ASSESSING IMPACTS OF FLOODS IN PAKISTAN 2010 - 2024

National Disaster Management Authority

National Institute of Disaster Management

Assessing Impacts of Floods in Pakistan

2010 TO 2024

Disclaimer

The recommendations and infographics used in this document are sourced from National and Global Academia, Official websites of relevant departments, scientific journals, and open-source information.

TABLE OF CONTENTS

CHAIRMAN'S MESSAGE

Lieutenant General
Inam Haider Malik, HI(M)
Chairman NDMA

The National Institute of Disaster Management (NIDM) is the National Think Tank of the National Disaster Management Authority (NDMA). It serves as a vital entity in addressing Pakistan's vulnerability to a wide spectrum of disasters, including earthquakes, floods, droughts, GLOFS, cyclones, landslides, forest fires, heatwaves as well as man-made disasters. NIDM extends support to NDMA through research and development, innovative solutions and recommendations with national/global best practices on disaster management.

With a mission to enhance disaster preparedness and response, NIDM is a knowledge hub, conducting research, trainings and capacity building programs in collaboration with government departments, responders, communities and industries. NIDM is collaborating with 400 universities around the globe and adapting the latest research and best practices for mitigating natural disasters regarding the complete spectrum of disaster management.

This document contains information on the floods of 2010, 2022, and 2023, which coupled with the heavy rains of 2024, vividly demonstrate the profound impact of natural disasters on Pakistan. These events exposed critical deficiencies in early warning systems, infrastructure resilience, and community readiness, amplifying hardships for vulnerable groups. Inadequate coordination, infrastructure upkeep, and community involvement hindered our response efforts. The heavy rains of 2024 underscored the necessity for climate-resilient infrastructure and adaptive measures to prevent future disasters and alleviate suffering.

Acknowledging operational deficiencies highlighted by recent disasters, NDMA is restructuring NIDM to prioritize "Know Risks," "Know Early," and "Pre-emptive Preparedness." Moreover, initiatives such as launching an NDMA e-library and NIDM portal for volunteer registration will further enhance information sharing and community involvement, promoting a proactive, knowledge-driven strategy to fortify Pakistan's resilience for the future

1 PAKISTAN'S FLOOD CONTEXT

Pakistan, renowned for its diverse landscapes and dynamic climate patterns, often experiences hot and arid conditions. However, recent years have witnessed notable fluctuations both in weather patterns as well as in resultants disasters. Particularly vulnerable are districts and urban areas situated along riverbanks, which face various flood risks such as riverine, flash, and urban floods, especially in Punjab and Sindh provinces besides in Khyber Pakhtunkhawa (KP) as well. These floods result in extensive damage, affecting hundreds of thousands of acres of fertile agricultural land and standing crops, as well as impacting adjacent communities, important public and private installations resulting in significant monetary losses amounting to billions of rupees. The primary casualties of these floods include agricultural grounds, crops, urban and rural inhabitants, as well as private and public infrastructure.

Riverine flooding is caused mostly by heavy rainfall in river catchments during the monsoon season, which is often exacerbated by snow melt. Monsoon currents from the Bay of Bengal (India), combined with weather systems such as the westerly wave from the Mediterranean Sea and the Season Low from the Arabian Sea, frequently cause heavy precipitation in the Himalayan foothills, occasionally triggering destructive floods in major rivers and their tributaries. Exceptionally large flood flows in major rivers occur on rare occasions as a result of the temporary formation and subsequent collapse of natural dams caused by landslides or glacier movements.

Flooding of the Indus River and its tributaries is the most serious danger in Pakistan, occurring primarily during the summer monsoon season from mid-June to mid-October. As a result, agricultural damage is mostly limited to standing Kharif crops. However, in some cases, waterlogged soils do not dry out in time, affecting Rabi crop sowing. However, in some cases, inundated lands fail to dry in time, interfering with Rabi crop sowing. Major rivers such as the Indus, Jhelum, Chenab, Ravi, and Sutlej, as well as tributary/secondary rivers like the Kabul and Swat, as well as high flood flows in some nullahs (Kalpani, Jindi), contribute to flood losses by submerging low-lying areas surrounding riverbeds, damaging irrigation and communication networks, and causing land erosion along riverbanks. Floodwaters spilling over high riverbanks in the upper Indus Basin, particularly in Punjab and Khyber Pakhtunkhwa, typically return to the main river channel because to inward river slopes.

In the country's lower areas, particularly in Sindh province's Lower Indus Basin, the River Indus flows along a ridge that is higher in height than the surrounding fields. As a result, first and second line of defense flood embankments have been built along both sides of the river. If floodwater breaches or overflows these embankments, it cannot simply return to the main river channel. This considerably increases the area and length of inundation, causing more damage to low-lying towns, standing crops, and both private and public infrastructure (FFC Annual Report, 2022).

2 HISTORICAL FLOOD EVENTS IN PAKISTAN

Pakistan has had multiple major flood occurrences between 1950 and 2022. Notable instances are those in 1950, 1955, 1956, 1957, 1959, 1973, 1975, 1976, 1977, 1978, 1981, 1983, 1984, 1988, 1992, 1994, 1995, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2019, 2020, and 2022. Among these, the floods of 2010 and 2022 are the most disastrous in the country's history, as seen in Table 1 below. These floods, which varied in severity, impacted large areas throughout the four provinces as well as Gilgit Baltistan, Merged Area (old FATA), Khyber Pakhtunkhwa, and Azad Jammu and Kashmir. Communities' vulnerability to coastal and urban flooding has increased in recent years as a result of the negative effects of climate change.

According to an NDMA report dated November 18, 2022, roughly 897,014 houses were completely destroyed, with another 1.392 million partially damaged as a result of flooding. Furthermore, the flooding has had a significant impact on livelihoods, resulting in the loss of over 1,164,270 livestock, which are a vital source of subsistence and revenue for many households. According to a study released on August 30, 2022 by the United Nations Office for the Coordination of Humanitarian Affairs, approximately 2 million acres of crops and orchards have been badly affected.

Flood damage is primarily caused by riverine flooding in major rivers, flash floods in secondary and tertiary rivers/hill torrents, cyclone-caused coastal flooding, urban flooding due to heavy rainfall and inadequate storm drainage infrastructure, and GLOFs in the country's northern regions. The severe floods of 2010 were among the most devastating riverine events in the country's history. Around 1,985 people died, 1,608,184 homes were damaged or destroyed, 17,553 communities were harmed, and a total area of 160,000 square kilometers was affected.

The 2022 Monsoon floods have been reported as surpassing the 2010 floods, which were primarily pluvial in nature, culminating in the largest humanitarian disaster, affecting over 33 million people and resulting in 1,739 deaths. Significant damage has been seen in cattle, dwellings, and other infrastructure throughout Sindh, KP, Southern Punjab, and Eastern Balochistan (FFC Annual Report, 2022).

Table-1: Major Flood Events Witnessed in Pakistan

S. No.	Year	Direct Losses (US$ Million) @1US$ = PKR 86	Lives Lost (No)	Affected Villages (No)	Flooded Area (Sq. km)
1.	1950	488	2,190	10,000	17,920
2.	1955	378	679	6,945	20,480
3.	1956	318	160	11,609	74,406
4.	1957	301	83	4,498	16,003
5.	1959	234	88	3,902	10,424
6.	1973	5,134	474	9,719	41,472
7.	1975	684	126	8,628	34,931
8.	1976	3,485	425	18,390	81,920
9.	1977	338	848	2,185	4,657
10.	1978	2,227	393	9,199	30,597
11.	1981	299	82	2,071	4,191
12.	1983	135	39	643	1,882
13.	1984	75	42	251	1,093
14.	1988	858	508	100	6,144
15.	1992	3,010	1,008	13,208	38,758
16.	1994	843	431	1,622	5,568
17.	1995	376	591	6,852	16,686
18.	**2010**	**10,056 @1US$ = PKR 86**	**1,985**	**17,553**	**160,000**
19.	2011	3,730 @1US$ = PKR 94	s516	38,700	27,581
20.	2012	2,640 @1US$ = PKR 95	571	14,159	4,746
21.	2013	2000 @1US$ = PKR 98	333	8,297	4,483
22.	2014	440 @1US$ = PKR 101	367	4,065	9,779

23.	2015	170 1US$ = PKR 105.00	238	4,634	2,877
24.	2016	6 1US$ = PKR 104.81	153	43	-
25.	2017	-	172	-	-
26.	2018	-	88	-	-
27.	2019	-	235	-	-
28.	2020	-	409	-	-
29.	2021	-	198	-	-
30.	**2022**	**30,000* 1US$ = PKR 225**	**1,739**	**6,631^**	**85,000`**
Total		68,225	15,199	203,704	701,558

(FFC Annual Report, 2022) ***PDNA Report,M/o PD&SI, ^ Union Councils (UC's): Source NDMA, ` United Nations Satellite Centre: 2022 Floods Imagery Analysis from 1.7.2022 to 31.9. 2022.**

3 FLOODS OF 2010

The 2010 monsoon produced Pakistan's worst flooding in 63 years. The extraordinary floods began in July 2010, following significant monsoon rainfall in KP, Sindh, Lower Punjab, and Balochistan. The heavy rainfall across a vast area caused rivers to surge and flood. (FFC, 2010). Figure-1 highlights the different causes and effects of 2010 floods.

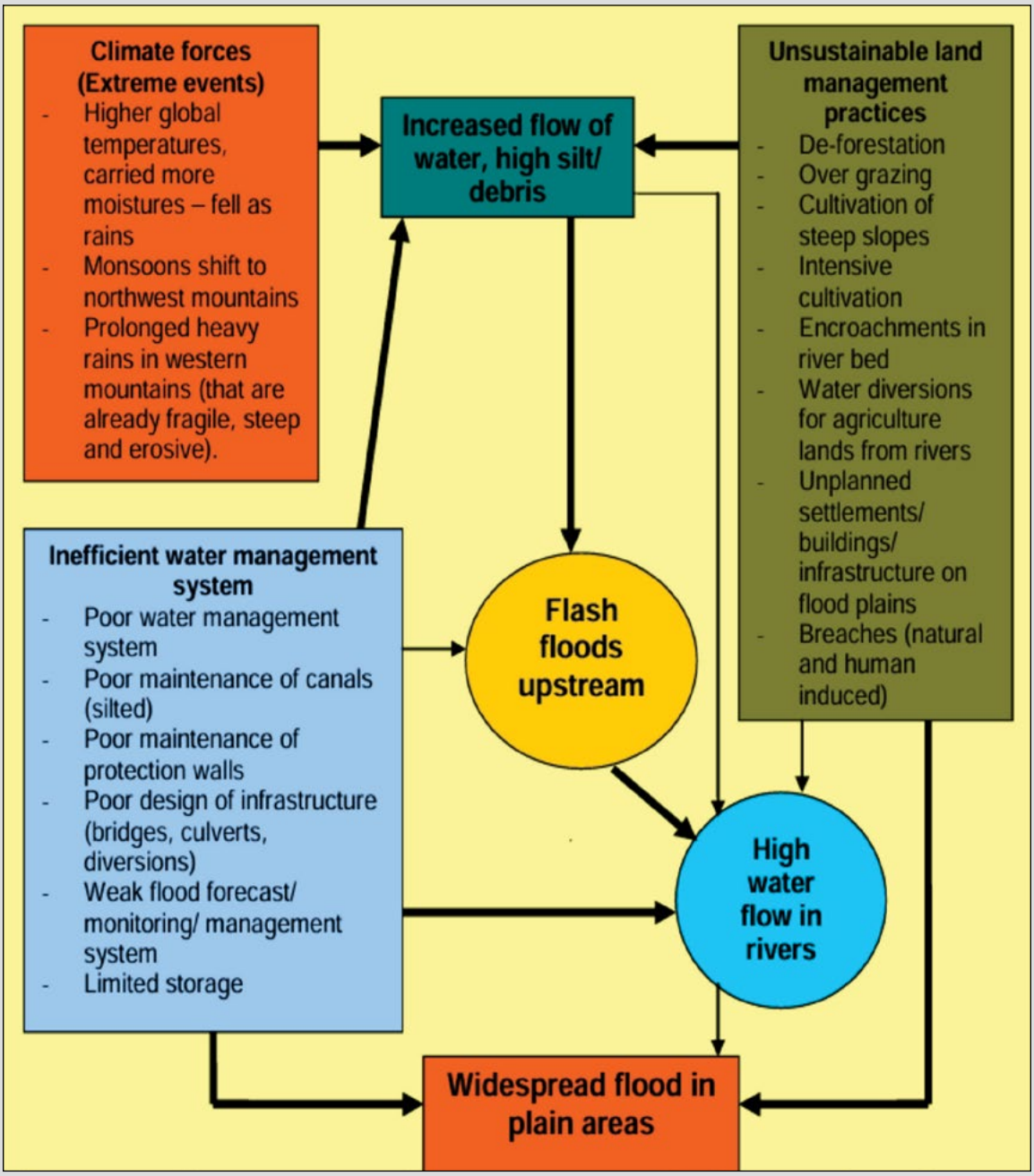

Figure-1: Causes and Effects of 2010 Floods (Hussain, 2015)

3.1 River Flows Situation

- During the last week of July 2010, Kabul and Swat rivers experienced exceptional rainfall. Heavy rainfall of more than 200 millimeters (7.9 inches) was observed in the provinces of KP and Punjab from July 27 to July 30, 2010.
- Floods in Swat and Kabul exceeded 400,000 cusecs, surpassing the previous record of 250,000 cusecs in 1929. Charsada, Nowshehra, and surrounding villages were inundated. Exceptionally high floods were also reported in the Panjkora River, Budni/other nullahs, as well as flash floods in the D.I. Khan hill torrents.
- Flooding occurred in the Jinnah-Taunsa Barrage reach of the River Indus from July 30 to August 2, 2010. On July 30, 2010, a high flood of 9,37,453 cusecs flooded the Right Marginal Bund of Jinnah Barrage, inundating low-lying areas and the Jinnah Hydropower Project.
- On August 1, 2010, the Chasma Barrage experienced a historic peak flow of 10,36,673 cusecs, exceeding its design capacity. Flooding occurred in the river plains of Mianwali, Bhakhar, and Layyah districts.
- On August 2, 2010, the Indus at Taunsa Barrage reached a flood peak of 9,60,000 cusecs, surpassing the historic peak of 7,88,646 cusecs recorded in 1958. Due to great pressure, the Left Marginal Bund (LMB) of the Barrage breached at RD 32-38 on August 2, 2010, flooding a number of abadies/villages and agricultural area on the left bank of the Indus River in District Muzaffargarh. Flood waters flowing through a breached part of the Left Marginal Bund (LMB) overtook the Taunsa-Punjnad Link at RD 10 and flooded the Muzaffargarh Canal at multiple sites between RD 13-14.
- On August 5, 2010, the Indus River experienced very high flood flows near the Guddu Barrage in upper Sindh.
- On August 5, 2010, the Indus River experienced very high flood flows near the Guddu Barrage in upper Sindh.
- On August 8-9, 2010, the Guddu Barrage experienced a flood peak of 11,49,000 cusecs, while the Sukkur Barrage experienced a flood peak of 11,31,000 cusecs. Due to enormous pressure, the 16-mile-long Left Marginal Bund (LMB) of the Guddu Barrage ruptured at five (5) locations (1 in Sindh and four in Punjab).
- Flood water in Rainee Canal exceeded design discharge by 9645 cusecs, causing 13 breaches on the canal's left bank. Tori Bund (1st line of defence), located on the right bank of the Indus River 30 kilometers south of Guddu Barrage, breached at mile 0/2 on August 6, 2010, flooding a large region. Six (6) breaches occurred in the Beghari Sindh (B.S) Feeder on August 8, 2010. Flood water breached Tori Bund and affected three Tehsils in Dadu district: Mehar, Khairpur Nathan Shah, and Johi.
- A second wave of extremely high flood went through Guddu and Sukkur barrages between

August 14-17, but the situation remained unchanged. On August 26, 2010, a breach developed at M.S Bund (Mile 18/2) on the eastern side of the Indus River in Thatta district. As the Indus River breached its western bank in the south Thatta city was evacuated..

- On August 27, 2010, Kotri Barrage had an unprecedented high flood flow of 965,000 cusecs. Inundation and riverine flooding occurred in low-lying regions of Hyderabad, Thatta, and Badin districts, particularly Sajawal, Mirpur Bathoro, Mirpur Sakro, Jhang Shahi, Jamshoro, Matiari, Makaro, Keti Bunder, and Shah Bunder. The whole Katcha area upstream and downstream from the Kotri Barrage was flooded. Flood water from the breach in M.S. Bund (mile 18/2) overwhelmed the area up to Sajawal Town and spread to Jati and Chohar Jamali, as well as the surrounding areas of District Thatta.
- In July 2010, rains and thunderstorms caused flash floods in northeastern Balochistan due to hill torrents. Major districts impacted include Zhob, Kohlu, Sibi, Barkhan, Kachhi, Nasirabad, Jafferabad, Musakhel, Shirani, Harnai, and Killa Saifullah (FFC, 2010).

A comparison of Historic Maximum Flood Peaks Vs 2010 Flood Maximum Flood Peaks is given in Table-2 below:

Table-2: Historic Maximum vs 2010 Maximum Peak Discharges (FFC, 2010)

River	Barrages/ Head-works/ Bridges	Designed Capacity	Historic Maximum Peak (cusecs)		Maximum-2010 Peak (cusecs)	
			Flood	Date	Flood	Date
Indus	Tarbela	15,00,000	5,10,000	31-7-89	8,33,000	30-7-10
	Kalabagh	9,50,000	9,50,000	14-7-42	9,37,453	30-7-10
	Chashma	**9,50,000**	7,86,600	3-8-76	**10,36,673**	01-8-10
	Taunsa	11,00,000	7,88,646	22-7-58	9,59,991	02-8-10
	Guddu	12,00,000	11,99,672	15-8-76	11,48,738**	8&9-8-10
	Sukkur	15,00,000*	11,66,574	15-8-76	11,31,000#	9&11-8-10
Jhelum	Kotri	**8,75,000**	9,81,000	14-8-56	**9,64,900**	27-8-10
	Mangla	10,60,000	9,33,000	10-9-92	3,44,400	30-7-10
	Rasul	8,50,000	9,32,000	10-9-92	2,63,800	30-7-10
Kabul	Warsak	5,40,000	1,50,680	8-7-78	1,52,710	30-7-10
	Nowshera	-	-	-	2,49,100^	10-8-10
Chenab	Marala	11,00,000	11,00,000	26-8-57	3,14,378	06-8-10
	Qadirabad	8,07,000	9,48,530	11-9-92	3,29,483	07-8-10
	Trimmu	6,45,000	9,43,225	8-7-59	3,28,926	11-8-10
	Panjnad	7,00,000	8,02,516	17-8-73	3,10,000	13-8-10
Ravi	Balloki	2,25,000	3,89,845	28-9-88	69,900	23-8-10
	Sidhnai	1,50,000	3,30,210	2-10-88	27,600	28-7-10
Sutlej	Sulemanki	3,25,000	5,97,000	8-10-55	58,300	03-9-10

* Existing design capacity as reported by PID, Sindh is 9,00,000 cusecs.
** Does not include flood flows passed through breach of LMB of Guddu Barrage.
# Does not include flood flows passed through Tori Bund reach u/s Sukkur Barrage.

^ The gauges were submerged at this discharge, it is estimated that a flood more than 4,50,000 cusecs passed through this point.

3.2 Hill Torrents Flooding

The D.G. Khan and Rajanpur hill torrents also witnessed heavy flash flooding in the final week of July and the first week of August 2010. Table 3 shows the peak discharges from hill torrent outlets in the D.G. Khan and Rajanpur areas.

Table-3: Peak Discharges in Hill Torrents - Floods 2010 (FFC, 2010)

Sr. No.	Date	Hill Torrents	Max Discharge (Cusecs)
1.	22-7-2010	KAHA	80,000
2.	22-7-2010	CHACHAR	35,000
3.	05-8-2010	SANGHAR	76,500
4.	05-8-2010	VIDOR	97,000
5.	05-8-2010	SORI LUND	51,640
6.	08-8-2010	VEHOWA	1,10,500
7.	08-8-2010	KAURA	67,200
8.	08-8-2010	MITHAWAN	61,900
08-8-2010		***Cumulative Potential:***	***2,39,600***

Table-4 and Figure-2 highlights the damage costs by sector in the 2010 floods. It shows that the economic sector was the most impacted sector.

Table 4: Estimate of Total Damage Costs by Sector (ADB, 2010)

Sector	Direct Damages PKR millions	Indirect Losses PKR millions	Total Damages	
			PKR millions	USD millions
1. ***Social Infrastructure***				
Housing	91,843	43,171	135,014	1,588
Health	1,562	2,661	4,222	50
Education	22,047	4,418	26,464	311
Subtotal	**115,451**	**50,249**	**165,700**	**1,949**
2. ***Physical Infrastructure***				
Irrigation and Flood Management	23,600		23,600	278
Transport and Communications 62,491		50,420	112,911	1,328
Water Supply and Sanitation	3,194	6,112	9,306	109
Energy	13,184	13,116	26,300	309
Subtotal	**102,469**	**69,648**	**172,117**	**2,025**
3. ***Economic Sectors***				
Agriculture, Livestock & Fisheries	315,547	113,257	428,805	5,045
Private sector & Industries	14,463	9,468	23,932	282
Financial Sector	110	57,141	57,251	674
Subtotal	**330,120**	**179,866**	**509,987**	**6,000**
4. ***Cross Cutting Sectors***				
Governance	3,141	2,835	5,976	70
Environment	992		992	12
Subtotal	**4,133**	**2,835**	**6,968**	**82**
Total	**552,173**	**302,599**	**854,771**	**10,056**

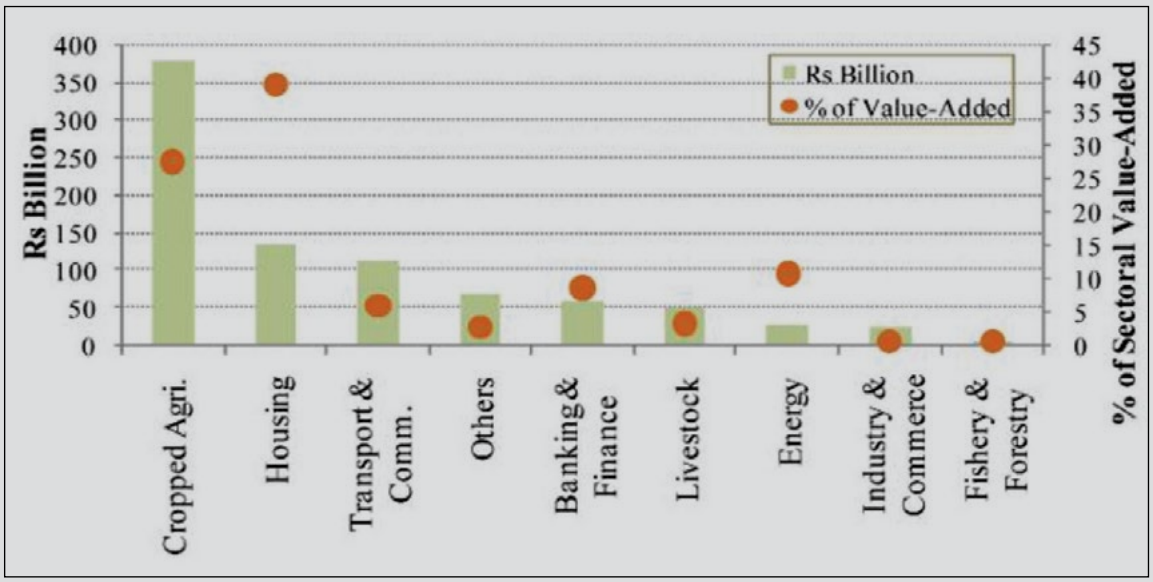

Figure-2: Flood Damages by Sector (ADB, 2010)

Figure-3 illustrates that most of the direct damages and indirect losses were observed in the Sindh province and the least in FATA, GB and AJK.

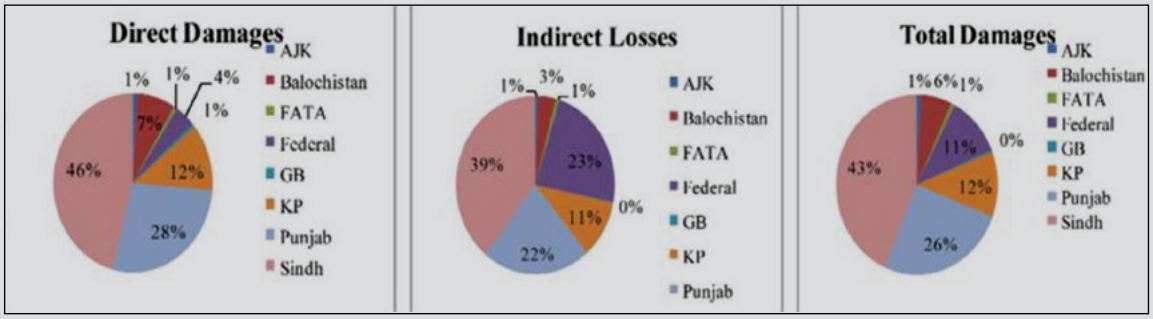

Figure-3: Geographical Distribution of Flood Damages (ADB, 2010)

3.3 National Response

The Pakistani government, in collaboration with province governments, launched rescue and relief activities, which were managed by the NDMA at the federal level and relevant agencies at the provincial level, with backing from the Pakistani military and several UN agencies. More than 20,000 army troops, including medical teams, as well as multiple helicopters, six C-130 planes, and over a thousand boats, were sent around the country to assist with flood relief and search and rescue activities. They also handed out emergency items to displaced and remote people. Call centers were set up to receive and respond to emergency calls. Concurrently, measures were made to strengthen weak riverbanks, and in some instances, controlled breaches were designed to regulate floodwaters. Temporary structures were quickly built to restore the destroyed communication networks. As of October 26, 2010, the NDMA reported the distribution of almost 1.1 million blankets, 184,035 tons of food, and the rescue of nearly 1.4 million people. To provide urgent financial help to individuals impacted by the floods, the Government of Pakistan, in partnership with NADRA, issued 977,570 Watan Cards (worth PKR 20,000 per family) around the country (ADB, 2010).

3.4 Civil Society and Private Sector Response

International and national non-governmental organizations (NGOs) responded quickly, comprehensively, and efficiently to the flood situation. Working together with the government, a varied range of non-governmental organizations (NGOs) were actively delivering emergency help to affected populations around the country. This help has mostly consisted of the distribution of clean water and water purification kits, food supplies, kitchen sets, shelter materials, sanitation kits, hygiene supplies, medical professionals, and mobile health care units. Furthermore, certain non-governmental organizations (NGOs) have built safe spaces specifically designed for children and women to provide comfort and support while allowing them to engage in a safe atmosphere. Individuals, corporations, and foundations have all contributed significantly to flood relief efforts, totaling more than US$17 million. The majority of these money have been allocated to various UN institutions and NGOs engaging in relief operations (ADB, 2010).

3.5 Lessons learnt

(a) The prolonged and intense rainfall caused considerable flooding, putting a strain on disaster/ flood management capacities at the national, provincial, and municipal levels, especially in districts.

(b) Inadequate implementation of national response and contingency plans, as well as ineffective early warning systems at the district and community levels, revealed gaps in disaster preparedness, emergency response mechanisms, and mitigation measures.

(c) The affected communities lacked disaster preparedness awareness, including understanding localized hazards, flood risk reduction strategies, and emergency response protocols. This knowledge is crucial for populations living in flood-prone areas (ADB, 2010).

(d) Flood management approach revolves primarily around river floods with limited attention to flash floods

(e) Inter-provincial, inter agency coordination lacks depth and real time action at the most critical time.

(f) Existing flood forecasting and warning capacities are good for short duration but requires drastic improvements as far as the medium and long range forecasting capabilities are concerned.

3.6 Conclusions and Recommendations

The 2010 floods underscored various vulnerabilities and deficiencies in Pakistan's disaster management and infrastructure. Key findings and recommendations included:

- The Pakistan Meteorological Department's Flood Warning System worked well, but experienced capacity restrictions due to both human and technological factors. Medium Range Forecasting needs to be improved from 2-3 days to 10 days. To address flash floods from hill torrents and riverine floods, additional weather radars should be installed in strategic locations such as Chitral, Cherat, Sukkur, Thatta/Badin, Quetta, and Pasni/Gwadar, as well as the establishment of Regional Flood Forecasting/Warning Centres in each province.
- Neglectful watershed management in KP, AJ&K, and Gilgit-Baltistan causes runoff and siltation in reservoirs.
- Proposed dams, such as Munda Dam and medium/small dams on Panjkora and Swat rivers in KP, as well as Akhori Dam and Diamer Basha Dams, have the potential to reduce flood losses.
- Deferred maintenance of flood embankments contributed to major losses that could have been mitigated with proper upkeep.
- Provincial flood management lacked professionalism, with deficiencies noted in machinery, stone reserve stocks, sandbags, evacuation routes, emergency shelters, and war room planning.
- Inadequate escape channels were identified, particularly upstream of Taunsa, Guddu, and Sukkur Barrages.
- Barrage safety was highlighted as a concern, as most structures, except Taunsa, had not been remodeled in over 63 years and lacked the capacity to safely manage floods of 2010 magnitude.
- Both the NDMA and PDMAs, which were newly constituted at the time, had capacity issues.
- Insufficient budget allocations for maintaining existing flood protection systems and new flood works.
- Federal and provincial agencies were unprepared to handle massive floods due to global climate change (FFC, 2010).

4 FLOODS OF 2022

In August 2022, the country had its wettest month since 1961. Sindh and Balochistan provinces received exceptional rainfall in their plains, exceeding average monthly totals by six and seven times, respectively. The unprecedented rain induced pluvial floods-2022 in Pakistan were caused by the **heavier than un-usual monsoon cycle** due to rise in sea water temperature, excessive and consecutive Heat Waves in southern parts of the country in May and June 2022 owing to the global warming by climate change. PMD predicted above-average rainfall (35% - 40%) for the 2022 Monsoon Season; instead, total rainfall received across the country was over 175% above normal. Table-5 provides province-specific information on real rainfall experiences.

Table-5: Rainfall experienced Province-wise - Floods - 2022 (FFC, 2022)

Sr. No.	Province	Rainfall Occurred (mm)	Rainfall Occurred (%age above Normal)
1	Sindh	703.1 mm	426%
2	Balochistan	320.7 mm	450%
3	Punjab	393.5 mm	70%
4	Khyber Pakhtunkhwa	341.1 mm	33%
5	Gilgit-Baltistan	81.1 mm	104%
6	Azad Jammu & Kashmir	382.6 mm	2%

The country map below shows the cumulative rainfall that actually occurred in Pakistan as been given in Figure-4.

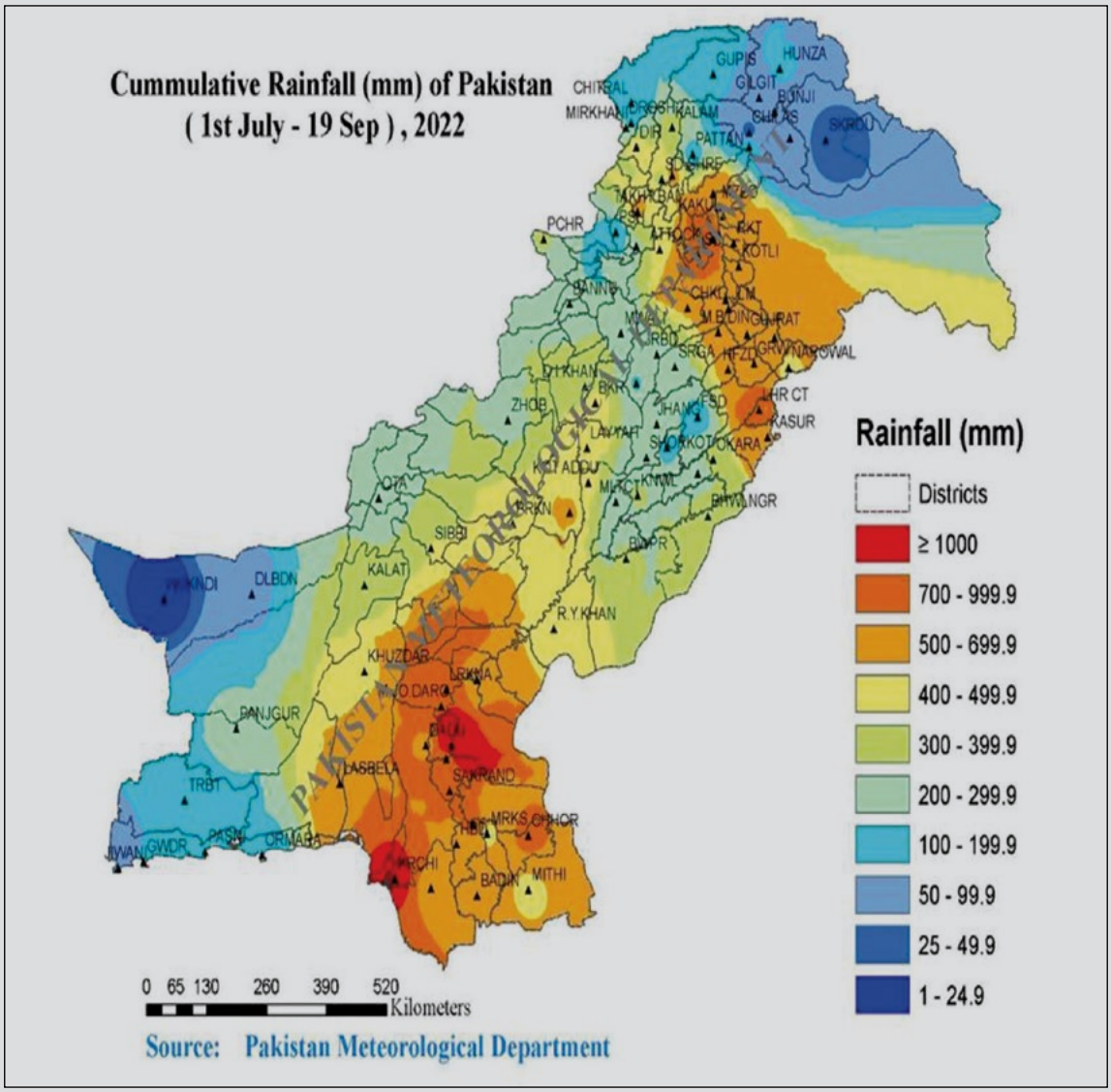

Figure-4: Rainfall (mm) Actually Observed across the Country (FFC Report on Hydraulic Characteristics of 2022 Floods)

Pre-monsoon rains began on June 13, 2022, and lasted until June 25, 2022. This was followed by the four (04) rainfall spells throughout the monsoon season 2022, as shown in Table 6.

Table-6: Rainfall Spells during Monsoon Season-2022 (FFC Report on Hydraulic Characteristics of 2022 Floods)

S. No.	Monsoon Spell No.	Date of Occurrence
1.	One	29th June - 9th July 2022
2.	Two	23rd July - 28th July 2022
3.	Three	5th August - 13th August 2022
4.	Four	23rd August - 26th August 2022

The four (04) individual monsoonal rainfall spells, as shown in Table-6 above are depicted in Figure-5 below.

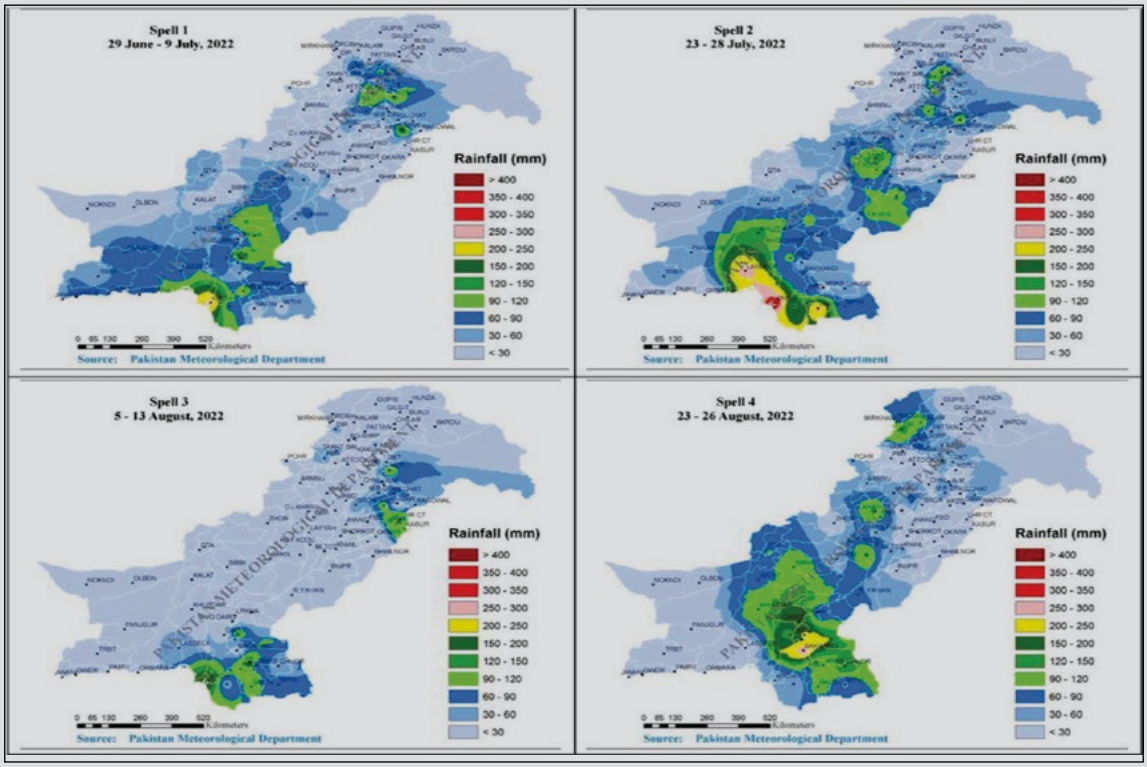

Figure-5: Four Individual Monsoon Rainfall Spells - Floods-2022
(FFC Report on Hydraulic Characteristics of 2022 Floods)

Figure-6 depicts details on the names of the cities and the rainfall they received during the rainfall spell in 2022. Padidan (Sindh) received the highest rainfall.

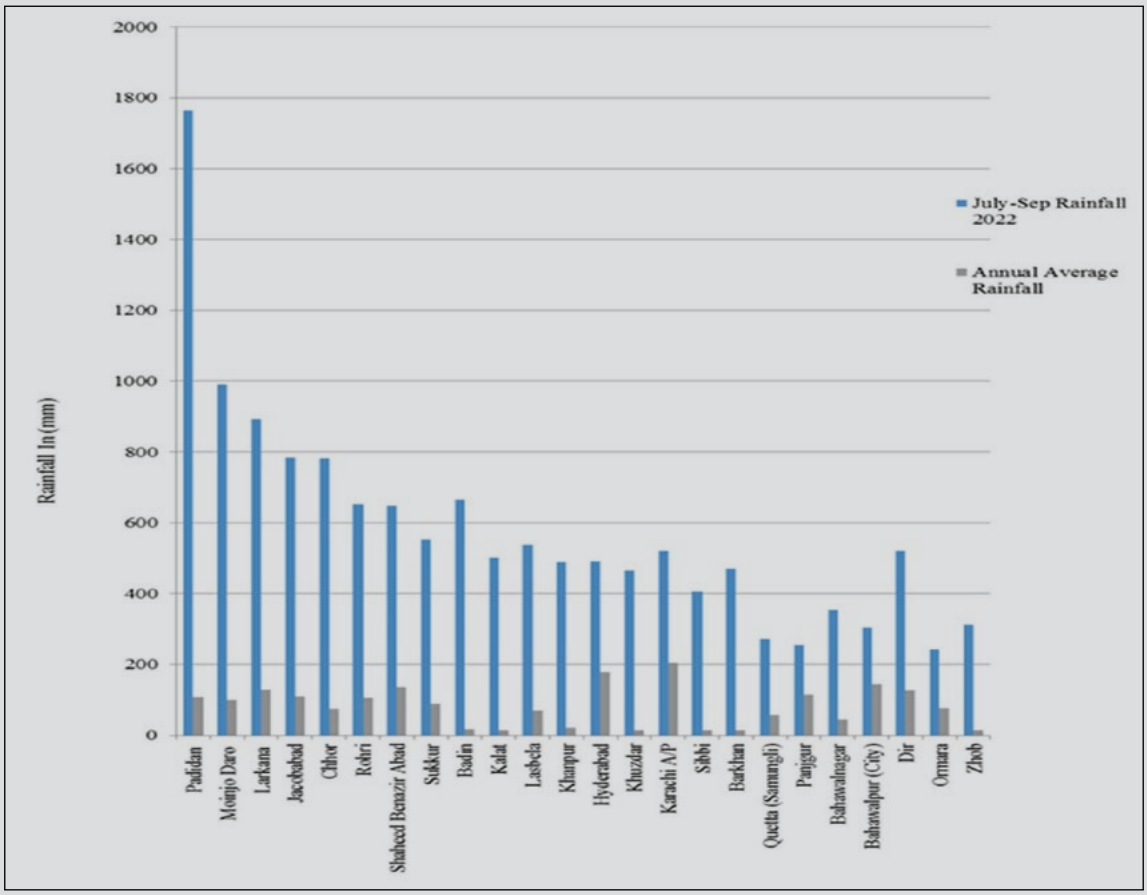

Figure-6: Bar Chart of Cities with Extremely High Rainfall in 2022 (FFC Annual Report, 2022)

The torrential rainfall resulted in devastating flash floods across Balochistan, Sindh, southwestern Punjab, and Khyber Pakhtunkhwa, leading to loss of life and significant damage to crops and properties. Surprisingly, riverine flooding along major rivers did not cause as much damage compared to the flash floods triggered by heavy rains in hill torrents. Initially, the floods of 2022 predominantly devastated the country›s southern regions, particularly Balochistan and Sindh provinces, as well as their urban centers. As a result, strong to extremely heavy rainfall in southern Punjab, particularly in the Koh-e-Suleiman Range, caused record flooding in the major hill torrents of D.G. Khan and Rajanpur Districts. These monsoon rains caused high to extremely high floods in certain tributaries of the River Kabul Basin in Khyber Pakhtunkhwa, as well as local tributaries of the Indus.

Up to 2021, the cumulative economic losses from floods in Pakistan amounted to approximately US$ 38.053 billion, with a significant portion of US$ 19.040 billion incurred since the devastating 2010 floods. These figures starkly illustrate the discernible impact of climate change. According to the Post-Disaster Needs Assessment (PDNA) Report for the 2022 floods, total damages are expected to exceed USD 14.9 billion, with overall economic losses estimated at around USD 15.2 billion. According to the Planning, Development, and Special Initiative Division of the Government of Pakistan›s Resilient

Recovery, Rehabilitation, and Reconstruction Framework (4RF) and 5Es Framework (Roadmap to Trillion Dollar Economy by 2025), the projected costs for resilient rehabilitation and reconstruction are at least USD 16.3 billion.

4.1 River Flows Situation

- From July to August 2022, the country saw unprecedentedly heavy rains, particularly in the lower half of the country in Sindh and Balochistan Provinces, resulting in high flows in numerous hill torrents around the country.
- Among these, some of D.G Khan›s Hill Torrents in the Koh-e-Suleman range, such as Kaura Sori Lund, Sanghar, and Vehova, received historically high floods of 268,149 cusecs, 154,362 cusecs, 105,668 cusecs, and 135,544 cusecs, respectively, resulting in a serious flood situation in Taunsa Barrage (Indus River) and downstream.
- The Kirthar Range in Sindh (Larkana, Sukkur, Kandhkot, Jacobabad, and Dadu Districts) and numerous hill torrents in Khyber Pakhtunkhwa and Balochistan were also hit by heavy flooding. As a result, extreme hydro-meteorological events (torrential rainfall) caused flash floods in hill torrent areas of Punjab (D.G Khan), Khyber Pakhtunkhwa, Azad Jammu and Kashmir, Balochistan (Lasbella, Barkhan), as well as urban flooding in significant cities throughout the country, particularly in Sindh.
- Heavy to very heavy rains in southern Punjab, notably in the Koh-e-Suleiman Range, caused record floods in the 13 main hill torrents of D.G. Khan and Rajanpur Districts, wreaking havoc in D.G. Khan Division.

Table-7 below depicts details of observed peak flood discharges by the D.G. Khan and Rajanpur Hill Torrents.

Table-7: Flood Peaks in Major Hill Torrents of D.G. Khan & Rajanpur (FFC,2022)

D.G. Khan Hill Torrent Region		Rajanpur Hill Torrent Region	
Gauge Station	**Flood Peak observed**	**Gauge Station**	**Flood Peak observed**
Kaura	105,668 @ **26.8.2022**	Kaha	108,941 @ **14.8.2022**
Vehova	154,362 @ **14.8.2022**	Chachar	75,900 @ **21.8.2022**
Sanghar	268,149 @ **14.8.2022**	Sori Janubi	17,000 @ **4.8.2022**
Sori Lund	135,544 @ **21.8.2022**	Pitok	5,000@ **25.8.2022**
Vidor	174,360 @ **21.8.2022**	Sori Shomali	7,150 @ **2.8.2010**
Sakhi Sarwar	32,643 @ **4.8.2010**	Zandi	9,000 @ **25.8.2022**
Mithawan	61,905 **@ 8.8.2010**	-	-

- The above-mentioned record torrential flood flows resulted in a «High Flood» in the River Indus at Taunsa Barrage, with a maximum discharge (outflow) of 622,000 cusecs on August 30, 2022. The impact then transferred to control structures downstream Taunsa, where the Indus River saw high flooding at the Guddu and Sukkur Barrages.
- The Guddu Barrage had a peak discharge of 576,000 cusecs on August 23, 2022, while on August 25, 2022 the Sukkur Barrage had a peak discharge of 580,000 cusecs.
- On September 10, 2022 the Indus at Kotri saw significant flooding, with a maximum discharge of 600,000 cusecs (upstream).
- Heavy rains in the catchment areas of River Kabul (a tributary of River Indus downstream Tarbela) caused "High Flood" at Warsak on August 27, 2022 (highest discharge of 139,086 cusecs) and "Very High Flood" at Nowshera on August 28, 2022 (peak discharge of 336,461 cusecs).
- On August 26, 2022, the River Swat, a tributary of the Kabul River, reached extremely High Flood stage in Khawazakhela (246,392 cusecs), Chakdara Bridge (275,215 cusecs), Munda Headworks (260,000 cusecs), and Charsadda Road (220,000 cusecs).
- The Indus at Khairabad (junction point after merging river Kabul in the Indus) experienced a peak discharge of 602,400 cusecs on 27th August 2022.
- Tarbela Reservoir attained its maximum conservation level (MCL) of 1550 feet on 20th August 2022. The outflows at Tarbela Dam were adjusted with the view to avoid peak at Khairabad (junction point of rivers Indus & Kabul). Also, around 57,000 cusecs were discharged into the Ghazi Barotha Power Channel. The adjustments in water levels of Tarbela Reservoir helped in reducing inflows at Khairabad to 600,000 cusecs; otherwise Khairabad could have received upto 700,000 cusecs or even more.
- On July 28, 2022, the River Chenab reached a high discharge of 210,936 cusecs (High Flood) at Marala Barrage. On August 12, 2022, the Chenab flowed at a high discharge of 210,945 cusecs (High Flood stage) at Khanki and 202,000 cusecs (High Flood stage) in Qadirabad. The Chenab at Trimmu and Panjnad flowed normally, with peak discharges of 112,891 and 112,564 cusecs, respectively.
- The Jhelum and Sutlej rivers have normal flow conditions. On August 16, 2022, the Ravi River flowed in low flood in Jassar; however, it remained in normal flow levels between Sulemanki and Islam.
- Balochistan's torrential waters were confined by the FP (Flood Protective) Bund and RBOD (Right Bank Outfall Drain) in Sindh province. The floodwater level rose above the maximum level of the FP Bund, resulting in breaches in both the FP and Suprio Bunds. Flood water reached the pocket between the FP Bund and the MNV drain, as well as the compartment between the MNV drain and the Suprio Bund, affecting the whole drainage system in the area.

- Manchhar attained a high level of (Reduced Level) RL 121.0 feet. After Manchar Lake reached its highest level of R.L. 123 feet on September 4, 2022, relief/controlled cuts were conducted in the Manchar Containing Bank at RD 14 and RD 52 to preserve Sehwan Sharif and Dadu city (FFC, 2022).

Table-8 highlights the different flood peaks observed during the floods of 2022 in the major rivers of Pakistan.

Table-8: Flood Peaks (Cusec) observed in Major Rivers during 2022 (FFC, 2022)

River Control Points	Peak Inflows (Cusecs)		Peak Outflows (Cusecs)		Flood Classification
	Flow	Date & Time	Flow	Date & Time	
River Indus					
Tarbela	**404,000**	26-08 @ 2359hrs	418,600	26-08 @ 2359hrs	Medium
Kalabagh	**427,000**	28-08 @ 0600hrs	423,000	28-08 @ 0600hrs	Medium
Chashma	**527,437**	28-08 @ 1200hrs	523,937	28-08 @ 1200hrs	**High Flood**
Taunsa	**622,000**	30-08 @ 0600hrs	622,000	30-08 @ 1500hrs	**High Flood**
Guddu	**576,000**	23-08 @ 1800hrs	576,000	23-08 @ 1800hrs	**High Flood**
Sukkur	**580,000**	25-08 @ 0600hrs	580,000	25-08 @ 0600hrs	**High Flood**
Kotri	**626,000**	11-09 @ 0600hrs	600,000	10-09 @ 0600hrs	**High Flood**
River Kabul					
Nowshera			336,461	27-08 @ 12:30hrs	**Very High**
Warsak			139,086	27-08 @ 12:30hrs	**High Flood**
River Jhelum					
Mangla	**95,000**	27-07 @ 0600hrs	40,720	01-07 @ 1200hrs	Normal
Rasul	**25,358**	22-06 @ 1200hrs	23,610	22-06 @ 1200hrs	Normal
River Chenab					
Marala	**225,836**	28-07 @ 1800hrs	210,936	28-07 @ 1800hrs	**High Flood**
Khanki	**216,907**	12-08 @ 0500hrs	210,945	12-08 @ 0500hrs	**High Flood**
Qadirabad	**221,000**	12-08 @ 1000hrs	202,000	12-08 @ 1000hrs	**High Flood**
Trimmu	**144,147**	31-07 @ 2359hrs	112,891	14-08 @ 1800hrs	Normal
Panjnad	**121,764**	03-08 @ 0600hrs	112,564	03-08 @ 0600hrs	Normal

			River Ravi		
Balloki	**52,435**	03-08 @ 0600hrs	35,235	03-08 @ 0600hrs	Normal
Sidhnai	**22,742**	27-07 @ 1800hrs	21,642	27-07 @ 1800hrs	Normal
			River Sutlej		
Sulemanki	**24,670**	19-07 @ 1800hrs	17,462	19-07 @ 1800hrs	Normal

As per 4RF document of PD&SI Division, there was a damage of USD 14,906 Million, loss of USD 15,233n Million and USD 16,261 Million are needed for restoration and rehabilitation as has been shown sector wise in Figure-7.

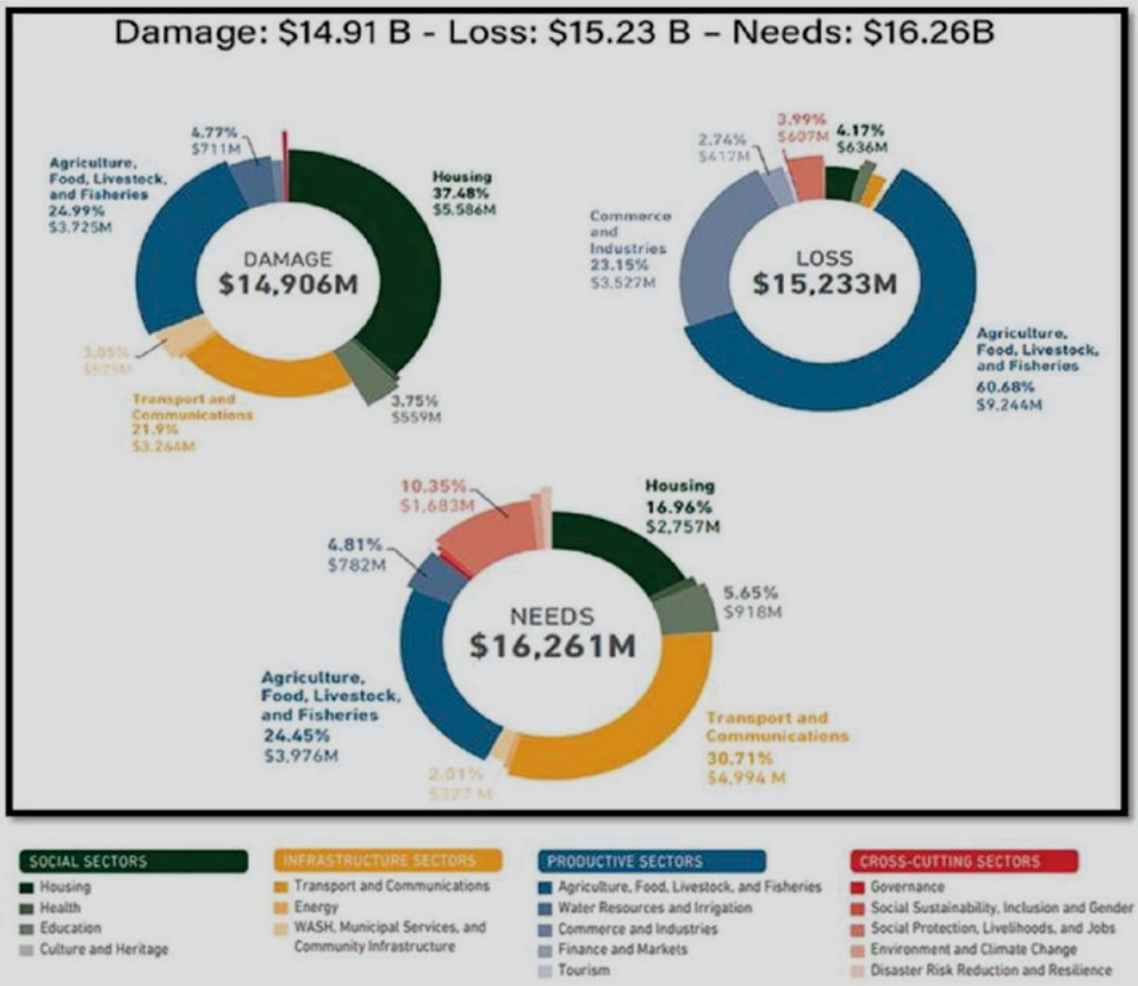

Figure-7: Sector-specific details on 2022 flood damage, losses, restoration, rehabilitation, and reconstruction needs **(4RF Document of PD&SI Division).**

4.2 Lessons Learnt

(a) Ensure wider participation of local partners, returnees, and women in response efforts, with clearly defined criteria for identifying communities for the recovery phase.

(b) Donors and humanitarian organizations should back the development of local capacity in disaster preparedness, risk reduction, coordination, and adherence to standards, thereby enhancing eligibility for direct funding.

(c) Strengthen coordination among agencies by exchanging information on programming, future plans, and joint assessments to enhance efficiency and prioritize needs effectively.

(d) Exercise financial prudence in cash programs, leverage local capacity, prioritize sectors with adequate capabilities, and focus on early recovery. Robust monitoring and evaluation can enhance confidence in government and donor funding.

(e) Strike a balance between swift action and well-planned priorities, integrating disaster risk reduction into construction endeavors during the recovery phase.

(f) Emphasize the necessity of future adaptation and preparedness, including investments in water and flood management, farming patterns, rural financing, and early warning systems.

(g) Consider directing assistance based on poverty status, particularly in urban flooding contexts, in the absence of detailed targeting data (ReliefWeb, 2022)

4.3 Conclusions and Recommendations

Given the recurrent nature of flooding in Pakistan, ongoing efforts to address the underlying vulnerabilities and enhance resilience are crucial. These may include:

- Continued investment in infrastructure upgrades to mitigate flood risks, such as improved drainage systems and flood barriers.
- Prioritizing climate change adaptation strategies to meet the growing frequency and severity of severe weather events, especially floods.
- Enhancing international cooperation and partnerships for disaster risk reduction and response, recognizing that floods often transcend national borders and require a coordinated regional approach.
- Strengthening community resilience through awareness programs, capacity building, and the development of local response mechanisms.

- Rapid evaluation of disaster impacts is crucial to prevent cascade effects, in addition to accurate forecasting of meteorological events such as floods, irregular rainfall, and droughts. It is also critical to translate climate-related losses into economic costs in order to measure the advantages of adaption efforts. This can facilitate the implementation of resource allocation for comprehensive climate change adaptation in public spending reporting.
- Enforcing land-use restrictions is crucial to prevent illegal human encroachment along river corridors and banks, given the severity of the harm.
- The patterns noticed in Pakistan are not exclusive to the country and have been seen throughout Asia. These trends can cause floods, and there is an opportunity for the scientific community to investigate the relationships between these events, enhance long-term flood forecasting, and develop early warning systems on a regional scale, allowing Pakistan to better prepare.


zong

5 COMPARISON BETWEEN 2010 AND 2022 FLOODS IN PAKISTAN

The floods of 2010 were riverine floods, triggered by prolonged and excessive rainfall leading to river overflow, typically occurring at a gradual pace. Conversely, the floods of 2022 were classified as flash floods, resulting from intense storms with substantial rainfall occurring within a brief timeframe. These occurrences are prevalent in regions characterized by arid climates and rugged landscapes, where sparse vegetation and soil conditions facilitate rapid surface runoff rather than infiltration.

Figure-8 highlights the different areas/districts of Pakistan that were affected by floods of 2010 and 2022. The maps clearly show that more area in 2022 was impacted by floods. Figure-9 gives us a comparison of flood inundation in 2010 and 2022.

Figure-8: Floods-2010 Vs Floods-2022: Areas Affected (OCHA, US State Department, Google Earth, Planet Labs/ September 5, 2022)

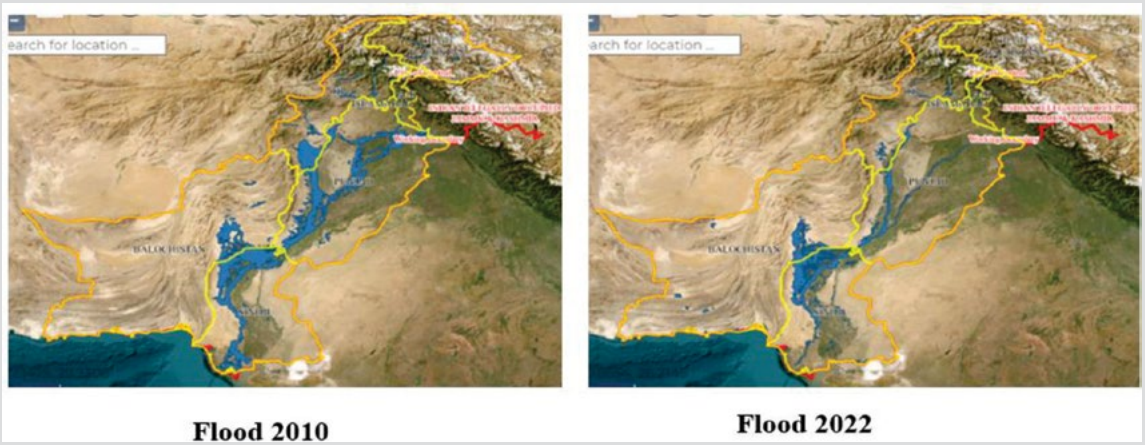

Figure-9: Flood Inundation Map (2010 vs 2022) (FFC, 2022)

Table-9 shows the complete comparison of the floods between 2010 and 2022. Showing that the floods of 2022 were the most devastating floods as 84 districts were affected as compared to 78 in 2010. Direct losses were 30,000 Million US dollars however in 2010 the direct losses were 10,000 Million US dollars respectively. About 33.046 Million population was affected by the 2022 floods much higher than the 2010 floods. The inundation areas were also different, 2010 floods KP was affected severely followed by Sindh and Punjab, however, in 2022 floods Sindh and Balochistan was affected.

Table-9: Comparison of Floods 2010 vs Floods 2022 (FFC, 2010; FFC, 2022)

S. No.	Comparison Parameter	Floods 2010	Floods 2022
1.	Flood Type w.r.t origin	Alluvial/Riverine	Pluvial/Rain caused
2.	Rainfall occurred (%age above normal)	**84%** (Source: **PMD**)	**175%** (Source: **PMD**)
3.	Main Inundation Areas	■ All provinces including GB, FATA (now Merged Areas) and AJ&K ■ KP was severely affected followed by Sindh and Punjab	■ All provinces including GB, FATA (now Merged Areas) and AJ&K ■ Southern parts in particular Sindh and Balochistan, were severely affected followed by Punjab & KP.
4.	Lives Lost (No.)	1,985	1,739
5.	Districts affected (No.)	78	84*
6.	Direct losses (USD Million)	10,000	30,000
7.	Population affected (Million)	20.185	33.046*
8.	Houses damaged (No.)	1,608,184	2,284,459*
9.	Roads affected (Km)	25,088	13,115*
10.	Person injured (No.)	2,946	12,867*

Source: FFC's Annual Flood Reports; ADB's Report on 2010 Flood Damages Need Assessment. * As per NDMA's Situation Report dated October 23, 2022.

6 MITIGATION MEASURES

The following are some of the main steps suggested to prevent widespread flood devastation in the country in the future:

- Urgently implement projects of 2022 flood rehabilitation and reconstruction in Sindh and Balochistan
- Priority implementation of Phase-I of National Flood Protection Plan-IV (NFPP-IV)
- Establishment of Regional Flood Forecasting Centres in four provinces, GB and AJ&K for ensuring regional/provincial level specific forecasting as well.
- Implementation of National Master Plan on Flood Telemetry (Phase-I comprising placement of telemetry station at 457 locations on primary, secondary and tertiary rivers).
- Implement the Fourth National Flood Protection Plan immediately to avoid huge financial losses. The PD&SI Division's 4RF (Resilient, Recovery, Rehabilitation, and Reconstruction) Framework Report strongly advises on the implementation of NFPP-IV.
- Build water storage dams in hill torrent zones, completing under-construction projects and starting new ones.
- Implement Phase-II of the National Master Plan on Flood Telemetry Network and establish automatic weather stations throughout the country, particularly in Balochistan.
- Remodeling of drainage channels to manage both storm water and irrigation effluent.
- Restore and reconstruct natural waterways/drains based on lessons acquired from super floods in 2010 and 2022. Review and revise design discharge return periods with relevant authorities.
- Introduce flood dispersal and diversion structures along major hill torrents.
- Develop Urban Flood Management SOPs by District Administrations and implement SOPs for managing torrential heavy flood flows within existing irrigation and drainage structures.
- Improve flood resilience in large cities by using structural measures like bypass canals and replicating successful forecasting systems.
- Implement large-scale afforestation and watershed management in upper catchments of all rivers to lower flood intensity and minimize climate change effects.
- Prohibit unplanned urban expansion without proper drainage systems, and separate normal and storm drainage to avoid future concerns.
- Prioritize restoration and reconstruction of damaged infrastructure, including roads, bridges, dams, and flood protection bunds, before the following monsoon season.
- Remove impediments from storm streams, rivers, and hill torrents, and prevent encroachment.
- Improve funding allocation and criteria for maintaining flood prevention infrastructure.

- Review design criteria and standards for climate-proof flood protection, irrigation, and drainage infrastructure, and incorporate additional safety measures as needed.
- Review current breach sections on barrages/bridges, expand capacity as appropriate, and provide additional interventions/flood bypass channels as necessary.
- Prepare Emergency Contingency Plans for large reservoirs, including Tarbela and Mangla, to address failures caused by past floods or natural disasters.
- Encourage nature-based solutions (NbS) to strengthen resilience to future floods and climate change impacts.
- Implement River Acts in all provinces and aggressively enforce existing land use rules.

Some of the mitigation measures suggested by the international experts are:

Chinese Governmental Flood Management Experts

- Provinces should integrate flood governance into river-related project building, including outlets and storage space.
- Improved flood protection bunds/dikes.
- Build river control and deflection structures for significant river sections in the Lower Indus basin.
- Connect rivers, drains, and canals to improve flood management.
- Improve agriculture drainage capacity by dredging drains in high-risk locations for flash floods.
- Implement flood control measures for floods that exceed construction standards.
- Create models for analyzing rainstorms and flash floods in tiny watersheds or hill torrent catchments.
- Improve forecasting technology for snow and glacier lake outburst floods.
- Improve flood warnings at the community level.
- Create a National High-Resolution Comprehensive Database including hydrometeorology and climatology.
- The Federal Government should create a flood prevention plan and regulation mechanism for the Indus River Basin.

Dutch Experts:

- Analyze existing Flood Management SOPs for major irrigation and drainage structures.
- Improved drainage infrastructure and techniques to manage hill torrent flows effectively.

- Evaluate operating requirements and possibilities for current and under-construction projects, including feasibility studies on multifunctional dams.
- Ensure present and new projects address cross-cutting flood risk issues.
- Improve water governance at sub-basin and basin levels, especially through IRSA.
- Improve drainage systems and build flood shelters in Sindh province's low-lying districts.
- Implement nature-based solutions in hill torrent areas, such as rainwater harvesting, vegetation/grazing, and flood dispersion structures, to improve water management and control.
- Improve flood forecasting systems to account for new infrastructure projects like bridges and dikes.
- Expand the current flood forecasting system to include pluvial floods.

7

FLOOD SITUATION 2023-2024

Flooding 2023

On June 10, 2023, extreme rainfall and related occurrences resulted in the terrible loss of at least 33 lives and roughly 150 injuries in Khyber Pakhtunkhwa (KP) and Punjab provinces. The aftermath included the partial demolition of three schools, the entire collapse of two residential structures, and partial damage to more than 160 homes. Three young girls died in Chan village, Khushab district, Punjab, when their house wall collapsed due to heavy rain. Additionally, twelve people were injured in rain-related accidents in Gujranwala. Heavy rainfall and dusty winds triggered power outages in KP and Punjab.

The effect of severe pre-monsoon rains persists throughout central and northern Pakistan, resulting in increased casualties and damage, primarily in the provinces of Punjab, Khyber Pakhtunkhwa, Balochistan, and Azad Jammu & Kashmir. On July 6, 2023, the National Disaster Management Authority (NDMA) recorded a death toll of 50, with 34 in Punjab, 10 in Khyber Pakhtunkhwa, five in Balochistan, and one in Azad Jammu and Kashmir.

Heavy rains and flash floods in Khyber Pakhtunkhwa districts including Khyber, Swat, Batagram, Mansehra, Karak, Mardan, Shangla, Upper Kohistan, Upper Dir, Lower Dir, Buner, Malakand, Bajour, Abbottabad, Upper Chitral, and Lower Chitral killed 11 people and injured ten others between July 17 and July 23, 2023. These accidents also caused damage to two schools and 109 dwellings, 17 of which were completely destroyed and 92 partially damaged. In Sindh province, flooding hit six union councils in Dadu district, affecting an estimated 183 villages and 102,268 people as main routes got swamped. In Awaran, Zhob, Killa Saifullah, and Nasirabad districts of Balochistan province, six people were killed, eleven were injured, and fifteen houses and ten shops/boundary walls were damaged as a result of rain. Similarly, in Punjab province, 10 people died and thirteen were injured as a result of rain-related disasters such as roof collapses and drownings in Lahore, Gujranwala, Okara, Rawalpindi, Faisalabad, and Bahawalpur.

The death toll from rain and flood-related incidents climbed to 179, with over 264 people injured, mostly in Punjab (67) and Khyber Pakhtunkhwa (51). Similarly, 1,594 dwellings were damaged, mostly in Balochistan (445). Dadu district in Sindh felt the brunt of the effects, with 183 villages impacted by flooded roadways. Furthermore, 70 villages in Pir Jo Goth and Gambat were cut off when the Indus River swamped the Katcha area of Khairpur district, while 324 buildings were damaged in Jacobabad and Sukkur districts. Balochistan's government has classified Jafferabad, Sohbatpur, Kharan, Jhal Magsi, Punjgoor, and Washuk districts as disaster zones and is seeking humanitarian assistance. Flash floods in Washuk and Kharan damaged 2,800 homes after the Panjgur-Newan dam failed during the recent monsoon. In the Gilgit-Baltistan region, flash floods and mudslides stopped the Karakoram Highway, causing damage to 80 dwellings and impacting 250 kilometers of highways.

Since the monsoon season began in 2023, 196 people have died, nearly 200 have been injured, and thousands of dwellings have been damaged around the country. Balochistan was especially heavily impacted, with 3,838 dwellings being damaged. In flood-affected districts, 29,282 people were displaced. Relief partners highlighted key requirements such as food, clean water, and secure shelter. In the Azad Jammu and Kashmir region, 16 people died and 444 dwellings were damaged. Beginning in mid-July, 672 residences in Chitral were damaged, either partially or completely. In addition, 230 irrigation channels, 217 water supply schemes, 68 bridges, 38

kilometers of roads, 13 micro-hydropowerhouses, 87 stores, 19 vehicles, 37 mills, and 119 cow sheds were impacted. An emergency proclamation was issued until August 15th to resolve the situation.

According to media reports as of August 27, 2023, 16 people died and 36 were injured in central Punjab Province, located in eastern Pakistan. Several hundred villages in the region were inundated by Sutlej River floods. According to the European Civil Protection and Humanitarian Aid Operations (ECHO), more than 150,000 people were evacuated from affected locations on August 28, 2023. According to the National Disaster Management Authority (NDMA), more than 378,000 individuals and over 20,000 animals were evacuated to safe locations to help lessen the disaster's impact.

Since August 17, 2023, sustained high monsoon rains have caused flooding in Pakistan's Sutlej River. The resulting high floodwaters breached levees and flooded settlements in various locations, displacing over 162,257 people. In addition, roughly 153,231 acres of land including standing crops were flooded. According to media sources, Punjab's Provincial Disaster Management Authority (PDMA) has set up 178 relief camps and 95 medical camps in the affected regions to aid those in need. The Sutlej River reached a "extremely high level" at Bahawalnagar, affecting 90 villages along its banks. Figure 10 depicts river Sutlej flows from August 16 to September 4, 2023.

Pakistan experienced strong rains once more on September 1st, 2023. Since the beginning of the monsoon season, 394,314 people have been relocated in flood-affected areas, with Punjab accounting for the bulk (323,612). Punjab, Sindh, and Balochistan have seen the most damage to homes and shelters. According to data from partners, 79,489 malaria cases had been reported as of September 1, 2023.

Since June 25, 2023, the National Disaster Management Authority (NDMA) has documented 226 fatalities, 349 injuries, and the evacuation and rescue of approximately 547,400 people, as well as nearly 5,800 homes damaged statewide. The NDMA's activities include the building of 349 relief and 249 medical camps to help affected populations. As of September 25, 2023, the European Union had provided an additional □ 1 million to meet critical needs in Balochistan, Sindh, Punjab, and Khyber Pakhtunkhwa. This financing provided multi-sectoral humanitarian assistance, including multipurpose cash aid, shelters, and non-food goods for needy individuals (OCHA, 2023; ECHO, 2023).

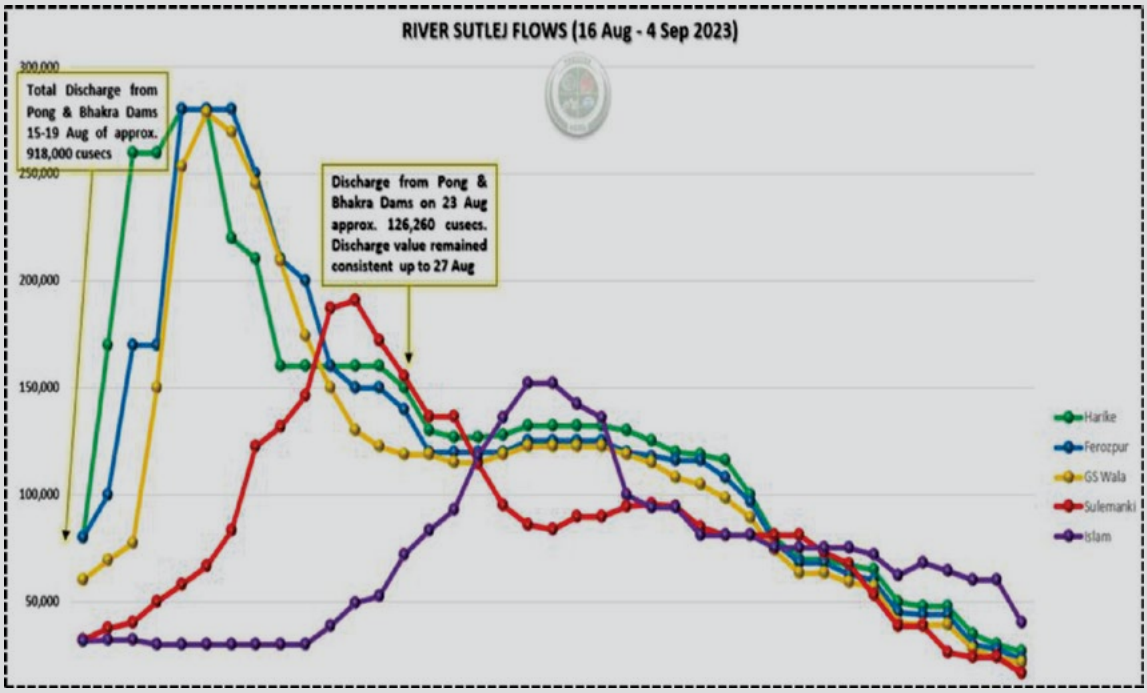

Figure 10: River Sutlej Flows (16th Aug- 4th Sep 2023) (Source: NDMA)


EURO

Torrential/Heavy Rainfall & Snowfall Feb/March 2024

According to Meteorological Department, estimated significant rainfall in certain locations, particularly Gwadar, which may exacerbate conditions, resulting in floods and associated disruptions in February 2024. On February 27th, 2024, strong rains triggered flooding in Gwadar, drowning several areas, including Gwadar city and Sarabandan. The Makran Commissioner said that Gwadar witnessed prolonged severe rains for nine hours, causing buildings to collapse and flooding in residential areas near Jinnah Avenue.

According to the Meteorological Department, rainfall was recorded in numerous areas of Balochistan, with Gwadar receiving the most at 58 millimeters. Furthermore, locations like Quetta, Dalbandin, Khuzdar, and Turbat received varying quantities of precipitation (Ahmed, 2024).

Table 10 shows the number of deaths, injuries, houses, livestock, and bridges damaged in different provinces/zones of Pakistan during the rainfall spell in Feb-March 2024. The highest number of deaths, injuries and damages to houses and livestock were observed in Khyber Pakhtunkhwa.

Table 10: Statistics on Rainfall-Related Damages in Various Provinces/Zones of Pakistan (Feb-March 2024)

Zones	Deaths				Injured				Houses Damaged			Livestock	Bridges Damaged
	Male	Female	Child	Total	Male	Female	Child	Total	Fully	Partially	Total		
Balochistan	1	1	3	5	1	0	0	1	82	155	237	0	1
KP	5	8	27	**40**	24	11	27	**62**	80	555	**635**	99	0
Punjab	0	0	0	0	0	0	0	0	0	0	0	0	0
Sindh	0	0	0	0	0	0	0	0	0	0	0	0	0
GB	1	0	0	1	0	0	0	0	0	3	3	0	1
AJ&K	6	2	0	8	0	0*	0	0	71	220	291	4	0
Total	**13**	**11**	**30**	**54**	**25**	**11**	**27**	**63**	**233**	**933**	**1,166**	**103**	**2**

Source Damage State: Official SITREPS reported by all PDMAs/GBDMA/SDMA as of 5 March 2024.

Table 11 provides the names of the districts in different provinces who faced death and infrastructural losses.

Table 11: District-wise Distribution of Rainfall-Related Fatalities and Infrastructure Losses Across Provinces (Feb-March 2024).

Zones	Human/ Infrastructural Loss	Districts
Balochistan	Deaths	Kharan & Barkhan
	Houses	Gwadar, Kech, Kharan, Quetta and Barkhan
	Bridge	Kech
KP	Deaths	Malakand, Bajaur, Swat, DI Khan, Khyber, Peshawar, Lower Chitral, Lower Dir, Abbottabad, Mardan, Lakki Marwat, Swabi, Upper Dir, Mansehra
	Houses	Malakand, Bajaur, Swat, DI Khan, Khyber, Peshawar, Bannu, Lower Chitral, Lower Dir, Abbottabad, Charsadda, Mardan, Swabi, Upper Dir, Battagram, Haripur, Mansehra, Mohmand, S. Waziristan, Hangu, Karak, Kohat, Orakzai, N. Waziristan, Buner, Nowshera, Torghar, Shangla
	Roads	N-35 KKH 1-way blocked at Pattan, open for LTV
GB	Deaths	Astore
	Houses	Gilgit and Ghizer
	Roads	AVR Blocked (work underway)
	Bridges	Hunza
AJ&K	Deaths	Neelum, Bagh, Sudhnoti, Jhelum
	Houses	Muzaffarabad, Neelum, Kotli, Bagh, Sudhnoti, Poonch, Jhelum Valley
	Roads	Leepa Valley Rd Blocked (work underway)

(Source: NDMA)

The map in figure 11 shows detailed ratio of deaths around the different provinces of Pakistan as a result of heavy rains in Feb-March 2024.

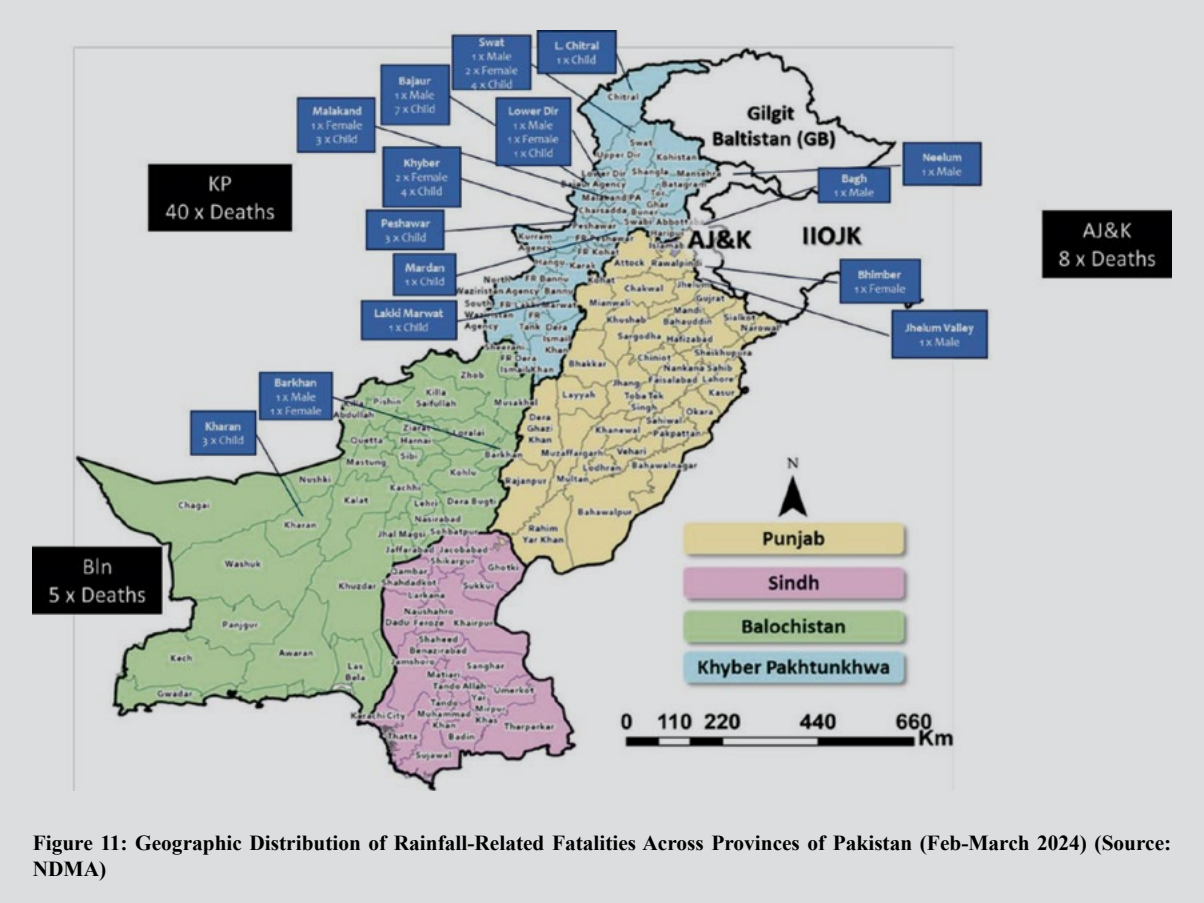

Figure 11: Geographic Distribution of Rainfall-Related Fatalities Across Provinces of Pakistan (Feb-March 2024) (Source: NDMA)

Rain Spells in April 2024:

Heavy rainfall commenced on April 12, 2024 in different regions of Pakistan, Khyber Pakhtunkhwa (KP) and Balochistan borne the brunt of the impact. The initial wave, spanning from April 12 to 24, led to significant devastation, including 107 fatalities, 130 injuries, damage to 464 schools, over 5,000 households affected, and the loss of more than 500 livestock across the country.

During the second spell of heavy rains occurring between April 28th and 29th, 2024, Khyber Pakhtunkhwa province bore the brunt of the impact, with 17 fatalities recorded (including 9 males, 3 females, and 5 children), along with 23 injuries (comprising 9 males, 3 females, and 11 children). Additionally, 139 houses sustained damage, along with 4 schools, and over 100 livestock perished across various districts of KP.

In Balochistan province, heavy rainfall resulted in 21 fatalities (comprising 8 males, 6 females, and 7 children) and 25 injuries (involving 10 males, 4 females, and 11 children). Over 2,200 houses suffered damage due to the rainfall. Additionally, the downpour caused the destruction of 4 bridges, 18 roads, 66 acres of crop areas, and the loss of over 140 livestock, as reported by PDMA Balochistan.

Heavy rainfall in Balochistan province caused 21 fatalities (8 males, 6 females, and 7 children) and 25 injuries (10 males, 4 females, and 11 children), damaging over 2,200 houses. The rainfall also destroyed

4 bridges, 18 roads, 66 acres of crop areas, and over 140 livestock, according to PDMA Balochistan. Rainfall in Punjab resulted in 21 deaths (10 males, 5 females, 6 children) and 5 injuries that include (1 male, 2 females and 2 children) as reported by PDMA Punjab. Table 12 shows district wise distribution of life and infrastructure losses.

In addition to the previously mentioned damages, the flash floods also inflicted extensive harm on a vast expanse of crops, notably the wheat crop, which were ripe for harvest. This led to substantial economic setbacks for local farmers and communities, exacerbating the losses incurred from the rain-related incidents (OCHA, 2023).

Table 12: District wise life and infrastructural losses/damages (Source: PDMA KPK)

District	Human Losses/Injuries									Infrastructure Damages								
	Death				Injured (Govt. Buildings, Bridges, Cattle Shed etc.)				Cattle Perished	Houses			Schools			Others		
	Male	Female	Child	Total	Male	Female	Child	Total		Fully	Partially	Total	Fully	Partially	Total	Fully	Partially	Total
Bajaur	2	5	4	11	5	5	12	22	36	4	95	99	0	0	0	0	1	1
Mohmand	0	0	2	2	9	7	9	25	11	32	269	301	0	2	2	0	2	2
Khyber	0	3	4	7	6	1	3	10	3	3	26	29	0	0	0	0	1	1
Lower Dir	4	2	5	11	3	0	2	5	42	47	721	768	0	1	1	0	3	3
Swat	5	0	4	9	3	1	2	6	87	49	205	254	0	3	3	0	9	9
Charsadda	0	1	4	5	0	1	8	9	0	39	366	405	0	1	1	0	2	2
Malakand	4	0	2	6	2	2	3	7	7	18	131	149	0	0	0	0	16	16
Upper Dir	0	2	4	6	1	3	1	5	11	28	147	175	0	0	0	0	4	4
Mardan	0	1	2	3	1	1	3	5	0	1	4	5	0	0	0	0	0	0
Karak	1	0	3	4	0	1	3	4	5	17	40	57	0	0	0	0	0	0
Mansehra	2	0	1	3	1	2	0	3	5	4	35	39	0	8	8	0	12	12
North Waziristan	0	0	0	0	0	0	6	6	0	5	9	14	0	0	0	0	0	0
Shangla	0	2	1	3	3	0	0	3	30	52	93	145	0	3	3	0	46	46
LowerChitral	1	0	0	1	5	0	0	5	179	177	843	1020	0	11	11	66	59	125
Hangu	0	2	0	2	2	0	1	3	7	3	80	83	0	0	0	0	0	0
Lakki Marwat	1	0	0	1	3	0	0	3	116	0	3	3	0	0	0	0	0	0
Tank	2	0	0	2	1	0	0	1	0	0	0	0	0	0	0	0	0	0
Bannu	0	1	0	1	1	1	0	2	1	6	34	40	0	0	0	0	0	0
Battagram	2	1	0	3	0	0	0	0	0	4	11	15	0	0	0	0	0	0
Nowshera	**0**	**0**	**1**	**1**	**1**	**0**	**1**	**2**	**0**	**10**	**70**	**80**	**0**	**0**	**0**	**0**	**1**	**1**
Buner	0	0	0	0	2	0	0	2	20	5	46	51	0	1	1	0	2	2
Dera Ismail Khan	0	0	0	0	0	1	1	2	0	0	3	3	0	1	1	0	0	0
Torghar	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Kohat	0	1	0	1	0	0	0	0	0	6	36	42	0	0	0	0	0	0
Orakzai	0	0	0	0	0	1	0	1	1	8	36	44	0	0	0	0	1	1
Kohistan Kolai Pallas	0	0	1	1	0	0	0	0	0	2	0	2	0	0	0	0	7	7
Peshawar	0	0	1	1	0	0	0	0	0	0	15	15	0	0	0	0	0	0
UpperChitral	0	0	1	1	0	0	0	0	0	75	399	474	0	0	0	0	0	0
Lower Kohistan	0	0	0	0	0	0	0	0	0	1	0	1	0	1	1	2	9	11
Abbottabad	0	0	0	0	0	0	0	0	0	1	8	9	0	0	0	0	0	0
Upper Kohistan	0	0	0	0	0	0	0	0	0	0	10	10	0	0	0	0	0	0
South Waziristan	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0
Total(s)	**25**	**21**	**40**	**86**	**49**	**27**	**55**	**131**	**561**	**597**	**3736**	**4333**	**0**	**32**	**32**	**68**	**175**	**243**

8 WAY FORWARD

There are two preparation procedures to minimize flood damage:

1. Implement structural measures to keep floodwaters away from communities.
2. Keep communities away from floodwater using nonstructural measures.

Structural Measures:

- While early warning systems have the potential to mitigate flood losses, their effectiveness in developing nations is often hindered by inadequate backup equipment and limited horological network coverage. Following the 2010 floods, UNESCO enhanced the Flood Forecasting Division of the Pakistan Meteorological Department (PMD) to improve response time for flood protective measures. However, community engagement remains a challenge, which is crucial for the success of early warning systems. Effective flood response strategies are necessary for optimal functioning of early warning systems. To fix this, Pakistan needs to extend its rainfall monitoring networks at the district and tehsil levels to include more communities, as the current 100 PMD stations are insufficient for the 540 tehsils, each with its own unique rainfall patterns.
- Area-specific evacuation plans should be included in media campaigns to highlight potential losses if inhabitants refuse to migrate, as they are often reluctant to leave their homes. Early warning reaction training should be included in school curricula in flood-prone areas to reduce losses. A centralized warning system is critical for reducing information duplication and building community trust. The responsible institute should take an active role in evacuating and relocating individuals. Establishing a district-level online portal for eligible organizations to register can help with centralized coordination and more effective actions.
- Water storage structures should be designed to suit the topography of the area. For example, in Baluchistan, where surface water storage is impractical due to harsh, arid conditions, emphasis should be placed on groundwater recharge methods such as water banking. By reducing the flow of floodwater through check/gabion structures, groundwater absorption can be enhanced, transforming a potential challenge into an opportunity. Integrating this insight into policy formulation can unlock the potential of hill torrents in the years ahead.
- The 2021 Public Sector Development Plan (PSDP) highlights ongoing development projects in Balochistan, including federally sponsored small dam developments, following the 2010 floods. A satellite-based assessment of these initiatives is required to determine their efficacy in floodwater conservation and drought mitigation. Similarly, projects aimed at increasing water use efficiency in agriculture, such as the Punjab Irrigated Agriculture Productivity Improvement Project, Sindh Irrigated Agriculture Productivity Enhancement Project, and Balochistan Integrated Water Resource Management Project, must be thoroughly evaluated. Bangladesh's flood risk management achievements, which include programs such as the Water Management Improvement Project and

the Weather and Climate Services Regional Project, provide useful lessons for future endeavors.

- Provincial and municipal governments often fail to implement effective floodplain management plans, despite significant investments. While the FFC creates activated floodplain and flood inundation maps, they are rarely reviewed during the approval of new housing societies for urban growth, resulting in ineffective enforcement. Recent cases of urban flooding in major Pakistani cities highlight compliance difficulties. To address these difficulties, a strong local government framework with greater support from provincial and national authorities is required.

- Pakistan is vulnerable to climate change and subsequent floods. Rather of using schools as temporary shelters during catastrophes, there is an urgent need to build specific flood shelter dwellings to protect the education sector from damages. Bangladesh has established a significant example by creating shelter homes suited for catastrophe victims, providing a template for reducing the impact of floods on education, particularly for vulnerable areas (Abedullah & Rose, 2022).

Non-Structural Measures:

- A coordinated approach to water resource management is imperative, given the involvement of over 15 institutions, both directly and indirectly engaged in flood-related activities. These include NDMA, MoCC&EC, FFC, Pakistan Commission for Indus Waters, Provincial Irrigation Departments, Pakistan Army, relief and social protection departments, as well as various NGOs. The presence of numerous entities complicates decision-making processes and hampers both preventive measures against floods and post-disaster relief efforts. This often results in duplication of initiatives and inefficient allocation of resources. To address these challenges, it is crucial to consolidate efforts under a unified framework at the local level, leveraging local expertise and knowledge. Vertical integration in disaster governance is essential to streamline operations. Civil society organizations, renowned for their extensive presence in disaster-affected areas, should play a pivotal role. Adopting a bottom-up approach to disaster management, supported by well-structured local government systems and cross-sectoral collaborations at the federal level, is paramount. Long-term cooperation beyond immediate relief efforts should be emphasized for effective disaster management.

- Financial support, such as grants or loans, is crucial for business recovery and Pakistan's economic stability following floods. Without such assistance, these enterprises may struggle to recover from significant revenue losses and damage to the local infrastructure. While the Flood Relief Cash Assistance program, run by the Benazir Income Support Programme (BISP), provides financial assistance of Rs. 25,000 to flood-affected families via the BISP database, there is a risk of resource misallocation due to an unclear scope and qualifying criteria. To limit this risk, it is critical to take a focused approach with well-defined scope and eligibility criteria developed through pre-flood risk assessments. Funds should be allocated as conditional cash transfers to facilitate the revival of local business.

- In the immediate future, adept management and strategic planning can help rectify the current scenario. The majority of the rainfall has been concentrated on agricultural lands across the country, ensuring ample soil moisture for timely planting and robust crop growth. It's imperative to educate farmers on the proper application of herbicides to mitigate potential weed challenges stemming from the heightened moisture levels. Employing appropriate tillage methods like deep plowing and Suhaaga is crucial for retaining moisture in the soil (Abedullah & Rose, 2022).

9 REFERENCES

- *Annual Report 2022. Federal Flood Commission.*
- *Federal Flood Commission, 2010.*
- *Hussain., S.S. (2015). Pakistan 2010 Floods: Causes and Lessons Learnt. Oxfam*
- *Pakistan Floods 2010 Preliminary Damage and Needs Assessment, (2010). Asian Development Bank, Government of Pakistan and World Bank.*
- *Federal Flood Commission, 2022.*
- *Report on the Hydraulic Characteristics of 2022 Floods. Federal Flood Commission, (2022).*
- *Pakistan Floods 2022: Lessons Learned. Reliefweb, (2022).*
- *Abedullah. & Rose., S. (2022). Rain Rain Go Away: A Snapshot of the Flood 2022 And Way Forward. Pakistan Institute of Development Economics.*
- *Resilient Recovery, Rehabilitation & Reconstruction Framework of Pakistan, PD&SI Division*
- *5Es Framework, PD&SI Division.*
- *United Nations Office for Coordination of Humanitarian Affairs (OCHA) https://reliefweb.int/disaster/fl-2023-000119-pak*
- *European Civil Protection and Humanitarian Aid Operations (ECHO) https://reliefweb.int/disaster/fl-2023-000119-pak*
- *Ahmed., Z. (2024). Pak: Pluvial/Flash Flood -02-2024 Torrential Rainfall/Thunderstorm & Isolated Hailstorm. International Federation of Red Cross and Red Crescent Societies (IFRC).*
- *United Nations Office for Coordination of Humanitarian Affairs (OCHA) https://reliefweb.int/report/pakistan/pakistan-flash-floods-flash-update-no3-30-april-2024*
- *Provincial Disaster Management Authorities.*
- *National Disaster Management Authority (OPS Wing).*

National Disaster Management Authority
Prime Minister's Office
Government of Pakistan
www.ndma.gov.pk