Research Article

Farmers' Perceptions about Climate Change Vulnerabilities and their Adaptation Measures in District Swat

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Abstract | Climate variability significantly affects water, food and energy sectors particularly in developing countries. The current study focused on farmer's perception about climate change vulnerabilities, their adaptation measures and relationship with the changing climatic records in the district Swat (Pakistan). The data collected through household interviews and focus group discussions. Total 177 questionnaires administered to sample households and 9 FGDs (Focus Group Discussions) in selected villages with the aim to understand local perceptions about changing climate, its vulnerabilities and farmers adaptive measures toward climate change in district Swat of Khyber Pakhtunkhwa, Pakistan. Additionally, vulnerability matrix was used to identify livelihood resources that are vulnerable to climate change induced hazards. Results showed that primarily deforestation and pollution contributed more to the perceived causes of climate change which resulted frequent and sever floods or droughts and reduction in agricultural productivity and poor farm householders with low farm holdings are more exposed to such extreme weather events. FGDs and interviews also showed various indicators of causes, impacts and observations of climate change in the study area. Vulnerability assessment revealed that cereals, vegetables and fruit orchards are vulnerable to both climatic and non-climatic factors resulting reduction in crop production. Climatic record in the study area such as increase in mean annual maximum (0.032 °C/year) and minimum temperatures (0.024 °C) and decrease in the mean annual precipitation (-0.73 mm per year) favors the local community perceptions about climate changes. To offset such worsening situation, future planning is vital to keep the natural resources intact while minimizing the risks in the years ahead.

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Introduction

Climate change is characterized as a leading global environmental concern and focus of the current research (Joshia and Chaturvedi, 2013). Progression of global temperatures, altering climatic conditions and extreme weather conditions such as floods and droughts have become more prevalent thus adversely affecting the developing countries (Mller-Kuckelberg, 2012), their rural livelihoods (Simatele et al., 2012; Miller-Kuckelberg, 2012; Dube and Phiri, 2013; Oremo, 2013), agriculture (Murphy et al., 2013) and other natural resources, which are important to withstand livelihoods of the communities (Barnett and Adger, 2007). More sever impacts have been observed in the mountainous regions where the livelihoods are mostly dependent on rain-fed agriculture (Gentle and Maraseni, 2012). In such areas, farming is getting difficult due to decrease in precipitation and increased temperature, and ultimately declining food productivity which leads to food insecurities (Dube and Phiri, 2013).

Most developing nations are dependent on agriculture-based economies and are suffering due to climate change (Miller-Kuckelberg, 2012). The most prominent effects are reduction in water availability, crops production and quality (Ashfaq et al., 2011), high temperature (Shakoor et al., 2011) and loss of rangelands (Enete et al., 2011). Pakistan is also an agriculture-based country and more than 47% of the population is economically dependent on agriculture sector (Government of Pakistan, 2013-14), which contributes 24% of the country's GDP (IUCN, 2009b; Government of Pakistan, 2012). Although, Pakistan shares a very low profile in greenhouse gas emissions (WHO and UN, 2015; Mir et al., 2017), but still suffers from the dire consequences of the changing climate such as floods, droughts, water shortages and shifts in weather patterns due to the neighboring developing industrial states (WHO and UN, 2015; Government of Pakistan, 2010). The vulnerability to extreme events in the recent history has been sufficiently demonstrated through the shifting patterns of climate in the country (Murphy et al., 2013). This includes severe droughts of 1999 to 2002, 2007 storm surges of Cyclone Yemyin and floods of 2010 that cost huge toll of human lives and Billions of Rupees damages to property and agriculture lands (ADB, 2010; Atta-ur-rehman and Khan, 2011). It is also anticipated that more incidents of similar nature will occur in the coming decades (Rasul et al., 2012) including variability in the monsoon pattern which will increase chances of droughts in the future and ultimately affect the food availability in Pakistan (IUCN, 2009a).

Due to anthropogenic interventions, the agriculture sector has also become vulnerable to the negative impacts of climate changes. The future climate predictions using climate models such as Regional Circulation Models (RCMs), affirm that the yield of major cereals in the country will decline by 15 to 20% in the coming decades (IUCN, 2009b; Ali et al., 2017). Furthermore, climate change will also affect other sources of livelihoods such as livestock production, rangelands, fruits, vegetables and horticulture (IUCN, 2009b). Increased temperature has resulted a decrease in growing season length and an increase in the Growing Degree Days (GDDs) – a heat index which is used to predict crop maturity (McMaster and Wilhelm, 1997) and in the future it would result in reduction in crops yield in the mountainous areas, such as Swat district (Hussain and Mudasser, 2007).

Despite the country's vulnerability to climate-induced hazards, research on climate issues is deficient in Pakistan. Studies on public perceptions of climate change are necessary to explore the degree of public support and willingness for climate change mitigation and adaptation policies (Lorenzoni and Nicholson-cole, 2007; Bord et al., 2000). It is expected in the near future that climate change will become more evident (Farooq et al., 2005) and therefore a true understanding of global warming and climate change is necessary for informed decision making and policy matters. Countries like Pakistan are in urgent need to conduct context specific studies to explore public perception about climate change for effective decision making towards mitigation and adaptation of the expected climate change.

Swat lies in the Hindukush Himalaya region where the impacts of climate change such as retreating glaciers, changing hydrological processes, extreme floods and snow cover changes are most prominent (Qing-Long et al., 2017). Our study contributes to the available micro scale research on climate change while specifically focusing on climate induced vulnerabilities to the agriculture sector and indigenous knowledge adopted about these vulnerabilities. The results of our study would also help the government and non-government organizations to get the in-depth information related to public perception about climate change and start awareness campaigns in the study area.

Study area

Swat is the administrative district of Khyber Pakhwtunkhwa province located at 34°46′58″N and 72°21′43″E bordering Chitral in the north, Dir in the west, Gilgit-Baltistan in the north-east and covers an area of 5337 Km^2 with a population of 1.26 million (GOP, 1999; Bangash, 2012). The district consists of nine tehsils (sub-district) and 65 union councils (small administrative units). The area is mostly mountainous region in the Hindukush mountain range, located in the temperate climatic zone where the elevation ranges from 600-6000 m above mean sea level and climate is controlled by different factors such as altitude, latitude, Indian ocean monsoon and western cyclonic currents (Bazinni, 2013; Ahmad et al., 2015). The total cultivated area is only 19.3% of the district's area which are mostly located in Saidu Sharif, Kabal, Matta, Barikot and Khawazakhela tehsils and constitute the southern part of the district (Bazzini, 2013). The district is inhabited by poor and small-scale farmers with average land holding below one hectare per family. Agriculture is the major livelihood source in the study area and around 42% of the people who produces a variety of crops, vegetables and cash-fruits such as wheat, maize, tomato, onions, persimmon, peach and apricot (Khan and Khan, 2009) are dependent on these products for their livelihood. (PDMA, 2015). June is the hottest month with maximum and minimum temperatures of 33°C and 16°C, respectively, while the extreme cold is experienced in the month of January when temperature reaches -2°C. The area receives an average precipitation ranging from 1000mm to 1200mm annually (Dahri et al., 2011; Bazinni, 2013).

Due to the environmental advantages, some of the off-season winter vegetables are grown in summer in the upper parts of the district which makes it available throughout the year and bears decent economic value (Qasim et al., 2013). The whole district and specially the areas along the river Swat in the lower part of the district are experiencing a shift from traditional crops to fruit orchids, however, in Matta sub-division, the fruits cultivation has already started on commercial scale (Khan and Khan, 2014; Öztürk et al., 2015). Apple, persimmon and peach are the main fruit species cultivated in these areas while the other fruits grown on smaller scale are grape, plum, pear, apricot and walnut, but the intercropping of the cereals with fruits trees are common the area. According to agriculture statistics, agriculture sector engages 56% of the labor force creating more than PKR 5.4 billion during the years (PDMA, 2015).

Climate change is most noticeable in the mountainous communities and has a direct effect on the livelihoods of people living there. Increased climate variability and change can cause frequent and high intensity climate induced hazards, thus pushing the communities to adapt to these changes or force to migrate from their areas. Barikot tehsil of District Swat was selected for this study because of its changing climatic conditions which is expected to get worse in the future (Shah and Hussain, 2012; Ali 2015; Khan and Mahmood-ul-Hasan 2016) and it is a major agricultural area which was highly affected by the floods in river Swat. Barikot consists of five union councils, of which three were selected using random number generator technique (Figure 1).

Methodology

Sample size and data collection

In this study, a purposive sampling technique was used and a total of 177 households were selected for interviews using semi-structured questionnaires and keeping the socio-economic conditions of the farmers. The questionnaire survey which was focusing on the negative impacts of climate change on the livelihoods of the respondent farmers were filled using face to face interviews. The interviews were conducted by the researcher and two trained assistants and it was ensured that each one of the questionnaires is filled and recorded properly. Interviews with household heads were conducted to get representative data of the household. In the absence of household head, the second senior person of the household was interviewed.

To find the social processes and insight into the people lives, 9 focused group discussions (FGDs) were also conducted during the research study. A group of 6 to 8 elders constituting a focused group were gathered in a hujra (local communal location) or another communal place. The FGDs were aimed to gather information on the past and present impacts of climate variability and vulnerability on the respondents' livelihoods and their local adaption strategies. Furthermore, these FGDs were particularly essential to engage the elders of the community to get the historic overview of the climate variability in the study area.

Analysis of meteorological data

Historical climate data including temperature and rainfall of 31 years (1985-2015) of the Saidu Sharif meteorological observatory (20 km away) was acquired from Pakistan Meteorological Department (PMD) as no meteorological observatory exists within the study area. Linear regression was used to analyze the climatic trends such as mean maximum and mean minimum temperatures as well as mean annual and mean seasonal rainfall (Salma, 2011). The above method was useful in visualizing the per year and

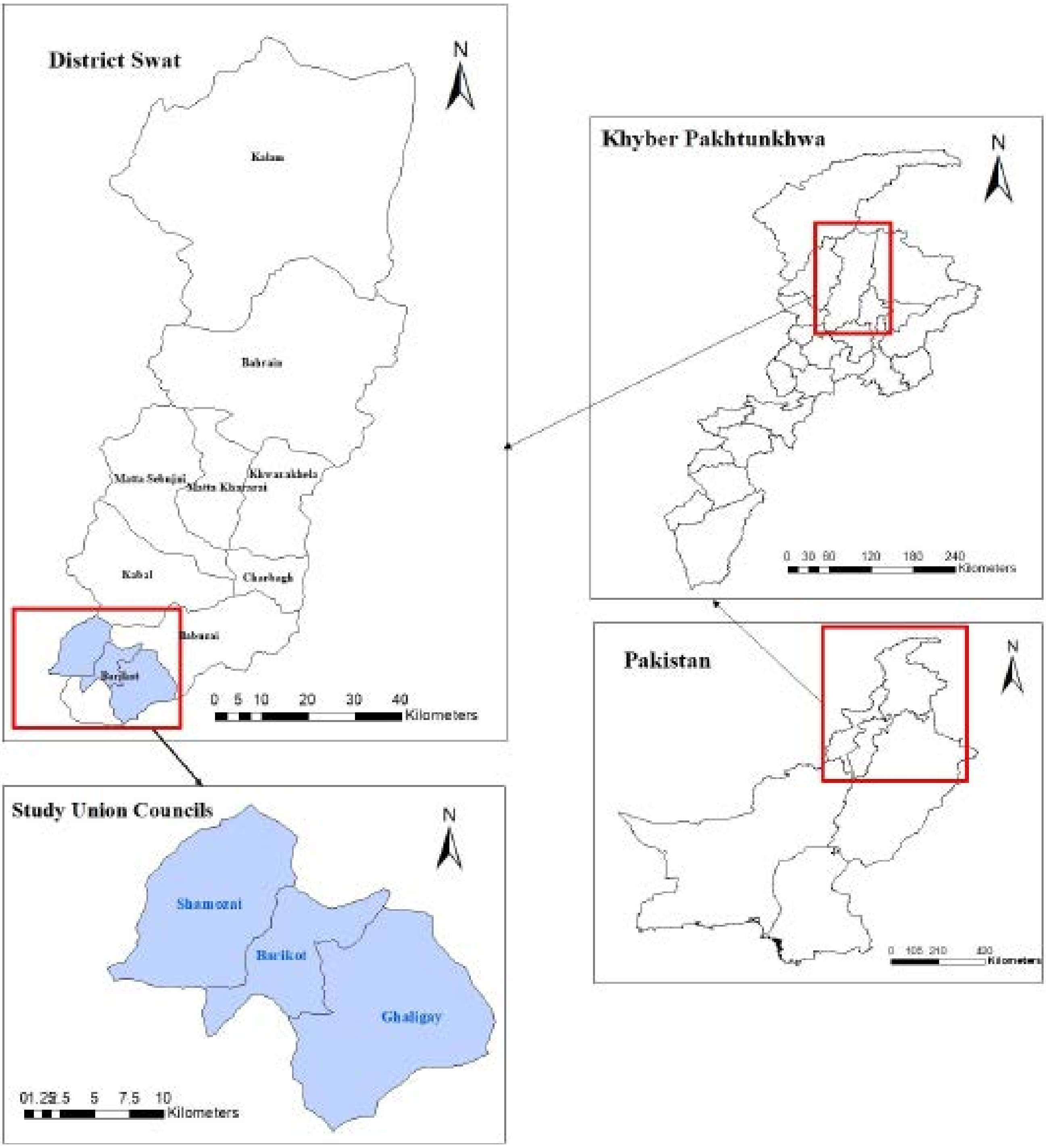

Figure 1: *Map of the study area*

decadal variation in temperature and rainfall as well as comparing their means.

Vulnerability matrix

Vulnerability assessment which falls under the participatory rural appraisal (PRA) techniques was used to get the community scale information regarding the climate change. For this purpose, climate vulnerability and capacity analysis (CVCA) developed by CARE International (Daze et al., 2009) was used, wherein, a group of 6 to 8 people was gathered, and a matrix was prepared using chart paper. We asked the group about their important livelihood sources and the related major hazards to them. Then, a scoring system was given to the group to decide an appropriate score for each hazard against the livelihood source and the scores decided for the identified hazards were: 3 = significant impact on the resource, 2 = medium impact on the resource, 1 = low impact on the resource, 0 = no impact on the resource. The group was then asked to decide with mutual consensus on the degree of impact that each of the hazards has on each of the livelihood resources. After the matrix completion, the group members were requested to further expedite the impacts of climate induced hazards and the coping strategies to these environmental stresses. This method was particularly useful in exploring the climate change impacts on people's livelihoods and their coping strategies.

Results and Discussion

Scio-economic attributes

The survey revealed assorted socio-economic characteristics of the respondents within the study area (Table 1). The average household size ranged between 8-9 persons and majority of the respondents were 36-50 years old while in Ghaligai and Shamozai union councils, the respondents were mostly (35% and 29%, respectively) within 21-35 and >50 age groups. A substantial proportion of respondents had no formal education in all villages but comparatively, Ghaligai and Shamozai had more formal educated respondents (45% and 42% respectively) than Barikot. The land holdings structure of the respondents showed low landholdings {less than 15 Kanals (0.76 Hectare), followed by 15-30 Kanals (0.76-1.52 Hectares)} by the respondents. Land ownership showed that majority (80-89%) of the farmers owned their lands while a little number (11-20%) rented for growing crops. This shows a high contrast of land ownership versus land holdings within the study area. The monthly household income presented high variation and poor economic condition of the respondents. In Barikot and Ghaligai majority of the respondents had medium income (PKR 20001-40000) while in Shamozai more respondents belonged to low income group (up to PKR 20,000).

Irrigation system is mostly canals irrigation system originated from the rivers/streams in the study area or drawing water directly from the river/streams through lift pumps to their lands (Statistics Department GoKP, 2016). 13-21% farmers use tube wells for the irrigation purposes. The main crops in the study area were cereals (wheat, maize and rice), vegetables (onion, tomato, peas, okra and garlic) and fruits (peach and persimmon). Cereals were mostly grown more in Barikot (56%), vegetables in Ghaligai (32%) and fruits in Shamozai (23%). These crops and fruits were mostly grown to support their livelihood (Khan and Khan, 2009).

Table 1: *Socio-demographic profile of the study area*

Variables	Categories	Barikot (UC1, %)	Ghaligay (UC2, %)	Shamozai (UC3, %)
Total population		43020	45250	45422
Total households		4889	5142	5162
Households size (persons)		9	9	8
Age groups (Years)	21-35	27	35	31
	36-50	48	43	40
	>50	25	22	29
Education	Formal education	38	45	42
	No formal education	62	55	58
Income (PKR)	Up to 20000 (Low)	38	35	44
	20001-40000 (Medium)	46	45	35
	>40000 (High)	16	20	21
Land holdings (kanals) (1 kanal = 505.857 sq.m.)	up to 15	68	64	58
	15-30	24	24	19
	30 and above	8	12	23
Land ownership	Possessing (Owned)	89	80	83
	Renting (Ijara)	11	20	17
Irrigation type	Tube well	13	21	18
	Canals/River/Stream	87	79	82
Crop types	Cereals	56	45	52
	Vegetables	26	33	25
	Fruits	18	22	23

Change in climatic parameters

Increase in temperature: The linear trend model (Figure 2) for the mean annual maximum temperature indicated an upward trend of 0.032 °C/year while the mean annual minimum temperature showed an upward trend of 0.024 °C per year. likewise, the mean annual mean temperature showed an increase of .028°C per year for 31-years period. The lowest and highest mean annual temperature were recorded in 1986 and 2004 as 15.32 °C and 20.02 °C, respectively, and the month of March showed an overwhelming increasing trend of 0.098 °C per year for the mean maximum temperature and 0.047 °C per year for the mean minimum temperature. Temperature increase has been reported by Iqbal et al., (2016) for 37 meteorically stations in Pakistan and other similar studies (Chaudhry et al., 2009; Salma, 2010; Yu et al., 2013; Chaudhry, 2017). The highest maximum temperature was recorded as 27.91 °C in 2001 while and lowest minimum temperature was recorded as 9.35 °C in 1986. Overall, the temperature increase was mostly observed in the mean maximum temperature as compared to mean and minimum temperature. The decadal variation of the temperature data also shows an increasing trend in maximum, minimum and mean annual temperature with more pronounced changes in the mean minimum and mean annual temperatures (Table 2). The mean minimum, maximum and annual temperature in the last decade (2006-2015) is increased by 0.51°C, 0.66 °C and 0.59 °C, respectively, as compared to 1985-1995.

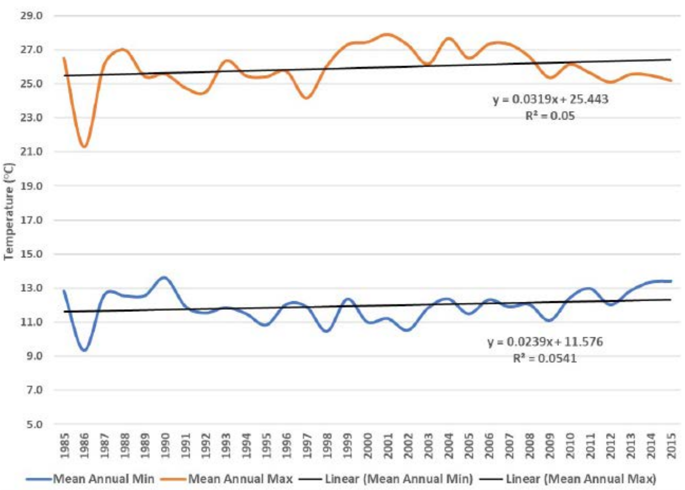

Figure 2: *Temperature variation in mean annual maximum and mean annual minimum temperature for 31-year dataset (Source: PMD Data)*

The statistical results were compared with the local knowledge and perceptions of local communities from interviews and focused group discussions, and we found that the respondents perception of changing climatic conditions, occurring of natural hazards and extreme weather events in the study area was similar to the meteorological data.

Table 2: *Variation of mean annual maximum, minimum and mean temperature in the last 31 years (1985-2015)*

Year	Mean min temperature (°C)	Mean max temperature (°C)	Mean annual temperature (°C)
1985-1995	11.9	25.3	18.6
1996-2005	11.5	26.6	19.1
2006-2015	12.4	26.0	19.2

Source: PMD Data

Decrease in precipitation: The statistical analysis of 31 years' rainfall data (1985-2015) revealed a noticeable variation in the precipitation pattern (Figure 3). The linear trend line for the mean annual precipitation indicated a decreasing trend of -0.73 mm per year, and a similar gradual decrease was also observed in the winter (-0.21), pre-monsoon (-1.73), monsoon (-0.26) and post-monsoon (-0.44) precipitation (Nayava, 1980). The highest decrease was found in the post monsoon period with the trend line showing a decrease of -1.73 mm/year for the 31 years' data. Maximum precipitation event was recorded as 136.7 mm in 1991 (wettest year) while the minimum precipitation was recorded as 60.9 mm (drought prone or driest year) in 2000. The highest monsoon precipitation (226.5) occurred in 2010 which resulted in massive flooding event in the valley (Atta-ur-Rahman and Khan, 2011; ADB, 2010). The decadal variation in the precipitation of the area is given in Table 3 where a remarkable decreasing trend was also found in post-monsoon rainfall. The average post-monsoon rainfall was decreased from 48.4 mm (1985-1995 decade) to 37.6 mm in the next decade (1996-2005) followed by 36.4 mm in the decade 2006 to 2015. The interviews and focused group discussions are in line with the statistical results from meteorological data.

Farmers perception of climate change

Causes of climate change: Perceived causes of climate changes (Figure 4) show that cutting down of forests was the most common cause of climate change which indicates the extent of deforestation in the study area. Other anthropogenic causes of climate changes included pollution (general), greenhouse gases, combustion of fossil fuels, and industrial pollution.

Table 3: *Change in precipitation pattern (mm) in the last 31 years (1985-2015)*

Year	Mean annual (Jan-December)	Mean Winter (Dec-Feb)	Mean Pre-Monsoon (March-May	Mean Monsoon (June-Sep)	Mean Post Monsoon (Oct-Nov)
1985-1995	105.5	93.1	139.0	112.9	48.4
1996-2005	81.9	78.4	88.2	102.1	37.6
2006-2015	91.0	91.1	103.0	110.9	36.4

Source: PMD Data

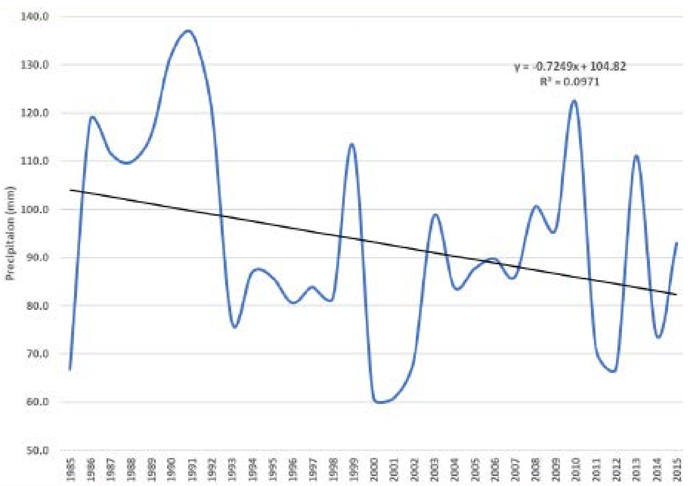

Figure 3: *Variation of mean annual prepetition in the last 31 years (1985-2015) (Source: PMD Data)*

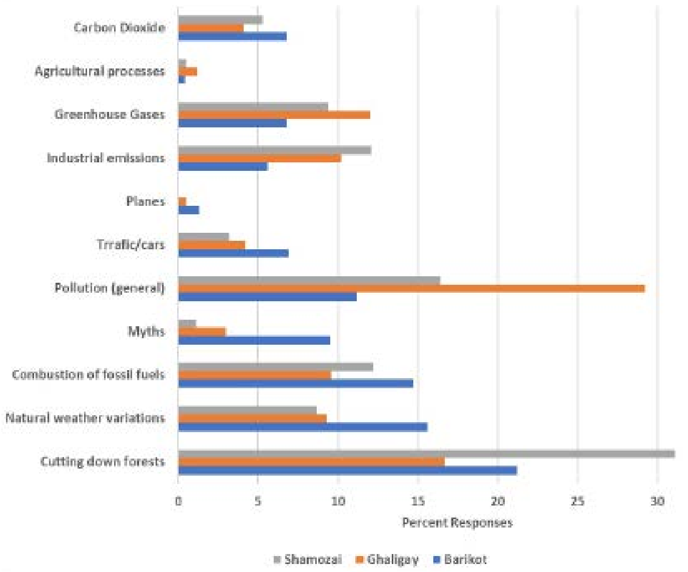

Figure 4: *Perceived causes of climate change in the study area (Source: Primary data from interviews)*

Respondents also pointed out some specific forms of pollution including emissions from traffic/cars, planes, carbon dioxide and agricultural processes. In Shamozai, 31.1% of the respondent stated that the main cause of climate change is the deforestation, however, in Ghaligay and Barikot, majority of the respondents (29.2%, 15.6%, respectively) mentioned pollution and natural weather variations as cause of climate change.

Other studies from literature review also signifies that majority of the public hold anthropogenic causes responsible for climate change (Whitmarsh, 2008; Yu et al., 2013; Kabir et al., 2016). When given a list of different causes, respondents tend to identify deforestation and pollution as the major cause for climate change relatively to other causes (Whitmarsh, 2008). Results from the interviews are in line with the impressions from FGDs with elders of the study area and literature review and shows a tendency towards the poor condition of forest resources in the area (Khan and Khan, 2009; Pellegrini, 2011; Ahmad et al., 2015).

Impacts of climate change: Interview results of the local communities indicated different perceived impacts of climate change in the study area (Figure 5). Majority of the respondents in the study area reported floods as the major impact of climate change, particularly in Barikot (22.6%). The other major reported impacts included droughts, erratic rainfalls, impacts on agriculture, increase in warm days, decrease in in cold days and water shortages. Majority of respondents from Ghaligay mentioned droughts or erratic rainfall (16.3%), floods (14.7%) and impacts on agriculture (12.8%) as the impacts of climate change. Apart from floods, respondents from Shamozai reported decrease in cold days (11.1%), droughts or erratic rainfalls (10.3%) and glacier melt/retreat (10.2%) as perceived impacts of climate change.

These interview results were in line with PMD data, FGDs and literature review of the similar studies. As the study area has suffered from extremes floods in the recent history (Atta-ur-Rehman and Khan, 2011), therefore, flooding in the study area as a common response was not surprising. Various other impacts of climate change such as reduced agricultural productivity has also been reported by other studies (Githeko et al., 2000; Martens et al., 1995; Hussain and Mudasser, 2007; Bryan et al., 2013).

Observed changes in weather: The local communities mentioned that climate of the area has changed considerably compared to the past 20 years and the respondents holds the opinion that mean annual and seasonal temperatures have changed considerably. According to the elders of the area, the winters were more severe, and summers were mild 20 years ago but now the winters are not severe anymore and the summers are warmer than the past. Temperature has risen since the past decades and now the locals observe warmer seasons than ever. Moreover, the number of winter days have decreased, and the summer months have extended. One of the respondents from Shamozai and Ghaligai expressed their views that "the temperature is quite increased in district Swat and now there is no difference between the (temperature of) Swat and plain areas anymore" and "Weather has changed. Ten years ago, we were experiencing cold till the month of May but now, we observe warm weather in April. In the past we had cold season after August but now we cannot see any change in the summers till September and October. The weather is changed now, obviously."

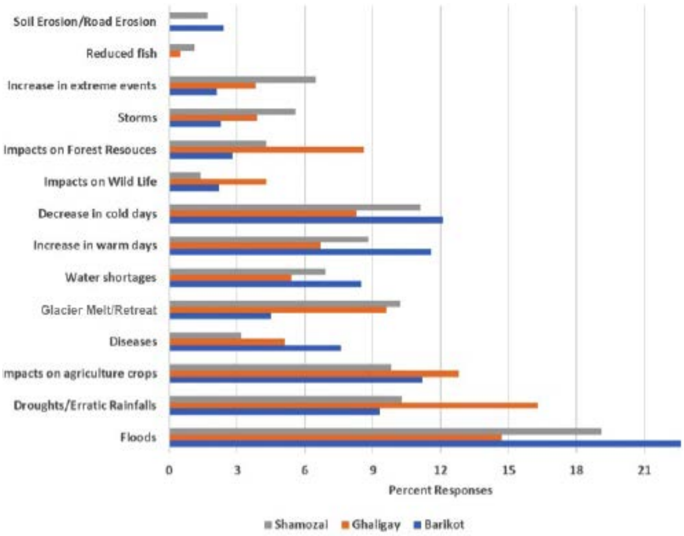

Figure 5: *Perceived impacts of climate change in the study area (Source: Primary data from interviews)*

Likewise, the rainfall pattern in both the seasons have also changed. According to the respondents, the long-wet spells of the winters have decreased while the monsoons are more erratic causing flash floods and riverine floods in the area. About the rainfall, the respondents reminded that they have observed rainy spells called "Jarai" spread over weeks in the past while there is no such thing existed now because there is a visible change in rainfall pattern. Rainfall is more erratic now compared to the past decades. Respondents from Barikot stated "There were no floods before. When it rained before it wasn't damaging. We now experience extreme rainfall with storms which sometimes causes floods", "Weather was very cold before. Snowfall was much more in the past. Summers have gotten worse now. The weather is changed now" and "I have experienced change in rainfall pattern in both the summer and winter season. In winters we had rainfall spells that lasted more than a week or two but now these spells have receded, limiting to 2 or 3 days only. Similarly, the monsoons in summers have changed".

These impressions are aligned with the statistical climate records of the area for example increase in mean annual maximum and minimum temperatures as well as variations in annual and seasonal rainfall. The same changes had also been observed in the rainfall pattern. The local observations of the changing climate from FDGs are shown in Table 4.

Climate vulnerability

Resource degradation: The study area is vulnerable to different climate induced hazards, primarily floods. The survey results indicated that climate induced hazards (especially floods of 2010) have affected large farming lands in the past 10 years (Figure 6). More than half of the respondents (52.7%) reported that they had received damages farming lands as the result of natural disasters while 35% did not receive any damages. In continuation the damage was assessed in all the study UCs (Figure 7). Interviews data revealed that climate induced hazards have affected more farming lands Barikot (57.4%) compared to Ghaligay (13.3%) and Shamozai (29.3%).

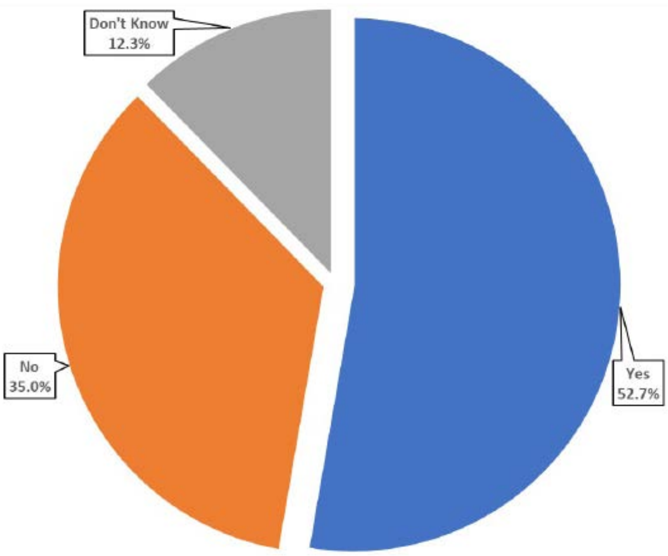

Figure 6: *Damages received to the farming lands in the study area (Source: Primary data from interviews)*

Table 4: *Public observations about the changing climate and related vulnerabilities in the study area*

Indicators	Public Perceptions
Temperature	Mean temperature of the area has changed. Most of the respondents from the interview data agree that mean annual temperature and seasonal temperatures have changed. As a result, the summers are warmer, and winters are less cold compared to the past 10-30 years ago.
Rainfall variability	Rainfall pattern has changed in the area. The rainfall amount has decreased in both winter and summer seasons and wide uncertainties were found over the time.
Snowfall	A decline in the snowfall amount has been observed in the study area
Soil Erosion	Soil erosion has increased due to the increasing flood events.
Flooding	Floods have increased in the area compared to past records. The major flood event of 2010 has resulted in major human and economic losses.
Landslides	Landslides happen in the study area as it is directly linked with the floods
Summer Days	There is an increase in the number of summer days since the past decade. Climate change has affected the length of summer and cold months. More hot days have been observed in the study area compared to the past 10/20 years.
Winter Days	The number of winter days and intensity has decreased.
Extreme Weather Events	Extreme weather events such as floods, droughts, extreme heat or heat waves have increased since the last decade. Now more flash floods and high intensity cyclones are experienced compared to before.
Early Springs	The springs arrive soon now. With change in the average yearly temperatures and extending summers, the springs are experienced in 1st half of February compared to its arrival in March 10/20 years ago.

Source: Focused Group Discussions

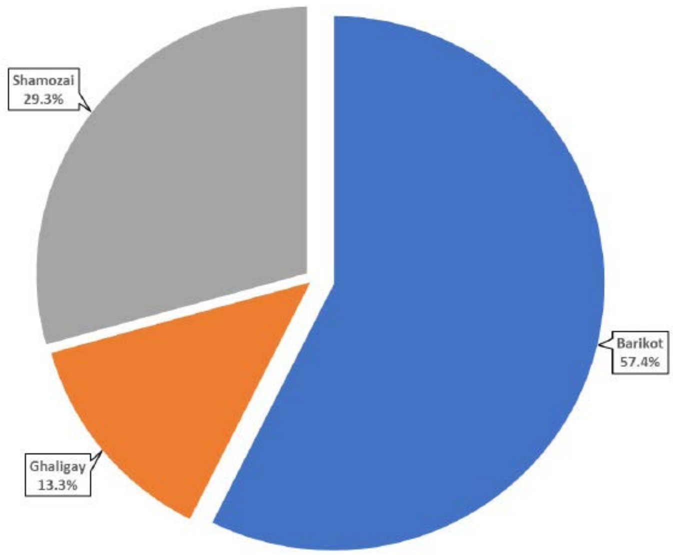

Figure 7: *Percentage of the crop production affected due to natural disasters in the past 10 years (Source: Primary data from interviews)*

The agriculture sector is one of the most affected entity in district Swat. The survey results are consistent with the damages reported by other researches. For example, the monsoon floods of 2010 quadrupled the troubles of farmers as 60% of farming land or 60,700 hectares of land was washed away by the floods in district Swat (Khaliq, 2011). One of the interviewee was irritated about the government steps taken about the damages caused by floods. "eight Kanals (one acre) of my agriculture land was swept away by floods, government promised assistance, but I did not receive anything, and more saddening is that I don't have that land anymore, completely washed away!". 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 (Ali, 2012; Zaidi, 2014). Local communities also reported that large areas of fertile lands were either swept away or hugely destroyed by the flooding event of 2010.

Farmer communities during the FDGs reported that drinking water sources from wells and springs are depleting especially in winter season due to shortage of rainfalls. To compensate for the shortages, the households carry water from far flung areas. These results are supported by the climate records of the area that indicates decrease in the winter, pre-monsoon, monsoon and post-monsoon precipitation. Furthermore, livestock rearing of the households are affecting due to damages incurred to the rangelands due to climatic and climatic factors. The above vulnerabilities are posing great threats to the livelihood security and household welfare of the local communities.

Effects on agriculture: Results from the interviews indicated that climate change is affecting crop production in the study area. Not only climatic factors but other factors (non-climatic) are also contributing to agriculture-based climate vulnerabilities (Figure 8), and a lack of modern agricultural techniques (20.60%) was one of the major non-climatic factors. Other non-climatic factors include lack of good variety of seeds (17.30%), irrigation practices (16.8%) and finances (15.20%). The climate factors responsible for reduced crop production included low rainfall/ droughts (12.20%), loss of land due to floods (8.20%), bad weather (7.30%) and high rainfall (2.4%).

During FGDs, local farmers believed that, they can't practice the modern techniques due to small farming areas. Some of them still don't rely on fertilizers and pesticides while others reported that the government provided bad variety of seeds last year which reduced their crop production. They were requesting government to provide good quality of seeds for better crop production. According to the respondents, the occurrences of droughts have increased that caused reduction in crop yields and one of the farmers replied that *"This year seems to be drought"*. Respondents from Shamozai stated that maize crop has been delayed due to low rainfall that is about 20 to 25 days late and moreover, the yield has been decreased by 40%.

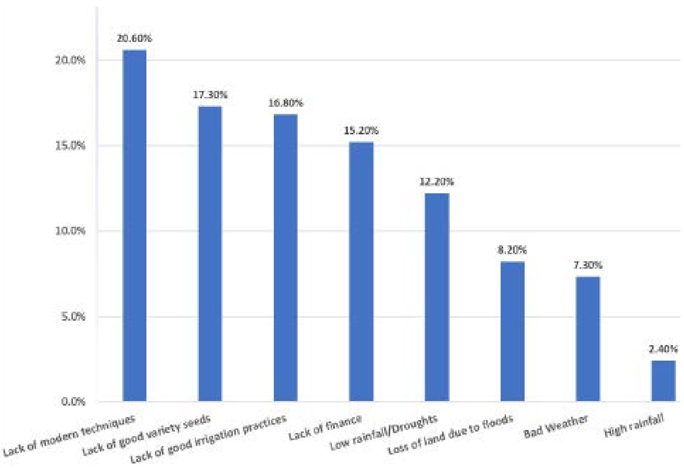

Figure 8: *Farmer perceptions about the major problems affecting crop production in the study area (Source: Primary data from interviews)*

Changes in the climate system has caused major changes in growing seasons. Local elders of the farming communities pointed out a considerable change in the sowing and harvesting period of various crops in the area. For instance, the sowing period of wheat started in the first week of December and lasted till end of December in the past while currently the wheat is sown in November (start to end of the month) representing a change of four weeks in the sowing period. Similarly, the sowing periods of Rice and Maize have also changed. These crops were sown in mid-July to start of August in the past, now they are sown in mid-June to start of July. The harvesting period for these crops have also changed, for example, wheat harvest started in early to mid-June in the past but now the harvest initiates in mid-May with a visible change of 15 to 30 days. These results were not surprising because similar patterns have also been observed in other parts of the country (Hussain and Mudasser, 2007).

Vulnerability matrix: As part of climate vulnerability and capacity assessment process, a vulnerability matrix of the study area was prepared (Table 5). During the exercise the participants identified floods, droughts, cold waves, storms, heat waves and vector borne diseases as major climate hazards while agricultural crops, livestock, forest resources and fisheries were identified as the major livelihood resources. The respondents scored various hazards against each livelihood resource with significant impact on that resource. According to the analysis, the most vulnerable hazards were floods with a total score of 23 followed by droughts (total score, 17) and storms (total score, 13). Climate change has severely affected the agriculture of the area. According to the respondents, climate change has resulted unpredictable weather conditions resulting in the increased irrigation requirements for the crops. The data from the PRA sessions with farmers and other community members showed that floods have severely damaged the standing crops and washed away fertile soils. Cereals such as wheat, rice and maize were ranked the most vulnerable livelihood resources with score of 26, 23 and 22, respectively. Fruits orchards, vegetables and livestock (fodder and grazing) were reported the other top ranked livelihood resources in the study area. These results are consistent with available literature (Gentle and Maraseni, 2012; Islam et al., 2014; Aryal et al., 2014) and historical climatic records of the area.

Adaptation measures

Figure 9 shows the adaptation measures taken against climate change vulnerabilities in the agriculture sector. And, farmers indicated that they have diversified crop varieties (23.4 %) to adapt with climate variability. To reduce the water losses from agricultural lands, 21.5% of the respondents reported water conservation techniques. A considerable number of respondents have selected improved seed varieties (20.9 %) as an adaptation measure to climate change while 14.8 % of the respondents have chosen that they irrigated more.

Table 5: *Vulnerability matrix of the study area*

Hazards to major livelihood resources	**Floods**	**Droughts**	**Storms/ Cyclones**	**Heat waves**	**Cold Waves**	**Vector borne diseases**	**Rank**
Rice	3	3	2	1	2	0	23 (II)
Wheat	3	3	3	1	2	0	26 (I)
Maize	3	3	2	1	1	0	22 (III)
Vegetables	3	3	2	1	1	0	21 (IV)
Fruit orchards	3	3	3	1	1	0	23 (II)
Livestock (fodder and grazing)	3	2	0	2	0	0	18 (V)
Poultry farming	0	0	0	2	2	3	16 (VI)
Forest resources (collection of NTFPs and medicinal plants	2	3	1	1	1	0	9 (VIII)
Fisheries	3	0	0	0	0	0	14 (VII)
Total rcore	23 (I)	17 (II)	13 (III)	10 (IV)	8 (V)	3 (VI)	

Significant impact =3, medium impact = 2, low impact = 1 and no impact = 0
Source: PRA sessions with local community members

The other adaptation measures include adopting soil conservation techniques (5.0%), leasing out land (3.5%), reduction of the number of livestock (2.8%) and migration (2.6%). The above adaptation measures can be grouped in to four categories; crop management, soil and water management, livestock management and livelihood diversification, where water and crop management were more adopted than the soil conservation techniques.

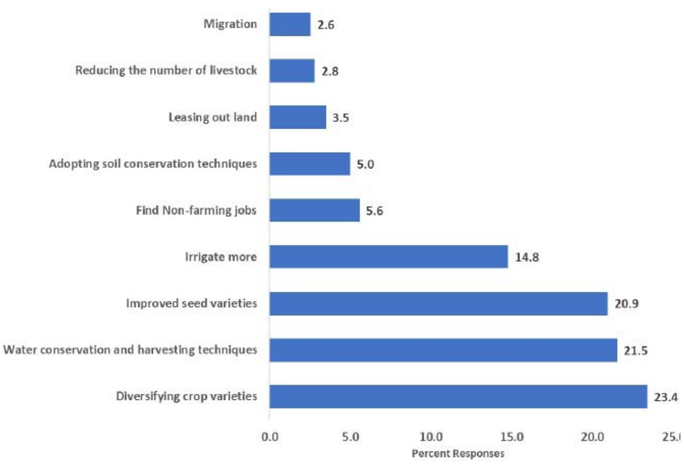

Figure 9: *Local adaptation and coping strategies to climate change vulnerabilities in Agriculture based livelihoods in Barikiot, Ghaligay and Shamozai UCs (Source: Primary data from interviews)*

Local adaptation and coping strategies to climate change perceptions from FGDs and interviews are summarized in Table 6. FDGs and interviews revealed that farmers have started using improved seed varieties for better yield as some of the respondents had experienced low production due to lower quality of seed in the past. Due to the damaged fertile soils, a few of the respondents stated that they were using soil enrichment techniques such as compost manures to adapt to the situation. Terrace farming and protection walls around the fields were also used by the local farmers to stop erosion or cutting of their lands, especially after the floods which washed away most of the fertile lands. Some of the famers needed assistance from the government to fight climate change vulnerabilities in the study area and their main requirement was the better variety of seeds. Due to low economic condition of the farmers, they were interested in the agricultural loans to continue their agricultural practices and non-agriculture-based jobs. They were pessimistic about the agricultural activities, so they wanted their offspring to change their livelihood sources and get a government job with a steady pay.

After the 18th constitutional amendment, several responsibilities including formulation of policies related to ministry of agriculture and livestock was mandated to provincial government. Therefore, to manage the natural resource and achieve the economic growth of the province, different policies were formulated. Thereafter, the provincial government developed Provincial Agriculture Policy 2015 with the support of Food and Agriculture Organization of the United Nations (FAO). This policy builds on its predecessor policies such as Agricultural Policy NWFP 2005, Horticultural Policy, Khyber Pakhtunkhwa Province, 2009 and Khyber Pakhtunkhwa Comprehensive Strategy 2010.

Table 6: *Adaptation measures and coping strategies against climate change vulnerabilities in district Swat*

Climate indicators	Impacts on livelihood sources	Adaptation measures	Potential Future Risks
Increase in Temperature	-Increased irrigation requirements for crops -Negative effects on crops that is loss of seeds and crops -Increase mortality rate in poultry and cattle	- Water conservation techniques to reduce water loss from soil - Switching to other jobs - Reducing livestock number	Livelihood insecurity
Rainfall variability	-Drought condition, lower agricultural productivity, food scarcity -Problems with natural grazing lands and fodder availability, -Drying of springs	- Installation of tube wells or pressure pumps on River Swat/other streams in the respective areas, - Delay in sowing different fruits and crops - Purchasing fodder from the market, reducing livestock number - Manually fetching water from far flung springs especially women on their heads.	Livelihood insecurity, increased expenses of livestock rearing
Extreme weather conditions	-Increased riverine and flash flood occurrences -Damaging agricultural lands, -Increased soil erosion washing away fertile soils -Cyclones with rise in temperatures destroying the crops	-Stream/river embankments -Plantation along the fields -No coping strategy	-Livelihood insecurity, -Decreased in the fertile soils/lands -Food insecurity
Warmer winters and less snowfall	-Increased human diseases -Increased livestock diseases	-Hospitalization -Vaccination	-Decreased household welfare -Increased output cost and less income generation

Source: Interviews and FGDs

The Agricultural Policy is envisioned to enhance agricultural productivity, address food security and income needs of the vulnerable population, and improve resource management, climate change adaption and disaster risk management. The provincial policy also focuses to increase the provincial government's reliance on its resources, improvement of government capacity in terms of effectiveness and efficiency and growing efforts for resource mobilization with donor agencies. Furthermore, the provincial government is committed to achieve economic growth by reducing poverty levels of the province in general and farmers in particular (Government of KP, 2015).

A considerable effort has also been made by Ministry of Climate Change, Government of Pakistan to formulate a National Climate Change Policy in 2012 that highlights the most vulnerable sectors to climate change. As per the goals of Planning Commission's Vision 2030, the policy stresses adaptation measures for energy, forestry, agriculture and livestock sectors (Government of Pakistan, 2012). In 2017, Government of Khyber Pakhtunkhwa province formulated its own Climate Change Policy with the goal to mainstream climate action in development planning. The policy provides adaptation and mitigation measures to climate prone sectors including but not limited to forestry, wildlife, irrigation, agriculture, livestock etc. It also emphasizes to integrate policy instruments pertaining to climate change in different sectors of the economy and developmental projects to achieve sustainable development and create resilience to climate-induced disasters (Government of KP, 2017).

Conclusion and Recommendations

Experiences shared by households and local elders about climate variability is supported by the climate records. This paper attempts to portray the local farmers perceptions of climate change and vulnerability to agriculture-based livelihoods in Swat district. Local farmers have experienced negative impacts of climate change in the form of damages incurred to their farming lands and crops. The major vulnerable livelihood resources are cereals, vegetables and fruit orchids which are the main sources of their livelihoods. These resources are greatly susceptible to climate induced hazards especially floods, droughts, storms and heat waves as ranked by the respondents. Poor farm householders with low farm holdings are more exposed to the extreme weather events/climate change and have received damages to their agriculture/horticulture. Lack of modern techniques, best variety seeds, good irrigation practices, low rainfall, floods are some of the factors responsible for the reduction in crop production. The local communities are coping the vulnerabilities by adopting diversification of crop varieties, water conservation techniques, improved seed varieties and irrigational infrastructure, soil conservation and water harvesting. Government assistance through provision of agricultural loans and better seed varieties are needed for sustainable crop production in the area. Moreover, raising awareness about the use of modern technology among the farmer community is also needed, so that they can make better plan for their crops and make informed decisions. The government should also extend the weather forecasting to the public, so that they can benefit from the advance prediction in crop harvests.

Keeping in mind these deteriorating situation, future planning is must to keep the natural resources intact and minimize the risks in the future. The government bears the responsibility to keep the greenhouse gas emissions at bay and anthropogenic activities in line with the national and provincial climate change policies. Participation of local communities and inclusion of indigenous knowledge should be ensured in formulation of climate change regulations. Furthermore, adaptation measures should be implemented on the ground to minimize the risks of natural hazards especially flooding in river Swat to agriculture sector.

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Author’s Contribution

Muhammad Suleman Bacha carried out research and prepared the manuscript. Mohammad Nafees supervised the study. Syed Adnan prepared the study area map, reviewed the manuscript and gave input for the improvement of the latter. All authors read and approved the final manuscript.

Conflict of Interest Statement

The authors declare that there is no conflict of interest regarding publication of this article.

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