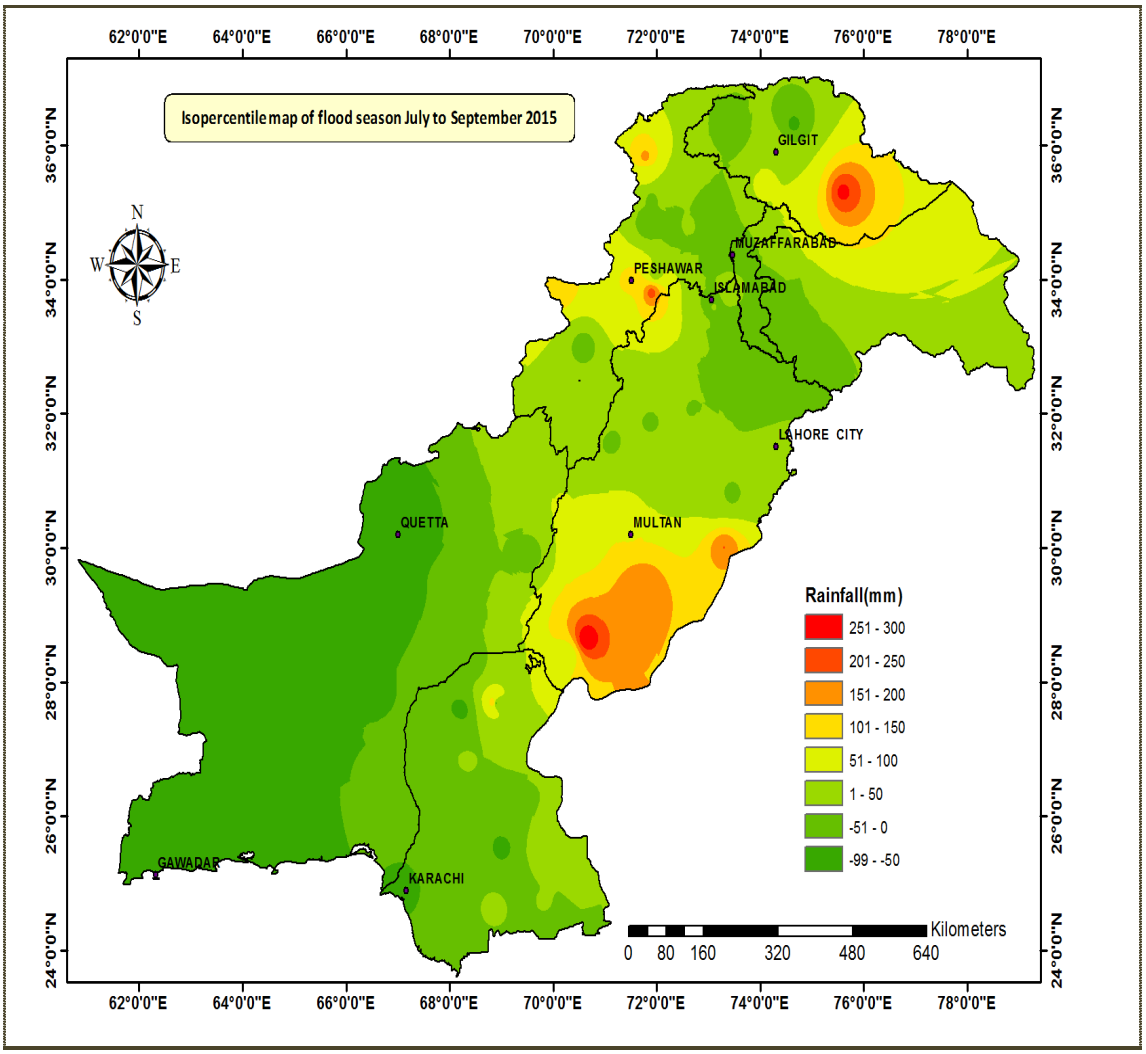


Figure 37: Seasonal percentage departure map (July-September 2015).

10 Kharif season forecast

Water availability (MAF) forecast for kharif season was issued on 02nd April, 2015 for River Indus at Tarbela & River Jhelum at Mangla. Comparison of forecasted and observed volume (MAF) is shown in fig 38:

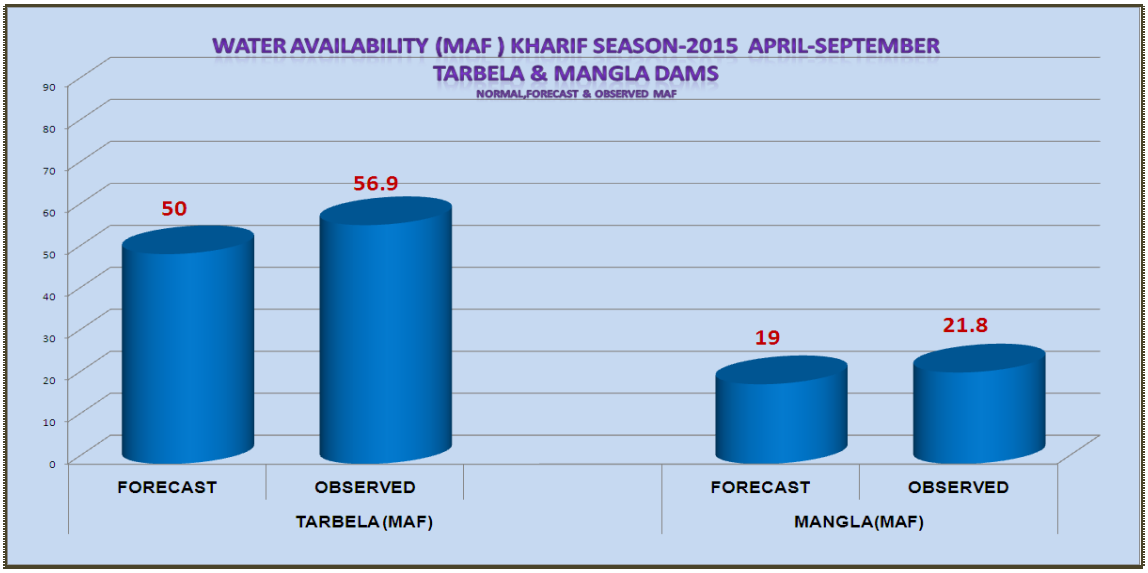


Figure 38: Seasonal percentage departure map (July-September 2015).

11 Flood forecast evaluation report

The Flood Forecast evaluation report for 2015 for all categories of flood is given below:

Date	Rivers	Station	Inflows (cusecs)	Forcast issued	% ac.
25/6/2015	Jhelum	Mangla	149000	70000-90000	60
22/6/2015	Kabul	Nowshera	93300	85000-95000	98
10/7/2015	Indus	Tarbela	338000	325000-355000	100
17/7/2015	Indus	Tarbela	404000	370000-400000	99
23/7/2015	Indus	Tarbela	380000	330000-350000	92
26/7/2015	Indus	Tarbela	490000	370000-440000	90
11/7/2015	Kabul	Nowshera	100700	85000-90000	90
20/7/2015	Kabul	Nowshera	115900	90000-110000	95
27/7/2015	Kabul	Nowshera	133500	90000-120000	90
12/7/2015	Indus	Kalabagh	358036	230000 R 320000	89
19/7/2015	Indus	Kalabagh	461665	400000-440000	95
27/7/2015	Indus	Kalabagh	517167	480000 R 600000	100

13/7/2015	Indus	Chashma	412793	300000 R 380000	92
19/7/2015	Indus	Chashma	502808	420000 R 510000	100
28/7/2015	Indus	Chashma	589090	460000-540000	92
16/7/2015	Indus	Taunsa	333752	290000-370000	100
22/7/2015	Indus	Taunsa	459732	420000-480000	100
30/7/2015	Indus	Taunsa	539677	530000 R 600000	100
20/7/2015	Indus	Guddu	356243	340000-370000	100
27/7/2015	Indus	Guddu	570768	500000-530000	93
31/7/2015	Indus	Guddu	722862	590000-650000	90
21/7/2015	Indus	Sukkur	283212	270000-290000	100
29/7/2015	Indus	Sukkur	539025	540000-570000	100
9/7/2015	Chenab	Marala	159315	900000-120000	75
12/7/2015	Chenab	Marala	183431	90000 R 160000	87
17/7/2015	Chenab	Marala	148610	160000 R 210000	93
26/7/2015	Chenab	Marala	145300	120000-150000	100
9/7/2015	Chenab	Khanki	132978	50000-90000	67
13/7/2015	Chenab	Khanki	157535	80000 R 130000	83
17/7/2015	Chenab	Khanki	119100	160000 R 210000	74
10/7/2015	Chenab	Qadirabad	138491	100000-140000	100
11/7/2015	Chenab	Qadirabad	146723	90000-130000	89
18/7/2015	Chenab	Qadirabad	125886	160000-210000	79
29/7/2015	Chenab	Trimmu	150865	145000-175000	100
6/7/2015	Jhelum	Mangla	98000	65000-80000	82
10/7/2015	Jhelum	Mangla	149000	80000-120000	81
21/7/2015	Jhelum	Mangla	196000	70000-100000	51
23/7/2015	Jhelum	Mangla	146000	110000-170000	100
24/7/2015	Jhelum	Mangla	148000	110000-170000	100
26/7/2015	Jhelum	Mangla	176000	90000-145000	82
28/7/2015	Jhelum	Mangla	132000	70000-100000	76
27/7/2015	Jhelum	Rasul	110101	90000-110000	100

19/7/2015	Ravi	Balloki	67180	50000-60000	90
2/8/2015	Indus	Tarbela	381000	350000-380000	100
6/8/2015	Indus	Tarbela	421000	390000-420000	100
2/8/2015	Indus	Kalabagh	533098	530000-580000	100
7/8/2015	Indus	Kalabagh	484275	470000-550000	100
3/8/2015	Indus	Chashma	638652	590000-640000	99
8/8/2015	Indus	Chashma	540630	480000-520000	96
5/8/2015	Indus	Taunsa	604714	545000-585000	97
10/8/2015	Indus	Taunsa	522175	495000-515000	99
3/8/2015	Indus	Guddu	754005	730000-800000	100
8/8/2015	Indus	Guddu	725324	695000-720000	99
4/8/2015	Indus	Sukkur	707256	700000-730000	100
9/8/2015	Indus	Sukkur	698385	675000-700000	100
17/8/2015	Indus	Kotri	634919	630000-650000	100
2/8/2015	Kabul	Nowshera	165800	90000-135000	82
9/8/2015	Chenab	Marala	146450	120000-160000	100
9/8/2015	Chenab	Khanki	132885	110000-150000	100
10/8/2015	Chenab	Marala	118210	90000-130000	100
3/8/2015	Jhelum	Mangla	79000	80000-120000	99
12/8/2015	Jhelum	Mangla	150000	80000-120000	80
23/09/2015	Chenab	Marala	180749	100000-225000	80
23/09/2015	Chenab	Khanki	154211	50000 R 180000	100
24/09/2015	Chenab	Qadirabad	166140	50000 R 180000	100
23/09/2015	Jhelum	Mangla	172000	20000 R 230000	100
24/09/2015	Ravi	Jassar	62652	40000-60000	97
24/09/2015	Ravi	Balloki	73740	50000-85000	100
27/09/2015	Ravi	Sidhnai	44370	30000-50000	100
OVER ALL PERCENTAGE ACCURACY					**92.70%**

R: Rising F: Falling

The overall accuracy of the forecast issued by FFD, Lahore during the flood season 2015 has been calculated which shows a good **92.7%** against all odds.

12 Flood limits (in lacs of cusecs):

RIVER	SITE	DESIGN CAPACITY	LOW	MED	HIGH	V.HIGH	EX.HIGH
KABUL	Nowshera	-	0.45	0.47	1.0	2.0	4.0
	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

13 Flood forecast dissemination

Dissemination of flood forecast and warning is an important part of flood mitigation.

Flood information is communicated on daily basis on respective mode of communication, phone/fax, cellular phone numbers and email addresses of all the concerned authorities. In this regard the contact numbers are collected /verified in pre flood season. The detail diagram of all the concerned authorities/agencies is shown below.

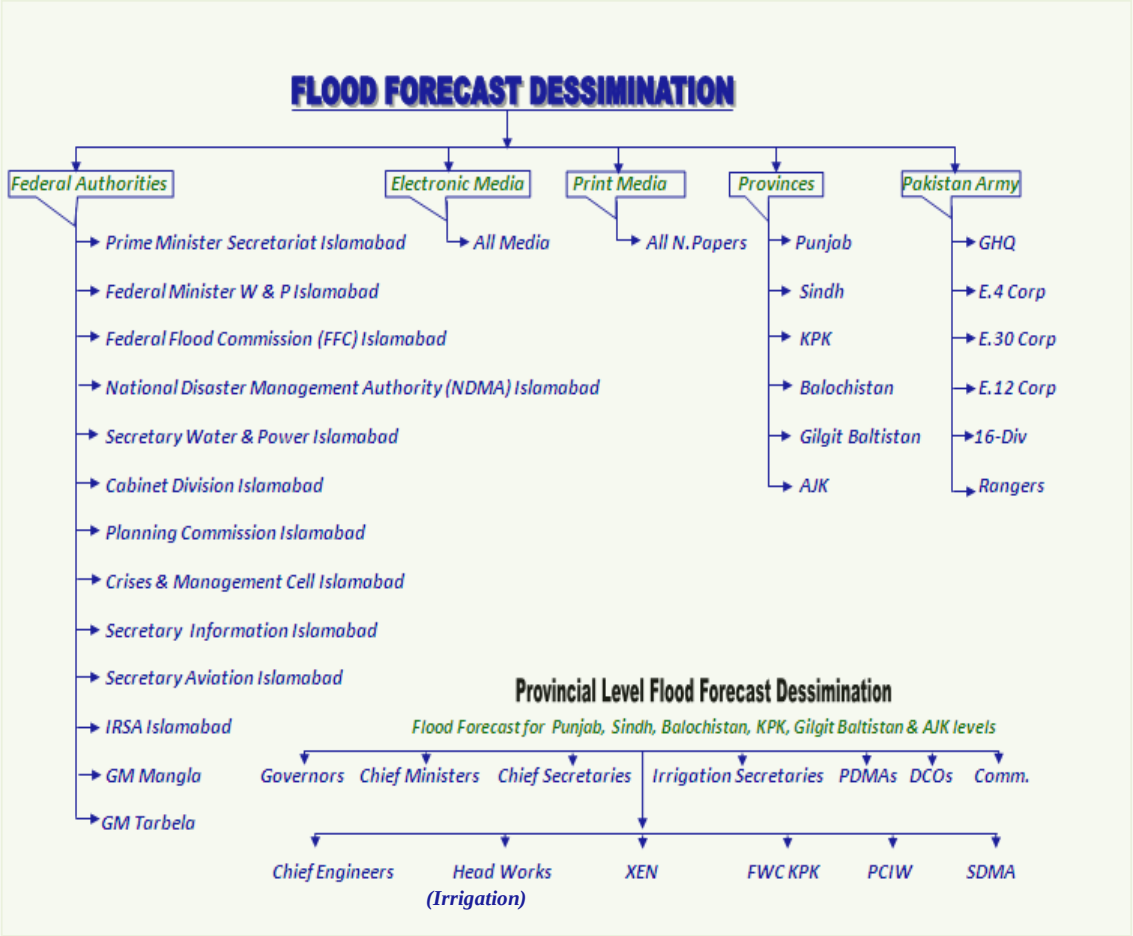
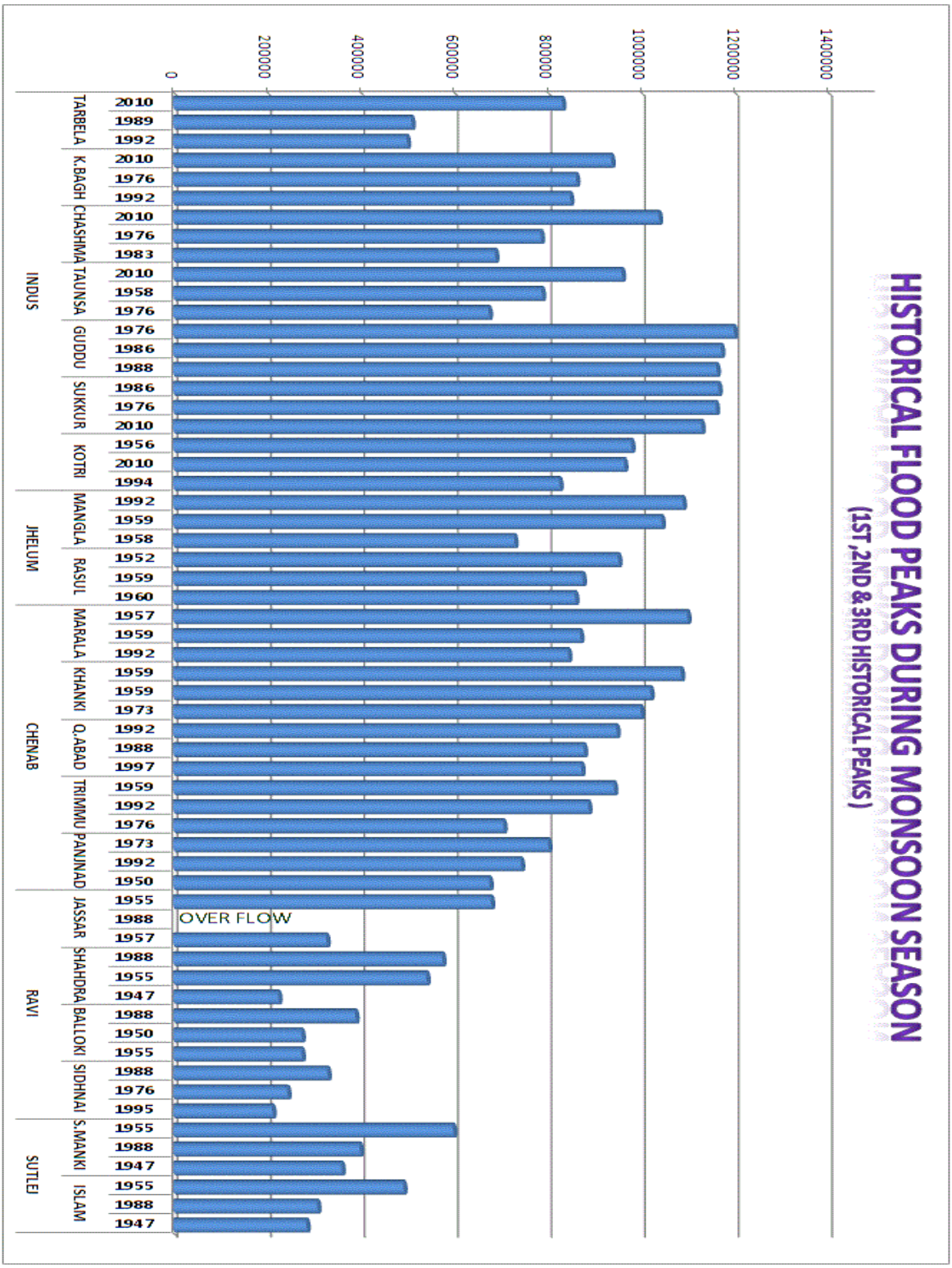


Figure 39: Flood Forecast Dissemination chart.


HISTORICAL FLOOD PEAKS DURING MONSOON SEASON
(1ST ,2ND & 3RD HISTORICAL PEAKS)
0
200000
400000
600000
800000
1000000
1200000
1400000
INDUS
TARBELA 2010 1989 1992
K.BAGH 2010 1976 1992
CHASHMA 2010 1976 1983
TAUNSA 2010 1958 1976
GUDDU 1976 1986 1988
SUKKUR 1986 1976 2010
KOTRI 1956 2010 1994
JHELUM
MANGLA 1992 1959 1958
RASUL 1952 1959 1960
CHENAB
MARALA 1957 1959 1992
KHANKI 1959 1959 1973
Q.ABAD 1992 1988 1997
TRIMMU 1959 1992 1976
PANJNAD 1973 1992 1950
RAVI
JASSAR 1955 1988 1957
SHAHDRA 1988 1955 1947
BALLOKI 1988 1950 1955
SIDHNAI 1988 1976 1995
SUTLEJ
S.MANKI 1955 1988 1947
ISLAM 1955 1988 1947
OVER FLOW