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ENVIRONMENTAL EFFECTS OF HAZARDOUS FLOOD OF 2010 IN THE PROVINCE OF KHYBER PAKHTUNKAWA (KPK), PAKISTAN, ITS CAUSES AND MANAGEMENT

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ABSTRACT: The devastating flood hit Pakistan during the last week of July 2010 due to prolonged monsoon rainfalls and the whole country remained flooded for two months. Initially the flash floods washed out all the villages in the flood ways in the mountainous areas of Khyber Pukhtunkhawa (KPK) and northern Pakistan. The continuous rains further worsened the situation and the flood water spread through out the country. The flood water over topped all levees and entered in the thousands of villages in the plane areas of the Punjab and Sindh located on the banks of the rivers. The loss of live and property was unprecedented due to this mega disaster. Million of the homes and thousands of the towns and villages were destroyed, and thousands of people dead or injured. This paper focuses on the environmental effects of the hazardous flood of 2010 in the province of Khyber Pakhtunkhwa, its causes and the anthropogenic influence which enhanced the hazards of the flood. Management measures and suggestions are also discussed for long term planning to handle the flood disaster in future.

Keywords: Environmental Effects, Hazardous Floods, Khyber Pakhtunkawa, Pakistan, Causes, Management

INTRODUCTION

During monsoon period heavy downpour is a routine event in Pakistan but in the last week of July 2010 the intensity of rainfall increased tremendously in the mountainous areas of the KPK and Azad Kashmir which resulted flash flood in the upstream area. Due to prolonged rains of monsoon, tremendous runoff was generated, causing destructive floods which spread through out the country (Fig. 1).

Floods are natural events which cause great losses in terms of human life, properties and infrastructure Montgomery [1]. The major sources of these floods are controled by rain fall and snow melting. Mostly the rivers in Pakistan receive their inflows during the monsoon period. During the past thirty years due to tremendous growth in population and global warming effects hydrological changes (Tables 1 & 2) are being observed in Pakistan and these changes are effecting the environment badly, the devastating flood of 2010 in Pakistan is combined effects of these activities.

There are many examples in the past that flash floods created great hazards in the mountainous areas of Pakistan. Rafiq [2] reported that, "about 263 people
were killed and a property of more than Rs. 900 million was lost in the single flood over a 36 hours period during September 1992 floods in Hazara". Hamidullah [3] documented a number of catastrophic floods in past with reference to Pakistan described as, "during Quaternary period catastrophic floods produced as a result of bursting of landslides & glaciers have inundated the middle Indus river valley in Pakistan.". According to Keller [4], "most river flooding is a function of the total amount and distribution of precipitation and the rate at which it infiltrates the rock or soil and the topography, however some floods results from rapid melting of ice and snow in the spring and on rare occasion from failure of a dam."

The floods and related hazards are not only common in Pakistan but these hydrological changes may affect even developed countries such as United Kingdom as reported by Flemings [5], "the autumn 2000 was the wettest in the UK since records began (over 270 years ago) much of the UK experienced prolonged and intense rainfall, for instance the rainfall in October was four times the average for the month."

Table 1: Heavy rainfalls recorded during the wet spell of July 2010 in KPK and northern Pakistan indicating new records [6].

City	Rainfall	Rainfall	Province
Risalpur	415 (New	16.3	Khyber Pakhtunkhwa
Islamabad	394	15.5	Islamabad Capital
Murree	373	14.6	Punjab
Cherat	372 (New	14.6	Khyber Pakhtunkhwa
Garhi Dopatta	346	13.6	Azad Kashmir
Saidu Sharif	338 (New	13.3	Khyber Pakhtunkhwa
Peshawar	333 (New	13.1	Khyber Pakhtunkhwa
Kamra	308	12.1	Punjab
Rawalakot	297	11.7	Azad Kashmir
Muzaffarabad	292	11.5	Azad Kashmir
Lower Dir	263	10.3	Khyber Pakhtunkhwa
Kohat	262 (New	10.3	Khyber Pakhtunkhwa
Balakot	256	10.0	Khyber Pakhtunkhwa
Pattan	242	9.5	Azad Kashmir
Dir	231	9.10	Khyber Pakhtunkhawa
D.I.Khan mail	220	8.6	Khyber Pakhtunkhawa

Table 2 Outflows of various rivers of KPK flood during August, 2010 [6].

River	Location	Discharge (Cusecs)	Flow Status
Swat River	Khawaza khela	14325	High
Swat River	Amandara	18997	Normal
Swat River	Munda Head Works	25249	Low
Swat River at Khlaiy	Charsada Road	25301	Medium
Panjkora River	Dir Talash	14631	Medium
Kabul River	Warsak	41650	Low
Kabul River	Nowsehra	75700	Medium
Adaizai River	Adezai Bridge	24694	High
Jandi River	Charsada	2188	Low
Dallus Nallah	Warsak Road	136	Normal
Kalpani Nallah	Mardan City	1466	Low
Gambila River	Gambila Bridge	811	Normal
Kurram River	Thall	17679	Low
Kaitu River	Spinwam	-	-
Indus River	Tarbela Outflow	279100	Low
Indus River	Kalabagh Outflow	372975	Low
Indus River	Chashma Outflow	505007	High
Indus River	Attock Khairabad	343800	Low
Peer Bala Khwar	Warsak Road	179	Normal
Budni Nallah	Charsadda	1454	Normal

Table 3 Effects on human life and livestock in various districts of KPK during flood 2010 [6].

District	Total Population (Million)	Dead	Injured	Total Population Displaced	Population inaccessible	Cattle	Crops (Acres)	Trans Former	Pole	Grid Station
Tank	0.343	11	20	35000						
DI Khan	1.247	31	61	20468			180252			
Lakki Marwat	0.708	12	26			35				2
Bannu	0.938	12	27	4310		135	89232			
Mansehra	1.526	36	37	28644				10	29	
Abbottabad	1.09	17	5	3304			1500			
Haripur	0.895	37	21	20629		141				
Battagram	0.607	33	18	1246		361		9		
Kohistan	0.478	85	10	32122	150000	14908		1	18	
Peshawar	3.054	46	68	37373		120	92797			
Charsada	1.431	66	115	145810		33559	40725			
Nowshera	1.226	167	10	350336						
Mardan	2.074	8	40	11403		8	700			1
Swabi	1.45	7	4	742			100			
Karak	0.63	23	63			6				
Kohat	0.821	35	36	50		302	3750			
Hangu	0.459	12	13	581		26				
Swat	1.863	95	207	101220	350000		34470			

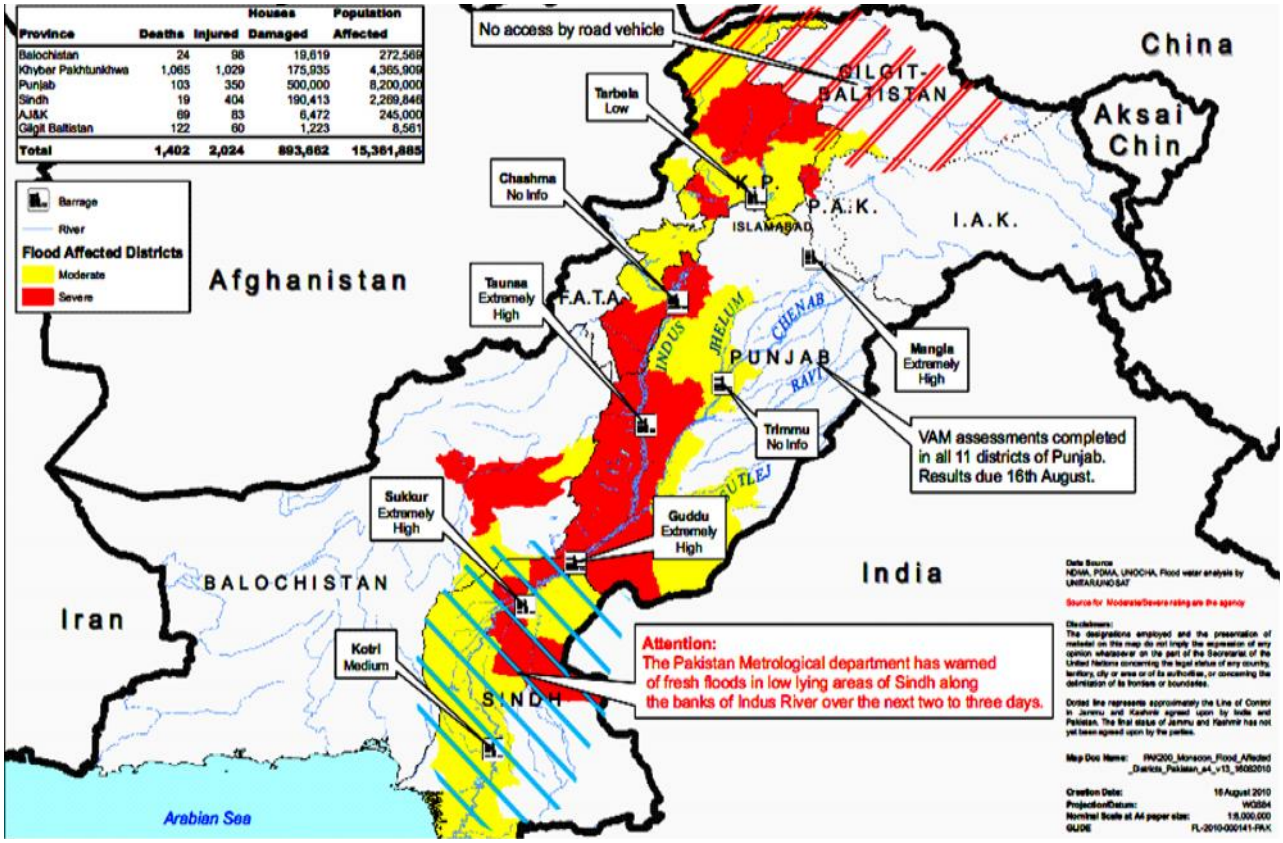

Fig. 1 Flood affected areas of Pakistan, monsoon flood 2010 [OCHA]

The situation in flooded areas of KPK remained similar as described by Thirumurthy, *et al.*, [7], "Complex urban economic systems and the individuals affordability factors often resulted in occupation of low lying areas closer to the city center along the river margins and other water sheds which primarily serve as a drainage basin for the whole city during monsoon seasons. These areas are often not well protected against flash floods and heavy rainfall and the people encounter a host of environmental problems besides heavy damages to properties. Under average rainfall conditions every year the impact of floods and inundation on the settlement are innumerable. The effects though of short duration, more often have longer impact".

Hickey [8] while discussing the extreme floods in the United States describes that: "Recent extreme flooding in the United States, Mississippi River Basin, 1993, Flint River Basin, 1994, Sacramento and San Joaquin River Basins, 1997, and the Red River Basin, 1997, has demonstrated the limitations of current flood protectional measures and heightened interest in nonstructural flood control. As memories of flood devastation fade behind the rebuilt walls of protective levees, so goes interest in pursuing new policy embracing environmentally sound, nonstructural control measures. Extreme floods not only present an opportunity to further research natural dynamics, but to institrute new policy based on previous research.

This study is being performed to analyze change rainfall pattern and flood caused changes to assess the flood controlling factors and propose remedial measures, because the future planning and management is greatly controlled by the relation of precipitation and floods.

BRIEF DESCRIPTION OF THE FLOOD EFFECTS IN KHYBER PAKHTUNKAWA

The effects in term of losses to life and property are unprecedented. The infrastructure such as, roads, bridges, houses, schools, water, gas and electricity supplying lines and power houses have been severely damaged or destroyed (Tables 3 & 4). The land containing crops over millions of acre were completely or partly damaged. Some of the adverse effects of the flood are as follows.

Losses of human life and livestock

According to the initial assessment by the Provincial Disaster Management Cell of KPK [6] is given in Table-3 which indicates that 1068 people were dead and 1109 injured during flood in the province. The devastating flood forced to displaced 9,12,999 people out of which more than 75 % (6,07,366 people) were from the greatly effected areas of Charsada, Nowshera, Swat and Dir Upper. The number of cattle

death is very high i.e. 52,750 and crops over an area of 5,07,423 acres were completely destroyed during the flood. The power supply system was also washed out at number of places which includes 605 transformers, 305 poles and 5 grid stations in the province.

Damages to the villages and infrastructure

The damages to the other infrastructure in the province are given in Table-4 which highlights that over all 544 villages were effected where in the households were approximately

5,46,003. Total houses effected were 191215 and out of these paka developed houses were 82551 and kacha developed houses were 108664. In other infrastructure damaged due to flood are 283 roads, 278 bridges, 23 culverts, 885 education facilities, and 178 Government buildings were also destroyed. The emergent relief to the effected areas is greatly linked with the availability of the transportation link. The status of link roads is given kin Table-5 during the month of September 2010 which shows that only 50 % roads could be partially opened for light traffic only.

Destruction of irrigation water supply system

The flood caused adverse effects on various crops in the province; especially the standing crop of the sugarcane was severely damaged. The flood also brought tremendous amount of sediments and spread thick blanket of sediments in the plane areas of Charsada & Nowshera. The debris blanket of 2-12 feet thick destroyed the water irrigation system. The hazards associated with these sediments are prominent in the districts of Charsada & Nowshera. The removal of debris and rehabilitation of irrigation water supply system is an important task.

Hydrological aspects of floods in Pakistan

The Indus River system of Pakistan is one of the largest rivers of the world which generates about 141-145 million acre feet of annual runoff. The prevailing hydrological cycle in the country is composed of two components which provide water through snow and rainfall. The snowfall generally is received by the northern areas of the country during winter every year. During the hot months of summer, sometimes the snow sheet is capable to generate more than 1,00,000 cusecs runoff only for 1^0C rise in temperature in the snow covered areas of Skardu. The other component of hydrological cycle, rainfall has two prominent spells in Pakistan, one during monsoon and the other winter rains mostly controlled by western winds.

During July 2010 the major storage reservoirs, Tarbela & Mangla were already on rising leg when the prolonged monsoon started in the last week of July. Hence the management of flood water through these major reservoirs became ineffective due to already reduced storage capacity.

CAUSES OF FLOODS WITH REFERENCE TO PAKISTAN:

Floods are natural events which occur throughout the world. In Pakistan the flood of 2010 is predominantly caused by unprecedented rainfalls during the monsoon period. However the hazards which occurred due to flood also have some other controlling factors which are as follows.

Prolonged precipitation

Rainfall is one of the major causes of floods in Pakistan. Pakistan receives two prominent spells of rainfall, monsoon rains, from mid June to mid September and winter rains from December to early March every year. Snowfall spell is from November to March in mountain area with elevation more than 5,000 feet. On melting during hot summer, this snowfall generates lot of runoff causing floods. The rainfall data (Table-1) for the wet spell of July 2010 indicates that at a number of places the past records of rainfall are broken for the same periods, which cause huge runoff, followed by uncontrollable flood.

Topography and steep slopes

Topography is another factor which play very important role in causing flash floods in Pakistan. The northern area of Pakistan which receives more than 50 inches mean annual rainfall where the altitude difference is more has 25,000 feet causing steep slopes. These steep slopes spread over thousands of square kilometer area are responsible for generation of quick runoff which caused flash floods in Swat, Kaghan, Neelum vallies and other mountainous areas of Pakistan.

Fig. 2. Washed out bridge & buildings (constructed in river course) by the flood in Ghazi, August 5, 2010 (Reuter's/Horace Murray/U.S. Army)

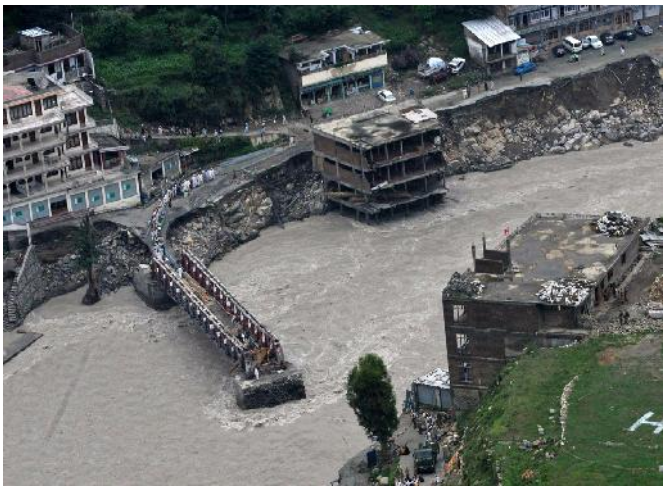

Fig. 3Settlements on the flood plane and damaged bridge, Kalam Valley, August 9, 2010 (Farooq Nadeem/AFP/Getty Images**)**

Role of urbanization in increasing flood hazards

One of the major causes of floods in KPK during the year 2010 is due to un-planned urbanization especially in the mountainous areas. Due to lack of plane land in mountainous area the population select the banks of valleys of the rivers for their residence construction which are usually in the flood hazards zones (Fig-2). Hence the natural regime of the rivers is greatly reduced due to construction of buildings on the flood plains (Fig-3). It is the responsibility of the government to introduce regulation to immediately stop the constructions of buildings in the flood ways. Flood hazards zones mapping should be carried out for future developments nearby river regimes.

Table 4: Damages to the Number of villages and infrastructure during flood of 2010 in KPK [6].

District	Affected Villages	HH Affected Approx	Infrastructure						
			Houses		Shops	Roads	Bridges & culverts	Education Facilities	Health & Govt Buildings
			PD	CD					
Tank	16	21,270			1	7	4	3	
DI Khan	26	56,373	846	2924		35	2	311	
Lakki Marwat	26	4,013	107	57	5	2	1	8	1
Bannu	60	8,046	8633	431		1	6	35	12
Mansehra	12	3,267		4092		33	6	9	33
Abbottabad			994	472			1		106
Haripur	42	8,092	1859	2947		1	4	39	161
Battagram	9	1,488	865	178	72		35	25	11
Kohistan	38	66,333	488	1902	3			107	11
Peshawar	16	33,867	15202	5339					
Charsada	34	71,819	13,827	20,830		34	3	32	
Nowshera	27	71,403	17,892	50,048			4	137	11
Mardan	43	2,856	6016	1629			8		
Swabi	11	2,198	3					30	
Karak	21	7,276	7	83	1		1		
Kohat	32	5,531	10601	311		1			
Hangu	19	6,549	100	83	1	2	1		
Swat	42	90,665	3	14460	161	2	24	69	13
Dir Lower	7	25,812	200	60		56	16	1	13
Malakand	6	6,441	738	348	224	20	7	16	48
Shangla	7	11,950	1874	1777		4	30	36	5
Buner	24	802	1343	473	15	15	9	8	3
Dir Upper	14	30,071	600	55		57	100	19	19
Chitral	12	9,881	353	165	17	13	39		
Total	544	546003	82551	108664	500	283	301	885	347

Therefore to avoid such situation in future, the construction of proposed Munda Dam on priority basis will control the flood water to protect the downstream areas. It will also stop further reduction of cross sectional area of the river Kabul due to high sedimentation in the downstream badly flood affected areas.

The role of forest cover in flood controlling is well established. Over the past two decades deforestation took place at fast rate. Due to high cost of petroleum products the local population in the mountainous area cut trees to meet their energy requirement. The alternate cheep energy options are required to be made by the government to save forests.

Infrastructure development

In most of the cases due to infrastructure development such as bridges, water and gas pipelines crossing across the rivers greatly impose adverse effects. For example the hazards occurred at Medain. Swat Valley where the bridge and surrounding multistory buildings reduced more than 50 % river course as indicated in Fig.3. As a result the flood water pounded behind the bridge which acted as a temporary dam. Due to prolonged heavy monsoon rainfalls the inflows increased tremendously and the lake burst, the released energy which washed everything in the way downstream. The similar phenomenon took place at many locations which caused unprecedented hazards in KPK.

Inherited tectonic set up and deforestation

Due to inherited fragile tectonic setup in the northern Pakistan, the process of weathering and erosion is very aggressive which is further increased due to deforestation. As a result the rivers in the KPK became highly silted in plane areas of Charsadda, Peshawar and Nowshera, hence became unable to accommodate high inflows which caused floods in these areas. Hence the impact of flood of 2010 was very severing in the districts of Charsadda, Peshawar and Nowshera.

Role of high rate of sedimentation in flood

The severity of the flood in KPK was further intensified due to high releases from Tarbela Dam where the reservoir was reaching maximum conservation level. In fact Tarbela Dam reservoir is the only storage which regulates the flood inflows from most of northern Pakistan but due to high rate of sedimentation it has lost the storage capacity of the lake approximately 35 % since its construction in 1975. The is dire need to immediately build additional storage reservoirs in the country to accommodate the lost storage capacity of Tarbela due to silting. in Pakistan the recurrence interval for wet year is 5-7 years. Therefore for long term planning to control floods, the proposed Munda Dam, Diamir Basha Dam and other dams are required to be constructed through national consensus.

Lack of Awareness

Due to the high ill-literacy rate prevailing in the mountainous areas of the Provence of KPK, the damages caused by natural disasters such as floods have increased many folds. The people do not follow the floods warnings issued by the Government. They do not evacuate the flood prone zones until the flood water enters in the houses and there is no time left to escape. Awareness campaign at large

scale is required to be initiated through educationg local population.

Impact of Prevailing Economic Conditions

The impact of poor economic conditions prevailing in the flood prone areas is very critical. In spite of knowing the fact that they are constructing their houses in the route of expected flood, they do not adopt other options due to their poor economic condition. A typical example in this regards can be quoted is the reconstruction of village Tur Landai in District Charsadda. This village has been adopted by Society for Environment Education & Development (NGO) for support to rebuild their houses because the whole village was completely washed during the flood. In spite of the campaign the local people are not willing to shift the location of their new construction out of flood prone zone due to unaffordable cost of new land. These types of issues are required to be settled at government levels otherwise same hazards will be repeated during the flood recurrence

CONCLUSIONS AND RECOMMENDATIONS

The destructive floods of 2010 in Pakistan are predominantly caused by the effects of prolonged monsoon rainfalls. The hazards caused by these floods are tremendously increased due to large scale construction and blockage of the river's regimes.

The role of big reservoirs in controlling and regulating floods, such as Tarbela Dam reservoir is ended due to loss of their storage capacity. Hence, immediately new medium and large storage reservoirs are required to be constructed to manage future flooding in Pakistan.

Flood hazards zonation mapping should be carried out in the light of the flood route of year 2010 and all type of settlements and construction should be stopped forthwith in the all river regimes.

During the rehabilitation programme, the selection of the location for construction of new villages should be given due attention to avoid flood route particularly in the mountainous areas of KPK.

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