Farmer’s Perceptions on Market and Climate Risks: Adaptive Behavior in Punjab, Pakistan

Dilshad Ahmad, Department of Management Sciences, COMSATS University Islamabad, Vehari Campus, Pakistan
Mah Rukh Shabbir, Ph.D. Scholar, Bahauddin Zakariya University Multan, Pakistan
*Salyha Zulfiqar Ali Shah, Assistant Professor, School of Economics, Bahauddin Zakariya University Multan, Pakistan

*Corresponding author’s email address: salyhazulfiqar@bzu.edu.pk

ARTICLE DETAILS

ABSTRACT

Purpose: Rural communities particularly in developing countries are consecutively facing losses of income and crops production due to dynamics of the market and climatic risks. The specific objective of this research is to investigate farmers’ perceptions of market and climate risks and their adaptive behavior in Punjab, Pakistan.

Methodology: A multistage random sampling approach was used for collecting the data of 480 household respondents from climate-based categorized three districts of Punjab, Pakistan.

Findings: For empirical correlation of risk perception of farmers with combined risks and adaptive behavior, this study used two Logit models. Estimates indicated as risk perception of the farmers market and climate change significantly affected their adoption behavior such as fall in agriculture products prices and drought while an increase in floods, rainfall and hail storms.

Policy Implications: For motivating farmers to adapt and risk management measures there is a need for adequate provision of financial support through formal institutions on the subsidized rate of interest in these study areas.

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Introduction

Climate change has increased extreme events of natural disasters drought, floods, hail storms and cyclones (Li et al., 2017; Xu et al., 2018; IPCC, 2018; Ahmad and Afzal, 2021), such disasters caused rural community livelihood to be more vulnerable (Duan et al., 2016) regarding crops cultivation, come upon environmental diseases and infusion of extreme weather coping physical
infrastructure (Tol, 2020; Howe et al., 2019; Alam et al., 2020). Risk exposure, geographical locations and lifestyle choices influence natural disasters (Trinh et al., 2018; Ahmad et al., 2019) and these disasters have no limits of economic, social, political, cultural and geographical boundaries of continent, countries and communities ( IPCC, 2018; Teo et al., 2018; Week and Wizor, 2020). In the global scenario, Pakistan ranked world 5th most climate change affected country the reason of considerable variation of rainfall located in critical geographical locations and projected to consecutive increase in temperature 2° to 3° till 2050 (Eckstein et al. 2019; Ahmad and Afzal, 2021; Kreft et al., 2021). In the last couple of decades, owing to climatic variability Pakistan consecutively confronted intense events of erratic heavy rains and floods which severely affected agricultural productivity and worsen rural livelihood (Abbas et al., 2016; Ahmad et al., 2019; Ali and Rahut, 2020). In Pakistan, the majority of the population almost 64% inhabited rural areas where agriculture source of employment to 43.5% labor force also a major source of food basket to population and providing raw material to the industrial sector of the country (BOS, Punjab, 2019; GOP, 2020).

In literature, the aspect of climate change is more preferably focused in various scenarios whereas the combined aspect of market fluctuation with climate change is not focused more particularly in developing countries like Pakistan. Thus, in literature paucity still exists on risk perception of local farmers regarding complex market fluctuations and climate change and their adaptive behavior. This study is more specifically focused on Pakistan to address this research gap. The more particular objectives of this study are (a) understanding the farmer's perceptions of collective risks owing to climate change, market fluctuations and variability of climate their adoption of adaptive strategies in reaction to combined market risks and climatic risks (b) to represent the empirical association in farmers risk perception and adaptive behavior (c) to clarify on Pakistani farmers decisions methods on risk management and make out promising ways of risk communication. This research study is categorized into four sections as the introduction elaborated in the first section and section two illustrated the material and method. The third section highlighted the results and discussion whereas the conclusion and suggestions are addressed in the last section of the study.

Material and Method
Study Area
Balochistan, Khyber Pakhtunkhwa, Sindh and Punjab are four provinces of Pakistan whereas Punjab provinces were purposively selected for the study on some significant basis. Firstly, Punjab most populated province having 52.95% population and shares 26% area of the country (PBS, 2020).

Geographical Features of the Study Area
Thus, these three districts have some diverse climatic, socioeconomic and demographic feathers which play the foremost role regarding the livelihood of rural communities of these districts. Family size and farm size are some significant variations whereas climate change variables such as temperature, rainfall, floods and drought sequences are considered the foremost differences regarding these districts as indicated in table 1.

| Socioeconomic feathers | Chakwal district | Gujranwala district | Muzaffargarh district |
|------------------------|------------------|---------------------|----------------------|
| Total population (in millions) | 1.495 | 5.011 | 4.328 |
| Urban population (in millions) | 0.283 | 2.949 | 0.698 |
| Rural population (in millions) | 1.211 | 2.061 | 3.630 |
| Latitude | N 33°40ʹ22.79ʺ | N 32°9ʹ58.8636ʺ | N 30° 4ʹ 27.7572ʺ |
| Longitudes | E 72°511ʹ2.59ʺ | E 74°11ʹ45.2400ʺ | E 71° 11ʹ4.7544ʺ |
| Types of climate | Semi-arid subtropical | Sweltering, humid, clear | Sweltering, clear, dry |
| Low extreme temperature | -3 °C | -4 °C | -1 °C |
| High extreme temperature | 41 °C | 42.8 °C | 54 °C |
| Annual average temperature | 29.9 °C | 30 °C | 32 °C |
Annual average precipitations (mm)

|                     | 196mm | 312mm | 114mm |
|---------------------|-------|-------|-------|
| Major metrological disasters | Gales, dust storms, drought | Heavy rains, gales, hailstorms | Floods, heavy rains, gales, hailstorms |
| Cropped area (thousand hectares) | 64 | 216 | 249 |
| Tehsils and union councils | 5 (tehsils) 64 (union councils) | 5 (tehsils) 192 (union councils) | 4 (tehsils) 93 (union councils) |
| Townships | | | 7 |

Source: Based on the author’s calculations

**Sampling Technique and Data Collection**

This study used a multistage random sampling approach for data collection from the study area, firstly Punjab out of four provinces purposively selected for the study, the reason of major contributor 53% in the country agriculture GDP (PBS, 2020) and highly affected from flood hazards and sometimes drought, the reason of climatic variations (PDMA Punjab, 2018; BOS Punjab, 2019). Secondly, three districts Chakwal, Gujranwala and Muzaffargarh from metrological based categorized areas of the province as upper, central and southern Punjab areas owing to climatic variation and its severity were selected for the study (NDMA, 2018; BOS Punjab, 2019). Thirdly, two tehsils from each district and two union councils from each tehsil were randomly selected based on climate risk severity as provided data of District Disaster Management Authority. Lastly, various villages from each union council and various numbers of household respondents from each village were randomly selected and interviewed according to information provided by the agricultural field officer and local patwari (legal land record-holder).

| Selected administrative units | Chakwal | Gujranwala | Muzaffargarh | Total |
|-------------------------------|---------|------------|-------------|-------|
| Selected Tehsils              | 2       | 2          | 2           | 6     |
| Selected union councils       | 4       | 4          | 4           | 12    |
| Selected villages             | 7       | 8          | 9           | 24    |
| Respondents numbers           | 149     | 167        | 164         | 480   |

Source: Based on the author’s calculations

In this study for the procedure of data collection, household considered the basic unit whereas household head (male/female) was indicated, major respondents. In attaining the minimum level of sample size Cochran’s (1977) sampling technique was used in this study as illustrated in equation (1). Heads of households were particularly targeted for data collection of 480 respondents, as indicated 5% population size as adequate for study (Kotrlik and Higgins, 2001). The sample size is illustrated by SS, Z shows the confidence level for points picking, p as the choice of percentage, decimal clarified as (0.5 used requisite size of sample) and precision value illustrated as e (0.07= ± 7).

\[
SS = \frac{Z^2(p)(1-p)}{e^2}
\]  

(1)

In data collection, respondents were directly connected and well-developed questionnaire was applied and data was collected from March to June 2020.

**Farmers Risk Perception Measurement and their Adaptive Behavior**

In this study, for measuring the farmers’ risk perception and their adaptive behavior modified and well-developed structured questionnaire Okonya et al., (2013) was used. In measuring the perceived variation regarding three climatic indicators as rainfall, winter temperature and summer temperature on the incidence of six severe climatic events such as snowstorms, floods, droughts, gale, hail and heavy rain as illustrated in table 3.

| Rainfall | 1-increased | 2-decreased | 3. no changing |
|----------|-------------|-------------|----------------|
| Temperature | Winter season | 1- warmer | 2- colder | 3- no changing |
|           | Summer season | 1-warmer | 2-colder | 3-no changing |
| Extreme climatic/weather events | Flood | 1-increased | 2-decreased | 3. no changing |
|           | Drought | 1-increased | 2-decreased | 3. no changing |
|           | Heavy rain | 1-increased | 2-decreased | 3. no changing |
|           | Gale | 1-increased | 2-decreased | 3. no changing |
Hail increased decreased no changing

Source: Based on the author’s calculations

### Table 4: Farmers Perceived Risks Response Measures List

| Measures category          | Measures description                                                                 | Measures abbreviation |
|----------------------------|--------------------------------------------------------------------------------------|-----------------------|
| Physical-based measures    | Farm improvement condition for drainage system and contour trenching                  | Improvement of farmland |
|                            | Construction of farm structure as ponds, channels, ditches and wells                   | Structure of farm     |
| Non-physical based measures| Adoption of pest resistance, drought tolerance and flood tolerance crop variations     | Varieties of crops    |
|                            | Planting schedule adjustments as planting earlier                                     | Adjustment in crops schedule |
|                            | New technology adoption such as seeding technology, irrigation, tillage, plow and fertilization | Technology advancement |
|                            | Additional crop insurance purchasing                                                 | Purchasing insurance  |
|                            | Agricultural inputs increasing as mulching plastic, pesticide and fertilizert         | Increasing inputs     |
|                            | Adoption of livelihood diversification sources                                        | Adoption diversification |
|                            | Exiting from the agricultural sector                                                 | Exit                  |
|                            | Increasing the activities of non-agriculture                                          | Option of non-agriculture |

Source: Based on the author’s calculations

### Model Specification

In estimating the relationship of farmers’ perception of the market and climatic risks with their responses measured in two logit models were more preferably used in this study. This model-dependent variable is dichotomous which indicated the decisions of farmers regarding adaptive measures adoption and independent variables include various variables correlated to farmers’ demographic variables and risk perception as illustrated in table 5.

#### Table 5: Model Variables Description

| Model variables                  | Types of variables | Description of variables |
|----------------------------------|--------------------|--------------------------|
| Dependent variable (binary)      |                    | Adoption = 1 no adoption=0 |
| Behavioral response decision     | Categorical        | Adoption = 1 no adoption=0 |
| Independent variables (demographic characteristics of the farmer) |                    |                          |
| Summer warmer temperature (C1)   | Dummy              | Warmer = 1 otherwise = 0 |
| Summer colder temperature(C2)    | Dummy              | Colder = 1 otherwise = 0  |
| Winter warmer temperature(C3)    | Dummy              | Warmer = 1 otherwise = 0  |
| Winter colder temperature(C4)    | Dummy              | Colder = 1 otherwise = 0  |
| Increase in rainfall(C5)         | Dummy              | Increased = 1 otherwise = 0 |
| Decrease in rainfall(C6)         | Dummy              | Decreased = 1 otherwise = 0 |
| Flood frequency increased(C7)    | Dummy              | Increased = 1 otherwise = 0 |
| Flood frequency decreased(C8)    | Dummy              | Decreased = 1 otherwise = 0 |
| Drought frequency increased(C9)  | Dummy              | Increased = 1 otherwise = 0 |
| Drought frequency decreased(C10) | Dummy              | Decreased = 1 otherwise = 0 |
| Agricultural products prices increased (M1) | Dummy | Increased = 1 otherwise = 0 |
| Agricultural products prices deceased (M2) | Dummy | Decreased = 1 otherwise = 0 |
| Independent variables (demographic characteristics of the farmer) |                    |                          |
| Farmer gender status (X1)        | Categorical        | Male = 1 female = 0      |
| Farmer age (X2)                  | Continuous         | In years                 |
| Farmers education (X3)           | Continuous         | Schooling years          |
| Farmer status household head (X4)| Categorical        | Yes = 1 otherwise = 0    |
| Size of the farm (X5)            | Continuous         | Area in acres            |

Source: Based on the author’s calculations

Both models have the difference regarding demographic variables indicated as controlled in model 2 whereas uncontrolled in model 1. Two binary dependent variables are used as perception variables portraying farmers’ climate change the subjective ruling. Socioeconomic characteristics of farmers are indicated as demographic variables such as education, age, gender, farm size and head of household. In these, some are binary variables such as household head and gender as measured with values of 1 or 0 whereas farm size, education and age are continuous variables taken as in hectare and years. Specifically, the model is designed such as in equation (2) model 1 and equation (3) as model 2.

\[
P(Y = 1) = \frac{e^z}{1 + e^z}
\]

4
\[
P(Y = 0) = \frac{1 - e^{z}}{1 + e^{z}}
\]
then
\[
\ln\left(\frac{P(Y = 1)}{P(Y = 0)}\right) = \ln\left(\frac{1 + e^{z}}{1 + e^{z}}\right) = \ln(e^{z}) = Z
\]

Model 1: 
\[
Z = \alpha + \beta C + \lambda M + \varepsilon
\]

Model 2: 
\[
Z = \alpha + \beta C + \lambda M + \theta X \varepsilon
\]

Dependent variable probability more specifically denoted as \(P\) and adaptive measures adoption is explained as \(Y\). The ratio of log value as probability \(Y=0\) to \(Y=1\) where log-odds are denoted by \(Z\). Perceptions of farmers regarding climate variability and climate change is illustrated by variable \(C\) which consists of rainfall, temperature and severe climate events such as drought and floods. Respondent’s demographic variables are shown as variable \(X\) while the perception of farmers regarding market risks is indicated as \(M\). The independent variables logic coefficients denoted as \(\beta, \lambda, \theta\) and the constant term is highlighted as \(\alpha\) whereas error term is explained as \(\varepsilon\), moreover STATA version of 14.1 more preferably used for empirical estimation of the study.

Results and Discussion
Demographic and socioeconomic characteristics of three study districts respondents are particularly shown in table 6 indicating as in the total sample majority of respondents 71.46% were male. In the study area, the majority of household heads (82.71%) were dominant in family decisions and respondents' average age was (56.87) years relatively consistent with the national average age (PBS, 2020). The majority of respondents (27.92%) were in the age group of 41 to 50 years whereas the limited number of farmers 9.58% were in the age of 30 years. Respondents' average schooling in the study area was 6.97 years, most of the respondents 29.79% were in the lower level of schooling within primary schooling even not completed their middle schooling, limited numbers 4.17% were above graduate year of schooling while respondents with average schooling were 6.97 years. The majority of the respondents 36.25% were having farm area up to 5 acres, 24.58% of farmers had a farm of up to 10 acres, 18.13% had a farm of up to 15 acres, while the limited number of respondents 7.91% were having the farm area above 20 acres.

| Characteristics          | Category | Frequency | Respondents | Maximum | Minimum | Mean (Standard Deviation) |
|--------------------------|----------|-----------|-------------|---------|---------|--------------------------|
| Farmer gender status     | Male     | 343       | 71.46%      | 1       | 0       | 0.18 (0.37)              |
|                          | Female   | 137       | 28.54%      |         |         |                         |
| Farmer age               | Up to 30 | 46        | 9.58%       | 87      | 23      | 56.87 (10.53)            |
|                          | 31–40    | 119       | 24.79%      |         |         |                         |
|                          | 41–50    | 134       | 27.92%      |         |         |                         |
|                          | 51–60    | 103       | 21.46%      |         |         |                         |
|                          | Above 60 | 78        | 16.25%      |         |         |                         |
| Farmers education        | Up to 5 | 143       | 29.79%      | 16      | 0       | 6.97 (3.14)              |
|                          | 6–8     | 126       | 26.25%      |         |         |                         |
|                          | 9–10    | 109       | 22.71%      |         |         |                         |
|                          | 11–14   | 82        | 17.08       |         |         |                         |
|                          | Above 14| 20        | 4.17%       |         |         |                         |
| Farmer status household head | Yes    | 397       | 82.71%      | 1       | 0       | 0.82 (0.37)              |
|                          | No      | 83        | 17.29%      |         |         |                         |
| Size of farm in acres    | 0–5     | 174       | 36.25%      | 28      | 2       | 12.79 (3.68)             |
|                          | 6–10    | 118       | 24.58%      |         |         |                         |
|                          | 11–15   | 87        | 18.13%      |         |         |                         |
|                          | 16–20   | 63        | 13.12%      |         |         |                         |
|                          | Above 20| 38        | 7.91%       |         |         |                         |

Source: Based on the author’s calculations
In general, perception of climate is revealed in questions as the climate is changing where higher changes in temperature are perceived by farmers in the study area as the majority of respondents observed significant variation in temperature during the last decade as indicated in figure 1. In summer, the majority of respondents (83.98%) observed increasing warmer, 12.53% indicated no change, while 3.49% highlighted increasing colder. Most of the respondents 39.87% have a perception of increasing warmer in winter, 27.43% illustrated increasing colder whereas 32.7% showed no change in winter in the last decade.

![Figure 1: Climate change farmers perceptions regarding winter and summer temperature changes](image)

Source: Based on the author’s calculations

In the study area, the majority of the respondents 249 the 51.87% have not adopted any risk management measures regarding climate change and market effects whereas less than half of respondents the 231 the 48.13% adopted one or more adaptation measures. Almost 6.79% of respondents adopted advanced technologies, 5.85% increased inputs as adaptation measures for risk management whereas a significant number of the respondent 8.95% exited from agriculture due to major losses in agriculture owing to uncertain climatic and market dynamics as indicated in figure 4. In avoiding unseen losses of income owing to yields and crops destructions there is a need to provide the familiarity of crop insurance policy in developing countries more particularly like
Pakistan for managing climatic risks.

Estimates of Ordinary Least Square (OLS) model 1 (uncontrolled) and model 2 (controlled) regarding adoption predicted behavioral response about demographic characteristics illustrated in table 7. Model 1, logistic regression estimates indicated the statistical significance in the model (P=0.000) and highlighted 18% variation regarding adoption behavior of farmers for using adaptive measures. Model explanatory capacity can improve by adding together demographic factors with statistically significant status (P=0.000) with increasing farmers’ adoption behavior variation of 28%.

Market risk perception (M2, P<0.000) is significantly correlated with the dependent variable illustrating as farmers’ perception of agricultural products prices decreasing, negatively and significantly affects the farmer’s decisions regarding adoption of adaptive responses.

**Table 7: Estimated Effects of Regression of Farmer’s Perception of Risks regarding Response Behavior**

| Farmer's perception of risk | Estimates of the model (1) without demographic characteristics | Estimates of the model (2) with demographic characteristics |
|----------------------------|---------------------------------------------------------------|---------------------------------------------------------------|
|                            | Odd ratios | Standard error | z value | P>|z| | Odd ratios | Standard error | z value | P>|z| |
| Summer warmer temperature (C1) | 1.53 | 0.62 | 0.89 | 0.380 | 1.79 | 0.79 | 1.18 | 0.240 |
| Summer colder temperature (C2) | 0.94 | 1.26 | -0.03 | 0.890 | 0.97 | 1.42 | -0.04 | 0.949 |
| Winter warmer temperature (C3) | 1.38 | 0.69 | 1.18 | 0.243 | 1.86 | 0.88 | 1.41 | 0.147 |
| Winter colder temperature (C4) | 1.19 | 0.47 | 0.29 | 0.774 | 1.37 | 0.56 | 0.79 | 0.398 |
| Increase in rainfall (C5) | 5.83*** | 3.99 | 2.38 | 0.001 | 12.87** | 11.76 | 2.97 | 0.001 |
| Decrease in rainfall (C6) | 1.26 | 0.59 | 0.68 | 0.497 | 1.44 | 0.63 | 0.76 | 0.451 |
| Flood frequency increased (C7) | 0.19*** | 0.11 | 2.12 | 0.003 | 0.13** | 0.11 | 2.34 | 0.003 |
| Flood frequency decreased (C8) | 0.45 | 0.19 | 1.24 | 0.158 | 0.49 | 0.28 | 0.88 | 0.297 |
| Drought frequency increased (C9) | 0.87 | 0.21 | 1.41 | 0.139 | 1.48 | 1.68 | 0.97 | 0.234 |
| Drought frequency decreased (C10) | 1.73*** | 0.84 | 1.59 | 0.000 | 1.82** | 0.71 | 2.83 | 0.000 |
| Agricultural products prices increased (M1) | 1.27 | 0.49 | 0.29 | 0.698 | 1.97 | 0.84 | 1.19 | 0.199 |
| Agricultural product prices deceased (M2) | 0.47** | 0.17 | -2.59 | 0.000 | 0.54*** | 0.16 | -1.68 | 0.000 |
| Farmer gender status (X1) | 14.86** | 12.98 | 2.47 | 0.001 |
| Farmer age (X2) | 1.14 | 0.03 | 1.39 | 0.238 |
| Farmers education (X3) | 1.59** | 0.18 | 3.83 | 0.000 |
| Farmer status household head (X4) | 0.04*** | 0.01 | -3.49 | 0.000 |
In model 2, while controlling the demographic variables estimates indicated the higher perception of an increasing flood (C₇, P<0.003), increasing rainfall (C₅, P<0.001), decreasing drought (C₁₀, P<0.000) and increasing market risks regarding decreasing prices of agricultural products (M₂, P<0.000) indicate the more significantly affects farmers adaptive measures and adoption behaviors. Estimates of model 2 indicated as farmer’s education (X₃, P<0.000), gender status (X₁, P<0.001), size of farm (X₅, P<0.000) and household head status (X₄, P<0.000) affects significantly to the possibility of adoption regarding adaptive measures. In literature, significant correlation is indicated in socioeconomic factors and risk management adaptation as these estimates are in line with the studies of Kellen et al., (2013), Smith et al., (2018), Abid et al., (2019) and Ahmad and Afzal, (2020). Educational status showed a significant correlation with using adaptation strategies indicating as the level of schooling increases farmers are more conscious of risks and higher willing to adopt adaptation measures. These results are in line with the studies of Abbas et al., (2017), Mase et al., (2017), Cheng et al., (2017), Yarong and Minpeng, (2020) and Cheng et al., (2021).

**Conclusion and Suggestions**

In Pakistan, during a current couple of decade’s agricultural productivity more particularly the pulses, cash and cereals crops severely affected owing to regional and global climatic dynamics. In risk management decisions regarding severe events of climate and market risks, farmers' risk perceptions are a crucial factor that significantly influences farmers’ decisions. The purpose of this study is to investigate the farmer’s perceptions of market and climate risks and their adaptive behavior in Punjab, Pakistan. Estimates of the study illustrated as in extreme climate events farmers’ perceptions play a significant role in shaping farmers' responsive behaviors because farmers are highly vulnerable to market fluctuations and extreme events of climate in contrast to average rainfall and temperature. Experience of the past couple of decades highlights as Punjab province remained under severe effects of consecutive erratic heavy rains and floods while decreasing drought which insists on farmers to take adaptive measures. In adopting adaptation measures, farmers were found more active regarding measures of climate risks while less active about market risk measures.

Demographic characteristics of farmers significantly affect their adaptive behavior such as large farm size household heads were unenthusiastic in adopting risk management measures while educated and male farmers were more willing to adopt these measures. Effective and innovative agricultural extension technologies, adequate access to finance and advanced communication climate risks need to include on a priority basis in rural programs and adaptation policies. The coping capacity of farmers regarding climate and market risks needs to enhance through planting and access to advance technologies, provision of climate resistance crop varieties and providing adequate risks based farming training. Insurance is considered the effective tool for farmers for avoiding losses and mitigating risks in most countries of the world yet not properly adopted particularly in developing countries like Pakistan need to appropriately converse the information to farmers regarding insurance and climatic risks. Enhancing climate change resilience and
reducing farmers’ vulnerability, livelihood diversification needs to encourage particularly among small household farmers. For motivating farmers to adapt and risk management measures there is a need for adequate provision of risks based training to the farming community and financial support through formal institutions on the subsidized rate of interest. In the context of rural areas of Pakistan, further research is required regarding the aspect of farmers’ perception of risk and adaptive behavior with more details farmer’s interviews, bigger sample survey with the usage of experimental economics. A more qualitative nature of this approach would more beneficial to examine various adaptive behaviors’ from different farmers groups and investigate the factors most important to the adoption of various adaptive measures.

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