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Abstract

Purpose – This study aims to investigate risks associated with climate change vulnerability and in response the adaptation methods used by farming communities to reduce its negative impacts on agriculture in Pakistan.

Design/methodology/approach – The study used the household survey method of to collect data collected in Charsadda district of Khyber Pakhtunkhwa province, involving 116 randomly selected respondents.

Findings – Prevalent crops diseases, water scarcity, soil fertility loss and poor socio-economic conditions were main contributing factors of climate change vulnerability. The results further showed that changing crops type and cultivation pattern, improved seed varieties, planting shaded trees and the provision of excessive fertilizers are the measures adapted to improve agricultural productivity, which may reduce the climate change vulnerability at a household level.

Research limitations/implications – The major limitation of this study was the exclusion of women from the survey due to religious and cultural barriers of in Pashtun society, wherein women and men do not mingle.

Practical implications – Reducing climate change vulnerability and developing more effective adaptation techniques require assistance from the government. This help can be in the form of providing basic resources, such as access to good quality agricultural inputs, access to information and extension services on climate change adaptation and modern technologies. Consultation with other key stakeholder is

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also required to create awareness and to build the capacity of the locals toward reducing climate change vulnerability and facilitating timely and effective adaptation.

Originality/value – This original research work provides evidence about farm-level vulnerability, adaptation strategies and risk perceptions on dealing with climate-change-induced natural disasters in Pakistan. This paper enriches existing knowledge of climate change vulnerability and adaptation in this resource-limited country so that effective measures can be taken to reduce vulnerability of farming communities, and enhance their adaptive capability.

Keywords Pakistan, Vulnerability, Climate change, Adaptation, Agriculture

Paper type Research Paper

1. Introduction

Recent changes in climate have confronted people all over the world – for some, it is a matter of changes in weather and for others a matter of survival. The real injustice of climate change is that although developing countries have contributed less to the annual global carbon dioxide emissions they are suffering most from its effects (Dazé, 2011; Van Aalst, 2006). It is expected that changing climatic conditions is likely to increase the frequency and magnitude of some extreme weather events and disasters like flood, droughts, storms and cyclones (Mirza, 2003; Greenough *et al.*, 2001; Field, 2012). This is due to geographical locations of some of the most vulnerable regions of the world, their high exposure, limited assets, rapid and unmanaged population growth, as well as the likelihood of their mal-adaptation (Huq *et al.*, 2004; Hay and Mamura, 2010; Atta-ur-Rahman and Khan, 2011).

South Asian countries including Pakistan are among those most affected by the risks associated with climate change (Ali and Erenstein, 2016). Pakistan's vulnerability to the impacts of climate change has been increasing with time despite its contribution to global warming being negligible. In 2012, Pakistan was at the 12th position, 8th in 2015 and 7th place among top countries of the world exposed to the vagaries of climate change and global warming (Kreft and Eckstein, 2013; IUCN, 2009). Recently, disasters related to climate change such as floods, droughts, cyclones and storms have hit Pakistan hard (Tingju *et al.*, 2014; Mueller *et al.*, 2014; Atta-ur-Rahman and Khan, 2013). These disasters have not only become more frequent but also caused more damage (Qasim *et al.*, 2015). Even after having been consistently affected by climate exigencies year after year, the country's response to solve the issue has remained lackluster. The burden of natural disasters in Pakistan is underlined by the fact that they have affected millions and killed thousands of people countrywide (Atta-ur-Rahman and Khan, 2013). Among others, rapid population growth, uncontrolled development and unmanaged expansion of infrastructure are the most common factors resulting in more people being vulnerable to natural hazards than ever before (Cardona *et al.*, 2003).

Studies suggest that poor people in rural areas of Pakistan are the most vulnerable to climate change (Ali and Erenstein, 2016; Deressa *et al.*, 2009; Füssel, 2007). These communities are struck hard by those changes in climate identified by many studies conducted throughout the country (Tingju *et al.*, 2014; Atta-ur-Rahman and Khan, 2013; Qasim *et al.*, 2015; Abid *et al.*, 2015). This is particularly because agriculture is climate sensitive and because of the huge number of rural populations predominantly dependent on agriculture as their mainstay of livelihood. Among others, the main challenges faced by farming communities in Pakistan include insufficient irrigation water; lack of technical knowledge, lack of education and limited number of extension facilities; widespread poverty among farmers and inadequate credit facilities; expensive farm inputs such as seeds, fertilizers and pesticides; lack of roads from field to market; low prices of agricultural output and the absence of agriculture-based industries (Abid *et al.*, 2015; Khan, 2013). Additionally, the inappropriate use of modern agricultural inputs such as fertilizers and pesticides has led to alarming environmental pollution (Khan *et al.*, 2013; Shahzada *et al.*, 2012; Yousaf and Naveed, 2013; Saif-ur-rehman and Shaukat, 2013).

A consistent major problem for Pakistan's authorities is that natural disasters occur regularly at all scales. Unfortunately, the authorities responsible for disaster risk reduction in Pakistan have not made adequate use of recent developments in scientific methodologies, methods and tools for cost-effective and sustainable interventions (Atta-ur-Rahman and Khan, 2013; Qasim *et al.*, 2015). Research aimed at identifying the main drivers of climate change vulnerability (CCV), adaptation and risk perceptions at household level is urgently needed to reduce the negative impacts of climate change on agriculture (Abid *et al.*, 2016).

Studies report that farmers use several techniques to adapt agriculture to CCV (Ali and Erenstein, 2016). Some of these techniques used at farm level include diversification in crop practices and changing the timing of operations (Deressa *et al.*, 2009); changing farm management practices such as type and amount of agricultural inputs applied (Abid *et al.*, 2016); livelihood diversification (Hussain and Mudasser, 2007); institutional changes, mainly government responses, such as subsidies/taxes and improvement in agricultural markets (Mendelsohn, 2001); and technological developments such as growing new and heat-tolerant crop varieties and advances in irrigation and water management techniques (Deressa *et al.*, 2009; Hussain and Mudasser, 2007). Climate change is generally detrimental to agriculture, but can partly be offset by deploying the various adaptation methods at farm level (Ali and Erenstein, 2016; Abid *et al.*, 2015). However, the degree to which a certain agriculture sector is exposed and vulnerable to climate change depends on the adaptive capacity of community or area to withstand or react to those changes (Adger *et al.*, 2003; Ullah *et al.*, 2015). In addition, some adaptation methods are highly localized and cannot be directly adopted and implemented in other regions or agriculture settings.

Knowing the importance of agriculture for rural communities in Khyber Pakhtunkhwa (KPK) province of Pakistan, the significance of identifying CCV, adaptation strategies and risk perceptions at farm level is crucial. Therefore, a growing number of agricultural experts have shifted their research interests toward the issue of climate change and its impacts on agriculture in Pakistan. The focus of these experts is on identifying perceptions of climate change related risks (Qasim *et al.*, 2015; Abid *et al.*, 2015; Khan *et al.*, 2013), vulnerability (Atta-ur-Rahman and Khan, 2013; Rasul *et al.*, 2012; Khan and Salman, 2012) and adaptations (Huq *et al.*, 2004; Abid *et al.*, 2016; Deressa *et al.*, 2009) particularly at farm level. Despite this, little research has addressed these issues in the case of KPK Province. Hence, this study provides an analysis of farmers' responses to farm risks, which has always been important issue and particularly so under changing climatic conditions. The paper also provides detailed farm-level evidence and discussion to highlight the actual situation of farmers and their decision environment. The specific objectives of the study include:

(1) to identify main factors of CCV;

(2) to investigate adaptation techniques deployed at farm level to reduce odd impacts of climate related risks; and

(3) to explore perceptions of rural farmers regarding their concerns on the impacts of climate change in the KPK province.

2. Research methods

This section presents methods, describing the main characteristics of the scoping study and the applied techniques of data collection and data analysis.

2.1 Study area

To assess how communities are vulnerable to climate change and in response deploy methods for adaptation, a comprehensive case study approach was chosen. KPK province was selected as a sample site because it was previously identified as vulnerable to climate change (Saif-ur-rehman and Shaukat, 2013; Ullah *et al.*, 2015; Rasul *et al.*, 2012; Malik, 2012), and agriculture contributes approximately 38 per cent to the provincial gross domestic product and provides employment for 44 per cent of the total population (Atta-ur-Rahman and Khan, 2013; Khan, 2012; Khan, 1994). The KPK province is divided into two parts for analysis purposes: northern and southern halves. The former is water sufficient and the latter is water deficient. The study area is the junction point situated along the bank of the Kabul River. This area faces two extreme conditions: drought and flood causing huge harm to humans, land and other property. Natural disasters, especially floods and droughts, have severely affected agriculture in the Charsadda district of KPK province. Two villages, Gulabad and Shabara, were selected from Charsadda district for this study (Figure 1). Gulabad lies on the main Peshawar – Charsadda Road; Shabara is located 3 km to the east of the main Peshawar – Charsadda Road and approximately 1 km to the east of the main

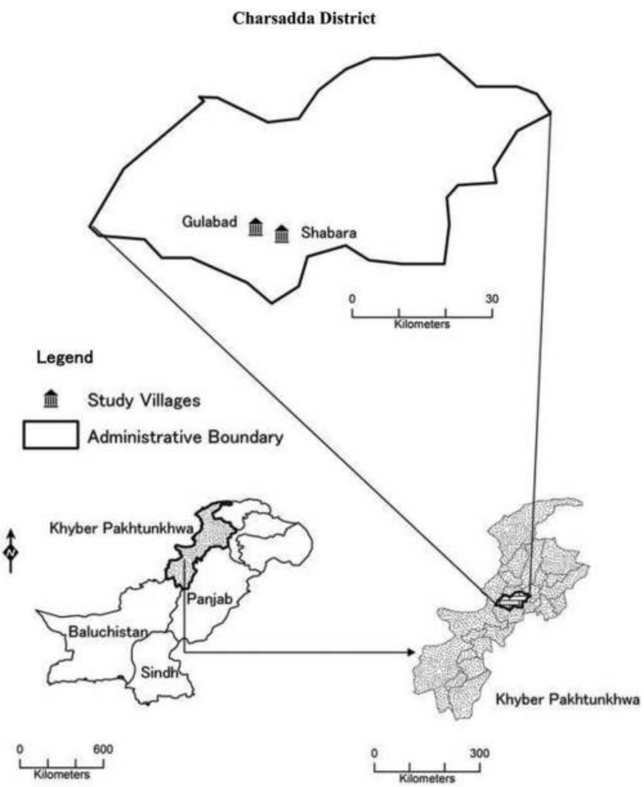

Figure 1.
Map of the study area

Peshawar–Islamabad Express Motorway. Other facilities such as transportation, distance to district headquarters, access to internet and availability of mobile service and roads are equally available in both villages. However, access to water for irrigation is the main attribute differentiating the villages.

2.2 Data collection and sampling design

The study used the household survey (HHS) method for collecting data. A bottom-up approach was used to investigate actual farmers' experiences with climate and their responses to various climate conditions that might influence their decisions. Initially, a meeting was arranged with knowledgeable people such as village elders, experienced farmers, elected members of the village and school teachers in Gulabad to identify potential villages for the study. Before the meeting, the study objectives were explained to them, and they were asked to provide best-fit case study villages based on their knowledge of the area. Seven potential villages were identified for the research team to visit using criteria of flood damage, access to transportation, distance to district headquarters, internet access, availability of roads and water availability for irrigation. Due to the time and financial constraints, sample selection was reduced to three villages based on distance from rivers and irrigation techniques used for farming. Out of these three villages, the research team randomly selected two: Gulabad and Shabara.

Using a structured questionnaire, the survey targeted representatives of households that in most cases were household heads. However, in cases of unavailability, other adult members of the household were interviewed. It is important to mention that this study was performed in a region where people with Pashtun ethnicity reside. In Pashtun societies, women are not allowed to mingle with male members (Qasim *et al.*, 2015). Hence, this study only covers perceptions of male respondents as it was impossible to capture women's perceptions for cultural and religious reasons. Two field assistants were hired to help the first author of this paper collect primary data from the study area. A one-day intensive workshop was arranged to train field assistants prior to visit study villages. All questionnaires were administered personally to the respondents by the research team. In total, 116 households (45 from Gulabad and 71 from Shabara) were randomly selected for interviewing. The sampling frame included residents of both villages, which were male farmers. All interviews were conducted based on shared research principles and ethics (Bogner *et al.*, 2009).

Before starting the HHS, the purpose and objective of the study was clearly explained and respondents were asked for informal verbal consent. During the field survey, the research team did not come across any household who refused to be interviewed. This might be because the study team and respondents shared the same language and other cultural attributes, which made respondents less hesitant. Generally, the HHS lasted for approximately one hour. The survey included questions on household socio-economic characteristics – for example, age, gender, farming experience, occupation, education, assets for livelihood like transportation, electrical, mechanical assets, agricultural or farm equipment, climate-related vulnerability perceptions, knowledge on climate change and its impacts on agriculture, adaptation techniques used to reduce adverse effects of climate change and constraints to adaptation. Perceptions on concerns from climate-related risks were also part of the survey. Perceptions on concerns from weather related changes were grouped into excess rainfall, temperature change and droughts from the answers given during the survey while concerns regarding agricultural production were grouped into severe weather condition, crop diseases and lack of access to agricultural inputs. The reported concerns from changing climate (each measured on a five-point Likert scale) included decrease in income from agriculture (1), no compensation in case of human or agricultural losses (2), increased threats (3), no access to irrigation (4) and no access to alternative income (5).

3. Results and discussion

The study findings start with the analysis of social and demographic characteristics (Section 3.1) and availability of assets for livelihood and farm characteristics at household level (Section 3.2). Next, results on key factors contributing to the CCV of farmers are presented (Section 3.3). The analysis then moves on to consider adaptation techniques used to cope with climate change at farm level (Section 3.4) and finally the concerns of respondents interviewed on climate-related risks in the region are presented (Section 3.5).

3.1 Demographic and farm characteristics

Demographic and farm characteristics of sampled households are presented in Table I. In both villages, respondents were all men, married and performing farming as a primary job. In both villages, the majority of respondents were in the age range of 31-50 years. In Gulabad, 44 per cent of the sampled households had 6-10 years of education and in Shabara this proportion was 35 per cent. The household size was large in both villages, i.e. 8-9 persons per household, providing a labor force for farming. The majority of farmers were experienced. Slightly more than half of the respondents in Gulabad had 20-35 years of farming experience, but in Shabara the ratios were evenly distributed with almost 25 per cent, among the all categories (Table I). Some respondents (20 per cent and 25 per cent in Gulabad and Shabara, respectively) could not provide their experience in years and explained that they have been involved in farming since childhood. In both villages, 76-89 per cent of farmers used tractors for plowing land. More than 60 per cent of households in both villages plowed their land a minimum of twice per year. Inhabitants of Gulabad irrigated their agricultural land with canal water, but in Shabara, more than 73 per cent of farmers used tube-wells for irrigation and the rest waited for rainfall. The land in Shabara is drier compared with Gulabad; hence, it needs water more frequently to get desirable yields. Surveyed respondents mostly heard about climate change either through electronic media, friends or from elders. Farmers' unions are important media for sharing knowledge and experience but in our study sites, those unions did not exist. Respondents further reported that they had never been invited by local government for training programs on agriculture, which could have built their capacity and taught them advanced farming techniques.

The literature has widely covered the importance of understanding farmers' socioeconomic and demographic characteristics in the context of CCV and adaptation concerning it (Abid *et al.*, 2016; Bryan *et al.*, 2009). The results have shown how policymakers can best support poor farmers, who are most vulnerable to climate impacts given limited resources to make changes in their farming practices. Providing support to the poorest farmers is critical because they are the least equipped and the most vulnerable (Bryan *et al.*, 2009). Addressing these issues requires strong leadership and government involvement in planning for adaptation and implementing measures to facilitate adaptation at the farm level (Bryan *et al.*, 2009; Adger and Kelly, 1999).

Indicators	Category type	Village name Gulabad (%)	Shabara (%)
Household size (persons)		7	9
Gender	Male	100	100
Marital status	Married	100	100
Occupation	Farming	100	100
	Shop keeping	7	4
	Others	7	1
Age (years)	11-30	4	17
	31-50	58	45
	>50	38	38
Education (years)	0	22	42
	1-5	33	23
	6-10	44	35
Farming experience (years)	Since childhood	20	25
	<20	11	24
	20-35	51	27
	>35	18	24
Land preparation	Use tractor	89	76
	Use both tractors and bullocks	11	24
Frequency of plowing per year	Once	18	7
	Twice	53	65
	Three and more	29	27
Means of irrigation	Canal	100	–
	Tube-well	–	73
	Rain fed	–	21
	Both tube-well and rain fed	–	6
Frequency of irrigation	Nil	–	15
	Weekly	22	37
	Twice a month	51	27
	Three times a month	24	13
	Monthly	2	8
Source of information on climate change	Media	36	10
	Village elders	44	70
	Own view	9	1
	Friends	7	11
	Do not know	4	4
Farmer's unions		Does not exist	Does not exist
Farmer training programs		Does not exist	Does not exist

Note: (–) means no responses were given
Source: Author's field survey

Table I. Socioeconomic and farm characteristics of sampled households

3.2 Assets for livelihood

Respondents of the HHS were asked about the assets they owned to support their livelihood. These assets included transportation, electrical, mechanical and agricultural or farm equipment (Table II). In both villages, most respondents owned televisions, cellphones and other common agricultural farm equipment such as spraying device, water pump and scale. Few respondents owned a tractor or post-harvest facilities. Very few respondents had access to advanced techniques of farming due to their poor socio-

Table II.
Assets for livelihood in study area

Asset type	Gulabad (%) Yes	No	Shabara (%) Yes	No
Motorbike	38	62	32	68
Bicycle	27	73	28	72
Electric generator	31	69	10	90
Cellphone	76	24	69	31
Regular phone	7	93	–	100
Television	38	62	48	52
Radio	4	96	4	97
Camera	2	98	–	100
Washing machine	80	20	90	10
Other (e.g. sewing machine)	78	20	94	6
Tractor	2	98	–	100
Plow	80	20	90	10
Chemical spraying device	80	20	85	15
Water pump	73	27	73	27
Wooden cart	9	91	–	100
Grain/flourmill	4	96	–	100
Scale	82	18	83	17

Note: (–) means no responses were given
Source: Author's field survey

economic situation. The majority of them faced poor economic conditions, which expose them to the vagaries of climate change. Other researchers have consistently mentioned that having more agricultural assets and access to improved technology stimulates agricultural growth, expands food supply and so results in poverty alleviation (Ali and Erenstein, 2016; Abid *et al.*, 2016; Deressa *et al.*, 2009).

Previous studies suggest that analyzing vulnerability does not only involve identifying threats but also the resilience and recovery from the negative impacts of changing climatic conditions [39]. This includes individual and household characteristics, socioeconomic status, farm characteristics, distance from markets and access to extension and credit. As suggested, households that wish to reduce the risks associated with climate change and have the resources or access to resources needed to make the appropriate changes are generally more resilient and have greater capacity to adapt (Abid *et al.*, 2015; Deressa *et al.*, 2011). Knowledge of these assets helps in understanding how livelihoods work, and how people respond to climatic variability and adapt to change. Hence, livelihoods are built on these assets – individuals, households and groups depend on these assets for agricultural production (Jodha *et al.*, 2012). The general conception is that farmers with more capital better survive the negative results of climate change (Deressa *et al.*, 2011; Blaikie *et al.*, 2014). In the case of our study area in particular, and Pakistan in general, the livelihoods of poor farmers are particularly at risk from the ever-increasing exposure to natural disasters like floods, droughts, heavy monsoons and heat waves (Qasim *et al.*, 2015; Abid *et al.*, 2015).

3.3 Major factors contributing to climate change vulnerability

This section addresses question about what perceived factors are the primary contributors to CCV in the study area. After a detailed literature review, 16 variables were identified that are considered important in CCV analysis (Abid *et al.*, 2016). The scores given for each indicator were measured and ranked on a five-point Likert-scale of very low (1), low (2), moderate (3), high (4) and very high (5), depending on how farmers perceived it in relation to the changing climatic conditions in the study area. Indicators that received a score 4 or 5 were considered primary contributing indicators to CCV, whereas those receiving 1 or 2 were perceived as low contributing factors.

There were mixed responses among respondents concerning gauging indicators of CCV. This might be due to the nature of different environmental risks people are exposed to in both Shabara and Gulabad. Consequently, the perceived threats from CCV were also seen differently (Figures 2 and 3). Indicators whose impacts were less threatening were perceived as low contributors to CCV in Gulabad and Shabara. Those indicators included drinking water, forest degradation, transportation system, grazing area, land resource, landslides, irrigation facility, animal diseases and minimum extreme temperature (Figure 3). However, soil problems (40 per cent), crop pests (42 per cent) and droughts (38 per cent) were perceived as low contributing factors to CCV. Flood was a major contributor to CCV in Gulabad and 38 per cent ranked it as a high and 47 per cent as a very high contributor.

In the case of Shabara, most of the indicators perceived as low, very low and moderately contributors to CCV were ranked similarly to Gulabad. A mix of responses was observed in ranking drinking water, with almost equal numbers of respondents in the different rankings concerning changes in availability of drinking water (Figure 3). Unlike in Gulabad, the agricultural land in Shabara is either irrigated with tube-wells or rain fed. Therefore, more than 20 per cent of respondents ranked irrigation with regard to CCV respectively as very low, low, moderate and highly vulnerable to negative impacts of climate change. In the case of flood, 27 per cent of respondents perceived that it was highly vulnerable to CCV. Flood is a major threat to CCV in both villages, possibly due to their proximity to the Kabul River

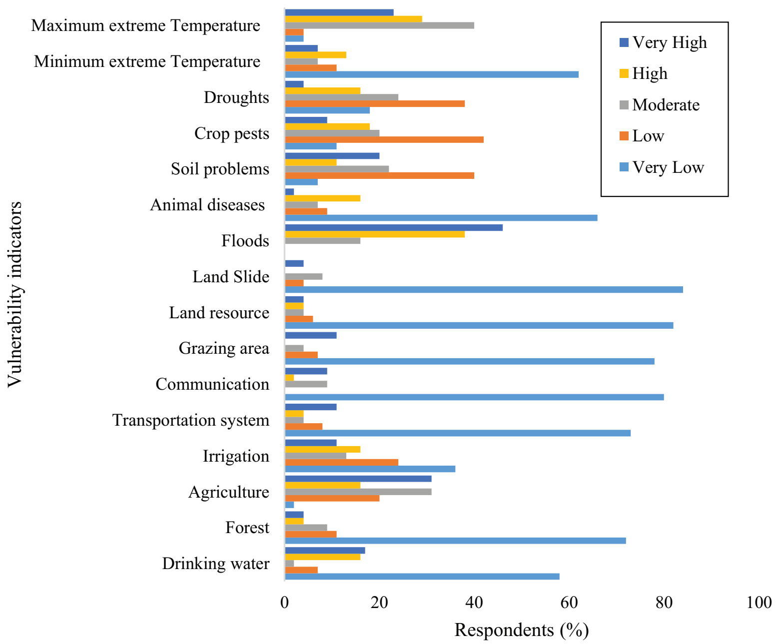

Figure 2.
Perceptions on causes of CCV in Gulabad

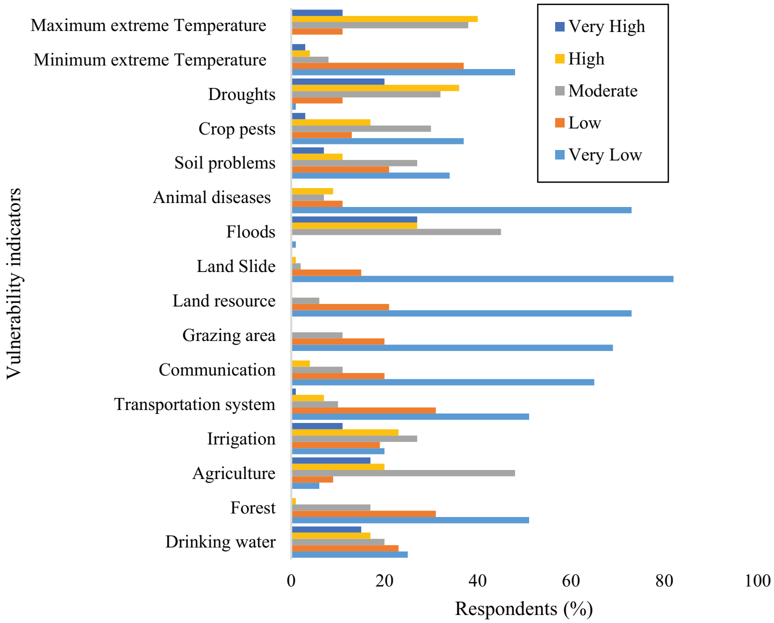

Figure 3.
Perceptions on causes of CCV in Shabara

that floods almost every year in the monsoon season of July-September, resulting in serious problems for the socioeconomic and physical environment of the study area.

Comparing these results with other studies around the world, as well as some conducted in Pakistan, clearly indicates that many rural populations especially those involved in farming are severely affected by impacts of changes in climate (Mirza, 2003; Greenough *et al.*, 2001; Field, 2012; Ali and Erenstein, 2016). For instance, Abid *et al.* (2015) found similar conditions in Panjab province of Pakistan where longer summers, decrease in precipitation and changes in agricultural growing season were recorded by the farming communities. An increasing trend has been seen in the frequency and magnitude of natural disasters like extreme temperatures, floods and droughts (Maheen and Hoban, 2017). Temperatures are predicted to rise by 3°C by 2040 and up to 5-6°C by the end of the century. Monsoon rains will drastically reduce but have higher intensity. According to Abid *et al.* (2016), farmers' identification of various risks shows the importance of climate-related conditions for their farm-level operations. However, differences in how risk is perceived by farmers in different regions are common due to changes in the environmental setting, geographical location, availability of resources and economic status of an individual.

Disaster risk management experts believe that the main causes of vulnerability to hazards are not solely environmental but also result from ignorance of the people and destitution of the country (Adger and Kelly, 1999; Wisner *et al.*, 2012; Mustafa, 1998; Smit and Pilifosova, 2003). More than half of Pakistan's population lives in extreme poverty and many live in disaster-prone areas. This specific social segment cannot be expected to make disaster risk reduction a priority although they suffer severely from disasters when they occur. One of the physical vulnerabilities of the people living in highly vulnerable areas might be attributed to this social issue (Mustafa, 2002). In the 2010 Pakistan flood, in many areas people ignored warnings about impending disasters for various reasons including lack of awareness, education and lack of trust between locals and government officials. Another example of social and economic vulnerability is seen in the irrigation system of the country, where high demand for water has led to inappropriate irrigation resulting in worsening the flood and drought conditions (Mustafa, 2002).

3.4 Adaptation techniques used by farm households

This section borrows previous methodology used to identify how farmers adapt to climate-related risks at farm level in Panjab province of Pakistan (Deressa *et al.*, 2011; Abid *et al.*, 2016). Adaptation strategies included in this study were grouped into four major categories:

(1) changing cropping practices, e.g. crop type and variety or planting date;

(2) changing farm management techniques such as fertilizer, pesticide, seed quality or irrigation;

(3) advanced land use management measures, i.e. changing farm management techniques such as sowing and harvesting, planting shade trees, stopping cutting trees, using less water, storing water and soil conservation; and

(4) livelihood options, including shifting from single to multiple crops, shifting from farming to livestock keeping, migration and renting more crop land.

Farmers in Gulabad changed crop variety, type and quality of fertilizer, pesticide and seed quality; plant shade trees; and shift from single to multiple crops to cope with climate change (Figure 4). The prominent methods of adaptation to reduce the negative impacts of climate change in Shabara included changing crop type, changing seed quality, plant shade trees and stopping cutting trees. The methods of adaptation to climate change were mostly similar in both villages.

Changes in cropping practices implemented by respondents were dependent on the nature of problem. A change in crop type or variety was mostly adopted due to pest and insect attacks on crops that negatively affected agricultural production. To overcome this problem, households reported that they had tried new fertilizers and pesticides to ensure desired production. It was also mentioned that these adaptation strategies did not help

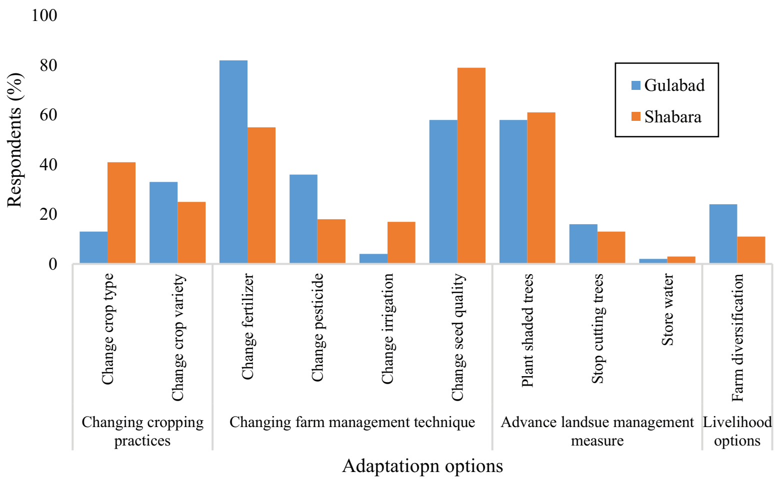

Figure 4. Adaptation strategies used to manage climate change and associated risks by farm households in Gulabad and Shabara

improve their yields. Farmers have started buying heat-tolerant wheat varieties to cope with extreme hot weather events, following farmers in Punjab province who usually get higher yields compared with farmers in the study area and in KPK province generally.

Changing farm management practices include changing fertilizer, pesticide, seed quality and frequency of irrigation were implemented by sampled households. For instance, in Shabara, during dry years (which happen often), farmers changed their irrigation frequency to ensure the desired production. Crops are exposed to pest attacks in cases of more rainfall. Farmers try different combinations of pesticides but mostly buy the cheapest available, partly due to availability in the village market – it is easier to buy it within their vicinity. The case of fertilizers is similar to that for pesticides. In response to loss of fertile soil layers by floods in 2005 and 2010, farmers used more fertilizers to balance nutrients in the soil and increase crop productivity. All farmers thought that their production had decreased in the last decade or so, and they try to add more fertilizer to their soil than before. It was reported that wheat and sugarcane production had reduced by more than half compared to 10 years ago. Most farmers believed that this was due to changes in climatic conditions, poverty and lack of support from local government.

Advanced land use management techniques were also adopted to protect livelihoods against negative impacts of climate-related risks. Although respondents understood the importance of water for agriculture, none used less water or stored it for winter (the season when there is insufficient water for irrigation). In Gulabad, availability of water for irrigation was considered a less important issue because they had good access to river water. Although a canal was built in Shabara, farmers get no benefit due to a lack of water channels to land. More than half of the respondents in Gulabad, and approximately 60 per cent in Shabara, have started planting Eucalyptus around their land especially near the river to reduce soil erosion from floods during July-September. However, farmers were unaware that Eucalyptus trees have high-water demand (Forrester *et al.*, 2010). Farmers in Shabara showed more concern after learning this fact because they already face water scarcity for irrigation.

All sampled respondents were primarily farmers and their whole household depended on it (Table I). Other livelihood options are currently rare. Farmers have tried shifting from single to multiple crops, planting Eucalyptus or replacing wheat with maize in some parcels of land. Due to the unavailability of grazing areas, few respondents were willing to depend on livestock for subsistence. One household migrated from a neighboring village to Shabara in response to loss of agricultural land due to floods in 2010 but was not satisfied with soil fertility in Shabara. Small numbers of farmers rented extra land within the village to increase their overall agricultural production and meet household food demand, which had been affected by infertile soil, lack of access to good agricultural inputs and high exposure to droughts and floods.

Due to the high exposure of agricultural communities to vagaries of climate change across Pakistan, many farmers tend to minimize these impacts by adapting. However, the impact of climate-related events strongly depends on the capacity to adapt to the risks. Although adaptation practices are potentially important, not all farmers use such practices due to lack of knowledge on what techniques are appropriate (Baig and Amjad, 2014; Ahmad *et al.*, 2013). This situation particularly applies to Pakistan where knowledge about the current process of adaptation and vulnerability aspects at farm level is still very limited due to lack of research on environmental vulnerability and local-level risk perceptions (Hussain and Mudasser, 2007). Abid *et al.* (2016) and Adger and Kelly (1999) reported that those who adapt in a timely manner may not only reduce the negative impacts of climate change but also profit compared with those who adapt late or not at all. However, the approaches to adaptation assume that people have access to the resources needed to put these strategies in place. For the most vulnerable people in many communities this is simply not the case. When people do not have secure access to these resources, their options are limited and they are less able to act on adaptation (Dazé, 2011; Mertz *et al.*, 2009).

3.4.1 Constraints to adaptation. During the HHS, farmers were asked to identify constraints that they perceived to be the most important barriers to changing their farming practices (Figure 5). Although farmers referred to several barriers to adaptation, the most important in both Gulabad and Shabara included poverty, lack of support from government and lack of assets. In Shabara, lack of water for irrigation, lack of information and knowledge on climate change weather and rainfall pattern, of an effective and timely early warning system and of market and price information were also among the dominant constraints to adaptation.

The capacity of a household to cope with climate risks depends to some degree on the enabling environment of the community, and is reflective of the resources and processes of the region (Smit and Pilifosova, 2003). At the local level, the ability to undertake adaptations can be influenced by such factors as managerial ability; access to financial, technological and information resources; infrastructure; the institutional environment within which adaptations occur; political influence; kinship networks and the socio-economic status of the household (Blaikie *et al.*, 2014; Watts and Bohle, 1993; Kelly and Adger, 2000; Roncoli *et al.*, 2002; Eakin 2003). However, to understand the importance of factors shaping farmers' decisions and responses to adapt, it is necessary to explore their perceptions regarding the barriers they face (Bryan *et al.*, 2009). Hence, in the next chapter, farmers' concerns about risks associated with climate change are described in detail.

3.5 Concerns regarding impacts of climate change on agriculture

This section explores perceptions of farm households regarding weather-related changes (Figure 6), primary risks to agricultural production (Figure 7) and finally their concerns from changes in climate in the region (Figure 8). The results showed that, in Gulabad, 69 per cent of the respondents perceived excess rainfall as a major weather threat, whereas in Shabara, 83 per cent of respondents perceived drought as the primary weather-related risk. The proximities of both villages to the Kabul River and the absence of any precautionary measures (e.g. high river boundary walls or effective

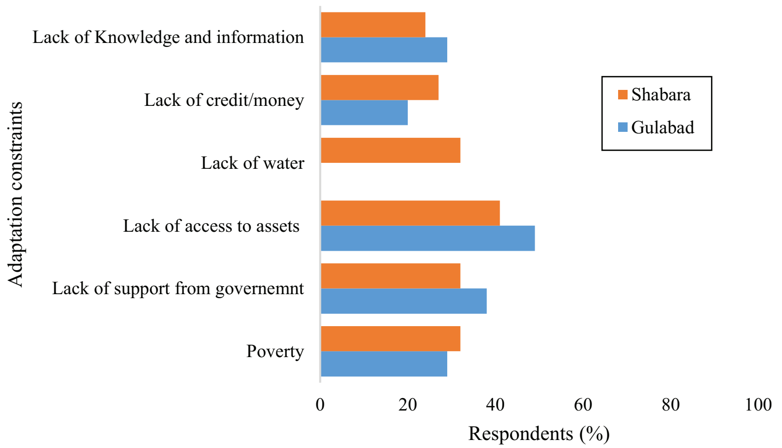

Figure 5.
Perceived constraints to climate change adaptation at farm level in Gulabad and Shabara

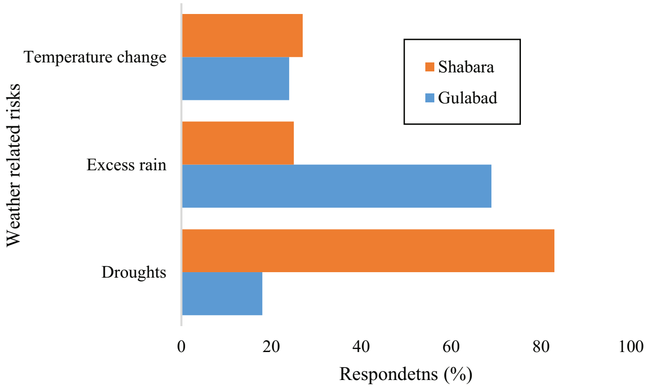

Figure 6. Perceptions on weather-related risks in Gulabad and Shabara

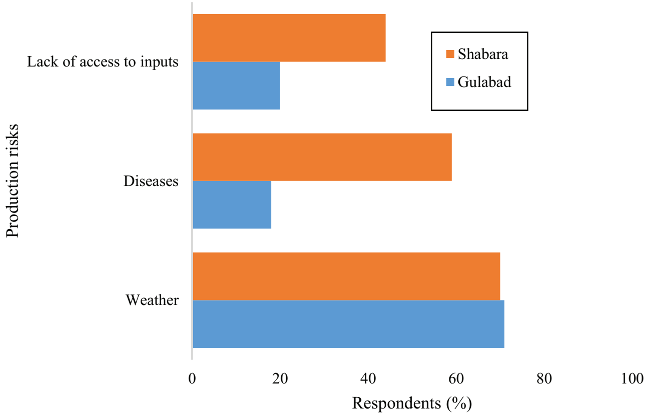

Figure 7. Perceived primary production risks in Gulabad and Shabara

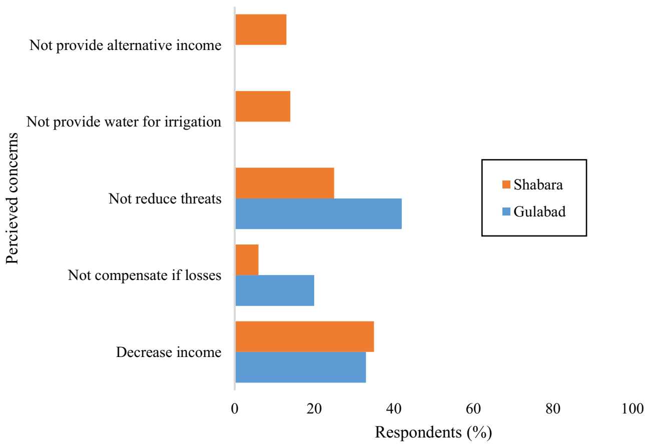

Figure 8. Perceived worries from changing climatic conditions in Gulabad and Shabara

early warning system) expose human lives, livestock, land and infrastructure to flood risk in the monsoon season.

Respondents were further asked about perceived primary risks for agricultural production. The majority of respondents, approximately 70 per cent in both villages, reported changing weather conditions especially hotter summers as the primary risk. Furthermore, crop diseases and lack of access to good quality agricultural inputs such as heat-tolerant seeds, fertilizers and pesticides; to improved soil conservation techniques and to post-harvest facilities were among other factors significantly affecting agricultural production in the study area.

Farmers were asked about their concerns regarding climate-related risks and the impacts on their household. Respondents in both villages acknowledged changes occurring in climate in the region (Figure 8). Respondents perceived that floods, droughts and warmer summers were due to climate change and were among the serious threats to their farming. As mentioned earlier, all surveyed households primarily depend on farming for subsistence. Respondents were of the view that these changes in climate would decrease farm income of their household. Some respondents (42 per cent and 25 per cent in Gulabad and Shabara respectively) reported that changing climatic situations would increase threats to agriculture, such as low yields, less fertile soil and more crop diseases.

Perceptions and response of farmers toward uncertain conditions are important as they can describe the decision-making behavior of farmers (Rasul *et al.*, 2012). Hence, it is important to study risk perceptions of those farmers who live in a risky environment. In this regard, perceiving climate variability is the first step in the process of adapting agriculture to climate change, as discussed by Deressa *et al.* (2009) in Ethiopia and Abid *et al.* (2016) in Pakistan. In addition to the limited access to farm resources such as fertilizers, pesticides, good quality seed, water for irrigation, labor, land and infrastructure there are other environmental factors including floods, droughts and storms that increase CCV of farmers (Rafiq and Blaschke, 2012; Ali, 2013; Asif, 2013; Bukhari and Sayal, 2011).

Furthermore, the literature consistently emphasizes the concerns arising from the impacts of climate change and its variability on agricultural production worldwide (Ullah *et al.* 2015; Hay and Mamura, 2010; Ali and Erenstein, 2016). Continuous reduction and inconsistency in yield of major crops has been reported across Pakistan due to climate-related risks (Tingju *et al.*, 2014; Ahmad *et al.*, 2013). This suggests that in addition to analyzing risks to which people are exposed there is a need to investigate the quality of the options they have for coping and how they are ultimately managing risks. This understanding can facilitate identification of the most vulnerable groups and can also create opportunities to identify effective and sustainable adaptation strategies (Adger and Kelly, 1999; Rasul *et al.*, 2012; Ahmad *et al.*, 2013).

4. Conclusion

This study provides insights into the climate-related risk perceptions of farmers, including their vulnerability and adaptive responses, constraints that limit their adaptive capacity and concerns regarding negative impacts of climate change on agriculture at farm level. Identifying individual's risk perception is important as it determines their responses and helps in designing a context-specific policy. Farmers perceived that in the future, climate change would be an even greater threat to agriculture.

The study identified that climate change is negatively affecting agriculture, which is in most cases is the only primary subsistence activity of rural farmers all over Pakistan, particularly in the KPK Province. This situation is consistent with other climate-related studies conducted throughout the country and in our study area. Recent changes in climatic conditions have exposed rural farming communities to numerous risks. For instance, farmers mentioned that disastrous floods, severe droughts, storms, extreme maximum temperatures, changes in rainfall pattern, crop diseases and loss of farmland due to floods, are among the worst situations negatively affecting agricultural production. Major adaptation methods identified by households were changing fertilizer, changing seed quality, changing crop type or variety and planting shade trees. Lack of access to financial services and to information on agricultural training and lack of support from provincial and local governments were among the major constraints to adaptation. Farmers in the study area had no access to agricultural extension or farmer training that could build their capacity. Government and other relevant stakeholders should provide easy access to those services so that farmers can learn advanced farming techniques and how to effectively adapt.

Therefore, building capacity of the locals toward reducing CCV and facilitating effective adaptations are important. Future policies need to address barriers to the adoption of advanced adaptation techniques at the farm level. There is a dire need for research on identifying locally specific adaptation of agriculture to climate change so that farmers can decide the most suitable adaptation measure to apply. Support from agricultural extension bodies, research institutions and policy makers is also needed to provide updated information on weather and access to quality inputs used for improving yields. Cooperation among farmers is also key in improving their adaptive capacity and resolving other problems at the community level. The study also recommends that other researchers, especially females, explore this issue with women as they are more vulnerable to climate-related risks, a topic that this study could not address due to cultural and religious barriers.

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