RESEARCH 4(16), October- December, 2018

ISSN 2394–8558 EISSN 2394–8566

Climate Change

Flooding as precursor of climate variability: causes and damages of 2010 flood event in District Swat, Pakistan

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Pakistan is extremely vulnerable to climate induced hazards such as floods, droughts, storms, heat waves and extreme weather events. Flooding is the most devastating natural hazard of Pakistan. Since the inception, the country has faced with multiple flood events costing thousands of lives and billions of losses in infrastructure. The situation has gotten worse since the past decades as the events of floods have increased in the country particularly the enormous floods of 2010 which shook the economy and till now we have not been recovered yet. This paper utilizes primary and secondary sources in gathering the data regarding damages of floods incurred by the inhabitants of district Swat. A total of 86 respondents were interviewed using semi structured household questionnaire. The survey results showed that flooding is the main perceived climate change vulnerability in the area. Damages include human, livelihood and household losses. Most of the respondents believe the incidents of floods have increased since the past two decades. The study area is most vulnerable to the negative impacts of climate change. Climate variability and increasing extreme weathers events are resulting in livelihood insecurities among the local communities. Poor households with low resource base and adaptation capabilities are most vulnerable to the natural disasters. This research recommends that government should prioritize the effected livelihoods of the study area by extending their support to the affected communities. Intensive research is needed to investigate to a full extent the climate change vulnerabilities particularly extreme weather events in the area. Local communities should be equipped with climate change knowledge and extension of climate technologies to offset the vulnerabilities with effective climate adaptation plans.

INTRODUCTION

Flooding is the most frequently occurring and most devastating natural hazard in Pakistan. Of all population who are affected by natural hazards, 90% are subjected to flooding (Tariq & van de Giesen, 2012). Due to excessive rainfall in the months of July to September 2010, Pakistan experienced unprecedented flooding in the whole country that affected about 20 million people and brought a death toll of 1800 people. The flooding event was recorded as one of the worst since 1929. Moreover, the flash floods caused great damages to the infrastructure affecting entire villages, urban centers, homes, crops and agriculture lands. The direct damages by the floods were calculated to US$ 6.5 billion while the indirect costs were calculated to be US$ 3.6 billion. The main sectors that were affected during the flooding were agriculture; livestock and fisheries costed US$ 5.0 billion (Asian Development Bank, 2010; Tariq & van de Giesen, 2012). It is anticipated that more incidents of similar nature will occur the coming decades. Moreover, variability in the monsoon pattern will increase chances of droughts in the future, thus affecting the food availability in Pakistan (IUCN, 2009).

Pakistan is vulnerable to climate change induced hazards including floods, droughts, water shortages, shifts in weather patterns, loss of biodiversity and melting of glaciers (Government of Pakistan, 2010). There have been 67 reported flooding events in Pakistan occurring since 1900 with a clustering of 52 events of various severity in the last 30–40 years. Around eight of these events that occurred between 1950 to 2010 were also accompanied with huge losses of life and property (Webster et al., 2011; Atta-ur-Rahman & Khan, 2011). According to available official statistics, about 8000 people lost their lives and economical losses amounted to approximately $10 billion between independence of the country in 1947 and the 2010 flooding (Baig, 2008). Likewise, the events of droughts recorded during 2000-2002 and fourteen cyclones recoded during 1971-2001 caused hoax and momentous damages (Asian Development Bank, 2010).

The change in the rainfall patterns and increase in precipitation during monsoon seasons is a clear indication of changing climate in the country. The future scenarios conducted for Pakistan points towards increase in the rainfall events over the north-west region instead of north-west. Due to the reason Indus and Kabul Rivers will be more vulnerable to flooding events in the future (Asian Development Bank, 2010). The 2010 flooding was triggered by many events. Due to low rainfall and severe drought in 2009, the vegetation cover was sparser in 2010. The region is mountainous with steep valleys and ridges. Moreover, severe deforestation in the region may have accelerated the runoff after heavy rainfall through the steep valleys during the months

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of July and August (Webster et al., 2011).

This research is based on the case study of two administrative units of district Swat, Pakistan. The area is selected because the impacts of climate change are more evident in the mountainous areas compared to the plain areas. The study area fits to this description as the climate of the area is already changing and might get worse in the future. The study area was one of the most affected areas due to devastating floods of the recent history.

Study Area

Swat is the administrative district of Khyber Pakhtunkhwa, Pakistanlocated at 34°46′58″N and 72°21′43″E. Swat borders Chitral in the North, Dir in the West and Gilgit-Baltistan in the North-east. Swat covers an area of 5337 Km^2 with a population of 1.26 million (GOP, 1999; Bangash, 2012). The district is enclosed by the sky-high mountains with Gilgit Baltistan and Chitral in the North, Dir in the West, and Mardan in the South, while Indus separates it from Hazara in the east (Sabir, 2003; PPAF, 2013). Topographically, Swat is a mountainous region, located among the foothills of the Hindukush mountain range. This range runs in the general direction of North and South and has a varied elevation within the Swat area, beginning from 600 meters above sea level in the South and rising rapidly up towards the North. Some of the peaks has elevations starting from 4500 to around 6,000 meters above sea level (Bazinni, 2013; PPAF, 2013). The Swat region, containing the meandering Swat River, is also home to lush green valleys, snow-covered glaciers, forests, meadows and plains (PPAF, 2013). The lofty Hindu Raj mountains surrounds the area and drained by a single watershed of Swat River originating in the high mountains to the north having an altitude more than 6000 m (Ahmad et al., 2015). The Swat district has a population of 1.25 million according to the 1998 census, with a growth rate of 3.9% and migration of 3.2% (GOP, 1999).

The study area lies in the temperate zone where various factors including altitude, latitude, Indian ocean monsoon and western cyclonic currents control the climate. The summer in lower Swat valley is short and moderate while it is cool and refreshing in the upper northern part. The hottest month is June with mean maximum and minimum temperature of 33°C and 16°C, respectively. The coldest month is January with mean maximum and minimum temperature of 11°C and -2°C, respectively. The winter season is long and extends from November to March; rain and snowfall occurs during this season. The average annual precipitation in district Swat ranges from 1000mm to 1200mm. (Dahri et al., 2011; PPAF, 2013, Bazinni, 2013). The population of Swat is dependent on Agriculture, Horticulture, Livestock, Fisheries, Tourism and Forest resources of the area (Khan and Khan, 2009; Sabir, 2003). Apart from dependency on the natural resources, the people also finds their jobs in several industries and have employment in multiple public and private sector organizations (Sabir, 2003). Moreover, some of the households are dependent on local and foreign remittances (Khan and Khan).

RESULTS

The Swat River

Swat River serves as the only drainage basin of district Swat. The River is originated in the upper part of the district, in the form of rushing streams of glacial lakes and permanent ice caps. The river flow is mostly determined by snow milt and monsoon rainfall in the months of March to June and July to August respectively. In the valleys of Mahodand and Gabral, these streams merge forming Ushu Gol and Gabral River. After flowing southwards, the two rivers after covering 34 to 40 km, give rise to the Swat River at Kalam (Ahmad et al., 2015). The length of River Swat is about 250 km from Kalam to its confluence with Kabul River near Charsadda. Many tributaries (seasonal and perennial) join River Swat along the way as it flows. Around 50 species of freshwater species have been recorded in River Swat (Hasan et al., 2013; Yousafzai et al., 2013; Ahmad et al., 2015).

River Swat can be divided into two types of ecology i.e. “The monsoon-excluded spating river ecology” and “the monsoon-prevailing sluggish river ecology”. The first system is constrained to upper part of the district also known as Swat Kohistan characterized by the torrent cold water. Being a main habitat of Trout fish due to this cold-water ecosystem, it is also termed as Trout ecology. In the lower part of this river non-trout ecology exists, represented by cold but relatively slow water movement (Ahmad et al., 2015). Having a major role in the local economy, SwatRiver is an attraction to thousands of visitors across the country. The river is also a source of water for irrigation and domestic purposes. Due to multitude of problems including pollution, unplanned urbanization, deforestation, illegal fishing, encroachments, the River is facing serious threats to its riverine ecosystem and water quality (PDMA, 2015). The situation needs immediate attention from the government and policy makers. Moreover, the above problems are exacerbated by the floods season. The year 2010 saw a major flood in the Swat River responsible for huge losses to the ecosystem, infrastructure and human settlements (Yousafzai et al., 2013). Figure 2 shows theflood inundation map of district Swat.

Causes of Flooding in River Swat

A variety of factors were responsible for triggering the events that lead to devastating floods of 2010 in the study area. In the pre-flood time, heavy snowfall was recorded at Kalam, Dir and Malam Jaba met observatories in the months of January and February of 2010, which subsequently contributed in the floods through heavy melting in June and July. Moreover, the months of June and July are among the hottest months in the region, which acted as a driving force behind the melting of snow (Atta-ur-Rahman & Khan, 2013). Monsoon is responsible for most of the rainfalls in the months of July to September in Pakistan. Originating from Bay of Bengal, it moves north-west before reaching Pakistan while in 2010; the course of monsoon rainfall was somehow different from the usual flow process and moved towards North West to central part of India. At the same high-speed cyclone, *Phet* entered Pakistan from south and joined with the usual monsoon track. The moisture laden winds from both the monsoons and *Phet* were responsible for heavy and prolonged rainfall over the north and north western mountains of Pakistan (Atta-ur-Rahman & Khan, 2013). The region experienced a huge anomaly of rainfall, that lasted four days starting from July 27 to July 30, 2010 and all the meteorological stations recorded rainfall above normal (Figure 3). According to the water discharge statistics of WAPDA, the river discharge in 2010 showed highest among recorded data. The maximum recorded discharge of Swat River at Amandara gauging station was 5663 Cumecs in 2010 floods and 175,546 Cusecs at Khawazakhela gauging station on July 29, 2010 (PDMA, 2015) while the discharge at Munda headworks reached 8495 Cumecs on July 29, 2010 which uprooted it due to the heavy influx of water (Atta-ur-Rahman & Khan,2013; Asian Development Bank, 2010).

The water discharge data gathered from Khwazakhela gauge station for the months of July and August through the years 2005 to 2013 is shown in figures 4a and b. The average monthly discharge for both the months reached its historical highest reading in 2010 with 26891 cusecs

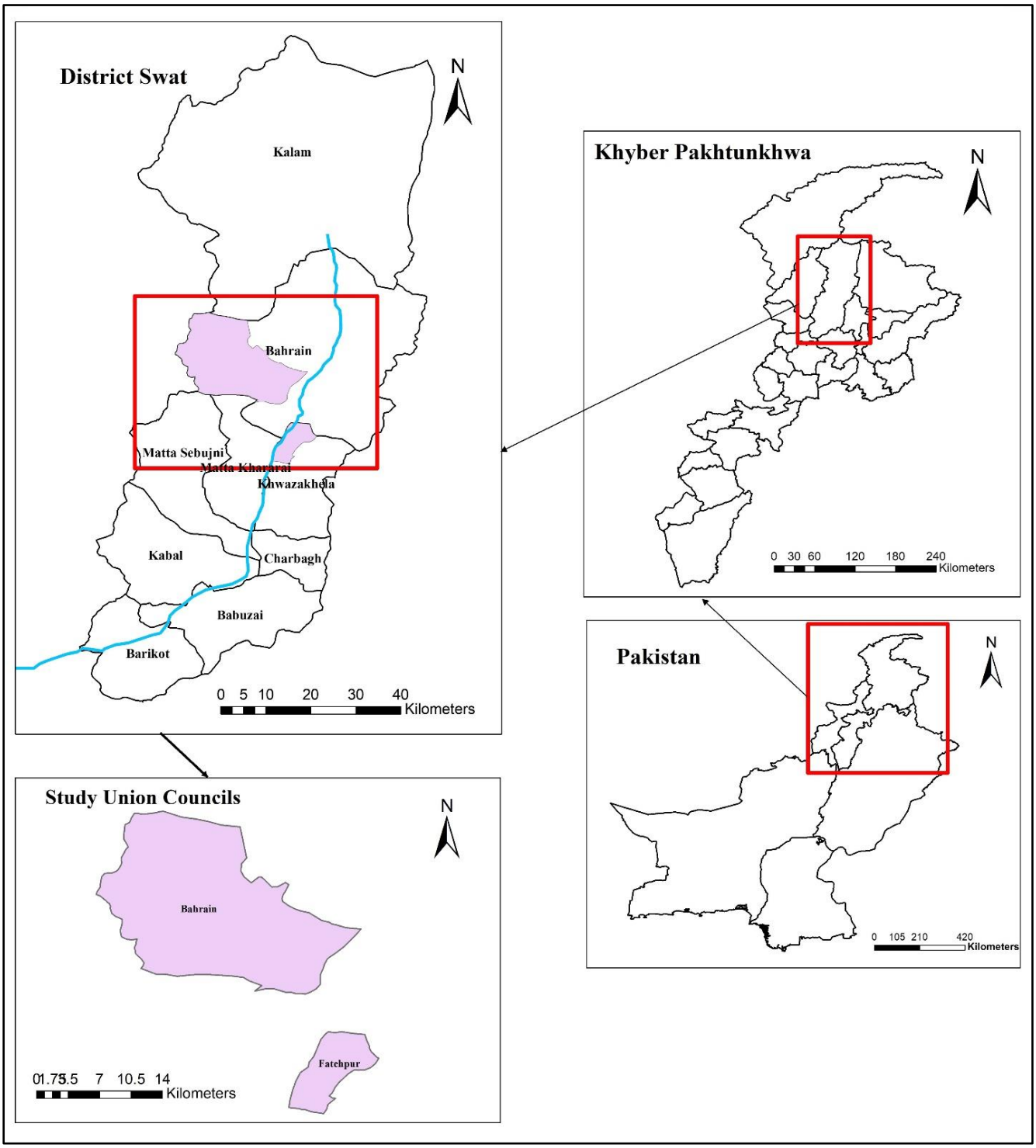

Figure 1 Map of the Study Area

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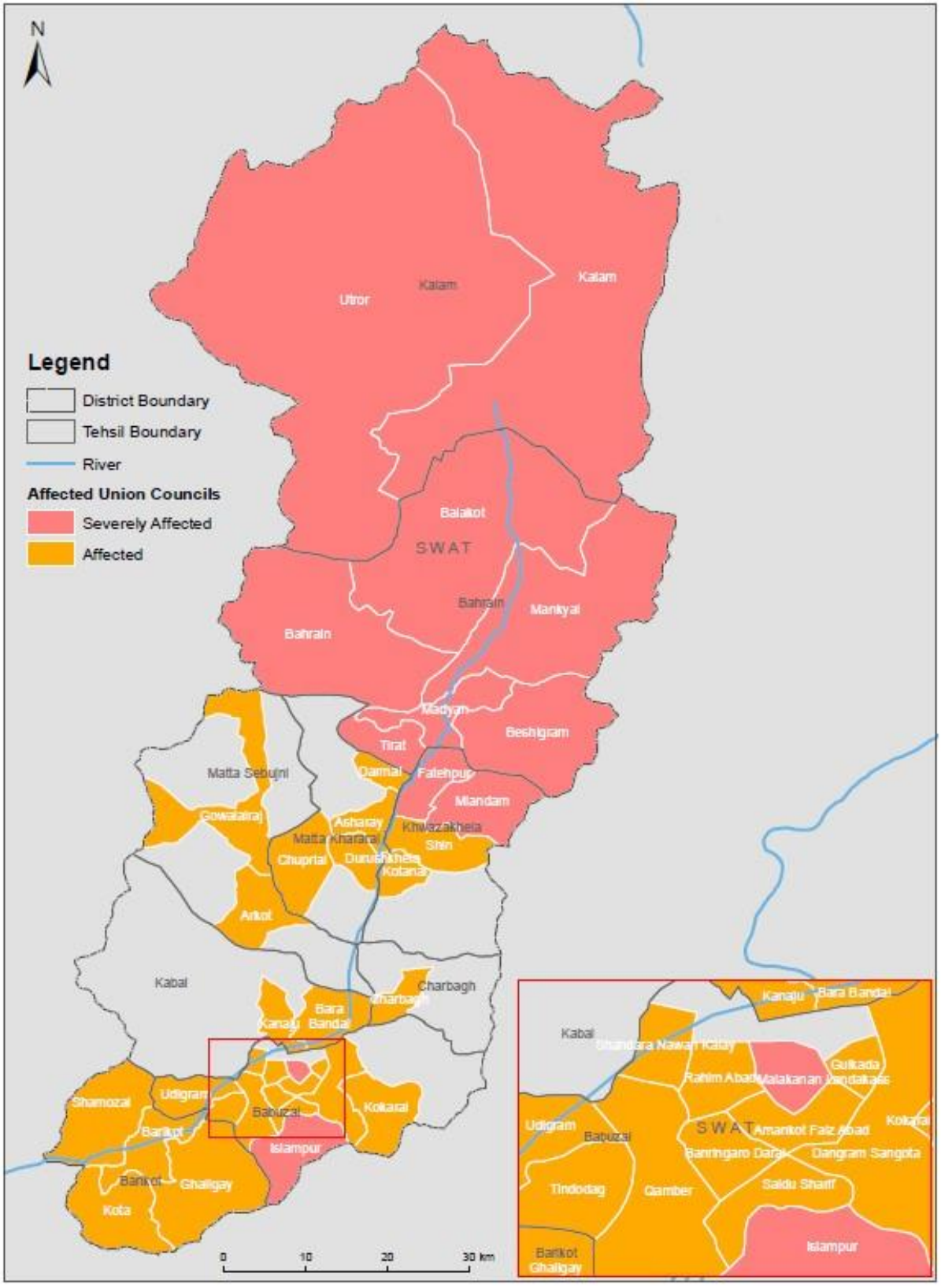
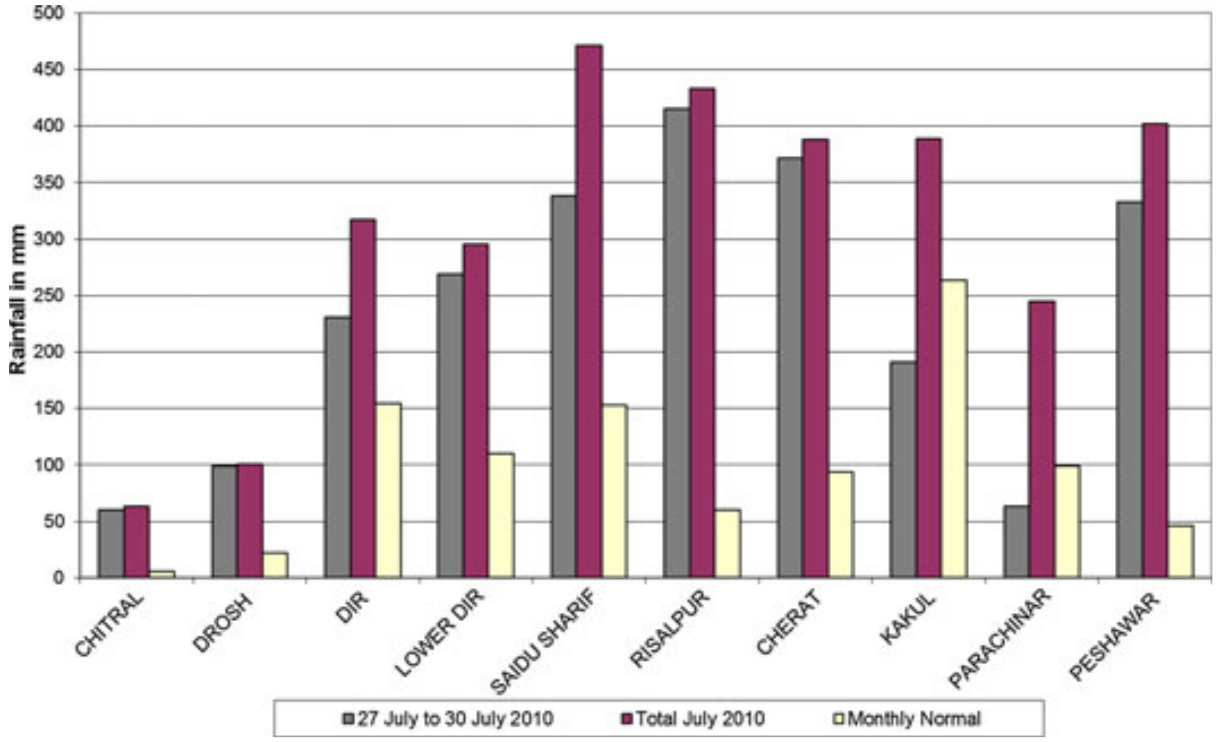


Source: UNOCHA

Figure 2 Flood Affected Union Councils of District Swat (as of 05 August 2010)



Source: Atta-ur-Rahman & Khan, 2013

Figure 3 The Four-Day Wet Spell for Selected Met Observatories that Caused Floods in Khyber Pakhtunkhwa

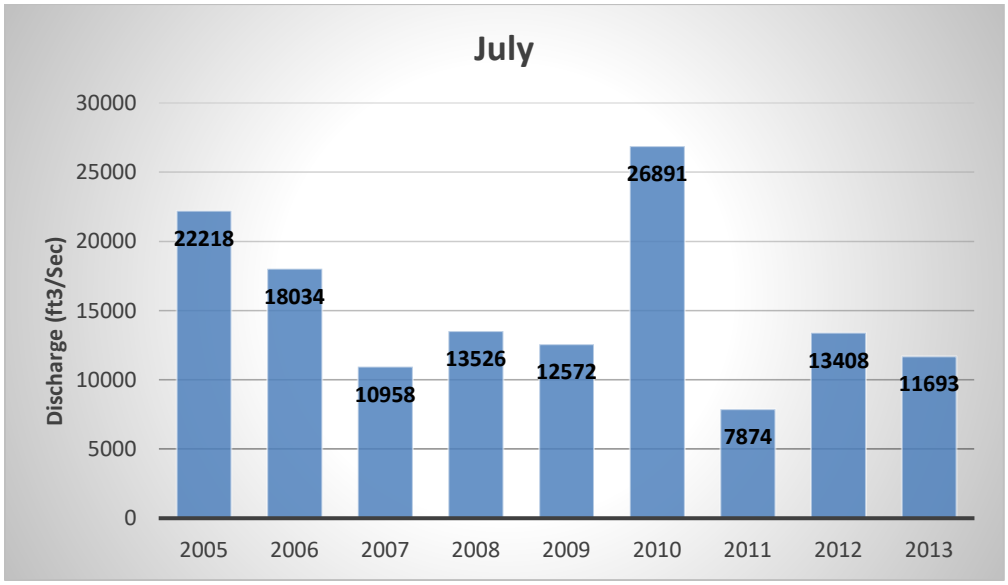


Figure 4a Average Monthly Discharge for July (2005-2013) at Khawazakhela Gauging Station, District Swat

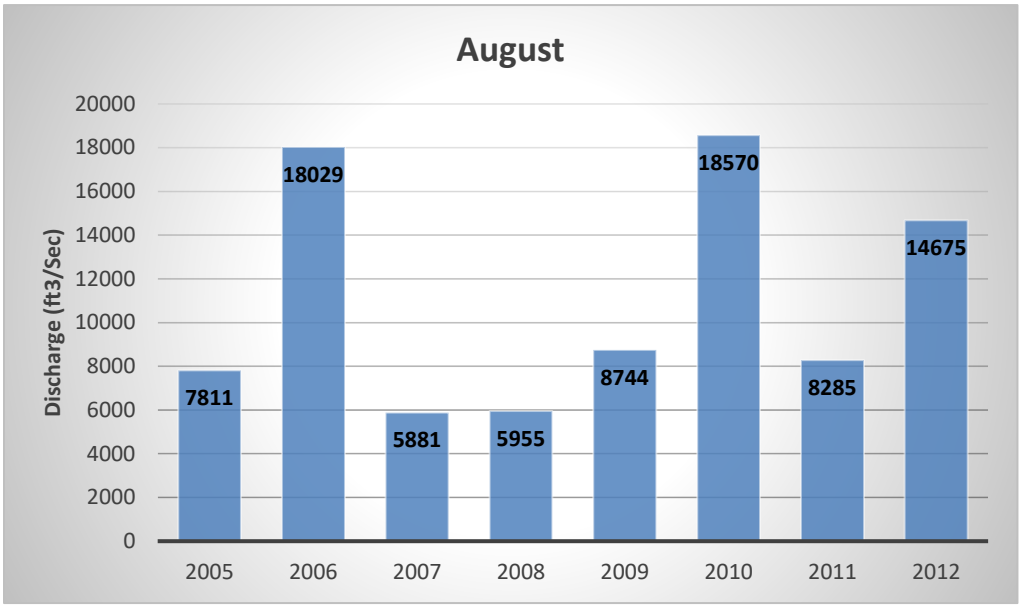


Figure 4b Average Monthly Discharge for August (2005-2012) at Khawazakhela Gauging Station, District Swat

Table 1 Socio-economic attributes of the surveyed respondents

Variable	Bahrain (Percent)	Fatehpur (Percent)
Family Size (Persons)	11	10
Age		
21-30	5.1	15.2
31-40	61.5	54.3
41-50 and above	33.3	30.4
Education		
Primary/Middle	23.1	34.8
Matric/O-Level	17.9	28.3
FSc/A-Level and above	5.2	4.3
No Formal Education	53.8	32.6
Income (PKR)		
10001-15000 (Very-Low income)	2.6	37.0
15001-20000 (Low income)	41.0	32.6
20001-30000 (Moderate income)	48.7	19.6
30001-40000 (High income)	7.7	10.9
Livelihood Source		
Farming/Agriculture	6.5	29.2
Fisheries	10.2	5.3
Hotel business	23.2	5.5
Restaurant	24.9	7.3
Transportation	11.2	16.4
Teaching	6.8	18.2
Tourist Guide	5.2	0
General Store	9.8	14.5
Retired	2.2	3.6

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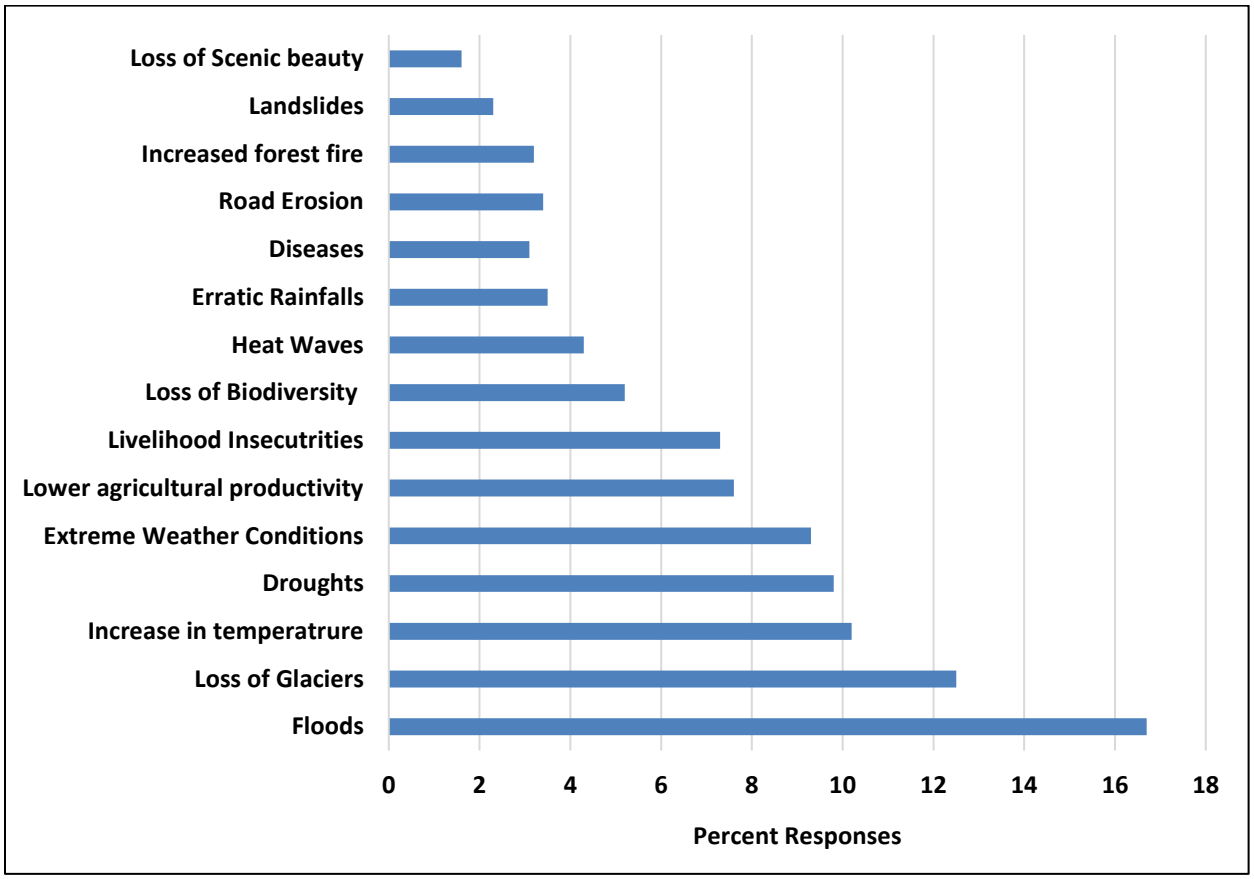

Figure 5 Climate Vulnerabilities in Bahrain and Fatehpur

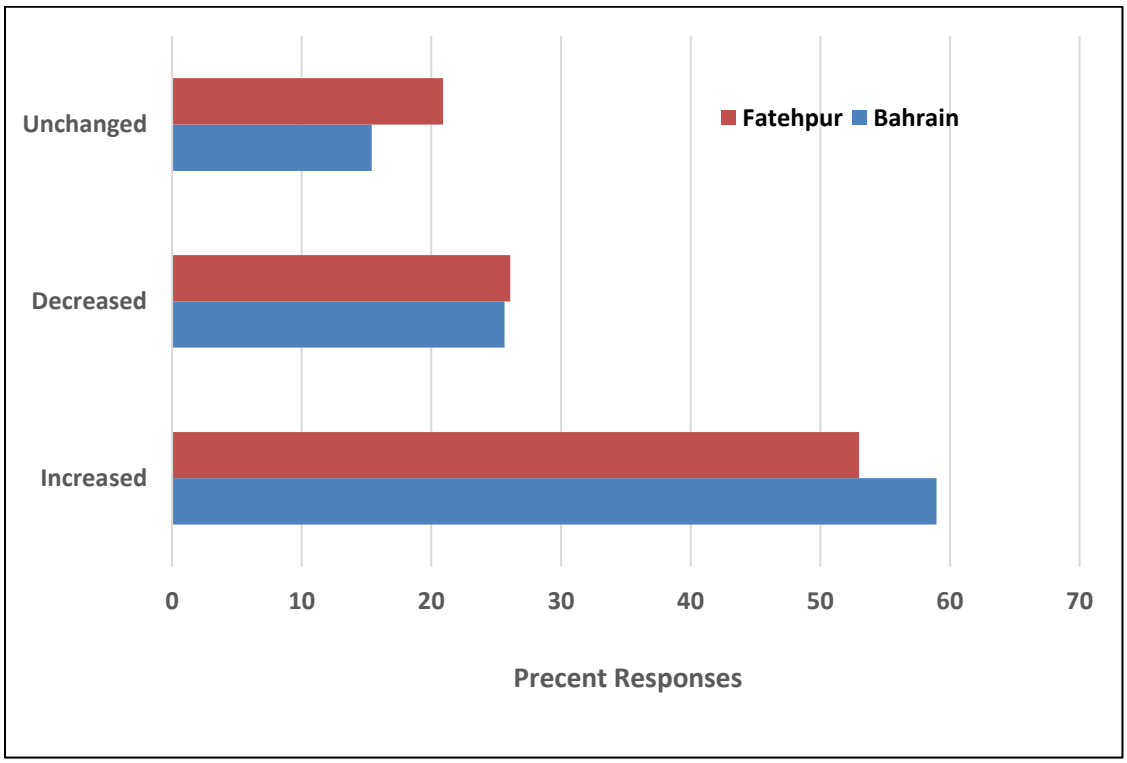

Figure 6 Public observation about the changes in flood events in study area

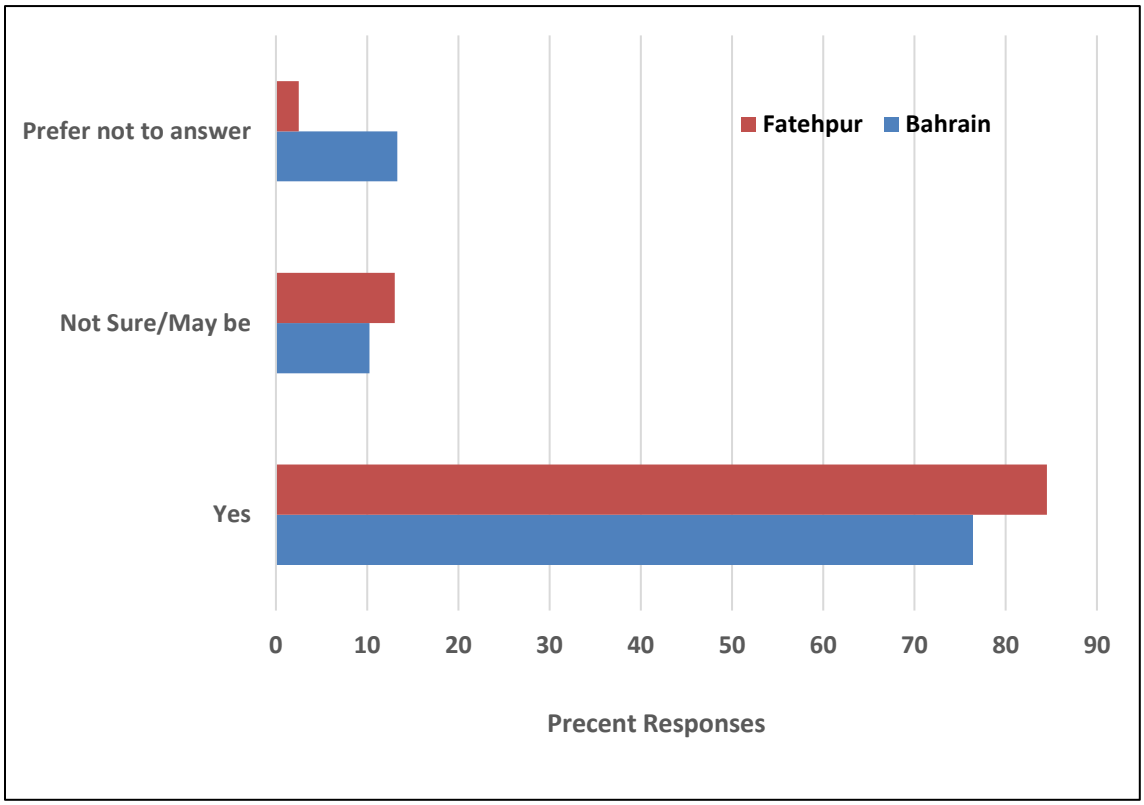

Figure 7 Public beliefs about relationship of floods to climate change in the study area

Table 2 Floods Damages Received by the Respondents/Households in the Study Area

Flood damages	Bahrain (Percent)	Fatehpur (Percent)
Human Life	2.4	3
House	26.4	31.2
Land/agriculture	41.4	50.3
Businesses	22.1	13.2
Other	7.7	2.3
Total	100	100

for July and 18570 cusecs for August. The data is not sufficient to draw future projections as data records of 30 to 50 years are required for assessing future trends (Salma, 2011) but it provides ample evidence for the event under reference and shows the severity of the floods.

As discussed before due to heavy deforestation in the catchment area, the fluvial processes of all the river systems have been affected seriously. There is a close link between the loss of forest cover and floods because during the past two decades, the forest resources have cruelly and indiscriminately destroyed (Kruseman & Pellegrini, 2013; Atta-ur-Rahman & Khan, 2013). Due to the above-mentioned reasons, and especially the four-day wet spell over the catchments of almost all the river in Pakistan, the flood originated. In KP province Swat, Panjkora and Kabul Rivers explicitly experienced high flood discharges during its course (Atta-ur-Rahman & Khan, 2013).

Socio-economic Profile of Respondents

The study revealed assorted socio-economic characteristics of the respondents in the study area (Table 1). The average family size is greater than normal in both the UCs due to joint family system of the area. Within both the studied UCs most of the surveyed respondents belong to 31-40 years age with slightly higher (61.5%) for Bahrain. In Fatehpur, comparatively more respondents belong to the age group 21-30 years. With respect to education, 53.8% of the respondents in Bahrain have No Formal Education followed by 23% of Primary/Middle standard education. Education ratio in the Fatehpur is slightly different where majority (34.8%) of the respondents belong to Primary/Middle standard education followed by respondents having No Formal Education (32.6%). Within both the cases, respondents with post Matric qualification are below 6%. Income distribution of the respondents show low to higher income levels in the studied UCs. Majority (48.7%) of the respondents in Bahrain had moderate income while in Fatehpur, majority (34.8) of respondents belonged to Very Low-Income Group. The surveyed respondents predominantly belonged to tourism sector in Bahrain and agriculture-based livelihoods in Fatehpur.

Public Perceptions about Climate and Flood Vulnerabilities

Climate Vulnerabilities in the Study Area

Figure 5 lists the climate change vulnerabilities in Bahrain and Fatehpur as reported by the respondents. Majority (16.7) of the respondents

reported floods as climate change vulnerability in both the UCs. Loss of glacier (12.5%), Increase in temperature (10.2%), Droughts (9.8%) and Extreme Weather Conditions (9.3%) are the other climate vulnerabilities. Lower agricultural productivity, diseases, livelihood insecurities, loss of bio-diversity, extreme weather conditions, landslides and loss of scenic beauty are directly linked with the negative impacts of climate change on livelihoods and household welfare. On the contrary, increase in temperature, erratic rainfalls and heat waves dictates the climate variability in the study area. Local elders during the interviews expressed that there is visible change in the climate system of the study area since the past couple is changed. The weather was much colder before as compared to these days.

Perceived Flood Variability

To know the extent of the changes in flooding events in the study area, respondents were asked whether floods have decreased or increased in the past two decades or remained unchanged. The survey results show that the in the study are increasing and getting dangerous since the past two decades in both the administrative units (Figure 6).Majority (59%) of the respondents in Bahrain reported that flood events have increased while comparatively more respondents in Fatehpur reported decrease and no change in the flood events.

In the other question, respondents were asked about the relationship of climate change and floods. In response most of the respondents (76-85%) in the study area believe that floods are a precursor of climate change. A little number of the response were not sure about the relationship or didn't chose to answer the question. Interviews from the local communities revealed that despite the overall decrease in the rainfall, uncertainty in the climate system is resulting in abrupt events of rainfall are causing floods in the sampled union councils which was not the case in the past. The survey results are depicted in figure 7.

Flood Damages in the Study Area

As shown in Table 2, respondents were asked about the damages received because of flooding, land/agriculture was reported as the major sector affected by the floods in both the administrative units. As most of the survey respondents in Fatehpur belong to agriculture sector therefore they tend to report more about land/agriculture damages in the respective administrative unit. Damage incurred to businesses included hotels, restaurants, shops and plazas which is higher in Bahrain (22.1%) compared to Fatehpur (13.2%) because majority of the survey respondents in this UC belonged to tourism-based livelihoods. Apart from livelihood-based damages, the study area suffered with human and infrastructure losses. In both the UCs, relatively high response rate was observed for damages received to houses.

Agriculture

The 2010 floods in district brought a great devastation to agricultural lands, irrigation system, water supply and drainage system, and roads infrastructure etc.The land holdings of the farmers are on average low due to the low availability of agricultural lands in the area, so damages to these fertile soils made a great deal of resource loss in the study area. Local communities during the interviews expressed that they had not been compensated for the losses they had incurred during the floods. Many of the fertile lands were swept away by the floods, which cannot be rehabilitated without external support from the government or international. According to Panhwar (2011), the floods swept away the coniferous forests and top fertile soil, which cannot be replenished over the coming decades. The loss of forest cover and soil directly affected many animals and avian species, either washed away with the flood or forced to relocate. The agriculture sector is one of the badly affected entity in district Swat. The survey results are consistent with the damages reported by other researches. The monsoon floods of 2010 quadrupled the troubles of farmers as 60 per cent of farming land, or 150,000 of 250,000 acres of land was washed away by the floods in district Swat (Khaliq, 2011a).

Tourism

The floods of 2010 damaged the infrastructure and road fabric of the district, negatively affecting the tourism sector in the valley. Due to the floods, the tourism hotspots including FizaGhat, Madyan, Bahrrain and Kalam were severely affected (Khan et al., 2010). The Taliban insurgency and monsoon floods badly affected tourism causing heavy financial losses to the hotel industry in Swat valley and other scenic spots. About 107 hotels are being destroyed by the floods in District Swat (Khaliq, 2011b). Collectively more than 800 hotels have been affected in the valley depriving thousands of peoples of their livelihoods (Khaliq, 2011b). According to the preliminary damage and needs assessment survey conducted by Asian Development Bank (2010), 320 hotels existed in district Swat (baseline data acquired from USAID), 70 hotels were completely damaged due to 2010 floods. A respondent expressed his loss that ""I lost half of my hotel building due to 2010 flooding in River Swat (the hotel is situated along the bank of River Swat)". Many of these instances are available where people lost their jobs and assets.

Majority of the individuals are concerned about their livelihoods as the climate change is going to affect tourism industry in district Swat by reducing the number of tourist visiting to the area. Field visits to the study area indicated various problems to the tourism sector. The government is still unable to rehabilitate the damaged infrastructure in the upper reaches of district Swat such as Makyal, Kalam, Ushu and Utror. The damaged roads in the area is restricting the tourist movement to the area thus by affecting the whole tourism sector. The government should take solid steps in rehabilitating the damaged infrastructure such as roads, bridges etc. the steps will not only improve the lives of the inhabitants but will help in the promotion of eco-tourism in the district.

Fisheries

Fisheries is one of the important livelihood sources of the study area. The River Swat which extends to a length of 250 Km is home to more than 50 freshwater fish species. The limiting factors for fishery production in the study area includes overfishing, flooding in River Swat, water pollution, fishing in breeding, change in water temperature and use of illegal fishing techniques. Floods are one of the major limiting factor for the fishery industry in district Swat.The floods destroyed the fisheries sector in the district by damaging the habitats in River Swat and private fish farms as reported by respondents. The 2010 flooding event destroyed fishery sector causing large scale mortalities of fish in River Swat and its tributaries. A total of 26 trout and 17 carp fish farms in both public and private sectors were destroyed while the trout hatchery of Madyan city was completely damaged while Mahsheer fish hatchery near Chakdara was partially damaged (Khan et al., 2010; ADB, 2010).

Floods effect the riverine ecosystem from microorganism to fish. Young fish tends to suffer more from the floods when the timing of high water flows coincides with the delicate life stage of fish (Godlewska et al., 2003). Moreover, the floods can change the group structure of fishes in rivers (Akhtar et al., 2014).

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CONCLUSION AND FUTURE RECOMMENDATIONS

Pakistan is vulnerable to many climate induced hazards including floods, droughts, heat waves, extreme weather events etc. The flooding event of 2010 was one of the greatest river disasters in modern history, which affected more than 14 million people in Pakistan. Although, the extreme rainfall between the months of July and September 2010 is the main contributing factor to this disaster, yet the human interventions in the river systems over the years made this disaster a catastrophe. According to the international and national organizations, the total direct and indirect losses caused by floods accounted for US Dollars 9 billion while the cost of reconstruction and rehabilitation needed was estimated from US Dollars 6 to 8 billion. After the floods, government of Pakistan and international organizations collectively contributed to the rehabilitation efforts of the flood damages in district Swat. Although infrastructure in various effected areas have been restored, yet there is much still to do. Tourism sector is still not fully functional fully because of the dilapidated road infrastructure in the upper part of the district.

The study area is most vulnerable to the negative impacts of climate change. Climate variability and increasing extreme weathers events are resulting in livelihood insecurities among the local communities. Poor households with low resource base and adaptation capabilities are most vulnerable to the natural disasters.

This research recommends that government should prioritize the effected livelihoods of the study area by extending their support to the affected communities. Intensive research is needed to investigate to a full extent the climate change vulnerabilities particularly extreme weather events in the area. Local communities should be equipped with climate change knowledge and extension of climate technologies to offset the vulnerabilities with effective climate adaptation plans.

MATERIAL AND METHODS

The survey was conducted using interview method of research. Two administrative units (Union Councils) namely Bahrain and Fatehpur were purposively selected for the study. Bahrain is a well-known tourist destination of the district, with tourism as the main livelihood source. Fatehpur is also known for its scenic beauty and majority of the public is involved in agriculture-based livelihoods. Situated along the river Swat, both administrative units were hugely affected by the floods.

In the step of data collection, available literature from research publications and departmental reports were utilized to assess the damages caused by the 2010 flooding event, hence the causes and damages of floods were documented. Moreover, discharge data of River Swat at Khwazakhela gauge station for the months of July and August through the years 2005 to 2013 were acquired from the Irrigation Department to know the extent of River discharge variation over the years. In the second step, a total of 85 respondents were interviewed using semi-structured questionnaire. The questionnaire covered topics flood damages, climate vulnerabilities and adaptation strategies in the study area. The results were analyzed using Statistical Package for Social Scientists (SPSS) Version 20.0 in the form of descriptive statistics and graphs. Figure 1 shows extent of the study area and sampled Union Councils.

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Keywords
Climate Change, Climate Vulnerability, Floods, Livelihoods, Tourism

Article History
Received: 02 April 2018
Accepted: 17 May 2018
Published: October - December 2018

Citation
Muhammad Suleman Bacha, Mohammad Nafees, Muhammad. Flooding as precursor of climate variability: causes and damages of 2010 flood event in District Swat, Pakistan. *Climate Change*, 2018, 4(16), 642-652

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