

Exploring underlying causes and assessing damages of 2010 flash flood in the upper zone of Panjkora River

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Abstract The paper assesses the damage caused by 2010 flash flood and its underlying causes in the upper zone of Panjkora River within district Dir Upper, Khyber Pakhtunkhwa (KP) Province in Pakistan. Floods in general and flash floods in particular are very common in the area, and the phenomenon has intensified in the wake of observed climatic changes in the region. Anticipating an increase in the multiplicity of causes and a rise in the human, livelihood, and property losses attributed to flash floods calls for a detailed study of affected communities in the region. Within the study area of District Dir Upper—within the band of 200 m on both sides of Panjkora River, three most affected communities, namely Barikot, Kalkot, and Sharingal, were picked on random basis to have detailed analysis of underlying causes and the quantification of damage assessment in the area. Questionnaire-based household survey and structured interviews were conducted to investigate physical and economic damages in the sample sites. Global positioning system (GPS) survey is also conducted to acquire absolute location of damages, and geographic information system is used to visualize land use, land cover, physical features, and GPS data. Monsoon winds interacted with the westerlies abnormally caused unprecedented high intensity rainfall in the valley. The steep topography of the area caused rainwater to accumulate rapidly in the Panjkora River channel, overpowering the withholding capacity of the river. The flash flood inflicted heavy losses to life and properties of the local population. The infrastructure such as houses, roads, retaining walls, bridges, water supply schemes, and irrigation channels were destroyed severely in the whole area particularly in Kalkot. Three explored underlying causes of flash floods and the degree of damage due to 2010 flash floods in the region call for an enhanced realization for climatic change adaptability, flood risk management, and mitigation measures, better flood response

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through early warning systems, and improved rehabilitation and recovery efforts within flood prone areas such as district Dir Upper, KP, Pakistan.

Keywords Flash flood · Underlying causes · GIS · GPS · Damages

1 Introduction

Pakistan is prone to copious geological and hydrological hazards based on its geology and hydro-meteorology (Atta-ur-Raman and Khan 2011). The magnitude of occurrence and frequency of flood have been increased in the past decades as result of climate change and human intervention (Gaurav et al. 2011). In the year 2010, a devastating flood occurred and human intervention over the past years in Indus basin made it more disastrous (Syvitski and Brakenridge 2013). As a consequence, over 1800 people died with a colossal economic loss of billions of US dollars and affected over 20 % of the total area and more than 14 million people (Tariq and Giesen 2012). The nature and direct effect of flood was variable because of the spatial variation in topography, land use, and population density (GoKP 2011). Fluvial floods are more devastating in the Indus Plain because of the flat surface and socioeconomic development. Flash floods are the second most destructive type which jeopardizes large area, property, and human lives (Tariq and Giesen 2012). In Pakistan, floods are recurrent phenomenon and cause heavy loss to human life, standing crops, and properties and flood-generating factors included proximity to the river, monsoon rain, and heavy melting of snow and glaciers. In addition to this, human-intensifying factors have also contributed much in fragile mountain systems. Monsoon is the biggest source of rainfall from July to September in Pakistan. Northeastern parts experience heavy monsoonal showers with spatiotemporal variation. The frequency of heavy rain events with 150 mm/day or more showed a significant positive trend which indicates an increase in the disaster potential of the weather system (Ahmad et al. 2015).

This paper presents underlying causes and assessing damages of 2010 flash flood in the upper zone of Panjkora River. Analyses of hydro-meteorological, topographic, and socioeconomic aspects were carried out to highlight flood-generating factors and associated damages. Three villages including *Kalkot*, *Barikot*, and *Sharingal* were selected from the flood-affected region in the upper zone of Panjkora for detail micro-level analysis.

2 Literature review

Natural disasters are increasing tremendously over the earth surface (Fendler 2008; Mahmood et al. 2016) and brining huge economic losses to property and services (Zhang et al. 2002; Lehner et al. 2006; Krausmann and Mushtaq 2008). The frequency of hydro-meteorological disasters is increasing, and many countries including Pakistan, India, Bangladesh, China, and Germany have been seriously affected by flood disasters. River flooding is expected to increase in frequency and intensity because of rising sea level and extreme precipitation events (Atta-ur-Rahman and Khan 2011, 2013). Mazzorana et al. (2009) mentioned that there are scientific evidence of increase in mean and extreme precipitation events, which implies that extreme flood events might become more frequent.

Ahmad et al. (2015) supported that frequency of heavy rainfall with intensity of more than 150 mm/day has been increasing flood disaster potential.

Flash floods are considered to be one of the worst weather-related natural disasters because they are sudden and highly unpredictable following short spells of heavy rain (Teng et al. 2006). “Flash floods occurrence in specific catchment is affected by orographic effect augmenting precipitation, anchoring convection and steep topography promoting rapid concentration of stream flow” (Rossa et al. 2010). Flash floods are generated by heavy precipitation in short period and topography of the watershed (Montz and Grunfest 2002; Borga et al. 2007). Intensity and duration of the rain are the most influencing factors for flash flood while drainage characteristics and anthropogenic activities influence its severity (Zhang et al. 2008). High-altitude regions in the mountains receive more rainfall in summer and snowfall in winter season, where major flash floods are more likely to occur in summer because of heavy rain and meltwater (Pande 2010).

Floods are the most catastrophic natural disaster and have been causing enormous damage all over the world. In the last decade, floods have directly taken about 100,000 lives and affected 1.4 billion people. According to Alderman et al. (2012), most flood-related fatalities have occurred in resource-poor countries and communities, primarily due to greater vulnerability and poor disaster management system. Unplanned rapid settlement growth and major land use changes had influenced the spatial and temporal pattern of hazards (Nathan 2008).

Flash floods are seasonal and localized hydro-meteorological disasters in terms of fatalities and economic loss (Forte et al. 2006; Borga et al. 2011). Flash floods mortality is higher than any other natural hazard and caused around 1550 casualties annually in each continent. Indirectly flood can cause the loss of economic and agricultural production (Jonkman 2005). The frequency and severity of flash flood are expected to increase because of change in hydro-meteorological conditions and socioeconomic development (Groisman et al. 2004; Beniston et al. 2011) and have potential to produce damages (Choudhury et al. 2004). In the year 2004, heavy rainfall event with intensity of more than 10 mm/h generated flash flood in Manawatu River catchment (Fuller 2008). According to Teng et al. (2006), diverse topography and climatic conditions are the main factors of floods in China. Pande (2010) stated that main causes of the flash floods are cloud burst, breaching of landslides dams and glacial lakes, or sudden melting of glaciers. Ghotour Chai Basin in the southwest of Iran is mountainous region with broad valley downstream hit by heavy flash flood in 2005. The major cause of this flood was heavy rainfall. The topography is characterized by steep slope with decreased vegetation cover resulted strong surface runoff, and Ghotour Chai received many tributaries which generated flood downstream (Asgharpour and Ajdari 2011). Zielinski (2003) described that in two consecutive years floods took place in the month of July, which affected the whole drainage basin of Nysa River and destroyed towns, villages, and water plants in the river proximity. This was generated by high precipitation with maximum intensity of 25 mm/h. Southern France was hit by flash flood in 1999 and 2002. The major causes of these floods were heavy rainfall which was more than 500 mm in 24 h over the area of 5000 km². The houses of 4500 people and more than 1100 vehicles were destroyed, and 9 deaths were reported (Vinet 2008). Similarly, flash floods recorded in UK in 1952 with 34 fatalities, Barcelona in 1962 with 400 fatalities, Italian Piedmont in 1968 and 1994 with 72 and 69 fatalities, respectively (Ibarra 2012). Summarizing above-mentioned causes of flash floods into natural and anthropogenic factors may be classified into natural and anthropogenic factors. Natural factors may contain climate change, heavy monsoon rains, snow melting, and steep topography, while anthropogenic factors may include increase in carbon and

greenhouse gases emissions, deforestation, increased population densities in temperate forest zones of higher altitude.

3 Study region

The study area Upper Dir is situated in the northwest of Pakistan and about 180 km from the capital city *Islamabad* (Fig. 1). Geographically study area extends from 35°04' to 35°46'N latitude and 71°32' to 72°22'E longitude. Relatively, it is bounded from the north and northwest by district *Chitral*, from the east by district *Swat*, from the south by *Dir Lower*, and from the southwest by *Afghanistan*. It is bounded from all sides by mountains except the southeast with total geographic area of 3699 sq km (GoP 1999).

The total population of the district was 575 thousand as enumerated in 1998, in comparison with 362 thousand in 1981. The age and sex composition is shown in Fig. 2, around 52 % population within the age group of below 15 years. The average annual growth rate remained 2.76 % per annum during the year 1981–1998. Projecting district population using this growth rate counts Upper Dir district as 798 thousand in 2010 and 914 thousand in the year 2015 with a population density of 216 persons/sq km in 2010 and 247 persons/sq km in the year 2015 (GoP 2012).

The elevation of study area varies from 5577 m in the north to 844 m in the south. The length of the valley is 120 km. The average gradient of the study area is 2.1 %. River Panjkora is draining the valley. Physically, *Hinduraj Mountains*, the offshoots of *Hindu kush Mountains* act as watershed between study area and the surrounded districts. These mountains have snow-covered peaks, accumulated snow in the valleys and glaciers in the northeast where elevation exceeds 5000 m. River Panjkora originates from these mountains. Panjkora watershed is an important physiographic unit drained by Panjkora and its tributaries including *River Kohistan*, *Barawal*, *Usherai*, and *Dir* (Fig. 3). Upper zone is narrow with deep gorge, and lower zone is broad. Average width of the channel is 1.4 km. Panjkora is the main tributary of River Swat. Study area is covered by temperate forests in higher altitude, while low-altitude areas are covered by degraded sub-tropical scrub forest. Forest cover area is 1,52,820 Hac (Champion et al. 1965; GoKP 2009). These forests are economically important in generating revenue, source of timber and fire wood. Furniture industry of Dir depends on these forests. Agriculture is the main economic activity, and 66 % of the district population is engaged in it. Crop cultivation is mostly in the form of terraced farming. As per 1998 census, around 96 % population of the district was residing in rural settlements, making agriculture as the largest economic sector in the district. Soil and climate are favorable for the cultivation of crops including wheat, maize, rice, onion, potato, tomato, and fruits: apple, apricot, pears, walnuts, and citrus fruits (GoP 1999).

4 Methodology

Data were collected both from primary and secondary sources to achieve the objective of this research. Primary data were collected through questionnaire survey, structured interviews, and personal observation. Prior to field survey, frequent field visits and meeting with local people were arranged to understand the problem of this disastrous flood and identify most affected sites in the study area. Based on initial visits, detailed micro-level investigation and analysis of the flood-affected areas were carried out. For this purpose,

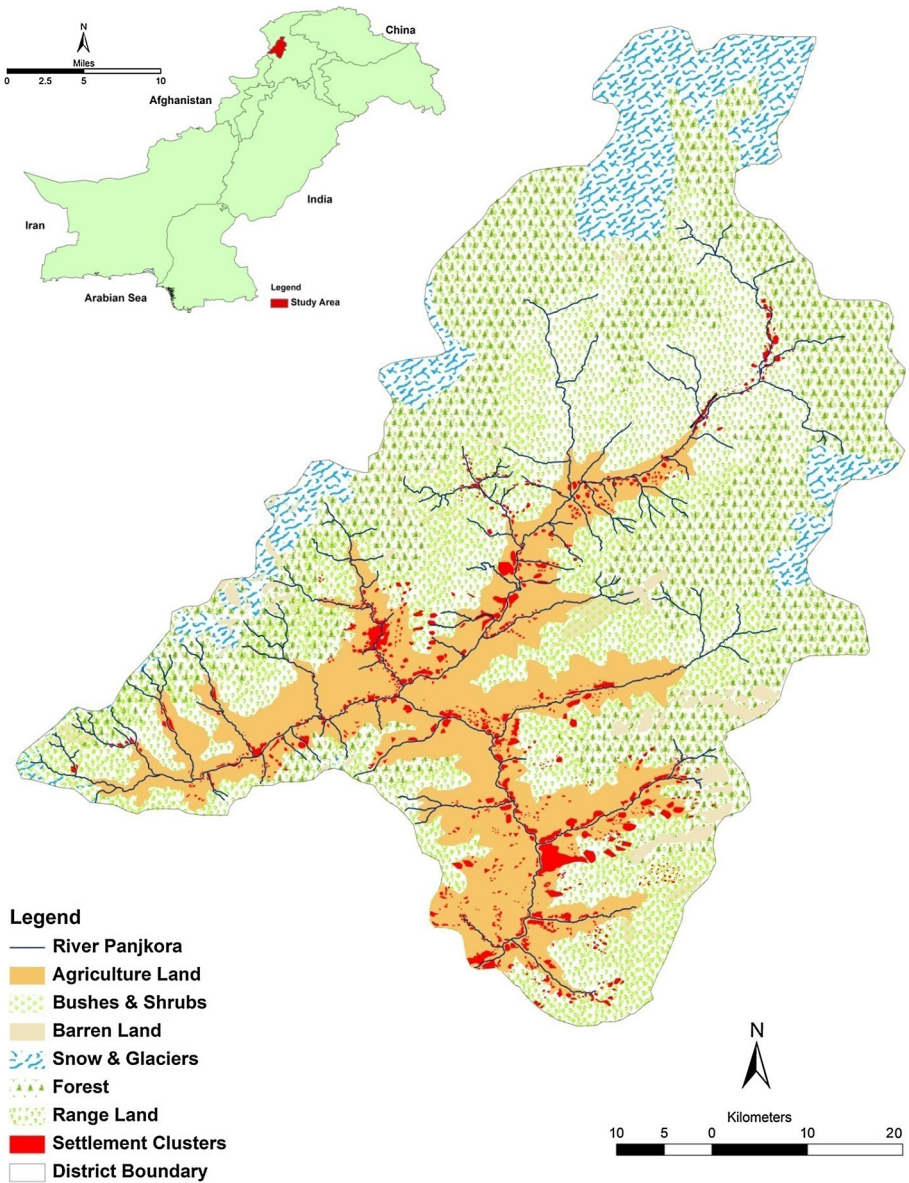


Fig. 1 Study area location, land use, and land cover

three sample sites *Sharingal*, *Barikot*, and *Kalkot* were selected randomly from the most affected sites in the upper zone of Panjkora River (Fig. 5). Field survey was conducted in the mentioned sample sites, and questionnaires were filled from flood-affected people using random sampling techniques. Separate structured questionnaires were designed for households head and related government department officials. Questionnaire survey was conducted directly in the sample sites by asking face to face questions regarding the causes

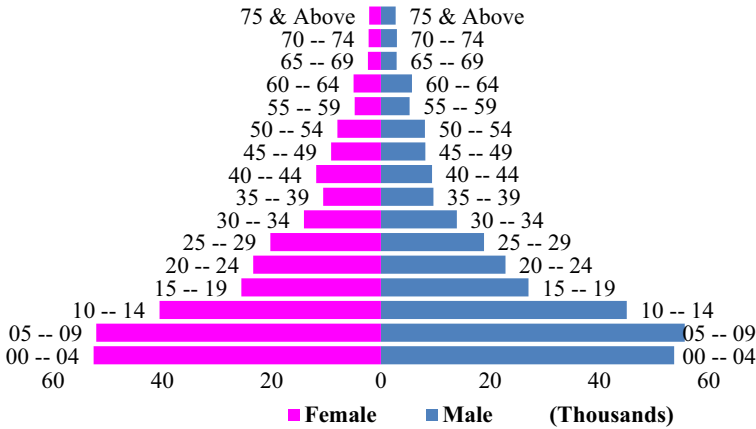


Fig. 2 Age–sex population composition in study area (1998)

of flood, nature of damages, and estimated rehabilitation cost. In the sample sites, 120 flood-affected household heads were interviewed. This is approximately 52 % of the people living in the 200 m buffer zone along Panjkora River in the selected sites. Concerned government department officials were also interviewed to explore the causes of flood, extent of damages, and rehabilitation cost. GPS survey was conducted to collect the geolocation of damages, altitude of the channel at selected points, and distance between points.

Gradient of the channel is calculated using the mathematical formula

$$\text{Gradient} = (\text{Rise}/\text{Run})100.$$

where “Rise” is the change in elevation between selected locations and “Run” is the horizontal distance between those points.

Precipitation normal is calculated for the past 43-year data using computer-based statistical program. Similarly, private property rehabilitation cost was calculated based on community perception using descriptive statistical analysis techniques. Average estimated rehabilitation cost of partially and completely damaged houses in million PKR/house, estimated economic cost of cattle including goat, sheep, and cow, land/hectares and crop/hectares were calculated in million PKR. Construction and works department, District Dir Upper, was consulted for infrastructure damages: bridges, roads, retaining walls and its rehabilitation cost. Similarly, public health department, District Dir Upper, was consulted for estimated rehabilitation cost of damaged water supply schemes.

Secondary data were collected from different concerned government departments. Rainfall and temperature data were collected from Pakistan Meteorology Department (PMD), Regional Office Peshawar. Population statistics were collected from Population Census Organization, Islamabad. Topographic map of the study area was collected from Survey of Pakistan (SOP), Islamabad. Shuttle Radar Topographic Mission (SRTM) Digital Elevation Model (DEM) of 30 m resolution was downloaded from United State Geological Survey (USGS) geodatabase. Watershed analyses were performed on DEM in ArcHydro extension of ArcGIS 9.3, to extract the drainage pattern. Land use map and damage map were prepared in ArcGIS 9.3 with 360 dpi (dot per inch). Damage map of the target area is prepared on scale 1:40,000.

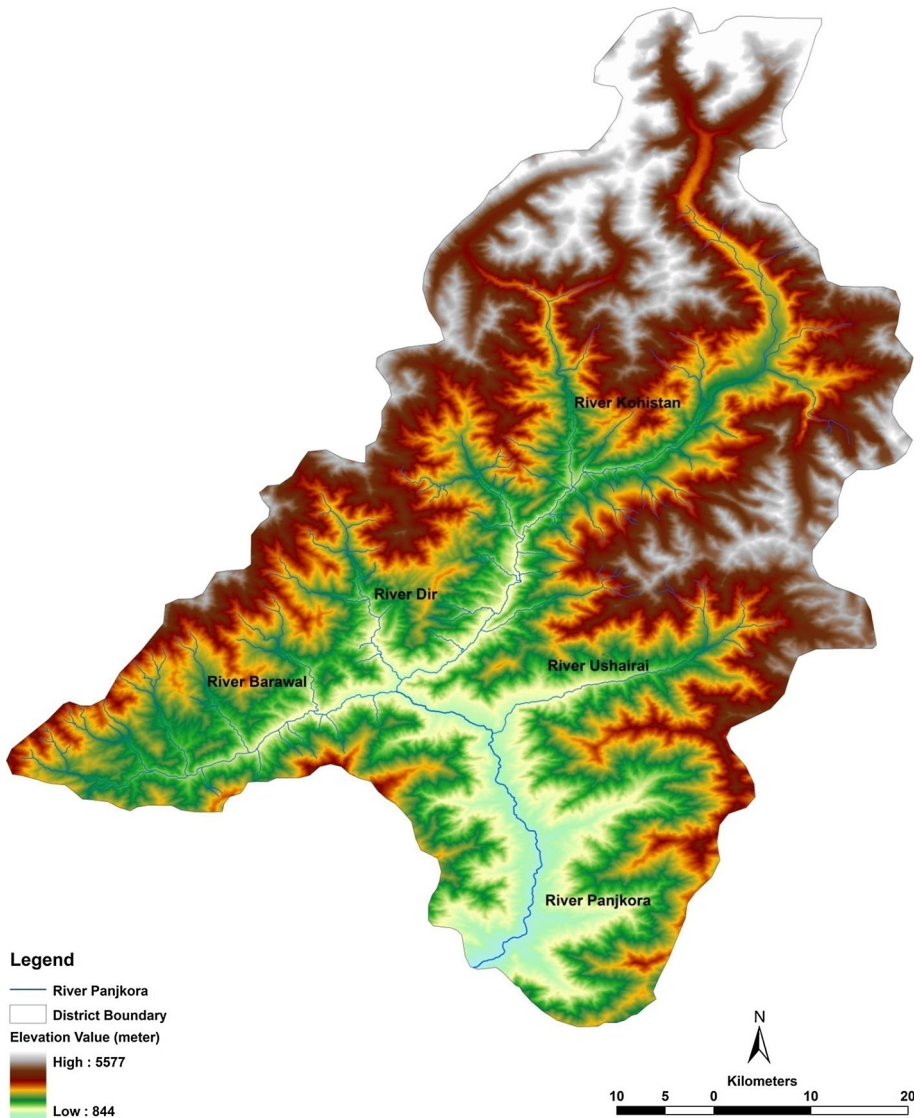


Fig. 3 Study area drainage pattern and digital elevation model developed from STRM data using ArcGIS 9.3

5 Results and discussion

5.1 Cause of flood in the study area

Study area is located in the upper zone of Panjkora River where the hazard of flash flood is frequent. Dir Upper has cool to hot summer; June to August is the hottest months with 32 °C maximum temperatures and 16 °C minimum temperatures, respectively. Winter season is long and cold with snowfall. Temperature rapidly falls from November onward.

December to February is coldest months, and temperature falls below freezing point. Mean maximum and minimum temperature in January is 11 and -2 °C, respectively. In summer season, the source of rainfall is local relief features while Monsoon winds are not much effective due to the location of study area northwest of Pakistan. Annual rainfall varies from 823 to 2149 mm. Rainfall shift is persistently increasing for the month of July since 1967. In the year 2010, rain was in the form of heavy downpour from 27 to 30 July in the entire watershed of Panjkora River. The normal value for the month of July is 159 mm, while in July, 2010 rainfall is 393 mm (Fig. 4b). This was the extraordinary activity of monsoon because of interaction with westerly and jet stream over the study region, resulting high degree of condensation and heavy rainfall. Unprecedented discharge in the Panjkora was increased by the same rainwater overpowering the withholding capacity of channel and produced massive and distractive flash flood. This flood was enhanced by meltwater and further intensified by steep topography of the area. Steep topography with gradient of 3 % resulted in the rapid collection of rain and meltwater in the main stream. The flash flood-generating factors in the study area are extraordinary activity of monsoon rain and steep topography.

Community perception regarding the genesis of flood is variable; 65 % respondents said that rainwater and meltwater has generated flood, while 35 % said that only rainwater is responsible for flood. According to the officials of forest department; deforestation is an important contributing factor in flood genesis. Forest-cleared areas intensify erosion and surface runoff, which results flood. According to the respondents, most of the trees are cut

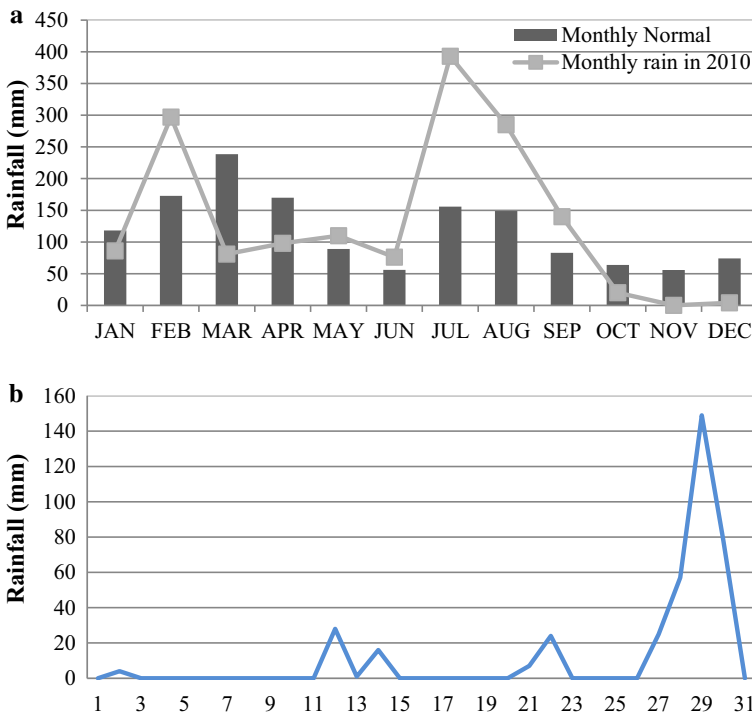


Fig. 4 a Monthly rainfall normal of the past 40 years and mean monthly rainfall of 2010. b Daily rainfall in July 2010

down by local people in the last two decades which has intensified flood frequency and intensity. The demand of wood for fuel and timber has accelerated the rate of deforestation in the study area. The forest area has been decreased by 12.37 % from 2000 to 2012 (Sajjad et al. 2015).

Analysis revealed that in the same year winter was very long and severe; temperature was below freezing point for many days; and snow fall was also more than the past. According to elder persons of the community after 30 years, we have seen such snow fall in the valley. These conditions were favorable for frost action and formation of regolith in the dead channels. Exposed rocks were disintegrated by frost action and debris fall into the dead channels; similarly, the banks of river channel were also weathered. This suggests that the flood-generating factors in the study area are due to unique weather conditions resulting from the interaction of three weather systems causing rainfall with high intensity. Steep topography and low detention capacity due deforestation further aggravated the conditions.

Climate change has caused shift in rainfall. Analysis revealed that there is positive shift in rainfall particularly in July since 1967. In the year 2010, monthly rainfall in July was 393 mm that is 147 times more than the normal, 159 mm, and resulted disastrous flood in the study area (Fig. 4a, b).

5.2 Damages assessment

Analysis revealed that in the year 2010 flood has seriously damaged physical and economic infrastructure in the study area. It has undercut foundation of the buildings, roads, and

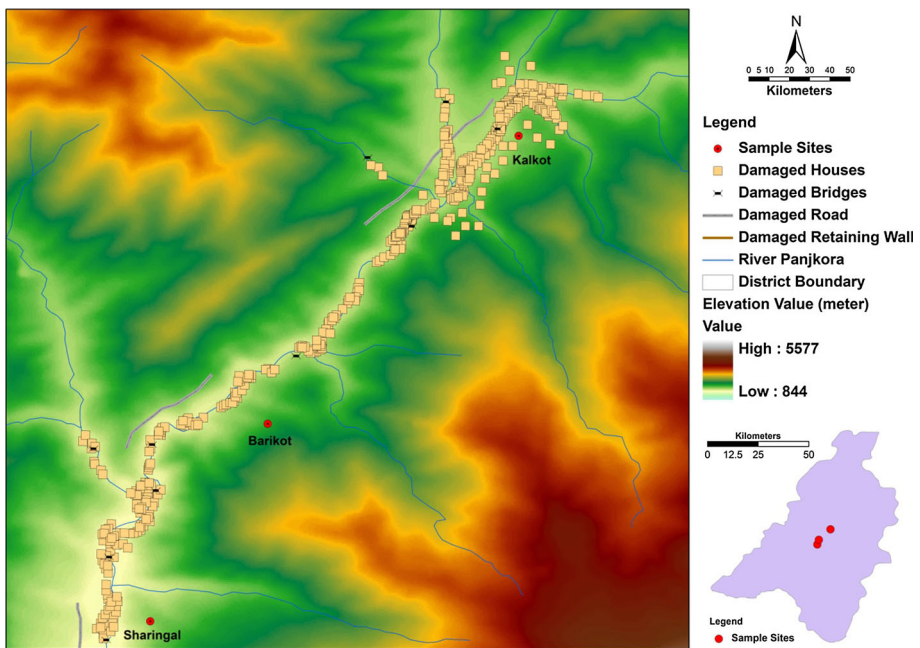


Fig. 5 Distribution of sample sites, damaged houses, road and bridges, map is developed in ArcGIS from GPS data and presented over DEM with 30 m resolution

Table 1 Damaged houses and estimated cost in 2010 flood (million PKR)

Villages	Partially damaged	Estimated cost*	Completely damaged	Estimated cost*
Barikot	25	5	115	80.5
Kalkot	0	0	156	109.2
Sharingal	2	4	40	28

* Construction and works department, district Dir Upper

Source Field Survey, 2011

irrigation channels. However, in the three selected sample sites *Sharingal*, *Barikot*, and *Kalkot*, damages have been assessed through questionnaire survey, observations, and interviews (Fig. 5). Most of the human settlements are located on both sides of the river where majority of the people are living in mudstone houses and rarely in concrete houses. Flash flood has damaged large number of houses. Damaged houses are located in the proximity of river because they were at risk. Load and speed of the flood have played an important role in the destruction of houses. The number of damaged houses was 156, 115, and 40 in *Kalkot*, *Barikot*, and *Sharingal* with estimated economic loss of 109.2, 80.5, and 28 million PKR¹¹, respectively (Table 1).

High drainage density is natural obstruction in people's movement from one village to another village, while bridges and culverts are filling this gap. Most of these structures had completely or partially damaged by flood. Total number damaged bridges were 36 with estimated cost of 67.1 million PKR. (Table 2). Peak discharge with maximum hydraulic pressure at bridging location and destructive load including tree logs and timber is responsible for the destruction of bridges (Fig. 6a).

Agriculture is the main economic activity, and people are earning their livelihood from it. They are cultivating wheat, rice, potatoes, tomatoes, and onion. Tomato, onion, and potato are commercial crops cultivated in the months of August and July. These crops were badly affected by flood in the study area. Animal herding including cow, sheep, and goat are also common on subsistence basis. Flood has severely affected animal life, and 107 animals were lost with estimated economic loss of 8.898 million PKR (Table 3). In study area, terraced farming is concentrated in the valleys which are susceptible to flood. Flood has eroded terraced fields in the proximity of river with estimated economic loss of 10 million PKR (Table 4). Lack of early warning system regarding flash flood has resulted human life loss. The reported number of fatalities was 8 while injuries were 13 (Table 5).

Road is the main source of transportation, constructed along the river in the study area. Seasonal and perennial streams have bisected the road at many locations because of high stream density. Road is strengthened by retaining wall, but flood has undercut the foundation of the retaining wall where road is near the river level. Undercut has resulted damages to retaining wall and road. Narrowness of the channel has further intensify the strength of flood flow, while bend in the channel has directed the flow to outer bank of the bend at certain locations in the channel and resulted damages to road and retaining wall. In *Sharingal*, length of the damaged road and retaining wall is maximum followed by *Kalkot*. The total estimated economic loss is 278 million PKR (Table 6). People depend on springs for drinking water, but densely populated areas depend on public water supply schemes. Hill torrents and springs are the sources of public water supply schemes. Flood has completely damaged 9 water supply schemes with its sources in the study area (Fig. 6b).

¹ 85 PKR (Pak Rupees) = 1US\$, price level, 2010.

Table 2 Damaged bridges and estimated cost (million PKR)

Villages	Partially damaged	Estimated cost*	Completely damaged	Estimated cost*	Suspension bridge	Concrete bridge	Total
Barikot	1	0.1	4	23	3	1	5
Kalkot	0	0	4	23	3	1	4
Sharingal	0	0	2	21	1	1	2

Source Field survey, 2011

* Construction and works department, district Dir Upper



Fig. 6 **a** Damaged suspension bridge in the study area (photography by Shakeel Mahmood). **b** Damaged water supply scheme source in the study area (photography by Shakeel Mahmood)

Table 3 Loss of livestock and estimated cost (million PKR)

Villages	Goat	Cow	Sheep	Total	Estimated cost
Barikot	26	12	22	60	1.008
Kalkot	23	9	10	42	7.8
Sharingal	4	1	0	5	0.09

Source Field survey, 2011

Table 4 Loss of agriculture land and crops and estimated cost (million PKR)

Villages	Affected area (Ha)	Est. cost of land loss*	Est. cost of destroyed crops*
Barikot	2.3	4.6	0.69
Kalkot	1.9	3.8	0.57
Sharingal	0.8	1.6	0.24

* Construction and works department, district Dir Upper

Source Field survey, 2011

The total estimated economic loss is 17.5 million PKR (Table 7). In study area, riverwater is an important source of irrigation on both sides of the Panjkora and its contributing streams. In the entire valley, water is diverted from river and steams in narrow channels to distribute water in the fields. In all the sample sites, irrigation channels were completely damaged by destructive flood and its load. Collective 8-km irrigation channels were damaged by flood with total estimated economic loss of 40 million PKR.

Table 5 Human fatalities and injuries in 2010 flood

Villages	Fatalities			Injuries		
	Male	Female	Total	Male	Female	Total
Barikot	8	0	8	2	0	2
Kalkot	0	0	0	1	1	2
Sharingal	0	0	0	9	0	9

Source Field survey, 2011

5.3 Total estimated economic loss in selected sectors and villages

In the year 2010, flash flood was devastating and produced severe damages in different sectors, infrastructure, housing, and agriculture, with huge economic loss. Houses and infrastructure were badly affected with estimated economic loss of 228.7 and 402.6 million PKR, respectively. Agriculture sector was also affected with total estimated economic loss of 20.398 million PKR. Total estimated economic loss caused by the 2010 flash flood in selected sector is more than 651 million PKR in the study area which is significant for the economy of our country, Pakistan (Table 8). *Kalkot* is most affected sample site with estimated economic loss of 253 million PKR while infrastructure, roads, retaining walls, water supply scheme, and irrigation channels, is most affected sector (Table 8).

6 Conclusions

The study concludes that flash flood in the year 2010 was damaging and destructive in the entire study area resulting in damages to buildings, infrastructure, and agriculture with huge economic loss. Narrowness of the channel and steep gradient of the catchment generated high water flow causing damages to roads, retaining walls, water supply schemes, agriculture, and human settlements in the proximity of river. It also seriously

Table 6 Estimated cost of damaged roads and retaining walls (million PKR)

Villages	Roads		Retaining walls	
	Length (km)	Estimated cost	Length (km)	Estimated cost*
Barikot	0.3	30	0.4	12
Kalkot	0.7	70	0.9	27
Sharingal	1	100	1.3	39

* Construction and works department, district Dir Upper

Source Field survey, 2011 and construction and works department district Upper Dir

Table 7 Estimated cost of damaged water supply schemes (million PKR)

Villages	Sources		Length (km)	Estimated cost
	Spring	Stream		
Barikot	02	04	3	10
Kalkot	0	02	2	5
Sharingal	0	1	2	2.5

Source Field survey, 2011

Table 8 Sector wise and site wise total economic damage (million PKR)

Villages	Buildings				Infrastructure				Agriculture			Total			
	Houses		Shops		Roads		Retaining wall		Bridges	Water supply scheme	Irrigation channel		Land	Crop	Livestock
	Houses	Shops	Roads	Retaining wall	Bridges	Water supply scheme	Irrigation channel								
Barikot	85.5	00	30	12	23.1	10	10	10	4.6	0.69	1.008	176.898			
Kalkot	109.2	02	70	27	23	5	05	05	3.8	0.57	7.8	253.37			
Sharingal	30	02	100	39	21	2.5	25	25	1.6	0.24	0.09	221.43			
Total	224.7	04	200	78	67.1	17.5	40	40	10	1.5	8.898	651.698			

affected human life. Extraordinary activity of monsoon due to the interaction with west-erlies generated flood in the valley which is further intensified by the gradient of the channel which is 3 % in the upper zone of Panjkora.

It was further explored that the flood waters undercut the foundation of road and retaining walls in the proximity of river and resulted damage to road and bridges. Infrastructure is most affected, while agriculture is least affected sector. *Kalkot* is with maximum economic loss because it is located where hill torrents drains into the main river from both sides; at this location, channel is broad and people had built houses and shops, eventually damaged by flood.

7 Recommendations

Flood has been very lethal for human life, property, and infrastructure. The future flash flood situation can be reduced through the following measures in the study area.

- (a) Human settlements in the proximity of river and hill torrents should be shifted to higher land.
- (b) Plantation on the slopes is needed to increase infiltration and detention capability of sub-watershed.
- (c) Channel deepening and widening is suggested where flow energy is maximum.
- (d) Bridges should be constructed higher than the recorded flood peak.
- (e) Storing tree logs and timber in the hill torrents and river proximity should be prohibited because it intensifies the disastrous effect of flood.

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