Research Article

Farmers' Adaptation to Climate Change in Pakistan: Perceptions, Options and Constraints

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Abstract | Agriculture in Pakistan is extremely vulnerable to climate change. Adaptation of the agriculture sector is imperative as it contributes 20 percent to the GDP and supports directly or indirectly about 68 percent of the population for their sustenance. Farmers' perception about climate change, current adaptation measures, and decision-making process is important for farmers' successful adaptation strategies. Using data of 205 conventional farmers from three district of Punjab province, this study provides insights into farmers' perceptions about climate change, on-going adaptation practices, and constraints to various adaption strategies. We found that majority of the farmers do not consider climate change as a potential threat to agriculture; therefore, they do not make any intentional efforts to change their farming practices. However, a few adaptation measures like use of different crop varieties, tree planting, and drip irrigation methods are prevalent in the research area. The major hurdles that farmers perceived in adaptation are limited access to credit, lack of access to information, and institutional support. As expected, no significant variations were found across districts in the characteristics of respondents (age and income) that can affect their perceptions, their adaptation strategies, and obstacles faced in adaptation. The results of the study need to be interpreted with caution, as we did not focus on other determinants like education, role of media, and government policies that can affect farmers' choices to adopt climate resilient farming practices.

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Introduction

Climate change is a serious threat to humanity and its impacts vary depending upon different types of production systems (Holzkämper, 2017). Developing countries are highly vulnerable to climate change due to their low level of adaptation (IFAD, 2010). Due to its high population growth, south Asia is expected to be severely smacked by climate change (Dhanya and Ramachandran, 2016). Climatic variation and agriculture are interrelated processes (Parry et al., 2007). Agriculture sector lies at the core of Pakistan economy, as agricultural production remains the main source of income for most of the rural communities. Agriculture contributes 19.5 percent to gross domestic product, employs 42.3 percent of the labour force and provides raw material for several value-added sectors (Jan et al., 2017). Its

contribution to total export earnings is 60 percent. The major crops include wheat, rice, sugarcane, maize and cotton that account for 23.85 percent of the value added in overall agriculture and 4.66 percent of GDP. Livestock constitutes major parts of agriculture activities as it accounts for 58.33 percent share in the agriculture and 11.39 percent to GDP. The rapid urbanization in Pakistan has further increased importance of agriculture as demand for vegetables, fruits, meat and dairy products will increase manifold in near future (GoP, 2017). In brief, agriculture is key to national production, food security and poverty elimination in the country. The large agriculture base of Pakistan makes it highly vulnerable to climate change and it is ranked at 12th among the list of highly vulnerable countries to climate change (Noman and Schmitz, 2011; Ullah, 2017). Many of the developing countries are dependent upon agriculture and facing sever threat of climate change (Miller-Kuckelberg, 2012).

Climate change can affect agriculture in Pakistan in different ways. For example, rising temperature are common in the country that can cause decrease in crop yield (Babar et al., 2014). Forecasting shows that by 2059 per hectare cereal yield will decline by 30% in south Asia (Parry, 2007). Water availability is expected to decrease (Ashfaq et al., 2011). To minimize the losses from climate change, perceptions and adaptation strategies of farmers are of paramount importance as if the impact of climate change is known, different steps can be taken to adapt agriculture management that can help to offset the negative impact of climate change (Schiermeier, 2015). Usually adaptation strategies are categories into short run (autonomous incremental responses mostly based on local knowledge), and long run (transformative responses) and both are essential for minimizing risks from weather extremes (O'Brien, 2012). In Pakistan, the importance of climate change has been recognized on highest level since 2005 and after the 18th amendment to devise local vulnerability index is required for the purpose of policy and development (Rahman and Salman, 2013).

To analyse farmers' adaptation to climate change is a multi-dimensional and complex process as it can occur in different forms (Bryant et al., 2000). Numerous studies are available that has assessed the adaptation behaviour of the farmers in different parts of the world (Smithers and Smit, 1997; Smit and Skinner, 2002; Svendsen, 2008). These responses could be reactive or proactive depending upon different circumstances like insurance, farm production process, scale and magnitude of the event, the frequency of extreme events and gender of the household head (Burton, 1997; Asfaw and Admassie, 2004; Nhemachena and Hassan, 2007). This shows that the role of farmers' perception in adaptation to climate change and policy framework is crucial. In the light of above discussion, this study aims to achieve the following objective:

1. To examine perceptions of farmers about climate change.
2. To know about the adaptation strategies adopted by farmers because of climate change.
3. To identify constraints faced by the farmers in adaptation.

Extensive literature is available that focuses the impact of climate change on agriculture but these studies have mostly covered the biological and physical aspects of climate change (Husnain et al., 2018). There is dearth of studies that try to examine perceptions and adaptation strategies of farmers in response to climate change in Pakistan. Recently Nasir et al. (2018) examined farmers' perceptions about climate change and found that farmers are well aware of the changes that are happening because of climate change. Based on their endogenous knowledge they can predict and forecast weather. This study improves this research at least in two ways. First, sample size of this study is at least three times larger than their study. Large sample size is more likely to provide reliable results as compare to small sample. Second, the sample area of this study locates in the region where climate change is going to hit hard through water shortage and droughts.

Despite numerous studies on the impact of climate change on agriculture, no consensus exists among the researcher on the issue. Majority of the studies report the negative impact of temperature on agriculture. For example, Husnain et al. (2018) reported the negative impact of temperature on agriculture. Ali et al. (2017) found that extreme temperature adversely affects crop production in Pakistan. Very little is known about farmers' perceptions on climate change in empirical literature (Simelton et al., 2013) as the focus of previous studies has been on the biological and physical impacts of climate change (Pidgeon and Fischhoff, 2011).

The farmers' perceptions to climate change are closely linked with community perceptions of climate variability. Mahmood et al. (2010) reiterated that perceptions about climate change help in the formulation of coping strategies. The climate change is going to hit hard small farmers due to their limited adaptive capacity (Archer et al., 2007). The climatic variations reduce resilience in poverty-hit regions (Lal et al., 2015). Traore et al. (2015) are of the view that adaptation can reduce the negative impacts of climate change in future and without adaptation the effect of climate change will be substantial. Likewise, Waha et al. (2013) also reported that adaptation to climate change reduces the intensity of its impacts on agriculture. Farmers can maximize their profits by adapting to climate change (Tilman et al., 2002). However, adaptation alone cannot be as effective as in case if it is integrated with farmers' understanding of risk. The farmers' perceptions related to climate change provide foundations for adaptation (Simelton et al., 2013). It is obvious from the literature that perceptions of the farmers are prerequisite to adaptation to climate change and negative climatic variations impacts soften because of adaptation. The rest of the paper proceeds as follows. Section titled 'material and methods' explain sampling technique, study area and statistical test applied. Section 'results and discussion' shows graphs and table. Discussion of results is also presented in this section. The final section contains conclusion and some of the policy implications.

Materials and Methods

The household-level data used in this study were collected as part of the project "The feasibility of organic agriculture in a semi-arid environment: the case of Punjab, Pakistan" funded by South Asian Network for Development and Environmental Economics (SANDEE). The study area is located in Gujranwala, Sheikhupura and Okara- three districts located in semi-arid area of Pakistani Punjab. Initially data was collected from conventional and organic farmers. In this study, we use data related to conventional farmers only. Consultations with farmers, agriculture officers in organic industry, NGOs and village leaders provided basis for the selection of these districts. Initially stakeholders were identified using snowball-sampling technique. We had some prior information about organic farming as some non-government organizations and firms were providing training to farmers on organic methods in these districts through farmers field schools (Husnain et al., 2017). The survey was conducted in May/June 2011. Primary data was collected from 224 farmers through a structured questionnaire. Farmers were randomly selected from different villages of Gujranwala, Sheikhupura and Okara districts of Pakistani Punjab (Figure 1), after their names were sorted alphabetically and assigned a number. This ensures equal probability to each farmer being included in the sample irrespective of his/her farm size in the study area. Our final data sets include information from 205 farmers (Gujranwala: 80; Sheikhupura: 72; Okara: 53). Information was collected from the household head on socioeconomic characteristics of the household, perceptions of climate change, adaptation strategies, and obstacles to adaptations. Frequencies of the responses are reported to understand the respondent behaviour. These frequencies are shown in figures for comparative analysis. To provide more insight about the difference across sample we apply one-way ANOVA as the data is collected randomly from three districts and samples are independent of each other. This will help understand the difference in characteristics of the respondents coming from three districts. The null and alternate hypotheses are:

$H_0 = \mu_1 = \mu_2 = \mu_3$, all the means are the same; H_1=two or more means are different from the others.

In case of rejection of null hypothesis, we will proceed to determine which means are different by applying HSD (Honestly Significant Difference) for post-hoc analysis suggested by Tukey (1949). In HSD test the computed t score for each pair of means is compared to q distribution (studentized range) instead of celebrated Student's t distribution to overcome the increased likelihood of a type I error.

Results and Discussion

Farmers characteristics

Farmers' characteristics like age, education, and gender can determine their perceptions and adaptation behaviour about climate change (Bagheri et al., 2008). The mean age of the respondent in the sample is 40 years with family size between 5-6 members per household. Majority of the farmers (above 70%) are literate and spend much of their time in agriculture activities. The average household per month income is PKR 29788 calculated using the expenditure method as proxy. Empirically it is well-established

fact that people hesitate to show their income due to the risk of tax imposition and are willing to tell their expenditure, therefore, this method is used in survey studies to indirectly estimate income of the respondents. Household head were male with a few exceptions.

Farmers' perceptions about climate change

Jarawura, (2014) noted that local perception along with scientific idea provides foundations for effective adaptation. Farmers adapt to climate change if they perceive it a potential threat. Surprisingly, the majority of the respondents opined that climate change is not a permanent phenomenon and fluctuations in the weather are common since the last two decades. Figure 2 shows the perceptions of farmers about the climate Change. Of 206, around 70 respondents reported that they do not know about the climate change and only 32 had a clear understanding of the climatic variations. Despite high literacy rate in the sample, this result was unexpected. Education is considered a key factor in increasing public's awareness of science (Elahi et al., 2015), therefore, environmentalists call for a more concrete publics understanding of climate change (Niepold et al., 2007). However, this result could have been due to geographic conditions of the region where the respondents are located. Bofferdinga and Kloserb (2015) state that "public action toward climate change varies across regions, cultures, and individuals." Empirical evidence shows that lack of declarative knowledge a key reason for not enacting particular behaviour in context of climate change (Truelove and Parks, 2012). Climate change, particularly rise in temperature are not obvious in this region. The climatic variations are more obvious in the northern areas of Pakistan where lake outburst, land sliding, melting of glacier and river flow are the indicators of climate change. This finding is contrary to results reached by Nasir et al. (2018) who report that "majority of the respondents are well aware of climate change and its effects on cropping calendar, crop variety, crop yield, crop diseases as well as an earlier blossoming of fruit trees". Similarly, Mendelsohn and Dinar (1999) stated that the majority of farmers believe that the climate has changed. This anomaly of findings can further be explained by the fact that more awareness programs are in practice in the northern areas as compare to our sample where farmers report absence of any information campaign. However, this finding is partially in line with thoseof Amadou et al. (2015) who concluded that farmers are aware of the increasing temperature, changing patterns of rains and drought frequency in Ghana. However, farmers have a different perception about the hailstorm and early/late arrival/departure of winter/summer. About 55 respondents knew little about the changing patterns of climate. These numbers were obtained when farmers were asked to report their understanding on the changing pattern of climate. They were briefed what the climate change is and what indicators exemplify the variation in climate particularly increases in temperature.

Figure 1: *Map of study area.*

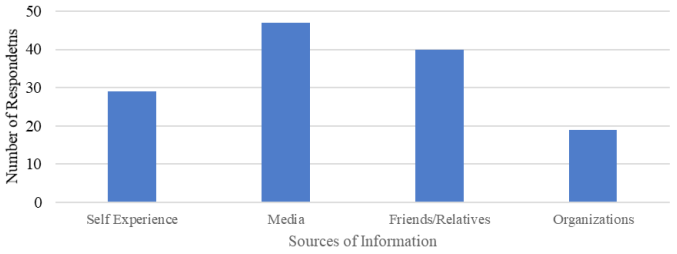

Figure 2: *Farmers' perception about climate change (n=205).*

The low level of respondents' knowledge about climate change significantly reduced (135) the sample size as 70 respondents who were unaware of the variations in the climate were excluded from further analysis. Respondents were asked about different sources of information about climate change and their responses are graphed in Figure 3.

It is clear that the farmers' get information about climate change from multiple sources. Out of 135 respondents, 47 reported that their knowledge about

climate change comes from media. This result is very common and easy to comprehend as role of media in providing information to different segments of the society is increasing as people have now more and more access to smart phones. However, it is alarming to know that only 19 respondents reported different awareness campaigns/organizations (Ministry of Environment, NGOs etc.) as their source of information about climate change. In a region where agriculture is the main stay of people, it shows institutional failure in equipping farmers with information about changing patterns of the climate. The findings favour the strong belief that farmers' knowledge about climate change emerges from local sources as 40 respondents mentioned friends and relatives as their source of information. Tucker et al. (2010) also report that local knowledge plays a critical role in formulating perceptions of farmers about climate change in Central America and Mexico.

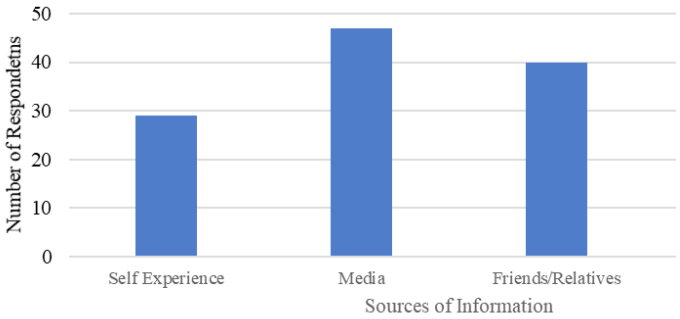

Figure 3: *Different sources of farmers' information about climate change (n=135).*

Rainfall patterns are significant determinants of agriculture productivity, therefore, farmers' perception about rainy days are of paramount importance for adaptation to climate change. Figure 4 shows farmers' perceptions about rainy days and hailstorm frequency.

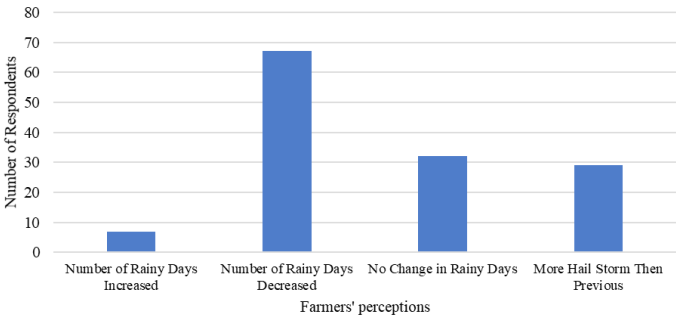

Figure 4: *Farmers' perceptions about rainy days and hailstorm (n=135).*

A large number of respondents (67) believe that number of rainy days has decreased over the last two decades while only 7 reported the opposite. A reasonable proportion was of the view that there is no change in the number of rainy days. A total of 32 farmers reported increase in the frequency of hail storm over the last 20 years. These results show that the people are feeling droughts that may affect their adaptation behaviour. This result is supported by Thornton et al. (2006) who found that over the time rain has become shorter in duration. (Dhanya and Ramachandran, 2016) also report that farmers have the opinion that rainy season is reducing and temperature is getting excruciating. On the other hand, this finding is partially contradicted with Ahmad et al. (2003) who stated that in monsoon regions of Pakistan generally no change has been observed in temperature. The surface air temperature is increasing in Asia, which is more pronounced during winter than in summer (IPCC, 2007) and these increases in temperature are most obvious in north Asia (Izrael et al., 2002; Gruza and Rankova, 2004).

Cropping and sowing seasons delay/early start can have also significant impact on crop production as well as the adaptation strategies of the farmers to offset negative effect of climate change. Farmers are very cautious about the changing pattern of growing season as they know that their production is negatively affected with either a late onset or an early cessation of the growing season (Mugalavai et al., 2008). Therefore, respondents were asked about the start/end of the winter/summer seasons and results are presented in Figure 5.

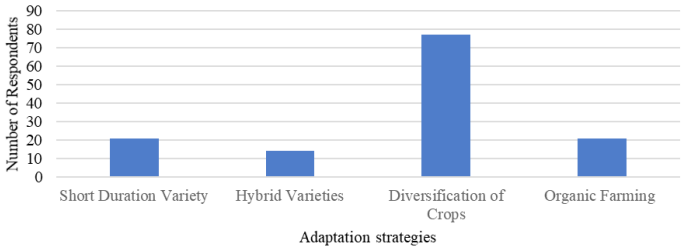

Figure 5: *Farmers' perceptions about winter and summer season (n=135).*

Out of 135 respondents' 119 believed that winter days are squeezing while summer has expanded over the last two decades. They stated that summer season starts on average 10-15 days earlier and ends on average 10-15 later usually. This change in season patterns have also affected the cropping time in the sample area.

Table 1: *Descriptive Statistics and ANOVA results.*

	Descriptive Statistics							
Factors	**Age**				**Income**			
Districts	**Count**	**Sum**	**Avg.**	**Variance**	**Count**	**Sum**	**Avg.**	**Variance**
Gujranwala	80	3102	38.78	3.5	80	2703084	33789	4322
Shiekhupura	72	2966	41.19	7.01	72	1877109	26071	90766
Okara	53	2130	40.19	6.4	53	1526347	28799	7861
	ANOVA							
Source of variation	SS	MS	F	P-value	SS	MS	F	P-value
Between Groups	1496	426.9	1.13	3.09	5516	956.8	1.35	3.09
Within groups	3780	378.5			2271	710.2		
Total	5276				7787			

Farmers' perceptions are key to adaptation (Jarawura, 2014). After analysing farmers' perceptions about climate change their different adaptation strategies are reported mentioned in Figure 6. Diversification of crops is the major strategy (77 out of 135) used in the sample in adaptation to climate change. Other three strategies include shift to word organic farming, use of hybrid varieties and sowing of short run varieties of crops. The high dependence on crop diversification may be due to lack of finance, awareness and skills on the part of farmers. Abid et al. (2015) report that with the increase in number of schooling of the household head's probability of adaptation to climate change also increases.

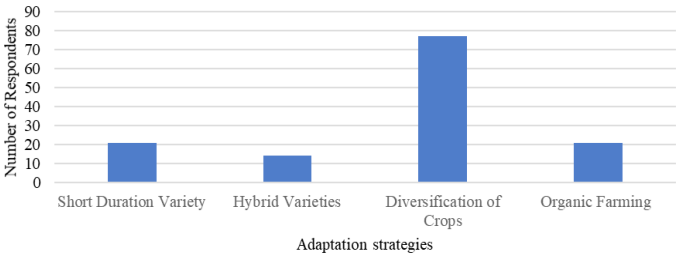

Figure 6: *Adaptation to perceived climate changes (n =133).*

The low level of climate change awareness and use of adaptation strategies in the sample provides insights that farmers' face some constraints in adaptation to climate change. The responses of the respondents are shown in Figure 7 when asked about the different constraints faced by them in adaptation. As expected, high number of farmers' stated lack of finance a major constraint in the way of adaptation followed by lack of information (29), fear of experiment (16) and others (16) respectively. This result is supported by Kurukulasuriya and Mendelsohn, (2006) who report that crop selection is considered a plausible adaptation technique to climate change.

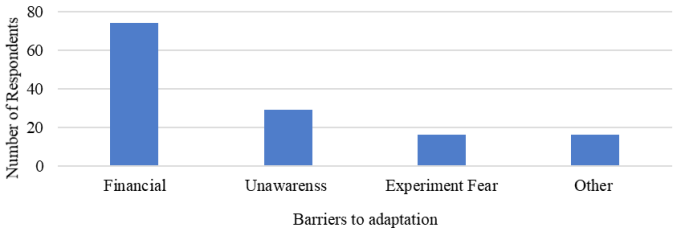

Figure 7: *Barriers to adaptation (n=135).*

After presenting frequency figures about farmers' perceptions, adaptations and barriers to adaptation, we report the results of one way ANOVA test applied on two characteristics of the respondents i.e. age and income as we firmly believe that these two factors can explain variations across sample. Family size was not included in the analysis, as there is no reason to assume that this factor can explain variations in farmers' perceptions, adaptation and barriers to adaptation to climate change. The one way ANOVA results are reported in Table 1.

From Table 1 it is clear that the null hypothesis that "all the means are same" cannot be rejected at conventional level of significance, which means a uniform pattern as no significant difference is found across the mean age and mean income across three districts included in the sample. This simply means that farmers' perceptions, adaptation behaviour and barrier to adaptation are almost similar from one district to other. This finding is logical as these districts are in proximity and have similar climatic patterns in addition to cultural norms. This suggest that a uniform policy framework to address climatic concerns of the farmers could be equally effective and applicable at macro level in the country or at least in the areas where climate does not differ considerably. As explained in methodological section, the next step

of ANOVA is only applicable if the null hypothesis is rejected.

Like many studies on the perceptions and adaptations of farmers to climate change, this study also faces some constraints. For example, individual perception of climate change is considered a vague concept particularly in the scenario where education level of the farmers' is low. Many internal factors like characteristics of farmers can affect perceptions. A significant relationship exists between perceptions and education, age and year of experience (Bagheri et al., 2008). This research solely depends on the answers of the farmers collected through a semi-structured questionnaire that are not matched with climatic data. Further, the number of respondents is small that restricts conclusion to be generalized across the country. Future researcher may focus more districts identified through snowball sampling. Focus group discussions could further help in finding farmers' perceptions regarding climate change.

Conclusions and Recommendations

The focus of this study was to analyse farmers' perceptions about climate change, adaptation measures in practice and obstacles faced by them in the way of adaptation by using the data collected through a household survey conducted in semi-arid areas of the Pakistani Punjab. The purpose was to provide insights, about farmers' decision-making, to policy makers to support adaptation to climate change at the farm-level. The findings show that only a minority of the farmers consider climate change as a potential threat to their agriculture, therefore, no intentional attempt were made to adapt to climate change. However, when asked about the changing patterns of crops and other adaptive measures they were of the view that these practices are the results of other factors instead of changing climate. Adaption of new crop varieties was the most prevalent in the study area as a climate adaptive measure along with improved irrigation. The main obstacles in the way of adaptation was lack of financial support and the fear to make new experiments in agriculture due to already poor condition of the farmers. The other dominant barrier was lack of information about different strategies to adapt to climate change. As expected, across district no significant variations were found in farmers' perceptions, their adaptation strategies and obstacles faced in adaptation.

The findings of the study draw some of the policy implications. First, policy-makers should extend and improve financial support to the farmers in such a way that it reaches to small-scale farmers also as majority of the farmers reported finance major constraint in the way of adaptation strategies to climate change. To achieve this objective, different microcredit schemes can be initiated targeting farmers particularly small landholders. Due to high vulnerability to climate change, poorest farmers need to be focused as they struggle to sustain their livelihood. This requires commitment on the part of policy makers. Target based strategies need to be tailored to enhance the effectiveness of these intervention as one size does not fit all. Raising awareness among the farmers can encourage them to adapt. Whirlwind campaigns need to be launched to equip farmers with the latest information about climate change and available adaptation strategies in the world. Role of organizations in spreading awareness among farmers regarding climate change is critical and these organizations can perform an effective role if they work in coordination with the government as these approaches are cost effective way to adaptation to climate change risk (Salman, 2009). Government needs to take lead in encouraging farmers for experimenting climate resilient varieties of crops to overcome the fear of experiment reported by the farmers. More focus should be on adaptation instead of mitigation and setting up of policies to lessen the effects of climate change (Gowdy and Salman, 2007).

Author's Contribution

Aneel Salman and Muhammad Iftikhar ul Husnain: Contributed in data collection, analysis, and results and discussion section. Inayatullah Jan and Muhammad Ashfaq: Contributed in writing abstract, introduction, and language editing of the paper. Mudassar Rashid and Usman Shakoor: Contributed in data collection, writing conclusion, references, and formatting the overall paper.

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