

FLASHFLOOD RISK ASSESSMENT IN PAKISTAN

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ABSTRACT

Pakistan has vastly varied topography, with Northern alps covered with glaciers and Southern Plains bordering the Arabian Sea. There are five big rivers flowing through the country from north to south namely the mighty Indus and its tributaries i.e. Jhelum, Chenab, Ravi and Sutlej. There is a well marked monsoon season from July to mid-September in which most of the country receives rainfall. Riverine flooding is common in the low lying areas along the rivers during monsoon season while flash flooding is also experienced in hilly and semi-hilly areas. Owing to climatic changes occurring across the globe, flash floods demonstrate ever increasing damage potential country wide. Traditionally, main focus has been on riverine flood management though construction of levees, bunds and spurs, to protect towns and precious lands along the main river courses. Pakistan has suffered from the worst flood of its history in monsoon season of 2010. As per DNA report of ADB / World Bank, the Floods affected an area of about 160,000 km² (one fifth of the country), claiming about 1,985 lives, damaging around 1.5 million houses, wiping out cropped area of more than 17 million acres and population of about 20 million have been displaced. The major portion of life damage in 2010 floods is attributed to flash floods. There is immense need for identification of flash flood prone areas and effective planning for flood damage mitigation in these areas.

This paper discusses in detail the assessment of flash flood risk on country wide basis. Thereupon the priority districts for flash flood mitigation have been identified and recommendations have been made for improvement in the data availability and effective flash flood risk management in these areas.

Key words: Flood risk. Flash flood, Flood mitigation.

1. Introduction:

By and large, prevention of floods is a universally known substantial impracticality; however, protection from floods and their management is viable and is of vital inevitability. Floods have been presented as a global phenomenon affecting both rich and poor, the prepared and unprepared. They are a complex, interdisciplinary problem-for some aspects satisfactory solutions have already been advanced, but for others no likely answers are as yet forthcoming[1].

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The fury of floods can be harnessed to safeguard human life and property through proper planning and effective management of available resources. Devoid of their destructive influence, excellent floods control activities provide and ensure water resource availability for the welfare of community by way of conservation and careful use during lean periods.

2. Flood Problems in General Perspective:

It is recognized world over that floods are the most destructive of natural hazards and the greatest cause of large-scale damages to lives and property. Over the years, major floods have occurred in almost all the South Asian countries, causing huge loss of life and property. Despite the investment of millions, even billions of dollars in efforts to tame the rivers of the region, the frequency of occurrence of major flood disasters has actually increased over the past 25 to 30 years. Consequently there is a growing consensus that the impacts of climate change may well lead to an increase in both the frequency and the magnitude of floods. Nevertheless mankind has to live with the floods and devise measures to better manage them to minimize the losses and harness benefits.

2.1 Floods in Pakistan:

Seventeen major floods that have hit the country since 1947 caused economic losses and damages estimated as US\$ 12 billion. These floods affected the basins of the rivers in Punjab and Sindh. In KPK, Balochistan and some areas of Punjab also, damage is caused mainly from hill torrents in which flash floods are generated by rains in monsoon season.

In upper to mid reaches of Indus river Basin, generally tributaries like Jhelum and Chenab are mostly the cause of flooding. River floods particularly hit Punjab and Sindh while hill torrents tend to affect the hilly areas of KPK, Balochistan and Northern areas. Districts of Charsadda, Mardan, Nowshera and Peshawar in KPK are exposed to risks from flooding in the River Kabul. In recent years, vulnerabilities of large cities to flooding have increased. Cities like Karachi, Lahore and Rawalpindi have experienced flooding due to inability of sewerage system to cope with heavy rains.

During the last sixty three years in Pakistan, the total losses ascribable to floods are colossal, while more than 10,000 people lost their lives besides affecting a large area. Heaviest direct flood damages in Pakistan occur to infrastructure, agricultural crops, damage to urban and rural property and public utilities. Historical flood damages up to 2010 in Pakistan are given in Table-1 below[2]:

Monsoon 2010 brought with it unprecedented abnormal rains in Pakistan resulting into countrywide massive and large scale flooding, which is being termed as the worst ever flooding in the living memory of the entire region. This has mainly been on account of persistent and severe rain spells over Pakistan, which has first hit country's southern Province of Balochistan in the third week of July 2010, followed by a second spell of heavy monsoon rains over Khyber Pakhtunkwa, in the last week of July 2010. These rains generated unprecedented flood flows in

major, secondary and tertiary rivers including hill torrents and local nullahs in Khyber Pakhtunkwa (KPK), followed by Punjab and Sindh. Flood wave of Indus River and the unprecedented combined flood wave of Kabul, Swat and Panjkora Rivers got superimposed, which resulted in exceptionally high floods in the River Indus all the way to the last control structure, i.e. Kotri Barrage. Unusual heavy flood contributions were also received from the hill torrents of D.I. Khan, D.G Khan and Rajanpur. Although the flood embankments in Punjab and Sindh were not overtopped, but they came under severe pressure for unusually long durations. Breached occurred at many locations and the resulting inundations caused heavy damages to the lives and properties. As per DNA report of ADB /World Bank the Floods affected an area of about 160,000 km² (one fifth of the country), claiming about 1,985 lives, damaging around 1.5 million homes, wiping out cropped area of more than 17 million acres and population of about 20 million have been displaced[3]. The life damage was mainly in areas prone to flash flooding.

Table-1: Historical Flood Damages in Pakistan

Year	Value of Property Damaged (Rs in Million)		Lives Lost	Villages Affected
	Unadjusted	Adjusted		
1950	199.80	11,282.00	2,190	10,000
1956	155.50	7,356.00	160	11,609
1957	152.50	6,958.00	83	4,498
1973	5,137.00	118,684.00	474	9,719
1976	5,880.00	80,504.00	425	18,390
1978	4,478.00	51,489.00	393	9,199
1988	6,879.00	25,630.00	508	1,000
1992	34,751.00	69,580.00	1,008	13,208
1995	6,125.00	8,698.00	591	6,852
2001	450.00	450.00	219	50
2003	5,175.00	5,175.00	484	4,376
2004	15.00	15.00	85	47
2005		Not Reported	59	1,931
2006		Not Reported	541	2,477
2007		Not Reported	586	6498
2008		Not Reported	157	800
2009		Not Reported	99	89
2010	819,381.00	819,381.00	1961	14,316
Total:	888,778.8	1,205,202.00	10,023	115,059

In order to discuss the causes of floods in Pakistan and protection from them, it would be appropriate to first glance through the urgency of flood management in the context of South Asia and existing Indus Basin River System and Irrigation Network of Pakistan.

2.2 Flood Management:

Flood remains as an annual unwanted visitor in many countries. It often takes the shape of a disaster and badly affects people's lives as well as the economic activities in the affected areas. Even experienced administrators and engineers are often caught by surprise under the emerging situation in taking decisions concerning necessary emergency measures. Agricultural and industrial production, services, and marketing systems are affected adversely and directly by floods. By damaging and/or destroying physical infrastructure, floods also disrupt passage/flow of goods and services to the flood affected communities.

People living in marooned areas become extremely distressed. Unfortunately, these people often do not find adequate and appropriate shelters; quality food and drinking water; adequate and hygienic sanitation; privacy for women, particularly for the lactating mothers and adolescent women etc. Floods often force the students out of academic activities since their learning centers are often used as makeshift flood shelters in affected areas. These disasters not only affect micro- and household-level activities but also have macro-economic/budgetary implications. As resources are required to address the relief and rehabilitation requirements, budgetary reallocation becomes necessary, adversely impacting on development activities from which resources are transferred. Moreover, contribution to national exchequer may be reduced, as people may be unable to pay their taxes as well as utility services.

Floods also create health hazards for the affected people. Widespread water borne diseases may loom large. Paradoxically, although there is excess water, potable water becomes very short in supply. The traditional potable water sources suddenly disappear or become dangerously contaminated. After shelter, the most sought after commodity in a flood situation is the potable water. Shelters often become congested with people of all ages, exhausted, in ill health, and suffering from water and vector-borne diseases. Sometimes due to disruption of communication, doctors are not available in the marooned villages.

In order to provide better services to flood victims during and after floods it is necessary to examine existing flood management capabilities and identify gaps with a view to develop and introduce a better flood management system. The cultural context of the affected people is an important aspect and should therefore, be considered in developing the approach/ approaches to flood management.

2.3 Integrated Approach in Flood Management:

In the past, floods were considered as a hydrological reality; only structural and non-structural measures were adopted to deal with this phenomenon, but now well-being of the people of the flood prone areas, their economic growth; and social

urgency for alleviating poverty prevailing in these floods affected areas, are overriding concerns.

Enough hard work is required to address these concerns from both national and regional perspectives. The regional approach is of particular significance as activities undertaken in one country may affect, positively or negatively, the extent of floods in the other regional countries, particularly the downstream ones.

To make full use of the experiences gained from flood management activities in the regional countries there is pressing need for exchange of views and experiences, data and information sharing, and working together to develop approaches and methods to address pertinent flood management issues, nationally and regionally, in an open and *trusting* atmosphere.

3. Indus Basin River System of Pakistan:

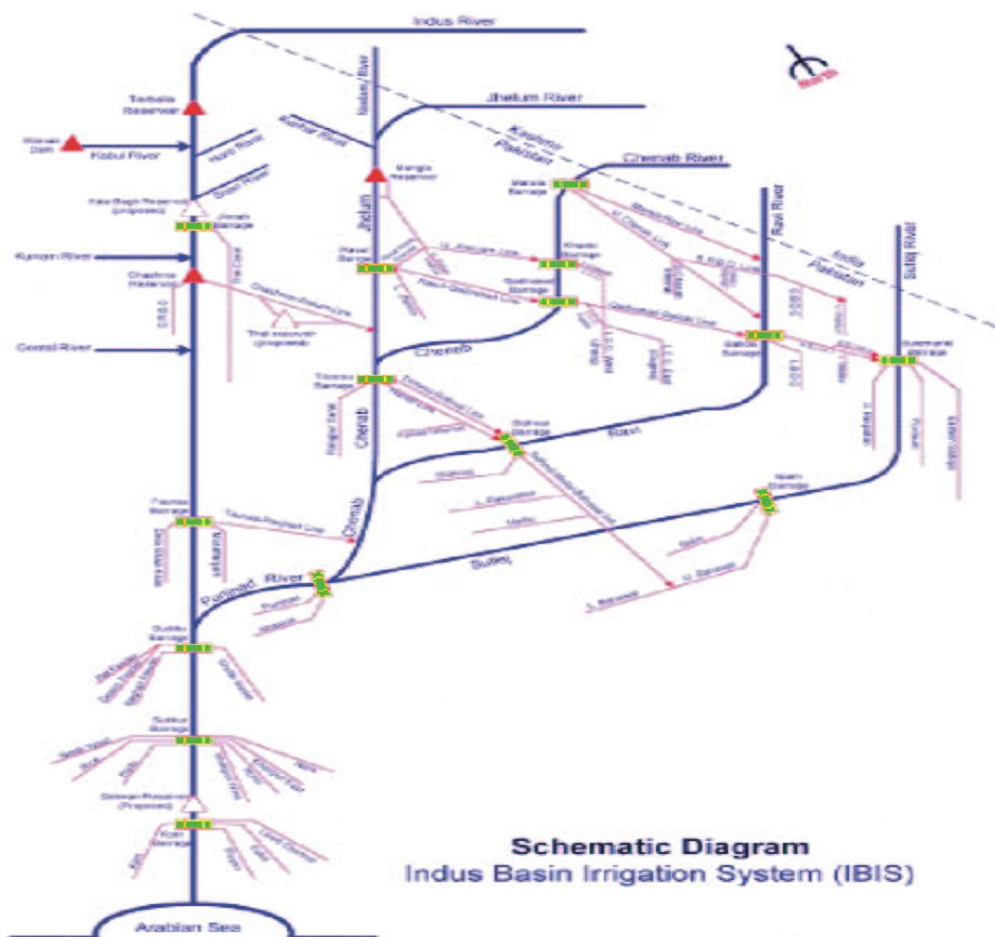
Five main rivers, namely, the Indus, Jhelum, Chenab, Ravi and Sutlej flow through the country's plains. Supplemented by a number of smaller tributary rivers and streams, these rivers supply water to the entire Indus Basin Irrigation System. The rivers have their origin in the higher altitudes and derive their flows mainly from snowmelt and monsoon rains. The catchment area of Indus is most unique in the sense that it contains seven (7) of the world's highest-ranking peaks, after Mount Everest. These include K-2 (28,253 ft), Nanga Parbat (26,660 ft), Rakaposhi (25,552 ft) etc. Likewise, barring the *polar areas*, seven (7) glaciers situated in the Indus catchment are amongst the largest in the world, namely, Siachin, Hispar, Biafo, Batura, Baltoro, Barpu and Hopper.

3.1 The Irrigation Network of Pakistan:

The Irrigation System of Pakistan is the largest integrated irrigation network in the world, serving 42 million acres of contiguous cultivated land. The system is fed by the waters of the Indus River and its tributaries. The salient features of the Irrigation Network are summarized in Table-2 below:

Table-2: Salient Features of Irrigation Network of Pakistan

<i>Structure</i>	<i>No.</i>
<i>Major Storage Reservoirs</i>	<i>3</i>
<i>Barrages</i>	<i>19</i>
<i>Inter-River Link Canals</i>	<i>12</i>
<i>Independent Irrigation Canal Commands</i>	<i>45</i>
<i>Large Dams (Approx. 3.00 MAF) of height 15 meter and above</i>	<i>143</i>



The major storage reservoirs include Tarbela (existing Live Storage Capacity = 6.948 MAF against original 9.70 MAF), Chashma (existing Live Storage Capacity = 0.435 MAF against original 0.70 MAF) on River Indus and Mangla (existing Live Storage Capacity = 4.542 MAF against original 5.30 MAF) on River Jhelum. The total length of main canals/ distributaries and minors is 64,000 KM. Watercourses comprise another 1,621,000 KM

Diversion of river waters into off taking canals is made through barrages, which are gated diversion weirs. The main canals in turn deliver water to branch canals, distributaries and minors. The watercourses get their share of water through outlets in the irrigation channels. Distribution of water from a watercourse is effected through a time-schedule called “warabandi”.

Annual water availability is 142 MAF whereas the annual canal withdrawals are 104 MAF. Water availability at farm gate is 106 MAF comprising 62 MAF of surface water and 44 MAF of groundwater. Supplemented by an annual groundwater withdrawal of some 42 MAF, the average depth of water available at the farm gate is 3.07 feet per acre. Approximately 3 million individual farms with an average size of about 12 acres benefit from this system. The inter-provincial water allocations are made by Indus River System Authority (IRSA) created in consequence of 1991 Water Accord between the provinces[2].

3.2 Causes of Floods in Pakistan:

The major cause of floods in Pakistan is heavy concentrated rainfall in the river catchments, which sometimes augmented by snowmelt flows, generally result into floods in rivers during the monsoon season. Occasionally, Monsoon currents originating in the Bay of Bengal (India) and resultant depressions often result in heavy downpour in the Himalayan foothills additionally affected by the weather systems from the Arabian Sea (Seasonal Low) and from the Mediterranean Sea (Westerly Wave) cause destructive floods in one or more of the main rivers of the Indus System. However, in some cases exceptionally high floods have occasionally been caused by the formation of temporary natural dams due to land sliding or glacial movement and their subsequent collapse. There are large seasonal variations in almost all the river discharges, which further aggravate the river course and morphology.

The major rivers cause flood losses by inundation of areas along their banks, by damaging irrigation and communication facilities across or adjacent to the rivers, and by erosion of land along the riverbanks. In the upper part of the Indus Basin System, floodwater spilling over the riverbanks generally returns to the river. However, in the lower part of Indus River, which is primarily flowing at a higher elevation than adjoining lands, spills do not return to the river. This phenomenon largely extends the period of inundation resulting in even greater damages. Although flood protection by embankments has been provided along almost the entire length in the Sindh Province and at many locations in the upper areas, the bund breaches can still occur. Such breaches often cause greater damage than would have occurred without the bunds because of their unexpected nature and intensification of land use following the provision of flood protection.

The inadequate existing discharge capacity of some of the important structures (Barrages and Rail or Road Bridges) on Rivers Indus, Chenab and Ravi are another major reason. During exceptionally high floods this results in afflux on the upstream side, which sometimes results in breaches in the flood embankments. At times, the flood embankments have to be deliberately breached at pre-selected locations to save the main barrage structures and other vital settlements and installations in the vicinity.

The encroachment of village abadies in riverine areas has also increased the quantum of flood damages and losses to humans and livestock. As there is no proper regulatory framework in the country regarding the settlement in riverine areas, most of the poor people have constructed their shelters along the vulnerable river banks and become victims to devastating floods. Some people are making the most of these areas for business purpose through promoting agriculture and cattle Ghats/dairies. All such activities are extending beyond the safe limits of riverine areas to achieve more economic benefits but in fact are posing a great threat to unprecedented and unruly flood; the losses due to which may be in hundred multiples of such small scale economic profit. The river catchments and flood plains are to be kept as prohibited area for the riverine community especially during the flood season.

In recent years, vulnerabilities of large cities to flooding have increased. Cities like Karachi, Lahore and Rawalpindi have experienced flooding due to inability of sewerage system to cope with heavy rains.

4. Flash Floods

Baseline information on flash floods in Pakistan has been reviewed and it has been observed that flash floods occur predominantly in mountainous and semi-mountainous regions and also in adjoining plains. The mountain ranges of the Himalayan region are young, unstable in geology, have steep slopes, and have a climate difficult to predict. Flash floods tend to occur more in recent years owing to changing weather patterns. The region is highly susceptible to natural hazards such as floods, flash floods, landslides, and earthquakes etc. Flash floods have wide vulnerability imprint as they have no early warning cover to warn vulnerable communities. Being a sudden onset hazard, flash floods pose a grave threat to lives besides accentuating socio-economic poverty. Following recent trends of flash floods have been observed:

- Flash floods generated by hill torrents are experienced in D.I. Khan, D.G. Khan, Kirther Ranges of Balochistan and Sindh Provinces.
- Flash floods caused by tropical cyclone adversely affect coastal areas of Sindh and Balochistan
- Flash floods are more likely to occur owing to the inconsistent rain pattern & cloud burst phenomenon. A cloud burst event was observed in Rawalpindi-Islamabad in July 2001 that caused record flash flooding in catchment area of Lai Nullah of Rawalpindi and Islamabad where 621 mm rainfall was recorded in Islamabad during a time period of 10 hours only.
- Flash flood events have become frequent especially in the Northern Areas and in Balochistan.
- The risk of flash floods associated with Glacial Lake Outburst Flood (GLOF) events has also increased.

In Pakistan heavy concentrated rainfall in the river catchments, sometimes augmented by snowmelt flows, generally causes floods in rivers during the monsoon season. Occasionally destructive floods are caused in one or more of the main rivers of the Indus River System due to monsoon currents originating in the bay of Bengal (India) and resultant depressions which often result in heavy downpour in the Himalayan foothills additionally affected by the weather systems from the Arabian Sea (Seasonal Low) and from the Mediterranean Sea (Westerly Wave). Exceptionally high floods occur due to the formation of temporary natural dams due to land sliding or glacial movements (GLOFs) and their subsequent collapse.

4.1 Province/Agency-wise Vulnerability to Flash Floods in Pakistan

Vulnerability is defined as the condition determined by physical, social, economic and environmental factors or processes, which increase the susceptibility

of a community to the impact of hazards. Warning systems in Pakistan lack the basic capacities or equipment, skills, and resources. The continuous impact of climate change has further necessitated the need for enhancing the capabilities in the field of early warnings of flash floods. For example, unusual high temperatures in northern mountains during the month of June 2006, accelerated snow melt which caused high to very high flooding in Kabul, Swat, Shah Aalam and Chitral rivers in KPK[2].

Mountainous regions of AJ&K and Gilgit-Baltistan are vulnerable to flash flooding, land slides and GLOF at alpine altitudes. Flash floods occur in rivers Kabul, Swat and Local nullahs and cause severe losses to adjoining areas/abadies situated in KPK. Also hill torrents in Punjab cause severe damage due to flash floods. Coastal regions of Sindh and its districts along Indus in the north are vulnerable to riverine floods and tropical cyclones followed by the flash floods. Vast coastal belt of Balochistan is also prone to tropical cyclones and flash flooding.

Out of 51 million acres of area in Punjab, 7.7 million acres lies in the active flood zone. Of 73.62 million population, 14.72 million lies in the flood zones. Besides riverine floods in rivers Indus, Jhelum, Chenab, Ravi and Sutlej heavy precipitation tends to cause serious hill torrents generated flash floods along the borders of Punjab and Balochistan in DG Khan and Rajanpur. Flash flooding in the plains occurs through numerous seasonal water channels in Sialkot-Jammu region that tend to impact districts Lahore, Gujranwala and Shiekhpora. Heavy rains also tend to cause urban flooding in Rawalpindi, Lahore and other cities due to changing weather patterns causing rising incidence of flash floods and cloud bursts.

Province of Sindh is traditionally vulnerable to precipitation generated flash flooding and urban flooding, primarily in the cities of Karachi and Hyderabad. Recent flood experiences indicates that some of the flood protection works were severely damaged this year due to flash floods. Flash floods tend to impact districts Larkana, Kamber-Shahdadkot and Dadu. Flash floods also result from heavy precipitation in Kirthar Range flanking Dadu district in the west.

In Khyber Pakhtunkwa Province, districts Chitral, Upper and Lower Dir, Shangla, Swat, Charsadda and Mansehra are prone to flash flooding, cloud bursts and land-sliding activity. The peculiar physical configuration of the province makes it vulnerable as some densely populated districts constitute catchment areas of major rivers where minor tributaries multiply and create flash floods vulnerability. District Charsadda is vulnerable to flash floods along Jindi Nullah and Shobla Nullah, both seasonal water channels. In Peshawar, locals have trained the water course of River Kabul tributaries for agricultural and domestic use which causes spill over in populated areas after even moderate precipitation. Damage due to flash floods was most severe in KPK during 2010 floods. D.I. Khan district is excessively vulnerable to flash flood along five nullahs, seasonal water channels, flowing into Indus off Koh-e-Sulaiman ranges to its west.

Balochistan faced Yemyin Cyclone in 2007 tinting its vulnerability to tropical cyclones and flash floods caused by heavy precipitation. Three regions of the province are vulnerable to such hazards: Mekran region (district Kech and

Gawadar), Kutchi plains (districts Sibi, Bolan, Jhal Magsi and Jaffarabad) and third region spans Kalat and Lasbela districts where flood water drains into the sea from higher regions. Flash floods bearing major seasonal rivers include Kech River and Nihange River (Kech), Pralli(Lasbela), Urnach (Khuzdar), Talli, Moollah, Bolan, Sukleji(Sibi, Bolan and Jhal Magsi districts) and Zhob nullah of district Zhob.

Nearly all districts of AJK State are located within the summer monsoon zone in the catchment area of rivers Jhelum/Chenab and remain vulnerable to excessive/abrupt flooding even after moderate to heavy precipitation. AJ&K is extremely vulnerable to flash floods that occur without warning. Most households are located on higher ground but the communication infrastructure remains vulnerable to severance both due to flash floods and sliding activity, causing population isolation in remote region. Early reopening of roads to restore accessibility remains critical for response. Makri Nullah of Muzaffarabad City is a source of local emergency. District Neelum is excessively vulnerable to flash flooding as a consequence of rains. Flash floods tend to temporarily block Neelum. Nakdar, Shuntar and Shoai Nullahs have cause similar disruption in recent years. In Bagh District, Mal Nullah poses hazard to Bagh City after excessive rains. Poonch River and Ranger Nullah in Bandi Abbaspur tends to cause local flash floods in Poonch District. To a smaller extent ,the southern districts of Kotli and Bhimber are also vulnerable to flash floods.

4.2 Flash Flooding due to Hill Torrents

Hill torrents that drain hilly and foothill areas, particularly in the zones of low annual rainfall, cause a severe flood problem in Pakistan. Almost all hill torrents/hilly nullahs originating from the mountains of these areas receive non-perennial flows and pass through large tracts of fairly leveled and fertile lands before they join the Indus Basin system. Under the prevailing conditions, these hill torrents carry flood water with flashy peaks, disperse in floodplains and then join the rivers. Very little flood discharge data for hill torrents is available as it is extremely difficult to measure the peak flow, because of their short period and unforeseeable timing and because of the number of hill torrents involved. There are 16 major areas in Pakistan, which are affected by flash flood of hill torrents. These areas are listed below:

Federal Areas & Azad Kashmir Hill Torrents

1. Gilgit Baltistan
2. Federally Administrated Tribal areas (FATA)
3. Azad Jammu & Kashmir

Khyber Pakhtunkwa Hill Torrents:

1. D.I.Khan-Bannu-Kohat
2. Hazara Area
3. Kabul River

Punjab Hill Torrents:

1. D.G.Khan
2. Pothowar Area
3. Rachna & Ghaj Doabs

Balochistan Hill Torrents:

1. Zhob-Loralai
2. Kachhi Basin
3. Kharan Closed Desert Basin
4. Makran Coastal Area

Sindh Hill Torrents:

1. Kirther Range
2. Karachi Area
3. Sehwan & Petaro area

The frequency and extent of inundation of above areas has not been studied in detail as has been studied for major rivers. This does not mean that losses due to floods do not occur in such areas. Most of these hill torrents have arid climate. The arid climates generally depict wide variation in rainfall. These high variations in rainfall result very low flows in some years and very high infrequent floods. The high infrequent floods generally take people by surprise and the poor people living in these areas are affected badly.

5. Conclusions

It has been observed that the districts Kohistan, Shangla, Lower and Upper Dir, Swat, Nowshera, D. I. Khan and Charsadda in Khyber Pakhtunkwa, Muzaffarabad in Azad Jammu & Kashmir, Mianwali, Dera Ghazi Khan and Rajanpur in Punjab, Nasirabad, Jaffarabad and Kharan in Balochistan and Larkana, Kamber-Shahdadkot, Dadu and Thatta in Sindh are prone to Flash flood hazards and special measures like efficient forecasting mechanism and community awareness campaign be adopted to avert the loss of precious lives and property in these areas.

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