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Fatalism, Climate Resiliency Training and Farmers' Adaptation Responses: Implications for Sustainable Rainfed-Wheat Production in Pakistan

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Abstract: Climate change is a severe threat to the agricultural sector in general and to rainfed farming in particular. The aim of this study was to investigate the factors that can potentially affect the adaptation process against climate change. This study focused on wheat farmers and farming systems in the rainfed agroecological zone of Pakistan. Farmers' data related to climate change *fatalism*, the availability of climate-specific extension services, socioeconomic and institutional variables, and farm characteristics were collected. A logit model to assess farmers' decisions to adopt an adaptation measure and a multinomial logit model to assess their choice of various adaptation measures were used. The results showed that fatalistic farmers were unlikely to implement climate change adaptation measures. The variables related to the climate-specific extension services, including farmers' participation in training on climate-resilient crop farming and the availability of mobile communication-based advisory services, had highly significant and positive impacts on farmers' decisions and their choice of adaptation measures. Input market access and tractor ownership also had positive and significant impacts on farmers' decisions to adapt and their choice of adaptation measures. This study highlights the need to improve rainfed-wheat farmers' education levels to change their fatalistic attitudes towards climate change. Furthermore, government action is needed to provide climate-specific extension services to ensure sustainable production levels that will ultimately lead to food and livelihood security under a changing climate.

Keywords: *fatalism*; climate-specific extension services; climate-resilient farming; rainfed farming; adaptation

1. Introduction

Agriculture is the only business entity that is under the direct influence of climate change, and the success of this business, especially crop farming, is directly related to changing climatic conditions. The problem of climate change is global in nature, but the situation in the developing world is worst

due to its poor capacity to fight against climate change and minimal knowledge about various methods of food production [1,2]. Based on the crop type and area of study, 25% losses are forecasted in a short time period, while some studies have predicted crop losses of approximately 50% by the end of 2080 [3]. Furthermore, 60% of the variability in crop yield is due to climate variability [4], which is dangerous for sustainable food production systems and global food security. The harmful impacts of climate change are not limited to only crop productivity, but they also have a negative effect on the income level of subsistence farmers who are totally dependent upon crop farming for their livelihoods. A recent study predicted a 20% global increase in people that are hungry by the end of 2050 [5].

The situation is more critical in South Asia, as the agricultural sector in this region is most vulnerable to climate variability. The region has been facing various challenges due to the changing climate such as rising temperatures, heat waves, droughts, and floods [5,6]. Crop farming is facing a severe threat from climate change in South Asian countries, including Pakistan, India, Bangladesh, and Nepal [6,7]. An increase of 1.4 °C to 1.8 °C and 2.1 °C to 2.6 °C in the average maximum temperature on an annual basis has been projected by 2030 and 2050, respectively, which would ultimately lead to 12% and 21% increases in the areas severely affected by heat stress in 2030 and 2050, respectively, in South Asia [8]. The Indo-Gangetic Plains (IGPs), which are found in Pakistan, India, Bangladesh, and Nepal, are considered the major food baskets in this region. Some forecasted estimates have reported that the area of the IGP may become unsuitable for wheat farming due to heat stress [9], which would clearly call into question the sustainability of wheat farming, and the livelihoods of farming communities and food security in South Asian countries [10,11]. A study reported a loss in the annual gross domestic product (GDP) of South Asian countries of 1.8% by 2050 and 8.8% by 2100 if appropriate adaptation measures against climate change are not implemented [12].

Pakistan is an agriculture-based country that has a significant share of its GDP in agriculture, at 18.9%. This sector also provides livelihood opportunities to 42.3% of the country's total population [13], and agriculture is therefore considered the backbone of Pakistan's economy. Agriculture mainly includes the livestock sector, poultry sector, fish farming, and crop farming with the major crops including wheat, rice, cotton, sugarcane, and maize. Wheat crop is highly important as it is the country's main food grain crop and is cultivated throughout the country to meet the domestic calorific intake requirements of the population in Pakistan. Pakistani agriculture is under severe threat due to the changing climate, as the country has been continuously listed among the top ten most vulnerable countries in the world due to climate change for more than the last five years [14]. The situation is worse in areas of the country where there is no canal and underground irrigation system, and crop farming is totally at the mercy of rainfall to meet crop water requirements. Therefore, the present research was conducted in the rainfed agroecological zone of Pakistan with a special emphasis on wheat crop as it is cultivated as the main food crop in this zone. The importance of rainfed-crop farming is evident globally and in Pakistan, as 80% of the globally cultivated land and 33% of Pakistan's cultivated land are rainfed [15,16].

Very effective and prompt actions to address climate change with sound adaptation measures are needed in Pakistan so that the farming community can minimize the harmful impacts of climate change to sustain food production and livelihoods. If appropriate and timely actions to minimize the harmful impacts of climate change are not taken, then the country might continuously face yield losses, food insecurity, and reduced farm income, which will severely affect the efforts of sustainable rural development and poverty eradication [2]. Some studies [2,17–19] have identified various adaptation measures to minimize the harmful impacts of climate change. The leading adaptation measures are changing sowing time and input mix, changing crop varieties, planting shade trees, supplementing irrigation, diversifying farms, etc. Different adaptation measures work in different ways depending upon the type of crop, climatic conditions, crop management practices, and the area where the particular adaptation is implemented. The main issue is related to the potential factors that can influence farmers' choices related to adopting a particular adaptation measure. Few studies [20,21] have also investigated the factors that can affect the adoption of a particular adaptation measure, which are farmers' age,

education, and farming experience, access to credit services and extension services, and climate and marketing information.

Before identifying the factors that may affect farmers' choices to implement various adaptation measures, it is important to determine whether farmers are ready to adopt certain suitable adaptation measures. Awareness about the existence of climate change is widespread in Pakistan [22], and the farming community has accepted the existence of climate change and its negative effects on the agricultural sector, especially crop farming [20]. However, the farmers who are ready to accept that climate change is occurring but are not ready to adopt different adaptation measures due to their spiritual way of thinking and beliefs need to be considered. This spiritual way of thinking allows acceptance of the existence of climate change but also involves the belief that all events, including events related to climate change, are predetermined and inevitable. They cannot escape from them, so they have to face that these events will happen anyway, and this typical belief is referred to as *fatalism*. *Fatalism* is a belief centered on the norm that "everything is predetermined" and is related to a belief in God [23]. Therefore, the possible impacts of climate change may be triggered by a supreme authority over which common people have almost no influence [24,25]. Hence, the present study investigates whether *fatalism* is responsible for the difference between adopters and non-adopters of climate change adaptation measures, and this study further analyzes the influence of *fatalism* on the adoption of different adaptation measures that the farming community has already taken in the rainfed agroecological zone of Pakistan.

This is the first study that attempts to investigate the relationship of *fatalism* with climate change adaptation implementation by rainfed-wheat farmers in Pakistan. Studies that have already been conducted in Pakistan investigated the effect of general advisory services (provision of extension services, climate information, and weather information), access to credit, and socioeconomic and institutional factors on the adaptation process either at the provincial level [2,20] or across different regions and agroecological zones of Pakistan [26,27]. None of the previous studies explicitly focused on the rainfed agroecological zone of Pakistan. Hence, the present study will focus on the rainfed agroecological zone of Pakistan with respect to climate change adaptation with a particular emphasis on climate-specific extension services, including mobile communication technology (MCT)-based advisory services and farmer training on climate-resilient crop farming. Timely provision and upgrade of advisory services through MCT can best help farmers cope with climate change through prompt access to general extension services and information on climate change adaptation [28] and reduce the information asymmetry among the farming community [29]. There is also a great need for climate-resilient adaptation strategies to ensure sustainable food production and future food security [30,31]. This result means that awareness among farmers about the importance of climate-resilient crop farming through training sessions is very important for sustainable crop production and food and livelihood security. The present study focuses on the unstudied rainfed agroecological zone of Pakistan because crop farming in this zone is heavily dependent upon two important parameters of climate change: temperature and rainfall. Therefore, the present study has two main objectives. First, the study aims to determine the impact of *fatalism* in addition to the impact of other socioeconomic, institutional, and climate-specific extension services and farm variables on the adaptation decisions of rainfed-wheat farmers (i.e., whether to adapt to climate change or not). Second, this study analyzes the impact of the various aforementioned variables on farmers' choices of particular adaptation measures that are already being implemented by rainfed-wheat farmers.

2. Main Theory and Conceptual Framework

Farmers' main motive to adapt to climate change is to avoid the yield losses that they may experience due to changing climatic conditions. The present study is based on the theory of production, where the producer uses different inputs to obtain a maximum output that ultimately leads to maximum revenue [32]. Studies previously conducted in Pakistan have proven the existence of climate change and people's perception that climate change is occurring [20,22,26]. The conceptual framework is

explained in Figure 1. Climate change is occurring in the country, and people, especially the farming community in general and rainfed-wheat farmers in particular, understand that climate change exists. Rainfed-crop farmers appear to intend to take adaptive measures against climate change to avoid yield losses; however, the majority of farmers still appear to be uncertain about implementing climate adaptation measures. As stated above, before discussing the other external factors that can affect the farmers' decisions to implement certain adaptation measures, there is a very important spiritual factor that can strongly affect farmers' decisions to carry out adaptation measures. Fatalistic farmers believe in the existence of climate change and have positive perceptions about climate change, but they also strongly believe that climatic events are predetermined and that nobody can escape the worst outcomes. Given this belief, these farmers might not implement any adaptation measure to avoid and cope with the possible and harmful impacts of climate change.

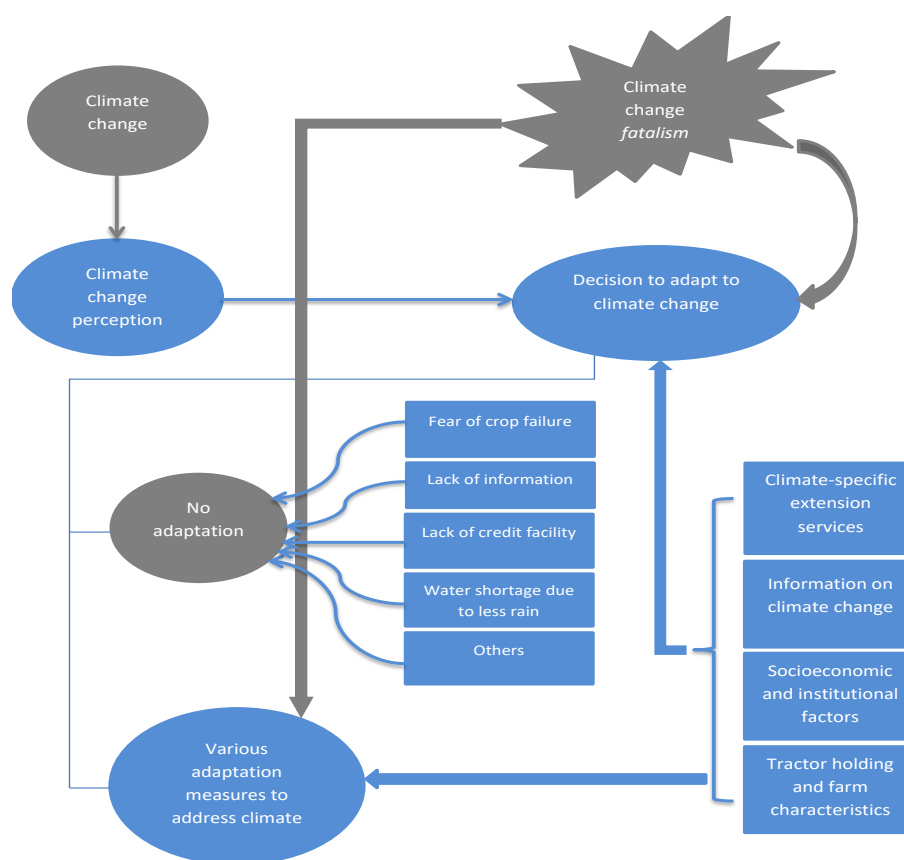


Figure 1. Conceptual framework showing factors affecting farmers' decisions and choice of adaptation measures against climate change. Source: Authors' own creation.

This scenario means that apart from many other factors, climate change *fatalism* is the most important determinant of adapting to climate change. Among other external factors, climate-specific extension services can strongly affect farmers' decisions to adapt and farmers' choices about various adaptation measures. Climate-specific extension services in the context of the present study include farmer training on climate-resilient crop farming and mobile communication technology (MCT)-based advisory services. Access to information on climate change can also affect farmers' decisions to adapt and choices of various adaptation measures to address climate change. Various socioeconomic and institutional factors, such as farmer age, male family members, input market access and crop farming as primary sources of income, can also have significant effects on farmers' decisions and choices of various adaptive measures to combat the negative impacts of climate change. Tractor ownership and farm characteristics, including monocropping, may also affect farmers' decisions and choices of various

adaptation measures against climate change. In rainfed areas, the majority of farmers is engaged in monocropping and grow only wheat crop due to a heavy dependency on rain to meet crop water requirements. Finally, there are some constraints that the rainfed farming community can face in adapting to climate change. These farmers might be those who believe in the existence of the climate change, do not have fatalistic beliefs, and actually plan to adapt but do not implement them due to specific constraints. These constraints could be fear of crop failure, lack of information, lack of a credit facility, and water shortage due to a decreased amount of rain, among others.

3. Materials and Methods

3.1. Study Region and Primary Data Collection

The rainfed agroecological zone of Pakistan consists of 13 districts (Bannu, Mianwali, Attock, Rawalpindi, Jehlum, Gujrat, Sialkot, Mandi Baha-ud-din, Lakki Marwat, Islamabad, Bhakkar, Chakwal, and Narowal), and it covers two different provinces in Pakistan; Punjab and Khyber Pakhtunkhwa (KPK) provinces. The map of the study area is shown in Figure 2.

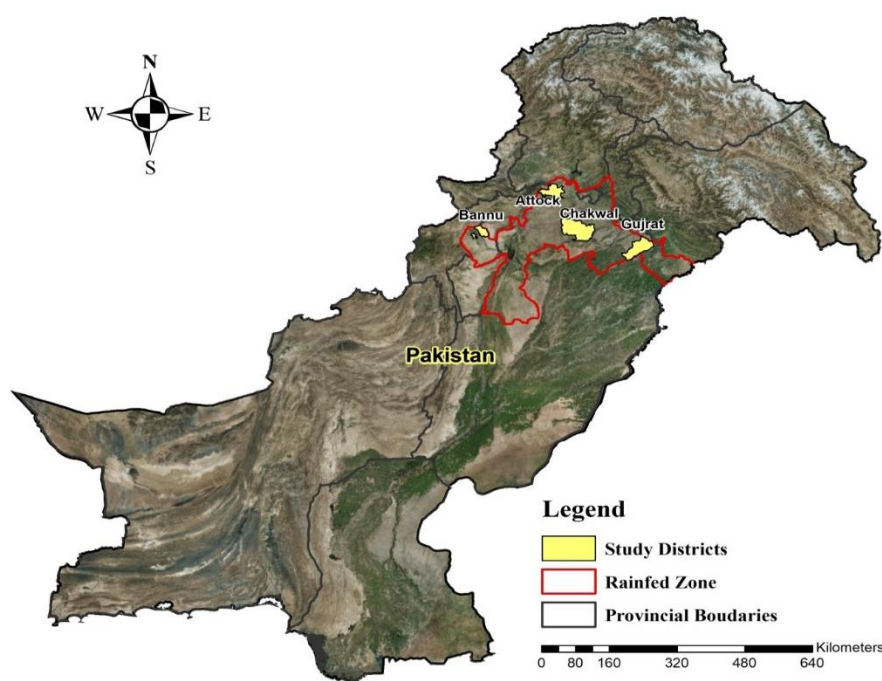


Figure 2. Map of Pakistan with the study area highlighted as yellow spots. Source: The map was reproduced by the authors using the agroecological zoning developed by Pakistan Agricultural Research Council).

We selected the wheat-crop and rainfed region because it is the main food crop of the region, as well as the country with the greatest amount of area under cultivation compared to that of any other crop. More than one-third of farmers in the rainfed agroecological zone are engaged in wheat monocropping due to water shortage. This result means that sustainable food production and food and livelihood security of rainfed-wheat farmers is completely dependent on climatic conditions. Therefore, a quick and very promising solution to fight against climate change is to implement different adaptation actions to address climate change. A random sampling technique was used to collect the primary data from rainfed-wheat farmers in Pakistan through face-to-face interviews.

A well-designed and pretested questionnaire was used for the data collection and carried out by a team of trained enumerators. Following a four-step procedure of a simple random sampling technique, 400 wheat farmers were interviewed from the whole rainfed agroecological zone of Pakistan. In the

first step, four districts (large administrative units) were randomly selected out of the 13 districts in the rainfed agroecological zone. One tehsil (small administrative unit) was randomly selected from each selected district in the second step, and one union council (smaller administrative unit) from each selected tehsil in the third step was randomly selected. In the fourth and final step, 100 farm households from each union council were interviewed for primary data collection. The collected data included information on variables of climate change *fatalism*, climate-specific extension services, availability of information on climate change, socioeconomic and institutional variables, tractor ownership, and farm characteristics. The variables and their descriptions and expected signs are presented in Table 1.

Table 1. Summary statistics of the explanatory variables with their expected signs.

| Explanatory Variables | Mean | Std. Dev | Type of Variable | Expected Signs |
|---|---------|----------|---|----------------|
| Climate change <i>fatalism</i> | 0.4225 | 0.4946 | Dummy takes the value of 1 if farmer has fatalistic belief of climate change; 0 otherwise | (-) |
| Farmer participation in trainings on climate-resilient wheat-crop farming | 0.2625 | 0.4405 | Dummy takes the value of 1 for participation; 0 otherwise | (+) |
| Availability of mobile communication technology (MCT)-based advisory services | 0.1775 | 0.3826 | Dummy takes the value of 1 for availability; 0 otherwise | (+) |
| Availability of information on climate change | 0.4875 | 0.5005 | Dummy takes the value of 1 for availability; 0 otherwise | (+) |
| Age of the respondent (years) | 48.9875 | 13.8141 | Continuous | (±) |
| Number of male family members (numbers) | 2.6925 | 1.1319 | Continuous | (+) |
| Input market access | 0.3000 | 0.4588 | Dummy takes the value of 1 if have access; 0 otherwise | (+) |
| Tractor ownership | 0.2325 | 0.4230 | Dummy takes the value of 1 if have ownership; 0 otherwise | (+) |
| Crop farming as main source of income | 0.3925 | 0.4889 | Dummy takes the value of 1 if yes; 0 otherwise | (+) |
| Monocropping | 0.7200 | 0.4496 | Dummy takes the value of 1 if yes; 0 otherwise | (+) |

3.2. Methods

The selection of the independent (explanatory) variables used in the present study was based on both a general literature review [33,34] and research already conducted in Pakistan [19,20]. In addition to the variables of climate change *fatalism* and climate-specific extension services (farmer training on climate-resilient crop farming and MCT-based advisory services), the variables that can potentially influence decisions about climate change adaptation and the choice of an adaptation measure(s) are information on climate change, socioeconomic variables (age and male member in farm household's family and crop farming as a primary source of income), institutional factors (input market access), tractor ownership, and farm characteristics (i.e., mono-cropping). Many studies have noted the importance of socioeconomic variables in relation to the climate change adaptation process [35,36]. Information on and awareness about climate change and its possible impacts are also important parameters that can strongly influence farmer behavior towards adaptation against climate change [22,37]. Finally, the specific attitudes and belief systems of farm households are on the frontline of the climate change adaptation process [38–40]. This special belief system determines whether a person may or may not implement adaptation measures to address climate change, regardless of whether that person is educated, understands climate change, or has easy access to climate-specific extension services. A farm household's decision to adapt to climate change requires a recognition of the long-term changes in two important weather parameters, i.e., temperature and rainfall [20,41]. Based on previous studies [20,41], we assumed that rainfed-wheat farmers will implement an adaptation practice only if they perceive net benefits in the form of an increased yield or a reduced risk to wheat productivity. Hence, in this study, we first (1) investigated the factors that can possibly influence farmers' decisions about adapting to climate change, and then (2) we determined the factors that influence farmers' choices of particular adaptation measures.

To address (1), we used a binary logistic regression model with the dummy variable ‘ Y_i ’, which indicates the expected benefits from any adaptation measure and has the value of ‘1’ or ‘0’. Thus, ‘ Y_i ’ = 1 for those who implemented any adaptation measure(s) and that ‘ Y_i ’ = 0 for those who did not adopt any adaptation measures. A binary logistic regression model is the best choice when the dependent variable is in the binary form [33,42]. The binary logistic regression can be further described through a probability function, which can be explained by the following equation:

$$P(y = (s|X)) = \frac{e^{\alpha + \beta_i x}}{1 + e^{\alpha + \beta_i x}}, s = 0, 1 \quad (1)$$

In Equation (1), ‘ y ’ is the dependent variable with a value of ‘1’ for adopters of adaptation measures and ‘0’ for non-adopters of adaptation measures, ‘ X ’ is the vector of the explanatory variables that can influence farmers’ choices to adopt any adaptation measure(s), ‘ α ’ is the intercept, and ‘ β_i ’ shows the regression coefficient of all the independent variables used in this model.

To address (2), we used a multinomial logit (MNL) model to investigate the factors that can potentially influence a farmer’s choice of a particular adaptation measure. The rainfed-wheat farmers were asked about their primary adaptation measures to identify the determinants of a single adaptation measure. Four major adaptation measures indicated by farmers and used in this analysis include using heat- and drought-resistant wheat-crop varieties, changing sowing dates, planting shade trees, and changing the composition of fertilizer. The MNL model has been widely used in recent relevant studies [34,41–44]. The MNL model is a very sound method when the dependent variable has more than two outcomes. The MNL model through the probability function can be explained as follows:

$$P = (y = (s|X)) = \frac{\exp(X\beta_s)}{1 + \sum_{i=1}^s \exp(X\beta_i)}, s = 1, 2, \dots, S \quad (2)$$

In Equation (2), ‘ y ’ is the dependent variable, and it can have a value of 1 to 5 with the base category of non-adopters of adaptation measures having a value of ‘1’. For example, ‘ y ’ equals ‘2’ for the farmers who used the heat- and drought-resistant wheat-crop variety as an adaptation measure, ‘3’ for the farmers who changed the sowing dates of wheat cultivation as an adaptation measure, ‘4’ for the farmers who planted shade trees as an adaptation measure, and ‘5’ for the farmers who changed the composition of the fertilizer used for wheat crop as an adaptation measure. Furthermore, ‘ X ’ is the vector of the explanatory variables that can influence a farmer’s choice of a particular adaptation measure, ‘ β ’ is the regression coefficient of the respective adaptation strategy ‘ s ’ in the MNL model. The parameters estimated through the MNL model only provided the direction of the effect of the explanatory variables on the variable of interest (i.e., the dependent variable). For the exact quantification of the probabilities, the marginal effects of the independent variables were calculated based on the equation below:

$$\text{Marginal effect (ME)} = \frac{\partial P_s}{\partial X_j} = P_s \left(\beta_{sj} - \sum_{s=1}^{S-1} P_s \beta_{sj} \right) \quad (3)$$

Equation (3) determines the change in the probability of the dependent variable (i.e., a particular adaptation measure) due to a one unit change in an independent (explanatory) variable. Both the logit and MNL models were run using STATA15.0.

4. Results and Discussion

4.1. Farmer Perceptions and Historical Climate Trends

A prerequisite of the climate change adaptation process is a farmer’s overall perception of climate change, with a main emphasis on temperature and rainfall [20,42]. As farmers initially experience

climate change, they plan accordingly by showing their intention to adapt, and finally, they make an adaptation decision (or do not adopt any adaptation measure).

Figure 3a shows that the majority (83.50%) of the rainfed-wheat farmers perceived an increase in temperature for the wheat-cropping period, a small number of farmers (15.5%) perceived a decrease in temperature, and only 1% of farmers perceived no change in temperature. Regarding rainfall, a large number of farmers (86.50%) perceived a decrease in rainfall, a very small number of farmers (9.75%) perceived an increase in rainfall (9.75%), and a very low percentage (3.75%) perceived no change in rainfall for the wheat-cropping period (Figure 3b). These findings are similar to the findings of previously conducted studies in different agroecological zones of Pakistan that have reported an increase in winter temperatures and a decrease in winter rainfall [19,20]. This finding means that the wheat crop is generally severely threatened in Pakistan, and in the rainfed agroecological zone in particular. Farmer household perceptions about climate change are relatively well matched with actual trends in the temperature and rainfall patterns from 1980 to 2017. We calculated the mean temperature and the total rainfall for the wheat-growing season from 1980 to 2017 and drew the trend lines in Figure 4, which clearly show that in the study area, a slight increase in temperature and a slight decrease in rainfall occurred over the last 37 years for the wheat-cropping period.

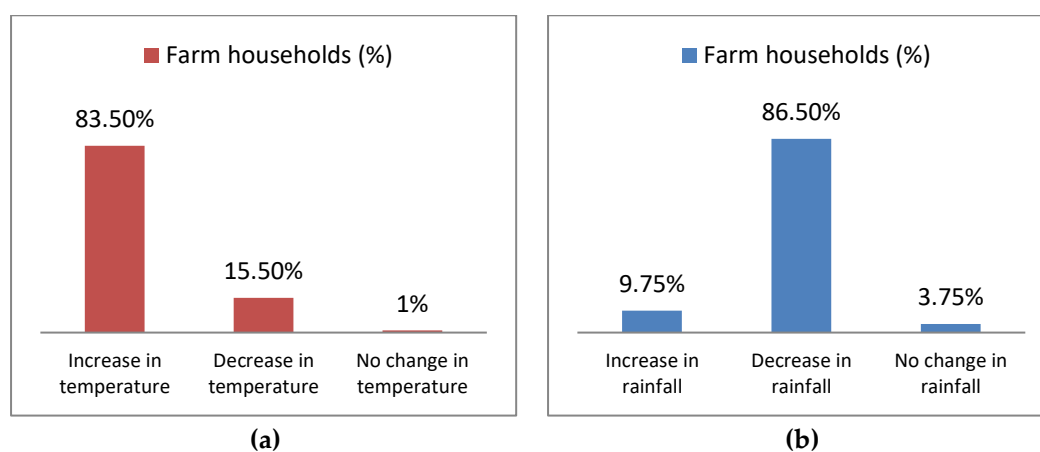
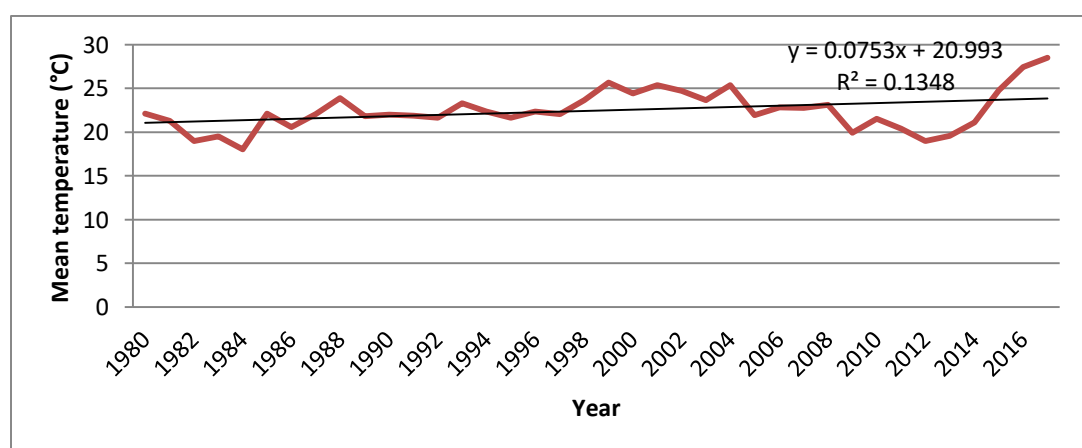
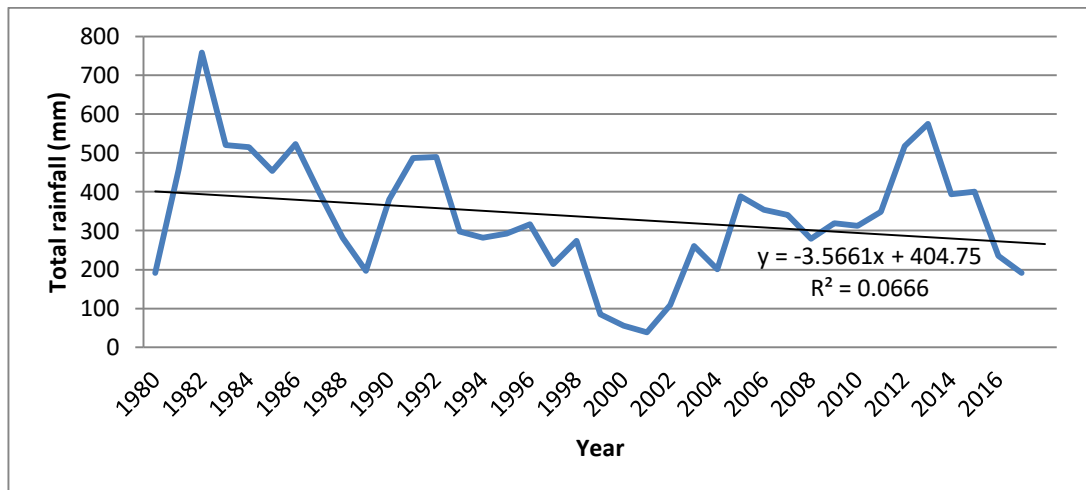


Figure 3. Farmers' perceptions of temperature (a) and rainfall (b) in the rainfed agroecological zone of Pakistan. Source: Authors' own creation.



(a)

Figure 4. Cont.



(b)

Figure 4. Wheat growing season mean temperature (a) and total rainfall (b) trends in the rainfed agroecological zone of Pakistan in 1980-2017. Source: Source: Authors’ own creation.

These conditions will make it difficult for rainfed-wheat farmers to achieve sustainable production if appropriate adaptation measures are not initiated.

4.2. Farmer Perceptions, Planning, and Implementation of Adaption and Constraints to Adaptation

The climate change adaptation process can generally be divided into three steps. The first step is the perception of climate change, the second step is the planning to adopt an adaptation measure, and the third step is the actual implementation of a climate change adaptation measure. The number of rainfed-wheat farmers’ affirmative responses significantly decreased from the responses related to the perception of climate change to those related the final implementation of an adaptation measure. In the first step, 98% of farmers responded that climate change is truly occurring. In the second step, 79% of farmers responded that they have a plan to implement an adaptation measure. In the last step, only 68.75% of farmers actually implemented any of the adaptation measures in the study year (Figure 5).

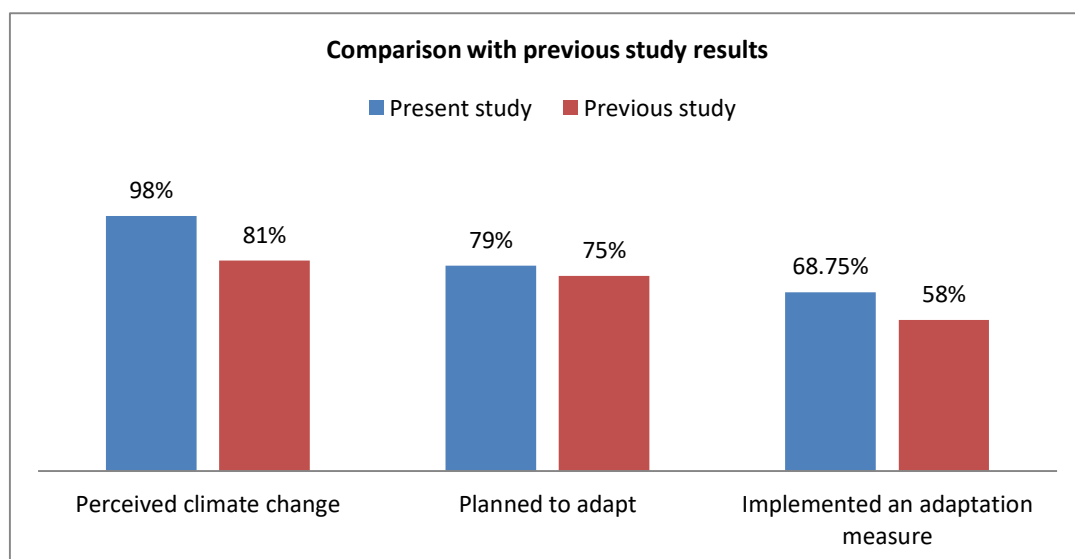


Figure 5. Perceiving climate change, planning for climate change, and implementing climate change adaptation in the rainfed agroecological zone of Pakistan in comparison to the results of a previous study. Source: Authors’ own creation.

The numbers (i.e., 98%, 79%, and 68.75%) in this figure are higher than the numbers (i.e., 81%, 75%, and 58%) reported in a study conducted in Punjab Province of Pakistan [20] in terms of perceiving climate change, planning for climate change, and implementing climate change adaptation, respectively, as shown in Figure 5. This result is because rainfed-wheat farmers were deeply concerned about climate change due to the heavy dependency of wheat farming on an important climate change parameter, rainfall. Rainfed-wheat farmers' substantial concerns about climate change were also due to the heavy dependency of wheat farming on rain to meet crop water requirements, as there is no proper irrigation system in the rainfed agroecological zone of Pakistan.

Furthermore, this study also noted the constraints that the farming community faces when implementing adaptation measures. These farmers actually perceived climate change and intended to adapt to climate change, but they did not adopt any adaptation measures due to constraints. The major constraints reported by the rainfed-wheat farmers (Figure 6) include fear of crop failure (30%), lack of proper information and knowledge (26.50%), lack of credit facilities (20.50%), water shortage due to decreased levels of rain (15%), and other constraints (8%). These constraints are similar to those found in past studies [20], except one, which was the fear of crop failure. This different constraint occurred because food security in rainfed areas is extremely reliant on high wheat yields, as wheat is the main food crop of this agroecological zone and the country as well.

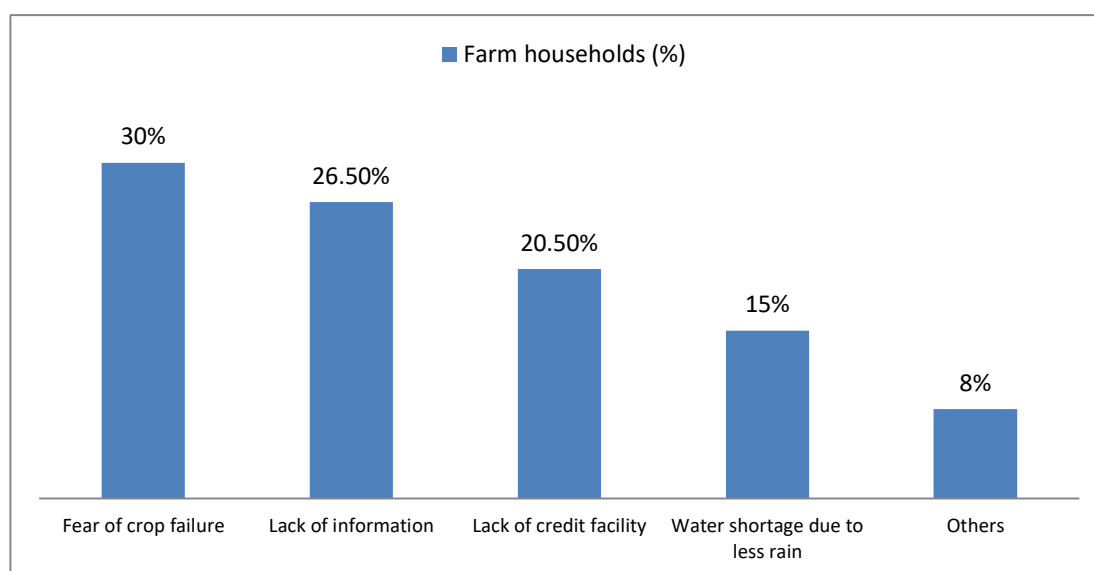


Figure 6. Major constraints to climate change adaptation in the rainfed agroecological zone of Pakistan. Source: Authors' own creation.

Interestingly, the majority of the rainfed farmers are farming with limited, indigenous knowledge that they acquired from their ancestors. They were not ready to farm in any other way that is out of the scope of their limited knowledge due to the fear that they may lower crop yields or even experience crop failure by implementing an adaptation measure. The second major constraint was the lack of access to proper information on the different adaptation measures that can be implemented to address various natural disasters and other factors, such as drought, heat stress, and water shortages. Microfinancing institutions appear to be reluctant to provide credit facilities to rainfed-wheat farmers due to the heavy dependency of their crop success on favorable weather conditions, such as sufficient rain and suitable temperatures for crop growth. The importance of credit facilities has been highlighted in many Pakistani provincial studies [19,45] because rainfed farmers have small land holdings and their adaptive capacity to address climatic challenges is largely dependent on external financial support from credit facilities. Hence, it is difficult for rainfed-wheat farmers to obtain agricultural credit, and this inability to obtain credit is the third major constraint that they faced in addition to limited resources

in adapting to climate change. The fourth major constraint was the shortage of supplemental irrigation due to the absence of proper canal irrigation and groundwater irrigation systems. Amidst these constraints, rainfed farmers are completely dependent upon rains for farming and for implementing any adaptation measure. Additional constraints included a lack of improved seeds and fertilizer and a lack of advanced implements and farm machinery for cultivation.

4.3. Farmers' Decisions and Choices of Climate Change Adaptation Measures

Farmers were asked about the main adaptation measures that they had already implemented to address changing local climatic conditions. The data indicated a number of adaptation measures, including using heat- and drought-resistant wheat varieties (24.50%), changing sowing dates (21%), planting shade trees (13%), and changing the composition of fertilizer (10.25%), as shown in Figure 7.

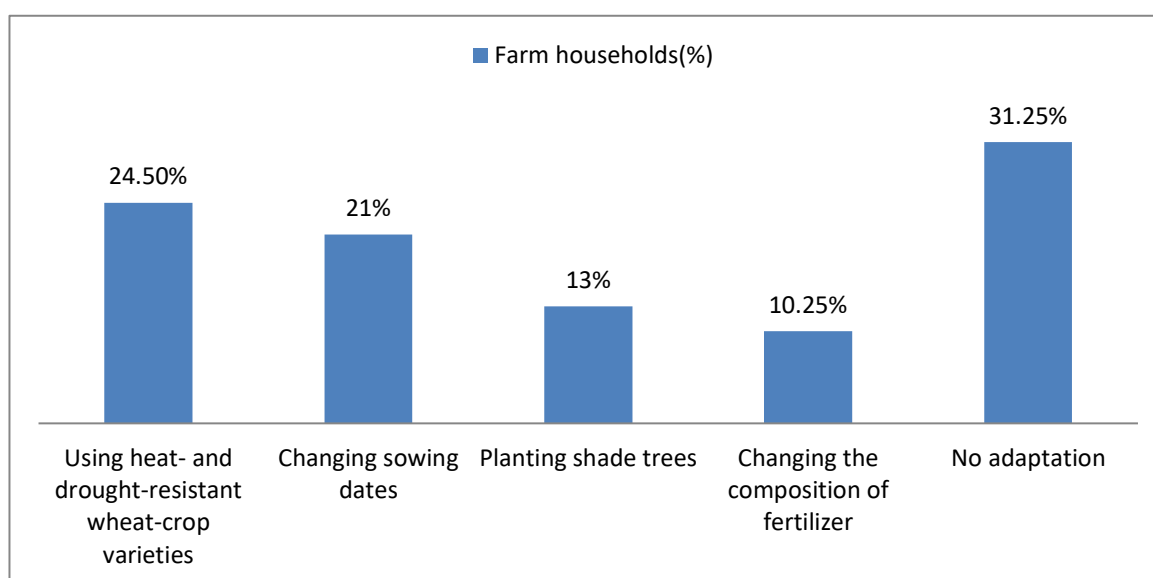


Figure 7. Wheat farmers' adaptation measures to address climate change in the rainfed agroecological zone of Pakistan. Source: Authors' own creation.

Approximately one-third (31.25%) of the farmers did not adopt any adaptation measure given the existing constraints. The available adaptation measure options in the rainfed agroecological zone of Pakistan are relatively less than those available in other zones, especially those relating to proper supplemental irrigation facilities through tube-well and canal irrigation systems. The main adaptation measures reported in previously conducted studies in Pakistan are diversifying crops, changing crop type, implementing supplemental irrigation, planting shade trees, and renting out agricultural lands [45,46]. For rainfed areas, however, the scope of diversifying crops and changing crop type is very limited due to the absence of a proper irrigation system. Approximately 72% of the total interviewed farmers were only growing one crop (i.e., wheat). Furthermore, renting out agricultural land in rainfed agroecological zone is very rare due to the very low rental value of the land. Monocropping systems, heavy dependency of agricultural output on rains, and limited options regarding crop farming are the major factors behind the low land rental values. These factors lead the rainfed-wheat farmers to be reluctant to rent out their lands, so they prefer to cultivate at least one crop (i.e., wheat) to meet their domestic food requirements.

4.4. Results of the Logit Model for Adaptation Decisions and Multinomial Logit (MNL) Model for Choice of Adaptation Measures

The present study used a logit model to investigate the effect of various explanatory variables (see Table 1 for details) on wheat farmers' decisions to adapt. An MNL model was used to analyze the effect of relevant variables on the farmers' choices to adopt a particular adaptation measure. The prerequisite to using the MNL model is to normalize one category, which is referred to as the "base category". The base category in this study was 'no adaptation'. The adaptation measures using heat- and drought-resistant wheat-crop varieties, changing sowing dates, planting shade trees, and changing the composition of fertilizer were considered the second, third, fourth, and fifth categories, respectively. A multicollinearity test was conducted using the variance inflation factor (VIF) by running an ordinary least square regression analysis. The VIF values for all the variables were less than 2 (ranging from 1.05 to 1.67), which clearly indicated the absence of strong multicollinearity in the model. Moreover, to use the MNL model, the null hypothesis that the irrelevant alternatives IA are independent must be satisfied [34,40]. This scenario means that the MNL model cannot be employed if the alternatives (which are adaptation measures in our case) are not independent and distinct from each other. For that purpose, the SUEST-based Hausman test was used to validate the assumption of independence of the irrelevant alternatives (IIA). This test failed to reject the null hypothesis of independent irrelevant alternatives (the values of χ^2 ranged from 13.18 to 21.44 with p -value ranging from 0.93 to 0.99). The alternatives were the four adaptation measures. Furthermore, likelihood ratio chi-square values of 166.16 ($p < 0.01$) for the logit model and 211.22 ($p < 0.01$) for the MNL model and pseudo- R^2 values of 0.3344 for the logit model and 0.1721 for the MNL model also showed the goodness of fit of both the logit and MNL models (see Table 2). The results of the logit and MNL models are presented in Table 2, and their estimated marginal effects are reported in Table 3.

4.4.1. Climate Change Fatalism

Fatalistic farmers did not adopt any of the adaptation measures, and the coefficient (-1.013) had a negative and highly significant ($p < 0.01$) value in the logit model.

Climate *fatalism* was also negatively significant in the marginal effect of the logit model, which showed that having fatalistic beliefs about climate change decreased the likelihood of rainfed-wheat farmers implementing any climate change adaptation measure by 13.56% ($p < 0.01$). Similarly, in the MNL model, the variable climate *fatalism* was also negatively significant (with $p < 0.01$, $p < 0.01$, $p < 0.01$, and $p < 0.05$ for the four adaptation measures included in the analysis). This result implies that fatalistic farmers were not inclined to adopt any of the four adaptation measures. Fatalistic beliefs reduced farmers' likelihood of using heat- and drought-resistant wheat-crop varieties by 8.56% ($p < 0.1$). Overall, the results showed that climate change *fatalism* in addition to the other explanatory variables significantly influenced the climate change adaptation process. Moreover, lack of awareness about climate change and poorly disseminated information were among the factors affecting farmers' skeptical behavior about climate change [47].

Table 2. Estimated results of the logit and multinomial logit models for the decision to adapt and choice of adaptation measure(s) to address climate change.

| Explanatory Variables | Logit Model | Multinomial Logit (MNL) Model | | | |
|---|---|--|--|-------------------|----------------------|
| | Dependent Variable: Decision to Adapt to Climate Change (yes = 1, no = 0) | Dependent Variable: Four Adaptation Measures | | | |
| | | | Using Heat- and Drought-Resistant Wheat-Crop Varieties | Changing Sowing D | Planting Shade Trees |
| | Coefficients | Coefficients | Coefficients | Coefficients | Coefficients |
| Climate change <i>fatalism</i> | −1.013 *** | −1.1182 *** | −1.2229 *** | −0.9186 *** | −0.8968 ** |
| Farmers' participation in trainings on climate-resilient wheat-crop farming | 2.3118 *** | 2.3641 *** | 3.3450 *** | 1.8749 *** | 2.2955 *** |
| Availability of mobile communication technology (MCT)-based advisory services | 0.7286 * | 1.3089 *** | −0.0301 | 0.5887 | 0.1990 |
| Availability of information on climate change | 1.1127 *** | 1.4879 *** | 0.3282 | 0.7352 * | 1.2920 *** |
| Age of the respondent (years) | 0.0022 | 0.0066 | 0.0040 | −0.0088 | 0.0170 |
| Number of male family members (numbers) | 0.3171 ** | 0.4418 *** | 0.3021 * | 0.3390 ** | 0.0185 |
| Input market access | 0.8007 ** | 0.9071 ** | 0.9319 ** | 0.7352 * | 0.6072 |
| Tractor ownership | 0.8383 ** | 0.8287 * | 0.2597 | 0.9122 ** | 1.1051 ** |
| Crop farming as main source of income | 0.9146 *** | 1.0891 *** | 1.0387 ** | 0.5865 | 1.1426 *** |
| Monocropping | 1.6990 *** | 1.4394 *** | 2.1167 *** | 1.5191 *** | 2.4151 *** |
| Constant | −2.4648 *** | −4.3324 *** | −4.5009 *** | −2.6745 *** | −4.8783 *** |
| LR chi-square | 166.16 *** | 211.22 *** | | | |
| Log likelihood value | −165.36 | −508.20 | | | |
| Pseudo-R ² | 0.3344 | 0.1721 | | | |
| Number of observations | 400 | 400 | | | |

Note: *, ** and *** show the level of significance at * $p < 0.1$, ** $p < 0.05$, and *** $p < 0.01$, respectively.

Table 3. Estimated marginal effects of the logit and multinomial logit models.

| Explanatory Variables | Logit Model | Multinomial Logit (MNL) Model | | | |
|---|--|--|-----------------------|----------------------|--|
| | Dependent Variable: Decision to Adapt to Climate Change (yes =1, no = 0) | Dependent variable: Four adaptation measures | | | |
| | | Using Heat- and Drought-Resistant Wheat-Crop Varieties | Changing Sowing Dates | Planting Shade Trees | Changing the Composition of Fertilizer |
| | Coefficients | Coefficients | Coefficients | Coefficients | Coefficients |
| Climate change <i>fatalism</i> | −0.1356 *** | −0.0857 * | −0.0447 | −0.0355 | −0.0146 |
| Farmers' participation in trainings on climate-resilient wheat-crop farming | 0.3095 *** | 0.9405 | 0.1923 ** | −0.0333 | 0.0371 |
| Availability of mobile communication technology (MCT) based advisory services | 0.0975 * | 0.2274 *** | −0.0569 | −0.0104 | −0.0495 |
| Availability of information on climate change | 0.1489 *** | 0.1638 ** | −0.0502 | 0.0209 | 0.0554 |
| Age of the respondent (years) | 0.0003 | 0.0012 | 0.0002 | −0.0030 | 0.0020 |
| Number of male family members (numbers) | 0.0425 ** | 0.0525 ** | 0.0059 | 0.0254 | −0.0306 * |
| Input market access | 0.1072 ** | 0.0728 | 0.0320 | 0.0242 | −0.0053 |
| Tractor ownership | 0.12122 ** | 0.0387 | −0.0407 | 0.0643 | 0.0622 |
| Crop farming as main source of income | 0.1224 *** | 0.0970 * | 0.0330 | −0.0392 | 0.0563 |
| Monocropping | 0.2274 *** | 0.0573 | 0.0779 ** | 0.0765 | 0.1242 *** |

Note: *, ** and *** show the level of significance at * $p < 0.1$, ** $p < 0.05$, and *** $p < 0.01$, respectively.

4.4.2. Farmer Participation in Training on Climate-Resilient Wheat-Crop Farming

This variable distinguishes this study from previous studies, as this study focused on farmer participation in training programs on climate-resilient crop farming as opposed to general training on seed, fertilizer, and technology use provided by local extension departments. The rainfed-wheat farmers who participated in the training program on climate-resilient wheat-crop farming were likely to adapt and likely to adopt all four climate change adaptation measures. The coefficient was positive and highly significant with $p < 0.01$ for both logit models and for all four adaptation measures in the MNL model. Maintaining the other factors constant, a one-time increase in farmer participation in climate-resilient crop farming trainings increased the farmers' likelihood of adapting by 30.95% ($p < 0.01$) and increased the farmers' likelihood of changing the sowing dates as an adaptation measure by 19.23% ($p < 0.05$). A significant number of studies have already proven the importance of general extension services [19,20,48], which can play an important role in helping farmers to maintain sustainable yields of various crops in the face of changing climatic conditions. A recent study conducted in the Punjab Province of Pakistan showed that farmers with better access to formal and informal advisory services had better wheat yields than those of farmers with little or no access to these advisory services [49]. However, special training programs on climate-resilient wheat farming are needed to maintain sustainable production levels of wheat crop in the rainfed agroecological zone of Pakistan under changing climatic conditions, as general advisory services are not enough to address this challenge.

4.4.3. Availability of Mobile Communication Technology (MCT)-Based Advisory Services

The roles of information and communication technology (ICT) in general and mobile communication technology (MCT) in particular have become extremely important in every sector. The present study emphasized the role and importance of a unique variable, MCT-based advisory service, which has not been explored in the context of rainfed agriculture in Pakistan. In 2017 (when the field survey was conducted), the provincial government launched a pilot project named the "Connected Agriculture Platform (CAPP)" with the help of a local mobile phone company (i.e., Telenor) operating in Pakistan. The government distributed cell phones to registered farmers through local agriculture extension departments at an extremely low price of only 500 Pakistani rupees. The partner mobile phone company equipped these mobile phones with a sophisticated application through which the farmers could contact agricultural experts. Farmers can seek expert help and occasional updates regarding crop improvements, area-specific weather forecasts, videos on the latest production technologies, and sowing calendars according to changing local weather conditions. The present study modeled this program as a dummy variable applying a value of '1' for the farmers who had mobile phones with the special application of advisory services and '0' for those who did not have the phones. The farmers with MCT-based advisory services were likely to adapt to climate change, as the coefficient of MCT was positively significant ($p < 0.1$) in the logit model. This result means that a one-unit increase in aforesaid variable increased the farmers' likelihood of adapting by 9.75% ($p < 0.1$). Similarly, in the MNL model, the farmers with these advisory services were likely to use heat- and drought-resistant wheat-crop varieties as an adaptation measure ($p < 0.01$), and a one-unit increase in MCT increased the likelihood of implementing this action by 22.74% ($p < 0.01$). Implementation of CAPP throughout the country, including the whole rainfed agroecological zone of Pakistan, could help farmers become aware of changing climatic conditions and implement area-specific adaptation measures to achieve sustainable wheat production and increase this production. Information and communication technology (ICT), including MCT, has played a tremendous role in every sector of the economy, including the agricultural sector. This technology is very helpful for obtaining market information and price changes and is also helpful for increasing awareness among farming communities of climate-smart agricultural practices [50].

4.4.4. Availability of Information on Climate Change

Farmers that had access to available information on short- and long-term climatic parameters (i.e., information on temperature, rainfall, and weather forecasts) were more likely to adapt to climate change than those farmers who did not have access to the information. The coefficient of the variable was highly significant ($p < 0.01$) in the logit model. A unit increase in this variable increased the farmers' likelihood of adapting by 14.89% ($p < 0.01$). Similarly, farmers with access to available information had a significant and positive impact on the likelihood they would use heat- and drought-resistant wheat-crop varieties ($p < 0.01$), plant shade trees ($p < 0.1$), and change the composition of fertilizer ($p < 0.01$); this variable also increased the farmers' likelihood of using heat- and drought-resistant wheat-crop varieties by 16.38% ($p < 0.05$). As explained previously, the role of various advisory services, such as climate information services provided by different state organizations, including the agriculture extension department, is an essential ingredient for maintaining and boosting the agricultural production levels of different crops in general, and wheat in particular [49].

4.4.5. Age of the Respondent

The age of the farmer did not show any significant effect across either the logit or MNL models, which means that increasing age did not have a significant impact on the rainfed-wheat farmers' likelihood of adapting. As the sign of this variable was positive for most adaptation measures, although not significant, it may still be inferred that a relatively older farmer is more likely to adopt an adaptation measure due to his long-term experience and observations of climatic changes. The positive impact of age on the adaptation behavior of farmers has been shown in a number of studies [20,45]. A relatively older farmer with considerable experience in changing weather conditions can make a better decision regarding sound adaptation practices on the basis of his/her experience to minimize losses from climate change.

4.4.6. Number of Male Family Members

The number of male family members showed a positive and significant ($p < 0.05$) impact on farmers' likelihood of adapting, and the addition of one more male family member resulted in an increase in likelihood of adapting by 4.25% ($p < 0.05$). The MNL model also showed that in comparison to those with less male family members, farm households with more male family members were more likely to use heat- and drought-resistant wheat-crop varieties ($p < 0.01$), change sowing dates ($p < 0.1$), and plant shade trees ($p < 0.05$) as adaptation measures. Furthermore, the addition of one more male family member increased the likelihood of using heat- and drought-resistant wheat-crop varieties by 5.25% ($p < 0.01$). This variable, however, did not have any impact on the likelihood implementing the adaptation measure of changing the composition of fertilizer, but the addition of one more male family member resulted in a decrease in the likelihood of changing the composition of fertilizer by 3.08% ($p < 0.1$). As opposed to using overall farmer family size, the present study used the male family member effect on the adaptation process. As the family head, the male family members in the study area had more adaptive capacity to adapt to the changing climate compared to that of female family members [51], and they were more productive in performing different farming tasks, including adaptation measures [45,52].

4.4.7. Input Market Access

Farmers with easy access to input markets were more likely to adapt to climate change ($p < 0.05$). This access increased the farmers' likelihood of adapting by 10.72% ($p < 0.05$). Easy access to input markets had a positive impact on the productivity levels of various crops, as this access enables the timely purchase of various agronomic inputs, such as fertilizers and pesticides [48,53]. This access further boosted the specialization effect through better information and timely available information about the latest technologies [54]. In the MNL model, this variable had a positive and significant impact

on the farmers' likelihood of using heat- and drought-resistant wheat-crop varieties ($p < 0.05$), changing sowing dates ($p < 0.05$), and planting shade trees ($p < 0.1$) as adaptation measures. Access to input markets, however, did not have any significant marginal effects on implementing adaptation measures.

4.4.8. Tractor Ownership

Farmers that owned tractors were more likely to adapt to climate change ($p < 0.05$), and this variable increased the farmers' likelihood of adapting by 12.12% ($p < 0.05$). Although tractor ownership had no significant marginal effects on the studied adaptation measures, it had a positive and significant impact on the farmers' likelihood of using heat- and drought-resistant wheat-crop varieties ($p < 0.1$), planting shade trees ($p < 0.05$), and changing the composition of fertilizer ($p < 0.05$) as adaptation measures. The ownership of farm machinery (including tractor ownership) can also improve and enhance the efficiency of the operation of various agronomic practices (e.g., early planting, drill sowing, and better plowing operations) [45] that can ultimately lead to improved yields of a particular crop.

4.4.9. Crop Farming as a Main Source of Income

Farmers carry out crop farming as their main source of income were more inclined to adapt to climate change ($p < 0.01$), and this variable increased their likelihood of adapting by 12.24% ($p < 0.01$). In the MNL model, this variable also had a positive and significant impact on the farmers' likelihood of using heat- and drought-resistant wheat-crop varieties ($p < 0.01$), changing sowing dates ($p < 0.05$), and changing the composition of fertilizer ($p < 0.01$) as adaptation measures. Moreover, this variable increased farmers' likelihood of using heat- and drought-resistant wheat-crop varieties by 9.70% ($p < 0.1$). Farmers with income from crop farms as their only source of income are more attentive regarding the adoption of better adaptation practices. They know well that their negligence and poor management under changing climate conditions can result in insecure livelihood and food situations.

4.4.10. Monocropping

Farmers who produce one crop annually were more likely to adapt ($p < 0.01$), and this variable increased the farmers' likelihood of adapting by 22.74% ($p < 0.01$). More importantly, the variable had a positive and highly significant impact on farmers' likelihood of using heat- and drought-resistant wheat-crop varieties ($p < 0.01$), changing sowing dates ($p < 0.01$), planting shade trees ($p < 0.01$), and changing the composition of fertilizer ($p < 0.01$) as adaptation measures. Furthermore, monocropping increased the farmers' likelihood of changing the sowing dates by 7.79% ($p < 0.05$) and changing the composition of fertilizer by 12.42% ($p < 0.01$). This result means that the farmers who cultivated one crop and did not grow any other crop in the second cropping season were more vigilant about climate change and more responsive regarding the adoption of various adaptation measures. Crop failure of the staple food crop in the rainfed agroecological zone could lead to the worst food security situation in the country, and in the rainfed agroecological zone as well.

5. Conclusions and Policy Implications

This study adds to the existing literature as it paid special attention to two important parameters that can play a significant role in the climate change adaptation process: climate change *fatalism* and climate-specific extension services. The rainfed-wheat farmers in Pakistan, compared to farmers from other agroecological zones, have strong perceptions and beliefs about the existence of climate change, but they tend not to adapt due their specific spiritual beliefs, referred to as climate *fatalism*. The fatalistic rainfed-wheat farmers believe that climatic events are natural and predetermined and that nobody can escape their effects. The present study used the logit model to investigate the impacts of climate change *fatalism* and climate-specific extension services in addition to other explanatory variables on rainfed-wheat farmers' decisions to adapt. A multinomial logit (MNL) model was used to analyze the impact of important explanatory variables on the farmers' choice of a particular climate change adaptation measure. The main adaptation measures in the study area were using heat- and

drought-resistant wheat-crop varieties, changing the sowing dates, planting shade trees, and changing the composition of fertilizer. The findings revealed that climate change *fatalism* had a highly significant and negative impact on rainfed-wheat farmers' likelihood of adapting to climate change. Moreover, the results of the MNL model showed that fatalistic farmers are unlikely to implement any of the four climate change adaptation measures due to their specific spiritual beliefs. The availability of climate-specific extension services (including farmers' participation in climate-resilient wheat-crop farming trainings and mobile communication technology-based advisory services), in addition to information on climate change, had a highly significant and positive impact on farmers' decisions to adapt and on farmers' choice of various climate change adaptation measures. Other variables, such as the number of male family members and easy access to input markets, also had a positive and significant impact on the farmers' decisions to adapt in the study area. Farmers owning tractors, cultivating only wheat crops, and using crop farming as their only source of income had an increased willingness to implement adaptation measures. The farmers who intended to adapt but did not implement any adaptation measures highlighted four major constraints: fear of crop failure, lack of information, lack of a credit facility, and water shortages due to decreased amounts of rain. In light of the aforementioned findings, the present study proposes the following policy implications:

- (1) Community-based extension efforts are needed to educate Pakistani rainfed-wheat farmers to change their attitude about the adaptation process to help minimize harmful impacts of climate change on crop productivity and help to ensure food and livelihood security.
- (2) The empirical results also show the importance of climate-specific extension services in addition to the general extension services.
- (3) The government of Pakistan could consider allocating significant resources to train farmers to address climate change by providing climate-resilient crop farm training and rapid advisory services via mobile communication technology.
- (4) The findings also indicate a need for sound climate change policies, i.e., farm-level training sessions to motivate farmers to adopt adaptation measures, could be a promising solution without the fear of crop loss.
- (5) The government could facilitate the provision of credit facilities for rainfed-wheat farmers with feasible terms and conditions that could help with the timely purchase of various agronomic inputs and farm machinery.
- (6) Finally, the government needs to assist rainfed farmers in constructing mini dams for rainwater harvesting to irrigate their crops for scenarios of no or decreased rain and also for use in multiple cropping systems. Agroecological zone-specific adaptation policies could lead to sustainable wheat production levels. These types of policies may also motivate farmers to implement multiple cropping in the studied rainfed agroecological zone of Pakistan.

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