IUB Journal of Social Sciences
ISSN 2790-6884 (E) & 2790-6876 (P)
DOI: 10.52461/ijoss.v5i2.2395
Vol. 5, No. 2, 2023, Pages: 398-418

Exploring Gender Dynamics in On-Farm Climate Change Adaptation Strategies and Food Security among Smallholder Farmers in South Punjab, Pakistan

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Keywords:
On-farm, Storage, Diversification, Mobility, Common Pooling, Assets

Article History:
Received:
October 16, 2023
Revised:
December 28, 2023
Available Online:
December 31, 2023

a Gold
Open Access Journal

ABSTRACT

The study explores the determinants of on-farm climate change adaptation strategies and food security in the South Punjab Province of Pakistan. On-farm climate change adaptation strategies are the actions that farmers apply to mitigate the influence of climate change on their specific farms. The study stands out by comprehensively addressing five sub-strategies of on-farm adaptation strategies. The previous studies employed qualitative techniques or frequency analysis, but this study applied regression analysis. Notably, there is a dearth of research on the intersection of gender, climate change adaptation, and food security in South Punjab. The study collected data from 1152 small landholders in four divisions (Multan, Bahawalpur, DG Khan) of South Punjab with a sample size of 384 small landholders from each division by using the Krejcie & Morgan (1970) sample size determination formula. The study employed a binary logistic technique to estimate the results. The findings suggest that male farmers exhibit greater confidence in adopting on-farm climate change adaptation measures compared to their female counterparts. Planned adaptation strategies demonstrate a positive influence on autonomous climate change adaptation measures. Additionally, the study identifies various constraints or barriers, such as limited access to services, shortage of non-land assets, and farmers' constrained income, as primary obstacles in the adoption of on-farm strategies. The study further reveals that food security negatively influences the adoption of on-farm strategies.

How to cite this paper?
Sheikh, M. R., Fida, A. & Sultan, S. (2023). Exploring Gender Dynamics in On-Farm Climate Change Adaptation Strategies and Food Security among Smallholder Farmers in South Punjab, Pakistan. *IUB Journal of Social Sciences*, *5*(2), 349-356.

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1 Introduction

It is noteworthy that nowadays, one of the primary concerns is climate change, which is having a profound impact on a large segment of the global population by seriously disrupting food production, the natural ecology, human health, and the availability of water (R. Hassan, Scholes, & Ash, 2005). The Inter-Governmental Panel on Climate Change's fourth assessment report (Martin L Parry, 2007) states that there will be fewer cold days and nights, as well as extreme climate events with frequent heat waves and heavy precipitation. The intensity and frequency of the weather are also changing. It has been recognized that the entire world needs to focus on climate change mitigation and adaptation techniques to lessen the intensity and frequency of climate change. Without effective adaptation, efforts to lessen the negative impacts would not be fruitful. The world needs to boost the degree and adaptation role to mitigate the negative effects of a constantly changing climate, such as rising temperatures that will likely continue for many decades notwithstanding the deployment of emission reduction plans (Martin Lewis Parry & Carter, 1989).

A system, region, or community's ability to adapt to the risks and effects of climate change is a major determinant of its ability to adapt. The higher the system's vulnerability, the worse its adaptive capability. A rise in exposure and sensitivity would make the system more vulnerable, but an increase in adaptive capability would have the opposite effect (Nair & Bharat, 2011). People can be damaged by climate change to a certain extent, but the more resilient they are to it, the less likely it is that they will suffer consequences (Rayner & Malone, 2001). A large amount of literature on the variables influencing adaptive capacity points to socioeconomic traits of households—such as financial resources, information and technology access, institutional infrastructure and good governance, human capital, equitable empowerment, political clout, kinship networks, and resource accessibility—as having the greatest bearing on a household's ability to adapt to climate change (Smit & Pilifosova, 2003).

According to the IPCC, 2007, global temperatures have risen by 1.5 degrees Celsius, and this trend of rising temperatures is expected to continue beyond the year 2100. On the other hand, if CO2 emissions are reduced, the rate of temperature increase will be slower. According to estimates, global warming will surpass 2 degrees Celsius by the year 2100 if CO2 emissions continue at their current rate. The global surface temperature will reach a limit of 1.5 degrees Celsius and will climb further beyond 2100 under all scenarios except the lowest emissions scenario, according to the 2014 Climate Change Synthesis Report. In cases when CO2 emissions are increased, global warming is probably going to be higher than 2 degrees Celsius by the year 2100. For development practitioners worldwide, acquiring evidence of the detrimental consequences of climate change on agriculture, particularly ecosystem services, has become an essential challenge (Woodward et al., 2014).

It is widely acknowledged that lower agricultural productivity translates into lower GDP, lower income and consumption for the most vulnerable communities, and worse household welfare. Therefore, the ongoing impact of climate change presents serious risks to rural economies (R. M. Hassan & Nhemachena, 2008). This presents a challenge to the advancement of cutting-edge technologies that have the potential to enhance rural residents' quality of life and preserve the surrounding ecosystem. Several grave ramifications of climate change have the potential to severely impact human well-being in terms of food, energy, and health. Climate fluctuations and their influence on weather patterns have already had a significant impact on the agriculture sector, notably on food production and global food security. The shifting patterns of the climate also hinder human endeavors to reduce poverty and promote socioeconomic development in climate-vulnerable industries like agriculture (Diao, Neafor, & Alpuerto, 2010; Ditta, Bashir, Hussain, & Hashmi, 2023). Climate changes could affect the frequency of extreme weather events, the cycles of drought, the patterns of rainfall, the prevalence of illnesses, and agricultural pests (Hewitson, 2010; Yanda, 2010).

Furthermore, as a result of climate change, agricultural fields' overall productivity generally declined (Makungwa, 2010).

Both the natural and human systems including ecosystems, biodiversity, agriculture, water cycles, living spaces and physical infrastructures are exposed to the consequences of climate change. Asian countries disproportionately encounter such effects, and smallholder (family) farmers are in the communities most affected to the fullest (Bryan, Deressa, Gbetibouo, & Ringler, 2009; Calzadilla, Rehdanz, et al., 2013; Cohn et al., 2017; Woodward et al., 2014). The sustainability of livelihood and economies of most Asian countries are highly dependent on poor farmer's agriculture which has quite low intensity and small plot sizes (Bryan et al., 2009; Cohn et al., 2017; Jirström et al., 2011; M. Salami et al., 2010). Climate change, variable weather conditions and extreme events create great challenges for smallholding farming (Calzadilla, Zhu, Rehdanz, Tol, & Ringler, 2013; Cohn et al., 2017). In addition to existing challenges, this threat also includes unstable land tenure, over-exploitation of natural resources, inadequate funding, poor construction of infrastructures and low-grade institutional systems (Cohn et al., 2017; Salami, Kamara, & Brixiova, 2010). Accordingly, Cohn et al. (2017)vsuggest that smallholder farming adopt adaptation to climate change as a key policy priority.

The rest of the paper is structured as: section 2 provides the literature review of the previous studies, model specification, data sources and methodology will be presented in Section 3. Section 4 provides the results and discussion and the last section will provide the conclusions and policy recommendations.

2 Literature Review

This section explains the literature review of gender and climate change. Table 1 shows the summary of the literature review on the previous studies.

Table 1: Review of Assorted Studies

Author(s)	Country	Observation/ Time Period	Methodology	Adaptation Strategy/ Recommendation	Main Results
(Gbetibouo, Hassan, & Ringler, 2010)	South Africa	794 people in 19 districts from 4 provinces for the year 2005	Multinomial Logit Model	On-farm, Diversification	Household size, wealth, size, farming experience, perception of the soil's fertility, access to credit, extension services, off-farm activities, tenure security, high temperatures, and little rainfall tend to improve a person's ability to adapt to climate change
(Kalungu, 2014)	Kenya	326 farmers	Descriptive and Inferential statistics	On-farm Adaptation	Gender had a significant influence on how people adapt to climate change, with women facing unique challenges and using different coping techniques than men.
(Van Aelst & Holvoet, 2016)	Tanzania	1971-2013 2004-2013	Logistic regressions	On-farm, Diversification	Divorced women were assumed relatively additional

					income instead of the farming sector
(Scheffran, Brzoska, Brauch, Link, & Schilling, 2012)	Gujrat, Rahimyar Khan and Barani, Pakistan	2015, 65 villages	Spearmen correlation, Qualitative	On-farm, Diversification, Mobility	As a result of climate change the adapted strategies of wheat crops affected positively significant to the crop net income and productivity
(Ali & Erenstein, 2017)	Sindh, Punjab, Khyber Pakhtunkhwa and Balochistan	2014-2015, 950 farmers from 275 villages	Probit model, Score propensity technique	On-farm Adaptation	The paper concluded that a large portion of lands of Sindh and Punjab were irrigated through canals, while in Balochistan and KPK the small land proportions were irrigated by canals
(Abid, 2017)	Pakistan	2016, 450 farm households from three agro-ecological zones	Social network analysis method	On-farm Adaptation	farmers have noted an increase in pests and diseases as well as a decline in crop output as a result of climate change. farmers have noted an increase in pests and diseases as well as a decline in crop output as a result of climate change.
(Tamako & Thamaga-Chitja, 2017)	Africa	2017, 135 smallholder farmers	Descriptive statistics and chi-square	Deal with food insecurity and On-farm adaption mechanisms	Social capital had a positive effect on the coping mechanisms employed by households
(Memon, Aamir, & Ahmed, 2018)	Tharparkar District of Pakistan	1975 to1994 and1995-2013	Pearson Correlation	On-farm, Storage, Mobility	The increased average annual rainfall with unpredictable patterns caused necessities lack and social security
(Arif, Khan, & Sathar, 2021)	Pakistan	From 1961 to 2018, 55 monitoring stations operated by the Pakistan Meteorological Department (PMD)	OLS technique	On-farm, Mobility	Regions with higher population density and lower socioeconomic conditions exhibited greater vulnerability to climate change impacts
(Ahmad & Afzal, 2021)	Pakistan	2017, 398 households	Probit Model, PCA	On-farm adaptation, Planned Adaptation	Muzaffargarh's Bait households were more exposed to sensitive to, and less able to adjust to flood disasters than households in other districts

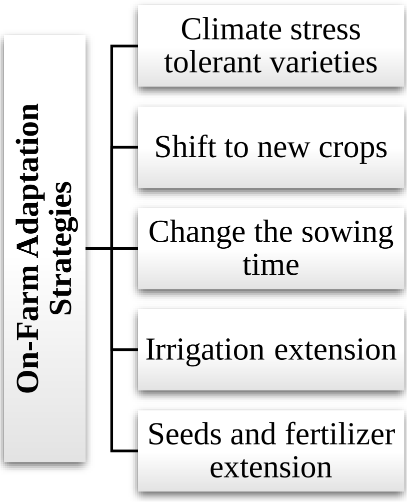
(Floro, Yesuf, & Woldesenbet, 2019)	Ethiopia	2012-2013	OLS technique	On-farm Adaptation	Information and extension in credit access played the main role in the adaptation which increased food production

Prior studies have articulated on-farm climate change adaptation strategies with a specific focus on one or a few sub-strategies. All on-farm climate change adaptation strategies have not been focused. On the contrary, this study is focused on five sub-strategies of on-farm climate change adaptation strategies implemented by small landholders to fill this theoretical gap. The climate change adaptation strategies through the lens of gender have not been focused on by the previous studies but this study focuses on the lens of gender to fill this gap. There is abundant literature on the climate change adaptation strategies, especially on-farm however, there is scanty literature focusing on the South Punjab Province of Pakistan. This geographical gap emphasizes the need for locally relevant research to understand the specific challenges and adaptation strategies of this region's community. Therefore, the present study fills this geographical gap by conducting a study in the understudied region, contributing to the literature on climate change adaptation. Most of the studies have done only frequency and percentage analysis but this study has devised several econometric models that suggest the determinants of on-farm climate change adaptation strategies by applying the binary logit model.

3 Model Specification, Data Source and Methodology

The study aims to explore the determinants of on-farm adaptation strategies in all divisions separately and in the South Punjab (as a whole) province of Pakistan. Figure 1 shows the five sub-on-farm adaptation strategies.

Figure 1: On-Farm Adaptation Strategies



The following models have been used to investigate the variables affecting the on-farm adaptation strategies.

Model 1: Determinants of Climate Stress Tolerant Varieties

This model explains the determinants of the climate stress-tolerant varieties

$$CSTV = f(AGE, MS, FS, DEPB, FEXP, EDU, LS, LO, LQI, NLAI, INC, ASI, CCI, FSI, PCCAS) \quad (1)$$

The econometric form of the model is given as:

$$CSTV = \beta_1 + \beta_2 AGE + \beta_3 MS + \beta_4 FS + \beta_5 DEPB + \beta_6 FEXP + \beta_7 EDU + \beta_8 LS + \beta_9 LO + \beta_{10} LQI + \beta_{11} NLAI + \beta_{12} INC + \beta_{13} ASI + \beta_{14} CCI + \beta_{15} FSI + \beta_{16} PCCAS + \varepsilon \quad (2)$$

Model 2: Determinants of Shift to New Crops

This model shows the factors that influence farmers' shifts to new crops.

$$SNC = f(AGE, MS, FS, DEPB, FEXP, EDU, LS, LO, LQI, NLAI, INC, ASI, CCI, FSI, PCCAS) \quad (3)$$

The econometric form of the model is given as:

$$SNC = \beta_1 + \beta_2 AGE + \beta_3 MS + \beta_4 FS + \beta_5 DEPB + \beta_6 FEXP + \beta_7 EDU + \beta_8 LS + \beta_9 LO + \beta_{10} LQI + \beta_{11} NLAI + \beta_{12} INC + \beta_{13} ASI + \beta_{14} CCI + \beta_{15} FSI + \beta_{16} PCCAS + \varepsilon \quad (4)$$

Model 3: Determinants of Change in Sowing Time

This model aims to predict the farmer's strategy to change in the sowing time based on several variables.

$$CST = f(AGE, MS, FS, DEPB, FEXP, EDU, LS, LO, LQI, NLAI, INC, ASI, CCI, FSI, PCCAS) \quad (5)$$

The econometric form of the model is given as:

$$CST = \beta_1 + \beta_2 AGE + \beta_3 MS + \beta_4 FS + \beta_5 DEPB + \beta_6 FEXP + \beta_7 EDU + \beta_8 LS + \beta_9 LO + \beta_{10} LQI + \beta_{11} NLAI + \beta_{12} INC + \beta_{13} ASI + \beta_{14} CCI + \beta_{15} FSI + \beta_{16} PCCAS + \varepsilon \quad (6)$$

Model 4: Determinants of Irrigation Extension

This model examines the factors determining the farmer's strategy for irrigation extension.

$$IE = f(AGE, MS, FS, DEPB, FEXP, EDU, LS, LO, LQI, NLAI, INC, ASI, CCI, FSI, PCCAS) \quad (7)$$

The econometric form of the model is given as:

$$IE = \beta_1 + \beta_2 AGE + \beta_3 MS + \beta_4 FS + \beta_5 DEPB + \beta_6 FEXP + \beta_7 EDU + \beta_8 LS + \beta_9 LO + \beta_{10} LQI + \beta_{11} NLAI + \beta_{12} INC + \beta_{13} ASI + \beta_{14} CCI + \beta_{15} FSI + \beta_{16} PCCAS + \varepsilon \quad (8)$$

Model 5: Determinants of Seeds and Fertilizes Extension

This model investigates the determinants of farmer's strategy of seeds and fertilizers extension.

$$SFE = f(AGE, MS, FS, DEPB, FEXP, EDU, LS, LO, LQI, NLAI, INC, ASI, CCI, FSI, PCCAS) \quad (9)$$

$$SFE = \beta_1 + \beta_2 AGE + \beta_3 MS + \beta_4 FS + \beta_5 DEPB + \beta_6 FEXP + \beta_7 EDU + \beta_8 LS + \beta_9 LO + \beta_{10} LQI + \beta_{11} NLAI + \beta_{12} INC + \beta_{13} ASI + \beta_{14} CCI + \beta_{15} FSI + \beta_{16} PCCAS + \varepsilon \quad (10)$$

The study used a binomial logit model to analyze the results. Given the shortcomings of the linear probability model, non-linear specification is a possibility. We have applied the Logit model to explain the dichotomous dependent variable. The following cumulative probability density function is assumed by the logit model:

$$P = \frac{1}{1 + e^{(-\beta x_i)}} \quad (11)$$

Where the exponential value is denoted by "e" and "P" is the probability of success. The column vector of the variables is "Xi," and the row vector of the parameters is β.

Since "P" is the observable probability of success, a dichotomous (0,1) variable is created, with '1' denoting success and '0' denoting failure. From the above logistic probability equation, it is simple to derive the following regression equation:

$$Ln\left[\frac{P}{1-P}\right] = -\beta x_i \tag{12}$$

The primary benefit of the logit model, when compared to the linear probability model, is that the relationship between the variables is nonlinear and the probability of happened grows with "x" but never crosses the 0–1 interval.

3.1 Marginal Effects

The study has also calculated the marginal effect. Marginal effects represent the change in the probability of success (or failure) resulting from a one-unit change in an independent variable while holding all other variables constant. In other words, it measures the impact of a small change in a particular variable on the likelihood of the outcome occurring. It is commonly used in logistic regression models where the dependent variable is binary (e.g., success/failure, yes/no). The formula is as follows:

$$ME = \hat{p}(1-\hat{p})\beta_i \tag{13}$$

Where $\hat{p}$ is the probability of getting 1 or the probability of success of the dependent variable whereas $1-\hat{p}$ is the probability of getting 0 or the probability of a failure of the dependent variable and β_i is the coefficient of the variable.

The study has used the primary source to collect the data. The data are gathered through a questionnaire-based survey from three divisions: Multan, Bahawalpur, and DG Khan located in South Punjab, Pakistan. We have used closed-ended questions to make up the questionnaire. The sample is drawn from eleven districts across all three divisions. The Bahawalpur division contains three districts: Bahawalpur, Bahawalnagar, and Rahim-Yar-Khan. The DG-Khan division has four districts: DG-Khan, Layyah, Muzaffargarh, and Rajanpur. The Multan division has four districts: Multan, Khanewal, Vehari, and Lodhran. Eleven districts' rural areas serve as the basis for the proportional sample approach used to acquire the data. The sample size for this study has been determined by using the Krejcie & Morgan (1970) approach. The formula to calculate the sample size is as follows:

$$s = X^2NP(1-P) + d^2(N-1) + X^2P(1-P) \tag{14}$$

where N is the population size, P is the population share, d is the degree of precision represented as a proportion or the margin of error, and X^2 is the table value of the Chi-square for 1 degree of freedom at the specified confidence level, which is 3.841.

$$S = \frac{Rural\ Population\ in\ District_i}{Total\ Population\ in\ Division_i} \times 384 \tag{15}$$

Table 2 shows the description of the variables their abbreviation and measurement.

Table 2
Description of Variables their Abbreviations and Measurement

Categories of Variables	Variables	Abbreviation	Variable's Description	Measurement
		Dependent Variables		
On-Farm Adaptation Strategies	Climate stress tolerant verities	CSTV	It represents whether the farmer opts to adopt the climate stress-tolerant varieties or not	0 for No 1 for yes
	Shift to new crops	SNC	It shows whether the farmer shifts to new crops or not.	0 for No 1 for yes
	Change in sowing time	CST	It denotes whether the farmer changes the sowing time or not.	0 for No 1 for yes
	Irrigation Extension	IE	It signifies whether the farmer extends the irrigation or not.	0 for No 1 for yes
	Seeds and Fertilizer	SFE	It implies whether the farmer extends the use of more seeds and fertilizer.	0 for No 1 for yes
		Predictor Variables		
Demographics	Age	AGE	Age of farmer (in years)	Continuous
	Marital Status	MS	The farmer is either married or single.	1 for Married 0 for Unmarried
	Family System	FS	Whether the farmer lives in a joint family or not.	0 for No 1 for Yes
	Dependency Burden	DEPB	The computation involves dividing the total number of non-earners by the total number of household members.	Continuous
Human Capital	Farming Experience	FEXP	It shows the length of time a farmer has been engaged in farming activities.	Continuous
	Education	EDU	It shows the total number of years of schooling.	Continuous
Land Related Variables	Land Size	LS	It depicts the actual size or area of the farmer's land.	Continuous
	Land Owner	LO	The land is either owned by the farmer or not.	0 for No 1 for Yes
	Land Quality Index	LQI	It represents an index comprising four variables constructed through Principal Component Analysis (PCA).	Continuous
Non-Land Assets and Income	Non-Land Assets Index	NLAI	It shows an index encompassing four variables constructed through Principal Component Analysis (PCA).	Continuous
	Income	INC	The monthly income of the household measured in rupees	Continuous
Access to Services	Access to Services Index	ASI	It illustrates an index including five variables constructed through Principal Component Analysis (PCA).	Continuous
Climate Change	Climate Change Index	CCI	It elucidates an index containing four variables constructed through Principal Component Analysis (PCA).	Continuous
Food Security	Food Security Index	FSI	It demonstrates an index including nine variables	Continuous

			constructed through Principal Component Analysis (PCA).	
Planned Climate Change Adaptation Strategies	Planned Climate Change Adaptation Strategies Index	PCCAS	It exemplifies an index comprising seven variables constructed through Principal Component Analysis (PCA).	Continuous

4 Results and Discussions

This section explains the results of the study. Tables 3, 4, 5, and 6 (Apendix) present coefficients of logit regression along with p-values and marginal[4] effects for various demographic, human capital, land-related, non-land assets and income, access to services, climate change, and food security variables concerning the on-farm climate change adaptation strategies by male and female farmers in South Punjab Province of Pakistan, Multan, Bahawalpur and DG Khan divisions respectively. There are five sub-on-farm climate change adaptation strategies namely: climate stress tolerant verities, shift to new crops, change in sowing time, irrigation extension and seeds and fertilizer. These are used as dependent variables.

4.1 Socio-Demographic Factors

4.1.1 Age

The first variable in a demographic category is age. In on-farm adaptation strategies, the age of male and female farmers is negatively related to climate stress-tolerant varieties, shift to new crops, change in sowing time, irrigation extension, and seeds and fertilizer extension in Bahawalpur Division, DG Khan Division, and South Punjab. However, the age of male farmers in Multan Division is positively linked with climate stress-tolerant varieties, shift to new crops, change in sowing time, irrigation extension, and seeds and fertilizer extension, and the age of female farmers in Multan Division is positively linked with climate stress-tolerant varieties and irrigation extension but negatively linked with shift to new crops, change in sowing time, and seeds and fertilizer extension. Male and female farmers may find it difficult or less willing to adopt new agricultural technologies or practices as they get older. Older farmers may be more hesitant to change traditional practices due to entrenched habits and skepticism towards unfamiliar methods, hindering the adoption of climate-resilient strategies essential for adapting to environmental challenges (Destaw & Fenta, 2021; Elahi, Khalid, Tauni, Zhang, & Lirong, 2022; Gebru, Ichoku, & Phil-Eze, 2020; Mabe, Sienso, & Donkoh, 2014). The higher age of male farmers in the Multan Division could indicate accumulated experience and information, which forces them to choose climate stress-tolerant varieties and make decisions about changing crops and adjusting sowing times. Since age is generally associated with increased financial independence, these individuals can afford to invest in infrastructure for irrigation and seeds and fertilizers of high quality. Older women in this region could be acculturated in their thoughts and decisions because they know how climate affects agriculture. By growing crops that are resistant to changing weather and insisting on knowledge about irrigation, their approaches seem logical due to previously gained experiences (Ho, Tsusaka, Kuwornu, Datta, & Nguyen, 2021).

4.1.2 Marital Status

Marital status is the second variable. While implementing the on-farm adaptation strategies both married male and female farmers have a negative correlation with climate stress-tolerant varieties, shift to new crops, change in sowing time, irrigation extension and seeds, and fertilizer extension under the Multan Division, Bahawalpur Division, DG Khan Division, and South Punjab. In the field, the paradigm of gender roles and relations, resource access, and power dynamics among the members of the family may deter a farmer from implementing new

[4] The values in parenthesis are the P-value while the value in the square brackets are the marginal effects.

farming techniques on their farms (Atube et al., 2021; Destaw & Fenta, 2021; Elahi et al., 2022; Gbetibouo et al., 2010; Gebru et al., 2020; Mabe et al., 2014; Marie, Yirga, Haile, & Tquabo, 2020; Swai, 2017).

4.1.3 Family System

The third variable of the demographic category is the family system. In on-farm adaptation strategies the joint family system in male and female farmers is positively related to the use of climate stress-tolerant varieties, shift to new crops, change in the sowing time, irrigation extension and seeds and fertilizer extension in Multan Division, Bahawalpur Division, DG Khan Division, and South Punjab, as they make decisions collectively and pool up their resources, which ensure in the adoption of climate-resilient practices including stress-tolerant varieties and crop diversification. With shared responsibilities and labor, joint families can implement changes in sowing times and irrigation practices more effectively. With joint responsibility and labor, joint families have more chance to change the sowing time and irrigation. The safety net created by a large number of support systems within the family system enables positive access to seeds and fertilizers (Ali & Erenstein, 2017; Atube et al., 2021; Destaw & Fenta, 2021; Gbetibouo et al., 2010; Mabe et al., 2014; Marie et al., 2020; Molla, Melka, & Desta, 2023; Ojo, Adetoro, Ogundeji, & Belle, 2021).

4.1.4 Dependency Burden

The fourth variable in a demographic category is dependency burden. In on-farm adaptation strategies, the dependency burden on male and female farmers is negatively related to climate stress-tolerant varieties, shift to new crops, change in sowing time, irrigation extension and seeds and fertilizer extension in all divisions and South Punjab. The negative relationship between the dependency burden on male and female farmers and agricultural advancements in South Punjab suggests that households with higher dependency burdens may face constraints in adopting innovative practices. Such burdens likely limit financial resources and labor availability, hindering investments in climate-resilient varieties, crop diversification, and agricultural inputs extension. Additionally, the need to prioritize immediate household needs may overshadow long-term investments in agricultural adaptation measures (Pandey & Jha, 2012).

4.2 Human Capital-related Factors

4.2.1 Farming Experience

In the human capital category, the first variable is farming experience. In on-farm adaptation strategies, the farming experience of male farmers is negatively associated with climate stress-tolerant varieties, changes in sowing time, irrigation extension, and seeds and fertilizer extension, while being positively correlated with shifting to new crops in Bahawalpur Division, DG Khan Division, and South Punjab. Conversely, in the Multan Division, the farming experience of male farmers is positively associated with climate stress-tolerant varieties, shifting to new crops, changes in sowing time, irrigation extension, and seeds and fertilizer extension. However, for female farmers in the Multan Division, farming experience is positively linked with climate stress-tolerant varieties, shifting to new crops, and irrigation extension, but negatively correlated with changes in sowing time and seeds and fertilizer extension. On the other hand, the negative association between the farming experience of male farmers, and stress-tolerant varieties, change of the time of sowing, irrigation, or agricultural input has been the usage of the practice entrenched traditional or made it difficult to change for adaptability for the farmer. In other words, their experience often ensures an easy transition for diversification, using whatever the farmer knows to meet a changing market requirement and pick up environmental problems. To this, their experience ensures a successful shift to new crops, as they use their experienced-based knowledge and acquired skill to meet market needs that are evolving and environmental requirements (Ali & Erenstein, 2017; Batool, Ali, Manzoor, & Mahmood, 2018; Gbetibouo et al., 2010; Gebru et al., 2020; Ho et al., 2021; Ojo et al., 2021). In the Multan Division, the positive association between male farmers' farming experience and to adoption of decisions or adaptive measures in agriculture is attributed to some factors. Firstly, farming experience allows male farmers to recognize Climatic patterns and agriculture submissions help in identifying stress-tolerant varieties and picking best suitable crops (Hirpha, Mpandeli, & Bantider, 2020).

4.2.2 Education

In the human capital category, the second variable is education. In on-farm adaptation strategies, an increase in the education level of male farmers is positively related to climate stress-tolerant varieties, change in sowing time, irrigation extension and seeds and fertilizer extension while negatively linked with the shift to new crops in Multan Division, Bahawalpur Division, DG Khan Division and South Punjab indicates that educated farmers are more favorable to adopt modern agricultural practices and innovations to reduce climate risks. However, the negative relation with the shift to new crops may also imply a conservative attitude of educated male farmers. The association may be explained by educated farmers gradient aversion or their limiting factor traditional crop varieties (Gebru et al., 2020; Ho et al., 2021; Kumar et al., 2023; Mabe et al., 2014; Molla et al., 2023; Ojo et al., 2021).

4.3 Land-Related Variables

4.3.1 Land Size

Among land-related variables, the first variable is land size. In on-farm adaptation strategies, an increase in the land size of both male and female farmers is positively related to climate stress-tolerant varieties, shift to new crops, change in sowing time, irrigation extension and seeds and fertilizer extension in Multan Division, Bahawalpur Division, DG Khan Division and South Punjab. It can be inferred that landholdings with better resources could become more resilient to climate stress to maximize agricultural productivity (Abid, Scheffran, Schneider, & Elahi, 2019; Ali & Erenstein, 2017; Atube et al., 2021).

4.3.2 Land Owner

The second variable in the domain of land-related is land ownership. In the on-farm adaptation, land ownership has a positive relationship with the adoption of climate stress-tolerant varieties, new crops storage, sowing times adjustment, irrigation extension, and seeds and fertilizers extension in all divisions and South Punjab among the male and female farmers. The positive relationship sign implies that the farmer with land ownership makes the holistic decision to invest in resilience and production (Ali & Erenstein, 2017; Atube et al., 2021; Hirpha et al., 2020).

4.3.3 Land Quality Index

The third variable in the land-related is the land quality index. The land quality index has a positive relationship with the adoption of climate stress-tolerant varieties, shift to new crops, sowing time changes, irrigation extensions, and seeds and fertilizers reinvestment in the on-farm adaptation measures among the male and female farmers in all divisions and South Punjab. Farmers with high-quality land have the motivation and ability to invest in new and better practices and technologies which boost production and resilience (Abid et al., 2019; Ali & Erenstein, 2017).

4.4 Non-Land Assets and Income-related Factors

4.4.1 Non-Land Assets Index

The first factors in non-land assets and income are the non-land asset index. The non-land asset index has positive relationship with the climate stress-tolerant varieties, shift to new crops, sowing time change, irrigation extension and seeds and fertilizer extension on the on-farm adaptation among male and female farmers in the all divisions and South Punjab. This implies that the land assets replace the non-land assets among small-scale farmers. In particular, non-land assets close the financing unseen investment gap; therefore, they increase the potential to a quit among farmers (Gebru et al., 2020; Marie et al., 2020).

4.4.1 Income

In the non-land assets and income category, the second variable is income. The income of both male and female farmers in on-farm adaptation strategies are positively related to changes in climate stress-tolerant varieties, shift to new crops, change in sowing time, irrigation extension and seeds and fertilizer extension in all divisions and South Punjab. The high income allows the farmer to finance with regard to innovative agriculture accessorial and technologies, enhancing their resilience to conditions and easing agricultural outcomes (Atube et al., 2021; Gebru et al., 2020; Hussain, Ahmad, Nawaz, & Bhatti, 2019; Mabe et al., 2014; Saguye, 2016).

4.5 Access to Services related Factors

4.5.1 Access to Services Index

For on-farm adoption in all the divisions and South Punjab, and for both male and female farmer's access to services index relates positively with climate stress-tolerant varieties, shift to new crops; change in sowing time, irrigation extension and seeds and fertilizer extension. The reason for this result is that increasing farmers' access to agricultural services, such as extension, irrigation facilities, and quality seed and fertilizers distribution, leads to greater effort to strengthen the farmers to adopt new practices, which allows for climate stress resilience, and ultimately optimum productivity in agriculture (Ali & Erenstein, 2017; Atube et al., 2021; Gebru et al., 2020; Mabe et al., 2014).

4.6 Climate Change Related Factors

4.6.1 Climate Change Index

In on-farm adaptation strategies, in male and female farmer climate change index is positively related to climate stress-tolerant varieties, shift to new crops, change in sowing time, irrigation extension and seeds and fertilizer extension in all divisions and South Punjab. This suggests that as the climate change index increase, the farmers are aware of the different environmental life stresses and begin to invest more on resilient cultivation and technologies to save themselves from the climate change scare in the region (Hayuning, Dzulhijjah, & Setiono; Hirpha et al., 2020; Marie et al., 2020).

4.7 Food Security related Factors

4.7.1 Food Security Index

In on-farm adaptation strategies, in both male and female farmers, the food security index is negatively related to climate stress-tolerant varieties, shift to new crops, change in sowing time, irrigation extension and seeds and fertilizer extension in all divisions and South Punjab except Multan Division. This may imply that farmers have more urgency for food security today, negating their interest in long-term adaptation measures. In that case, farmers have higher chances to adapt to traditional techniques and crop varieties, even though the latter face severe threats due to climate. these adaptive practices reflect a holistic approach to agricultural resilience, aiming to safeguard food availability and access for both male and female farmers in the Multan Division, amidst evolving environmental conditions (Ali & Erenstein, 2017; Molla et al., 2023; Ojo et al., 2021).

4.8 Planned Climate Change Adaptation Strategies

4.8.1 Planned Climate Change Adaptation Strategies Index

In on-farm adaptation strategies, in both male and female farmers planned climate change strategies index is positively related to climate stress-tolerant varieties, shift to new crops, change in sowing time, irrigation extension and seeds and fertilizer extension in all divisions and South Punjab except DG Khan division. Thus, the more South Punjab farmers plan their adaptation strategies, proactively, the more likely they will invest in planned adaptation to enhance agricultural sustainability and reduce climate risks.

5 Conclusions and Policy Recommendations

The primary aim of this study is to investigate gender-specific on-farm climate change adaptation strategies among small-scale landholders in the South Punjab Province of Pakistan. The research utilizes cross-sectional data obtained from 1152 small landholder farmers across three divisions in South Punjab. The sample size of 384 farmers is drawn from each division. Analysis of the results employs the binomial logit model. The study categorizes dependent variables into five sub-on-farm adaptation strategies. This encompasses climate stress-tolerant varieties, crop shifting, altered sowing times, irrigation extension, and seed and fertilizer extension. These five adaptation strategies serve as dependent variables, while independent variables are grouped into eight categories: demographic, human capital, land-related, non-land assets and income, access to services, climate change, food security, and planned climate change adaptation strategies. Demographic variables include age, marital status, family structure, and dependency burden. Human capital variables encompass farming experience and education. Land-related variables consist of land size and ownership. Non-land asset and income variables are captured through an index. Access to services is represented by an index as well. Climate change, food security, and planned climate change adaptation strategies are also indexed, and constructed using Principal Component Analysis (PCA). The initial findings of the study indicate that male farmers demonstrate a higher level of confidence in embracing climate change adaptation strategies compared to their female counterparts. This discrepancy in confidence levels is influenced by several factors, including differential access to resources, educational opportunities, and societal roles. Historically, male farmers have enjoyed better access to information, technology, and financial resources, contributing to their increased confidence in implementing adaptation measures. The study also found that planned climate change adaptation strategies have a positive impact on autonomous climate change adaptations in both genders. Additionally, there are different kinds of interrelated barriers such as lack of access to services, and income that act as constraints hindering the adoption of climate change adaptation strategies.

The policy recommendations of the study based on the findings of the South Punjab (as a whole) are as follows:

- The planners should target the incentives through training and financial training to attract and encourage the younger farmers to pursue and improve the agriculture sector as the age of male and female farmers is negatively related to on-farm adaptation strategies.
- The married male and female have adopted the on-farm adaptation strategies so policymakers should encourage marriage among both genders so that they can adopt the on-farm climate change adaptation strategies with the help of consultation.
- The joint family system of male and female farmers is positively linked with on-farm climate change adaptation strategies so the policymakers should encourage and promote the joint family system within society to facilitate the adoption of on-farm climate change adaptation strategies through collaborative discourse among family members.
- The dependency burden harms on-farm climate change adaptation strategies so the government ought to alleviate this dependency burden to enable the adoption of on-farm climate change adaptation.
- The farming experience of male and female farmers is inversely related to the on-farm climate change adaptation strategies so the planners should target and mentorship and training programs that improve the experience of farmers to facilitate the knowledge and skills thereby enhancing the on-farm climate change adaptation strategies.

- With respect to education, the education of male and female farmers has a positive impact on on-farm adaptation strategies so the policymakers should enhance the educational opportunities among male and female small landholder farmers.
- Based on the land-related variables, the land size, land ownership and land quality index are positively linked with on-farm climate change adaptation strategies so the government should focus on enhancing the land size, land ownership and land quality among both male and female small-scale farmers.
- The non-land assets and income are positively linked with on-farm climate change adaptation strategies so the policymakers should introduce financial support programs aimed at enhancing access to non-land assets and diversifying income sources for farmers.
- Considering the access to services, the planners should focus on providing services such as credit, advice to farmers, etc.
- Male and female farmers share similar perspectives on climate change adaptation strategies based on their understanding of climate change. Given the positive impact of farmers' knowledge on climate change, the government should enhance climate change education through different channels.
- Food security is inversely related to on-farm climate change adaptation strategies among both male and female farmers policymakers should not enhance the food security to adopt the climate change adaptation strategies.
- Male and female farmers exhibit consensus regarding planned climate change adaptation strategies. Considering the positive influence of planned climate change adaptation strategies on on-farm climate change adaptation strategies, the government should implement planned climate change adaptation initiatives through various means of communication.

APPENDIX:

Table 3

On-Farm Climate Change Adaptation Strategies w.r.t Gender in South Punjab

Variables	Male					Female				
	On-Farm Adaptation Strategies					On-Farm Adaptation Strategies				
	Climate Stress Tolerant Varieties	**Shift to New Crops**	**Change in Sowing Time**	**Irrigation Extension**	**Seeds and Fertilizer Extension**	**Climate Stress Tolerant Varieties**	**Shift to New Crops**	**Change in Sowing Time**	**Irrigation Extension**	**Seeds and Fertilizer Extension**
	Demographics									
Age	-0.5866 (0.0005) [-0.1369]	-0.2332 (0.0045) [-0.0481]	-0.5896 (0.0003) [-0.1420]	-0.1114 (0.0001) [-0.0225]	-0.1435 (0.0826) [-0.0274]	-0.2806 (0.0008) [-0.0655]	-0.3892 (0.0825) [-0.0776]	-0.7681 (0.0025) [-0.1920]	-0.0503 (0.0000) [-0.0106]	-0.2176 (0.0002) [-0.0358]
Marital Status	0.4152 (0.0000) [0.0969]	0.2279 (0.0006) [0.0470]	0.7995 (0.0005) [0.1926]	1.8959 (0.0000) [0.3833]	0.1884 (0.0008) [0.0359]	0.4733 (0.0000) [0.1104]	0.4201 (0.0007) [0.0838]	0.8323 (0.0603) [0.2081]	0.1577 (0.0028) [0.0333]	0.2487 (0.0009) [0.0410]
Family System	0.3381 (0.0000) [0.0789]	0.1605 (0.0006) [0.0331]	0.1474 (0.0008) [0.0355]	0.4578 (0.0073) [0.0925]	0.4755 (0.0051) [0.0907]	0.3497 (0.0009) [0.0816]	0.1337 (0.0004) [0.0267]	1.0579 (0.0076) [0.2645]	0.8302 (0.0553) [0.1755]	1.0163 (0.0007) [0.1673]
Dependency Burden	-0.7800 (0.0020) [-0.1820]	-0.8325 (0.0270) [-0.1716]	-0.4039 (0.0004) [-0.0973]	-0.2872 (0.0001) [-0.0581]	-0.4261 (0.0092) [-0.0813]	-0.1435 (0.0007) [-0.0335]	-0.6424 (0.0003) [-0.1282]	-0.2723 (0.0082) [-0.0681]	-0.6320 (0.0041) [-0.1336]	-2.1860 (0.0088) [-0.3599]
	Human Capital									
Farming Experience	-0.1448 (0.0003) [-0.0338]	-0.1923 (0.0399) [-0.0396]	-0.5139 (0.0005) [-0.1238]	-0.4481 (0.0071) [-0.0906]	-0.4482 (0.0000) [-0.0855]	-0.3576 (0.0055) [-0.0834]	-0.7129 (0.0006) [-0.1422]	-0.2752 (0.0043) [-0.0688]	-0.1093 (0.0006) [-0.0231]	-0.8924 (0.0099) [-0.1469]
Education	0.4749 (0.0009) [0.1108]	0.4893 (0.0097) [0.1009]	0.1360 (0.0003) [0.0328]	0.5731 (0.0045) [0.1159]	0.6664 (0.0007) [0.1272]	0.7858 (0.0037) [0.1833]	0.1148 (0.0870) [0.0229]	0.2765 (0.0072) [0.0691]	0.1404 (0.0224) [0.0297]	0.4616 (0.0087) [0.0760]
	Land Related Variables									
Land Size	0.3624 (0.0010) [0.0846]	0.2438 (0.0001) [0.0503]	0.6445 (0.0144) [0.1552]	0.1666 (0.0022) [0.0337]	0.4081 (0.0052) [0.0779]	0.3222 (0.0041) [0.0752]	0.2286 (0.0490) [0.0456]	0.1899 (0.0214) [0.0475]	0.3282 (0.0022) [0.0694]	0.2824 (0.0122) [0.0465]
Land Owner	0.3059 (0.0002) [0.0714]	0.9132 (0.0096) [0.1882]	0.8130 (0.6141) [0.1958]	0.7879 (0.0000) [0.1593]	0.1666 (0.0005) [0.0318]	1.9618 (0.0034) [0.4577]	1.6126 (0.0001) [0.3217]	1.0999 (0.0350) [0.2750]	1.9449 (0.0043) [0.4110]	1.5515 (0.0776) [0.2555]
Land Quality Index	0.7841 (0.0002) [0.1829]	0.6135 (0.0016) [0.1265]	0.1820 (0.0083) [0.0439]	1.3240 (0.0034) [0.2677]	0.1922 (0.0005) [0.0367]	1.2774 (0.0006) [0.2980]	2.1634 (0.0069) [0.4316]	1.6214 (0.0937) [0.4054]	2.3327 (0.0534) [0.4930]	2.4367 (0.0612) [0.4012]
	Non-Land Assets and Income									
Non-Land Assets Index	0.5155 (0.0005) [0.1203]	1.1811 (0.0012) [0.2435]	0.1715 (0.0050) [0.0413]	1.0732 (0.0048) [0.2170]	0.5291 (0.1556) [0.1010]	0.6365 (0.0027) [0.1485]	2.4104 (0.0329) [0.4809]	0.3973 (0.1587) [0.0993]	3.0805 (0.0029) [0.6510]	0.4881 (0.0012) [0.0804]
Income	0.0115 (0.0004) [0.0027]	0.1065 (0.0418) [0.0220]	0.1078 (0.0182) [0.0260]	0.6757 (0.2416) [0.1366]	0.1185 (0.0230) [0.0226]	0.2453 (0.1764) [0.0572]	0.3367 (0.1076) [0.0672]	0.1014 (0.0033) [0.0254]	0.3609 (0.0603) [0.0763]	0.4358 (0.0260) [0.0718]
	Access to Services									
Access to Services Index	1.5012 (0.0003) [0.3502]	1.7819 (0.0000) [0.3673]	0.6241 (0.0014) [0.1503]	2.5909 (0.0000) [0.5238]	0.5924 (0.0002) [0.1130]	3.9993 (0.0041) [0.9330]	0.3806 (0.0004) [0.0759]	0.9979 (0.0076) [0.2495]	0.0583 (0.0095) [0.0123]	1.2015 (0.0056) [0.1978]
	Climate Change									
Climate Change Index	0.4151 (0.0080) [0.0968]	1.1698 (0.0000) [0.2411]	0.2787 (0.0996) [0.0671]	0.3760 (0.0445) [0.0760]	0.5302 (0.0008) [0.1012]	3.9704 (0.0000) [0.9263]	1.0877 (0.0005) [0.2170]	0.3880 (0.0095) [0.0970]	0.5575 (0.0304) [0.1178]	1.0722 (0.0084) [0.1765]
	Food Security									
Food Security Index	-1.1344 (0.0003) [-0.2647]	-0.3981 (0.3829) [-0.0821]	-0.8672 (0.0333) [-0.2089]	-0.9446 (0.0460) [-0.1910]	-1.8598 (0.0001) [-0.3548]	-0.0739 (0.0000) [-0.0172]	-6.5074 (0.0000) [-1.2982]	-2.0484 (0.0527) [-0.5121]	-0.0902 (0.0436) [-0.0191]	-0.4888 (0.0004) [-0.0805]
	Planned Climate Change Adaptation									
Planned Climate Change Adaptation Index	2.68399 (0.0008) [0.6262]	0.3736 (0.0001) [0.0770]	1.4556 (0.0038) [0.3506]	1.5132 (0.0030) [0.3059]	0.1894 (0.0000) [0.0361]	0.6292 (0.0091) [0.1919]	1.9272 (0.0000) [0.3845]	0.4847 (0.0012) [0.1212]	0.3770 (0.0092) [0.0797]	0.9463 (0.0000) [0.1558]

Table 4
On-Farm Climate Change Adaptation Strategies w.r.t Gender in Multan Division

Variables	Male					Female				
	On-Farm Adaptation Strategies					On-Farm Adaptation Strategies				
	Climate Stress Tolerant Varieties	**Shift to New Crops**	**Change in Sowing Time**	**Irrigation Extension**	**Seeds and Fertilizer Extension**	**Climate Stress Tolerant Varieties**	**Shift to New Crops**	**Change in Sowing Time**	**Irrigation Extension**	**Seeds and Fertilizer Extension**
	Demographic									
Age	0.0443 (0.0253) [0.0070}	0.0158 (0.0075) [0.0031]	0.0081 (0.4878) [0.0020]	0.0017 (0.0024) [0.0003]	0.0234 (0.0664) [0.0044]	0.0406 (0.0046) [0.0097]	-0.0396 (0.0078) [-0.008]	-0.0192 (0.4567) [-0.4567]	0.3649 (0.0079) [0.0853]	-0.3620 (0.0023) [-0.0715]
Marital Status	1.6085 (0.0118) [0.2544]	0.2437 (0.0776) [0.0491]	0.5477 (0.0007) [0.1314]	2.5424 (0.0007) [0.4796]	0.0643 (0.0044) [0.0120]	0.0880 (0.0924) [0.0209]	0.6085 (0.0308) [0.1290]	0.4299 (0.0018) [0.5818]	0.1856 (0.0001) [0.0434]	0.9304 (0.4607) [0.1839]
Family System	0.8614 (0.0079) [0.1362]	0.0402 (0.0872) [0.0081]	0.0044 (0.0063) [0.0011]	0.4645 (0.0000) [0.0876]	0.4185 (0.0017) [0.0783]	0.0714 (0.0002) [0.0170]	0.3628 (0.0402) [0.0769]	0.3375 (0.0036) [0.6536]	2.0065 (0.0449) [0.4692]	0.1497 (0.0067) [0.0296]
Dependency Burden	-0.8031 (0.0072) [-0.1270]	-0.2138 (0.0985) [-0.043]	-0.7973 (0.0087) [-0.191]	-0.2086 (0.0093) [-0.0393]	-0.9576 (0.0097) [-0.1792]	-0.2219 (0.0008) [-0.052]	-2.4476 (0.0203) [-0.518]	-2.0811 (0.0008) [-0.4308]	-3.9111 (0.0063) [-0.9146]	-2.7653 (0.0047) [-0.5466]
	Human Capital									
Farming Experience	0.0278 (0.0081) [0.0044]	0.0106 (0.4866) [0.0021]	0.0015 (0.0071) [0.0004]	0.0059 (0.0071) [0.0011]	0.0463 (0.0038) [0.0087]	0.0187 (0.0062) [0.0044]	0.1355 (0.0536) [0.0287]	-0.0392 (0.0007) [0.3607]	0.1112 (0.0756) [0.0260]	-0.0182 (0.0013) [-0.0036]
Education	0.1256 (0.0028) [0.0199]	0.0735 (0.0826) [0.0148]	0.0528 (0.0818) [0.0127]	0.0405 (0.0706) [0.0076]	0.0544 (0.0009) [0.0102]	0.0043 (0.0684) [0.0010]	0.1835 (0.1945) [0.0389]	0.0244 (0.0089) [0.8089]	0.3105 (0.0171) [0.0726]	0.2671 (0.0475) [0.0528]
	Land Related Variables									
Land Size	0.0604 (0.0072) [0.0096]	0.1948 (0.0053) [0.0392]	0.0945 (0.0410) [0.0227]	0.0042 (0.0403) [0.0008]	0.0577 (0.0006) [0.0108]	0.3071 (0.0047) [0.0731]	0.3817 (0.0061) [0.0809]	0.2534 (0.0959) [0.0959]	0.5255 (0.0093) [0.1229]	0.6088 (0.0116) [0.1203]
Land Owner	0.5289 (0.1267) [0.0836]	0.2685 (0.0882) [0.0541]	0.1029 (0.0011) [0.0247]	0.6846 (0.0359) [0.1291]	0.4431 (0.0045) [0.0829]	1.0253 (0.0019) [0.2439]	0.0989 (0.0632) [0.0210]	1.5319 (0.0075) [0.1975]	4.8047 (0.0100) [1.1235]	0.4363 (0.0066) [0.0862]
Land Quality Index	1.3435 (0.0062) [0.2125]	1.1521 (0.0171) [0.2322]	0.2655 (0.0014) [0.0637]	1.2361 (0.0049) [0.2332]	0.2671 (0.0036) [0.0500]	0.1118 (0.0063) [0.0266]	0.8654 (0.0554) [0.1835]	0.8604 (0.0064) [0.6400]	0.4070 (0.0082) [0.0952]	0.1036 (0.0084) [0.0205]
	Non-Land Assets and Income									
Non-Land Assets Index	0.1548 (0.0034) [0.0245]	1.0895 (0.0882) [0.2196]	0.2617 (0.0094) [0.0628]	0.9172 (0.1764) [0.1730]	0.8191 (0.0053) [0.1533]	0.2778 (0.1878) [0.0661]	4.5713 (0.0985) [0.9691]	1.0322 (0.0083) [0.4883]	6.0266 (0.0172) [1.4093]	4.4773 (0.0804) [0.8849]
Income	0.2316 (0.0395) [0.0366]	0.0936 (0.0044) [0.018]	0.1432 (0.0816) [0.0344]	0.0060 (0.0063) [0.0011]	0.0270 (0.0038) [0.0050]	0.1545 (0.0069) [0.0367]	0.8791 (0.0963) [0.1864]	0.4448 (0.0024) [0.1624]	1.3169 (0.0145) [0.3080]	0.4517 (0.0069) [0.0893]
	Access to Services									
Access to Services Index	0.3797 (0.0063) [0.0601]	1.5293 (0.0025) [0.3083]	0.2228 (0.0082) [0.0535]	2.1804 (0.0038) [0.4113]	0.5129 (0.0085) [0.0960]	4.6838 (0.0437) [1.1141]	1.3921 (0.0847) [0.2951]	0.4575 (0.0033) [0.7933]	0.9041 (0.0087) [0.2114]	4.6439 (0.0985) [0.9178]
	Climate Change									
Climate Change Index	0.7777 (0.0162) [0.1230]	0.1706 (0.7378) [0.0344]	0.1342 (0.0006) [0.0322]	0.7405 (0.0055) [0.1397]	0.6508 (0.1982) [0.1218]	2.3254 (0.0138) [0.5531]	0.4425 (0.0051) [0.0938]	2.0190 (0.0066) [0.1366]	3.9672 (0.0164) [0.9277]	1.7601 (0.0012) [0.3479]
	Food Security									
Food Security Index	2.1026 (0.0336) [0.3325]	1.7813 (0.0034) [0.3591]	1.0958 (0.0001) [0.2630]	1.6153 (0.0723) [0.3047]	1.4662 (0.0893) [0.2743]	2.6132 (0.0229) [0.6216]	9.1347 (0.0069) [1.9366]	3.3111 (0.0013) [0.1313]	4.8245 (0.0978) [1.1282]	4.8534 (0.0061) [0.9593]
	Planned Climate Change Adaptation									
Planned Climate Change Adaptation Index	0.1866 (0.0001) [0.0295]	1.2987 (0.0231) [0.2618]	2.0574 (0.0083) [0.4938]	2.4901 (0.0941) [0.4697]	1.8299 (0.0198) [0.3424]	2.9859 (0.0381) [0.7102]	1.9684 (0.0078) [0.4173]	0.6410 (0.0034) [0.1565]	0.6162 (0.0000) [0.1441]	0.4670 (0.0000) [0.0923]

Table 5
On-Farm Climate Change Adaptation Strategies w.r.t Gender in Bahawalpur Division

Variables	Male					Female				
	On-Farm Adaptation Strategies					On-Farm Adaptation Strategies				
	Climate Stress Tolerant Varieties	Shift to New Crops	Change in Sowing Time	Irrigation Extension	Seeds and Fertilizer Extension	Climate Stress Tolerant Varieties	Shift to New Crops	Change in Sowing Time	Irrigation Extension	Seeds and Fertilizer Extension
	Demographics									
Age	-0.0412 (0.0430) [-0.0064]	-0.0201 (0.0001) [-0.004]	-0.0193 (0.0094) [-0.004]	-0.0103 (0.0062) [-0.0022]	-0.0115 (0.0049) [-0.0023]	-0.4214 (0.0049) [-0.095]	-0.2665 (0.0022) [-0.045]	-0.0233 (0.0846) [-0.0058]	-0.0331 (0.0262) [-0.0062]	-0.2882 (0.0004) [-0.0466]
Marital Status	2.1733 (0.0086) [0.3353]	0.5050 (0.0076) [0.1073]	0.6493 (0.0092) [0.1574]	1.4752 (0.0056) [0.3187]	0.1186 (0.0089) [0.0235]	0.3781 (0.0044) [0.0853]	0.9381 (0.0028) [0.1603]	1.4576 (0.0888) [0.3644]	0.6684 (0.0057) [0.1253]	1.4778 (0.0965) [0.2392]
Family System	0.5215 (0.0039) [0.0805]	0.2656 (0.0081) [0.0564]	0.3385 (0.0037) [0.0820]	0.2868 (0.0086) [0.0620]	0.1266 (0.0066) [0.0251]	0.1953 (0.0048) [0.0441]	0.3686 (0.0032) [0.0630]	1.0400 (0.0916) [0.2600]	1.5649 (0.0117) [0.2934]	2.9836 (0.0657) [0.4829]
Dependency Burden	-0.0365 (0.0039) [-0.0056]	-0.9064 (0.0083) [-0.192]	-0.1469 (0.0031) [-0.035]	-0.0390 (0.0064) [-0.0084]	-0.5750 (0.0041) [-0.1138]	-3.1519 (0.0658) [-0.711]	-2.0463 (0.0018) [-0.349]	-0.4014 (0.0713) [-0.1003]	-3.3666 (0.0267) [-0.6312]	-11.3115 (0.0357) [-1.8309]
	Human Capital									
Farming Experience	-0.0172 (0.0076) [-0.0027]	-0.0103 (0.0024) [-0.002]	-0.0274 (0.0941) [-0.006]	-0.0052 (0.0017) [-0.0011]	-0.0370 (0.0384) [-0.0073]	-0.0624 (0.0295) [-0.0141]	-0.3756 (0.0009) [-0.064]	-0.0628 (0.0442) [-0.0157]	-0.1912 (0.0584) [-0.0359]	-0.0314 (0.0723) [-0.0051]
Education	0.0760 (0.0507) [0.0117]	0.0661 (0.0094) [0.0140]	0.0041 (0.0073) [0.0010]	0.0414 (0.0034) [0.0090]	0.0364 (0.0051) [0.0072]	0.2095 (0.0945) [0.0473]	0.1179 (0.0335) [0.0201]	0.1149 (0.0478) [0.0287]	0.1544 (0.0833) [0.0290]	0.3564 (0.0885) [0.0577]
	Land Related Variables									
Land Size	0.0869 (0.1851) [0.0134]	0.0505 (0.0005) [0.0107]	0.0462 (0.0041) [0.0112]	0.0071 (0.0012) [0.0015]	0.0248 (0.0056) [0.0049]	0.3587 (0.0437) [0.0809]	0.4375 (0.0591) [0.0748]	0.0754 (0.0596) [0.0189]	0.1468 (0.0815) [0.0275]	0.4356 (0.0508) [0.0705]
Land Owner	0.5928 (0.0876) [0.0915]	0.6027 (0.0559) [0.1280]	0.2601 (0.3709) [0.0630]	0.8032 (0.0113) [0.1735]	0.0278 (0.0084) [0.0055]	2.5955 (0.0258) [0.5855]	1.3046 (0.0449) [0.2229]	1.2913 (0.1216) [0.3228]	2.1071 (0.0892) [0.3951]	1.5672 (0.0386) [0.2537]
Land Quality Index	0.3039 (0.0046) [0.0469]	0.0912 (0.0068) [0.0194]	0.4559 (0.0068) [0.1105]	1.2364 (0.0979) [0.2671]	0.2436 (0.0067) [0.0482]	3.7182 (0.1235) [0.8388]	1.7334 (0.0488) [0.2962]	2.3824 (0.0765) [0.5956]	2.4335 (0.0306) [0.4563]	5.7431 (0.0111) [0.9296]
	Non-Land Assets and Income									
Non-Land Assets Index	0.1545 (0.0066) [0.0238]	1.3224 (0.0288) [0.2810]	0.1005 (0.0026) [0.0243]	1.2190 (0.0525) [0.2633]	0.0186 (0.0076) [0.0037]	0.3037 (0.0693) [0.0685]	3.7076 (0.1702) [0.6336]	1.5980 (0.0905) [0.3995]	7.8455 (0.0118) [1.4710]	2.6508 (0.0385) [0.4291]
Income	0.0531 (0.0095) [0.0082]	0.0137 (0.0015) [0.0029]	0.1036 (0.0067) [0.0251]	0.1158 (0.0067) [0.0250]	0.1631 (0.0839) [0.0323]	0.4237 (0.0025) [0.0956]	0.2169 (0.0918) [0.0371]	0.1997 (0.0371) [0.0499]	0.4789 (0.0451) [0.0898]	1.2111 (0.0180) [0.1960]
	Access to Services									
Access to Services Index	0.0341 (0.0045) [0.0053]	1.7380 (0.0119) [0.3693]	0.3715 (0.0059) [0.0900]	2.3871 (0.0008) [0.5156]	0.6988 (0.3034) [0.1383]	6.5746 (0.0337) [1.4831]	2.8217 (0.0027) [0.4822]	1.6917 (0.0233) [0.4229]	1.9891 (0.0837) [0.3730]	7.5567 (0.0514) [1.2232]
	Climate Change									
Climate Change Index	0.5378 (0.0232) [0.0830]	0.5431 (0.0047) [0.1154]	0.2810 (0.0098) [0.0681]	0.9418 (0.0546) [0.2034]	1.1380 (0.0189) [0.2253]	6.2385 (0.0027) [1.4073]	1.7899 (0.0104) [0.3059]	0.2090 (0.0567) [0.0522]	2.4819 (0.0926) [0.4654]	4.7807 (0.0220) [0.7738]
	Food Security									
Food Security Index	-1.2317 (0.0158) [-0.1900]	-0.5674 (0.4567) [-0.120]	-0.4937 (0.0081) [-0.119]	-0.8034 (0.3038) [-0.1735]	-1.3051 (0.0893) [-0.2583]	-3.1933 (0.0303) [-0.7204]	-5.4416 (0.0437) [-0.930]	-1.9788 (0.0003) [-0.4947]	-3.4046 (0.2780) [-0.6384]	-8.5691 (0.0555) [-1.3870]
	Planned Climate Change Adaptation									
Planned Climate Change Adaptation Index	1.9256 (0.0341) [0.2971]	1.6779 (0.0001) [0.3565]	0.7065 (0.0037) [0.1712	0.6651 (0.0000) [0.1437]	1.4721 (0.051) [0.2914]	2.6251 (0.0000) [0.592]	1.0933 (0.0000) [0.1868]	1.1665 (0.0031) [0.2916]	0.2911 (0.0046) [0.0545]	1.9188 (0.0000) [0.3105]

Table 6
On-Farm Climate Change Adaptation Strategies w.r.t Gender in DG Khan Division

Variables	Male					Female				
	On-Farm Adaptation Strategies					On-Farm Adaptation Strategies				
	Climate Stress Tolerant Varieties	Shift to New Crops	Change in Sowing Time	Irrigation Extension	Seeds and Fertilizer Extension	Climate Stress Tolerant Varieties	Shift to New Crops	Change in Sowing Time	Irrigation Extension	Seeds and Fertilizer Extension
	Demographics									
Age	-0.0824 (0.0046) [-0.0146]	-0.2366 (0.0006) [-0.048]	-0.8095 (0.5518) [-0.194]	-0.3734 (0.0450) [-0.0747]	-0.0129 (0.0008) [-0.0024]	-0.0407 (0.0061) [-0.009]	-0.0734 (0.0057) [-0.015]	-0.0521 (0.0075) [-0.0127]	-0.1188 (0.0417) [-0.0245]	0.7408 (0.0000) [0.0921]
Marital Status	1.6621 (0.0064) [0.2953]	0.5749 (0.0001) [0.1173]	0.9923 (0.0168) [0.2384]	2.8773 (0.0008) [0.5757]	0.7194 (0.1321) [0.1346]	0.8358 (0.0012) [0.1973]	1.7801 (0.0045) [0.3802]	0.2939 (0.0086) [0.0715]	0.1672 (0.0024) [0.0345]	0.4604 (0.0008) [0.0572]
Family System	0.3442 (0.0063) [0.0611]	0.2127 (0.0000) [0.0434]	0.0454 (0.0034) [0.0109]	0.7229 (0.0209) [0.1446]	0.8875 (0.0057) [0.1661]	0.7717 (0.0057) [0.1821]	1.3599 (0.0006) [0.2904]	1.3764 (0.0810) [0.3349]	1.2183 (0.0039) [0.2513]	0.6249 (0.6543) [0.0777]
Dependency Burden	-0.5638 (0.0023) [-0.1001]	-2.2015 (0.0002) [-0.449]	-0.2273 (0.0046) [-0.054]	-0.2956 (0.0068) [-0.0591]	-0.7182 (0.0033) [-0.1344]	-0.4136 (0.0097) [-0.097]	-6.7385 (0.0032) [-1.439]	-1.8268 (0.0057) [-0.4445]	-5.2944 (0.0073) [-1.0921]	-0.0742 (0.0020) [-0.0092]
	Human Capital									
Farming Experience	-0.0205 (0.0033) [-0.0036]	-0.3957 (0.0188) [-0.080]	-0.9886 (0.0096) [-0.237]	-0.2578 (0.0009) [-0.0516]	-0.0489 (0.0000) [-0.0092]	-0.0429 (0.0052) [-0.0101]	-0.0994 (0.0055) [-0.021]	-0.6240 (0.0097) [-0.1518]	-0.1457 (0.0319) [-0.0301]	-0.6231 (0.0430) [-0.0774]
Education	0.0939 (0.0106) [0.0167]	0.2990 (0.0005) [0.0610]	0.3791 (0.0076) [0.0911]	0.9527 (0.0124) [0.1906]	0.0725 (0.0054) [0.0136]	0.2031 (0.0073) [0.0479]	0.3881 (0.0635) [0.0829]	0.0953 (0.0443) [0.0232]	0.0810 (0.5894) [0.0167]	0.8392 (0.0071) [0.1043]
	Land Related Variables									
Land Size	0.0706 (0.0074) [0.0125]	0.0237 (0.6519) [0.0048]	0.8137 (0.0857) [0.1955]	0.3968 (0.0071) [0.0794]	0.1241 (0.0305) [0.0232]	0.6018 (0.0417) [0.1420]	0.4263 (0.0042) [0.0910]	0.3055 (0.0883) [0.0743]	0.4031 (0.0690) [0.0832]	0.4457 (0.0041) [0.0554]
Land Owner	0.3953 (0.2187) [0.0702]	0.2853 (0.0072) [0.0582]	0.5291 (0.0016) [0.1271]	0.7196 (0.0047) [0.1440]	0.2706 (0.0096) [0.0506]	4.7261 (0.0198) [1.1155]	0.9334 (0.0074) [0.1993]	1.7670 (0.0037) [0.4299]	2.6730 (0.1021) [0.5514]	0.5856 (0.0065) [0.0728]
Land Quality Index	0.4436 (0.0063) [0.0788]	0.0905 (0.0096) [0.0185]	0.2822 (0.0059) [0.0678]	1.4297 (0.0906) [0.2861]	1.0709 (0.0009) [0.2004]	0.0734 (0.9796) [0.0173]	3.2640 (0.0078) [0.6970]	1.0007 (0.0075) [0.2435]	2.3817 (0.0003) [0.4913]	0.2468 (0.0000) [0.0307]
	Non-Land Assets and Income									
Non-Land Assets Index	0.2461 (0.0039) [0.0437]	0.8719 (0.0094) [0.1779]	0.3198 (0.0086) [0.0768]	0.9694 (0.1852) [0.1940]	1.2960 (0.0732) [0.2425]	2.9320 (0.3900) [0.6920]	3.6891 (0.0079) [0.7878]	1.2710 (0.3783) [0.3092]	1.1016 (0.0071) [0.2272]	0.4694 (0.0054) [0.0583]
Income	0.0381 (0.0097) [0.0068]	0.1434 (0.0065) [0.0293]	0.1098 (0.0014) [0.0264]	0.1618 (0.0049) [0.0324]	0.3229 (0.0015) [0.0604]	0.7794 (0.1091) [0.1840]	1.0047 (0.0503) [0.2145]	0.1362 (0.0047) [0.0331]	0.3347 (0.0099) [0.0690]	0.6520 (0.0000) [0.0810]
	Access to Services									
Access to Services Index	0.7533 (0.0075) [0.1338]	2.1016 (0.0015) [0.4289]	0.4269 (0.0088) [0.1026]	2.8754 (0.0001) [0.5753]	0.2620 (0.0024) [0.0490]	3.4579 (0.0006) [0.8162]	3.4827 (0.1975) [0.7437]	1.3135 (0.0016) [0.3196]	0.8838 (0.0062) [0.1823]	0.3488 (0.0000) [0.0434]
	Climate Change									
Climate Change Index	1.0667 (0.0376) [0.1895]	0.3903 (0.0082) [0.0797]	0.5795 (0.0092) [0.1392]	1.6590 (0.0020) [0.3319]	1.4908 (0.0043) [0.2790]	7.4793 (0.0037) [1.7654]	0.6151 (0.0068) [0.1314]	0.7581 (0.0005) [0.1845]	0.6368 (0.0088) [0.1314]	0.1157 (0.0000) [0.0144]
	Food Security									
Food Security Index	-0.3547 (0.0071) [-0.0630]	-0.3258 (0.0003) [-0.066]	-1.3134 (0.0025) [-0.315]	-0.7321 (0.0013) [-0.1465]	-3.1105 (0.0003) [-0.5820]	-1.6147 (0.0009) [-0.3811]	-8.4672 (0.0207) [-1.808]	-2.3468 (0.0055) [-0.5710]	1.3210 (0.0039) [0.2725]	-0.1621 (0.0000) [-0.0202]
	Planned Climate Change Adaptation									
Planned Climate Change Adaptation Index	-1.7761 (0.0000) [-0.3155]	-1.0418 (0.0028) [-0.212]	-0.0473 (0.0069) [-0.011]	-0.1948 (0.0017) [-0.0389]	-2.7302 (0.0023) [-0.5108]	0.7086 (0.0001) [0.1673]	1.5495 (0.0075) [0.3309]	1.9355 (0.0079) [0.4709]	2.0052 (0.0041) [0.4136]	0.6598 (0.0000) [0.0118]

Acknowledgment

We extend our sincere gratitude to the Higher Education Commission (HEC) for generously funding this research project under Project No. 17123. Furthermore, we wish to acknowledge Ms. Anam Fida for her valuable contribution; this paper has been extracted from her PhD thesis. We appreciate the support and resources provided by the HEC, which have been instrumental in the completion of this study.

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