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Climate Change Adaptation, Food Security and Livelihood: A Case Study of Multan Division

Anam Khan[1], Muhammad Ramzan Sheikh[1*], Shakeel Ahmad[1], Muhammad Imran Mushtaq[1]

Affiliations
Bahauddin Zakariya University
Multan-Pakistan

*Corresponding Author Email:
ramzansheikh@bzu.edu.pk

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Abstract

The study examines the relationship between climate change adaptation, food security, and livelihoods in the Multan division. Data was collected from four districts, including Multan, Vehari, Khanewal, and Lodhran, for the year 2023. The study employed the Ordinary Least Squares (OLS) method to estimate the results, utilizing five regression models with five dependent variables: on-farm adaptation strategy, storage adaptation strategy, diversification adaptation strategy, common pooling adaptation strategy, and mobility adaptation strategy. The independent variables considered in the analysis encompassed age, male-headed households, joint family structure, dependency burden, farming experience, years of schooling, land size, land ownership, land quality index, non-land assets index, income, access to services index, climate change index, and food security index. This research contributes to understanding the interplay between climate change adaptation, food security, and livelihoods in the Multan division, offering valuable insights for policymakers and stakeholders in designing effective strategies for sustainable development.

Keywords: *Climate Change, Adaptation, South Punjab, Livelihood, Food Security*

JEL Classification: *D64, Q22, Q120*

1. Introduction

The process of adapting to the effects of climate change is of the utmost significance in view of the growing danger posed by this phenomenon. It is necessary to provide top priority to adaptation techniques that can aid society and ecosystems in coping with the impacts of climate change as global temperatures continue to rise and extreme weather events become more frequent and severe. This is because it is imperative to give top priority to adaptation techniques that can assist society and ecosystems in coping with the consequences of climate change. Adaptation techniques encompass a diverse array of activities, such as the development of resilient infrastructure, the improvement of emergency readiness, the development of environmentally friendly farming practices, and the protection of biological variety.

One of the most important aspects that contribute to the significance of climate change adaptation is the capacity to lessen the impact that climate change will have on vulnerable groups. The effects of climate change are felt most acutely in developing countries, particularly those that have little resources and a deficient level of infrastructure. These implications could include a decrease in agricultural production, an increase in the danger of natural disasters, and an increased scarcity of water. Developing effective adaptation measures, such as early warning systems, climate-resilient infrastructure, and social safety nets, will help to mitigate the negative consequences that climate change will have on communities that are particularly susceptible (UNFCCC, 2015).

Furthermore, protecting ecosystems and biodiversity requires adapting to climate change. Ecosystems offer a variety of services, such as carbon sequestration, water filtering, and habitat creation. Ecosystems are significantly disrupted as a result of temperature and precipitation changes brought on by climate change, which can result in habitat loss, species extinction, and ecosystem degradation. We may increase ecosystem resilience and foster their capacity to adjust to changing conditions by putting into practice adaptation techniques that concentrate on protecting and repairing ecosystems, such as reforestation and protected area management (IPCC, 2014).

A vital worldwide issue, food security includes the availability, use, and stability of food to guarantee that everyone has access to enough, safe, and nourishing food to lead healthy lives. It is crucial for several reasons. First off, public health and nutrition are directly related to food security. For human growth and development, especially in vulnerable groups like children, pregnant women, and the elderly (FAO, 2020), adequate access to nourishing food is essential. Malnutrition, stunted growth, impaired immune systems, and increased susceptibility to diseases are all consequences of inadequate food access (FAO, 2020; WHO, 2020). In order to improve global health outcomes and lessen the burden of diseases linked to malnutrition, food security must be promoted.

Second, socioeconomic development is significantly influenced by food security. People who have access to enough food can be useful members of society, which promotes economic growth and lowers poverty (FAO, 2020). People may concentrate on their education, skill development, and work prospects when they are not concerned about where their next meal will come from. This increases productivity and income levels. Food shortages and hunger can cause social discontent, conflicts, and migration, which makes food security important for social stability and peace (FAO, 2020).

Individuals' well-being and the growth of societies as a whole are reliant on their ability to earn a living. It includes how individuals earn a living and meet their fundamental needs, such as food, shelter, and healthcare. Economic security, social integration, and a sense of purpose are provided by a person's means of subsistence, which demonstrates the significance of this factor. According to Sen (1999), a means of subsistence enables individuals to escape poverty and enhance their standard of living, thereby fostering human capabilities and enhancing the quality of life as a whole. If a person or family has access to a consistent and sufficient income, they are in a better position to meet their fundamental requirements, make investments in education, and improve their health. According to Chambers and Conway (1992), this, in turn, contributes to the economic prosperity and social stability of the community.

In addition, having a means of subsistence is essential for promoting social cohesiveness and inclusion. People who do not fear for their financial futures are better able to contribute meaningfully to society, maintain meaningful relationships with others, and build social networks (DFID, 1999). It does this by building a sense of belonging and communal participation among individuals, which in turn helps to the general health and resilience of communities and individuals. In addition, sustainable professions give power to underprivileged groups such as women and young people by giving them access to economic opportunities and lowering their risk of being exploited and excluded (Ashley & Carney, 1999). According to the United Nations Development Programme (UNDP), 2015, livelihoods contribute to the elimination of inequities and the promotion of social justice, both of which are vital for sustainable development.

According to the Intergovernmental Panel on Climate Change (IPCC), climate change has the potential to affect food security by reducing the availability of water resources for irrigation, reducing crop yields, and increasing the frequency of parasites and diseases. Small-scale farmers, whose means of subsistence, including income and food supply, are directly threatened by these developments because agriculture is their primary source of income and sustenance. In addition, climate change can cause an increase in the

volatility of food prices, which can have an effect on both the ability of vulnerable populations to buy food and the availability of food (FAO, 2016).

To overcome these challenges, adaptation solutions to climate change are absolutely necessary to implement. According to the Intergovernmental Panel on Climate Change (IPCC), an adaptation strategy may include the implementation of climate-resilient agricultural techniques such as conservation agriculture and agroforestry. These activities increase soil fertility, water management, and crop variety. These approaches assist farmers in adjusting to the shifting weather conditions, which in turn helps them boost their income and their overall output. In addition, diversification of livelihoods beyond agriculture, such as through the development of non-farm enterprises or alternative income-generating activities, can increase resilience to the effects of climate change and reduce reliance on climate-sensitive sectors (FAO, 2016).

In a nutshell, the relationship between food security, livelihood, and climate change adaptation emphasizes the need for integrated approaches that address both agricultural productivity and the socioeconomic well-being of communities. Individuals and societies can increase their resilience, ensure food security, and sustain livelihoods in the face of climate change challenges by implementing adaptive strategies.

2. Review of Literature

Climate change poses significant challenges to global food security, necessitating comprehensive adaptation strategies. Table 1 provides a summary of studies that explore the intricate relationship between climate change adaptation, food security and livelihood.

Table 1: Summary of Studies on Climate Change Adaptation and Food Security

Author(s)	Country	Time period/ observation	Methodology	Measurement	Main Results
Wesche and Chan (2010)	Canada	Multiple methods and survey : 1997 to 2000 Food frequency interview, harvest calendars, 24-h recalls, social agricultural interviews	Comparative analysis technique	Consumption	Temperature, land, water, vegetation and wildlife (+)
Urama and Ozar (2011)	Central Africa	Questionnaire 1490 household participated in questionnaire Secondary data collected from 2005 to 2009	Mean, standard deviation, percentage scores.	Productive stage of life	Agricultural innovations, food security (+)
Sonag et al. (2011)	Kenya	Interviews and questionnaire	Indigenous knowledge strategies	Skill and Knowledge	Income, trade and knowledge (+) Price (-)
Hannah et al.(2013)	Mexico, west Africa, Himalayas, new Guinea, Sulawesi	The eco crop dataset, global biodiversity information facility	Multiple climate and emissions scenarios method	Investment priority	Poverty, agricultural production , ecosystem, international policy(+)

Rasul and sharma (2015)	South Asia	1990 to 2010	The development oriented approach Sectorial adaptation approach	-	Food security, water, energy (+)
Summary of Studies on Climate Change Adaptation and Livelihood					
Osbahr et al. (2008)	Mozambique	Qualitative data Data collected from 2003 to 2004 Quantitative data 1997-2001 in flooding 1983-1984, and 1994-2003 in drought	Mixed qualitative and quantitative technique	Investment	Drought, storm and flood, poverty, income and rural Livelihood (+)
Iwasaki et al, (2009)	India	Qualitative method 25 household in each community from November 2007 to December 2007	Sustainable livelihood approach (SLA)	Qualitative Analysis	Human capital, Natural capital, Financial capital, Social capital and physical capital (+)
Nuorteva et al.(2010)	Cambodia	Interviews held in2008 19 participants	Crosscut approach	Qualitative Analysis	Population , drought, flood, price (+)
Pouliotte et al. (2011)	Bangladesh	Interviews held in 2004 21 individual participated	Bottom-up approach	Qualitative Analysis	Income, Food, Safe Drinking water, Safety of property, Health (+)
Bryan et al.(2012)	Kenya	Interviews held July 2009 to February 2010 710 participants	Soil and water conservation techniques	Crop system simulation Model	Food security, profitability ,Greenhouse gas mitigation (+)
Summary of Studies on Climate Change Adaptation, Livelihood and Food Security					
Lambrou et al. (2013)	India	Questionnaire 190 individuals participated in survey	Chi- square method	Qualitative Analysis	Food security, livelihood (+) Gender inequality discrimination (-)
Boutin and Smit (2015)	Sub- Saharan Africa	Qualitative data	General circulation model	Qualitative Analysis	Food security and livelihood (+)
Funk et al. (2019)	India	Primary method 215 household participated in survey	Binary regression model	Qualitative Analysis	Education, HS, Livestock ownership, Poverty, Climate change awareness (+)
Shah et al. (2020)	Trinidad and Tobago	Primary method 138 household	OLS	Qualitative Analysis	Food security and Livelihood (+)

The study addresses several research gaps in the existing literature. Firstly, there is a lack of studies specifically focusing on the Multan Division, which limits our understanding of the unique challenges

and potential adaptation strategies in this region. By conducting a case study in Multan Division, this research contributes to filling this gap by providing valuable insights into the climate change adaptation, food security, and livelihood dynamics in the area. Secondly, while existing literature primarily focuses on on-farm adaptation strategies, this study aims to broaden the scope by examining a range of adaptation strategies including on-farm, storage, diversification, common pooling, and mobility. By considering multiple adaptation strategies, this research provides a more comprehensive understanding of the diverse approaches that individuals and communities employ to cope with climate change impacts and enhance their food security and livelihoods in Multan Division. Lastly, an additional research gap in the literature is the lack of studies that explicitly link climate change adaptation with food security and livelihood outcomes. This study seeks to bridge this gap by investigating the interrelationships between climate change adaptation measures and their impacts on food security and livelihoods in Multan Division. By examining these linkages, the study contributes to the broader understanding of how climate change adaptation strategies can enhance food security and livelihood resilience in the context of a specific region.

3. Data Source and Sampling Design

Data play a crucial part in the research process, acting as the basis on which every step are based. The goals of the research must be in line with data collecting as a deliberate task. Any research project must start with the crucial duty of gathering data, followed by careful data analysis and the subsequent interpretation of the findings. For the collection of data for this study, we have used primary sources. The data are collected from the small agricultural farmers of four districts of Multan division (Multan, Vehari, Khanewal and Lodhran).

An effective sample size determination method is needed because empirical research requires a representative statistical sample. Krejcie & Morgan (1970) created a sample size chart to fill the gap.

The formula for the determination of sample size is as follows:

$$s = X^2 NP(1-P) + d^2(N-1) + X^2 P(1-P) \tag{3.1}$$

where, X^2 is the table value of chi-square for 1 degree of freedom at the desired confidence level (3.841), N is the population size, P is the population portion (Assumed to be 0.50 since this would provide the maximum sample size) and d is the degree of accuracy expressed as a proportion (0.05).

We have determined the sample size by utilizing Krejcie & Morgan (1970) formula which suggests that 384 is the sample size to determine the sample size for a finite population of 1000000 or more. We have used proportional sampling to determine the sample size based on rural population as our study is related to agriculture sector. Following formulas is applied to find the proportional sample size:

$$S = \frac{Rural\ Population\ in\ district_i}{Total\ Population\ in\ Mul\tan Division} \times 384 \tag{3.2}$$

Table 2 presents an overview of sample size determination.

Table 2: Sample Size Determination

District	Rural Population	Sample Size (based on rural Population)	Sample Taken in Actual
Multan	1802103	1802103/6263028x384=110	120
Vehari	1754984	1754984/6263028x384=108	120
Khanewal	1704229	1704229/6263028x384=104	120
Lodhran	1001712	1001712/6263028x384=61	80
Total Population in Multan Division	6263028	384	440

4. Model Specification and Methodology

After collecting the data, the subsequent step involves employing suitable techniques to derive results. In this study, the analysis would be organized into two stages. The initial stage entails conducting a descriptive or preliminary analysis of the data, while the second stage involves performing multivariate analysis to determine the factors that affect the on farm, storage, diversification, common pooling and mobility diversification.

4.1 An Elementary Data Analysis

An elementary analysis of the data consists of the frequency and percentages analysis of the variables under study.

4.2 Econometric Analysis of the Determinants of Climate Change Adaptation

To explore the factors of climate change adaptation in Multan division, we have used five types of climate change adaptation strategies i.e., on farm, storage, diversification, common pooling and mobility adaptations. The impact on on-farm, storage, diversification, common pooling, and mobility adaptations is investigated using the ordinary least square (OLS) regression analysis.

Model 1: Determinants of On-Farm Adaptation Strategy

This model aims to predict the on-farm adaptation strategy based on several socio-demographic and economic variables.

$$OFA = f\left(AGE, MH, JF, DB, FEXP, YOS, LSIZE, LOWNER, LQI, NLAI, INC, ASI, CCI, FSI\right) \quad \textbf{(4.1)}$$

The econometric form of the model is:

$$\begin{aligned} OFA = {} & \beta_0 + \beta_1 AGE + \beta_2 MH + \beta_3 JF + \beta_4 DB + \beta_5 FEXP + \beta_6 YOS \\ & + \beta_7 LSIZE + \beta_8 LOWNER + \beta_9 LQI + \beta_{10} NLAI + \beta_{11} INC \\ & + \beta_{12} ASI + \beta_{13} CCI + \beta_{14} FSI + \varepsilon \end{aligned} \quad \textbf{(4.2)}$$

Model 2: Determinants of Storage Adaptation Strategy

This model aims to predict the storage adaptation strategy based on several socio-demographic and economic variables.

$$SA = f\left(AGE, MH, JF, DB, FEXP, YOS, LSIZE, LOWNER, LQI, NLAI, INC, CCI, FSI\right) \quad \textbf{(4.3)}$$

The econometric form of the model is:

$$\begin{aligned} SA = {} & \beta_0 + \beta_1 AGE + \beta_2 MH + \beta_3 JF + \beta_4 DB + \beta_5 FEXP + \beta_6 YOS \\ & + \beta_7 LSIZE + \beta_8 LOWNER + \beta_9 LQI + \beta_{10} NLAI + \beta_{11} INC \\ & + \beta_{12} ASI + \beta_{13} CCI + \beta_{14} FSI + \varepsilon \end{aligned} \quad \textbf{(4.4)}$$

Model 3: Determinants of Diversification Adaptation Strategy

This model aims to predict the diversification adaptation strategy based on several socio-demographic and economic variables.

$$DA = f\left(AGE, MH, JF, DB, FEXP, YOS, LSIZE, LOWNER, LQI, NLAI, INC, CCI, FSI\right) \quad \textbf{(4.5)}$$

The econometric form of the model is:

$$\begin{aligned} DA = {} & \beta_0 + \beta_1 AGE + \beta_2 MH + \beta_3 JF + \beta_4 DB + \beta_5 FEXP + \beta_6 YOS \\ & + \beta_7 LSIZE + \beta_8 LOWNER + \beta_9 LQI + \beta_{10} NLAI + \beta_{11} INC \\ & + \beta_{12} ASI + \beta_{13} CCI + \beta_{14} FSI + \varepsilon \end{aligned} \quad \textbf{(4.6)}$$

Model 4: Determinants of Common Pooling Adaptation Strategy

This model aims to predict the common pooling adaptation strategy based on several socio-demographic and economic variables.

$$CPA = f\left(AGE, MH, JF, DB, FEXP, YOS, LSIZE, LOWNER, LQI, NLAI, INC, CCI, FSI\right)$$

(4.7)

The econometric form of the model is:

$$\begin{aligned} CPA = {} & \beta_0 + \beta_1 AGE + \beta_2 MH + \beta_3 JF + \beta_4 DB + \beta_5 FEXP + \beta_6 YOS \\ & + \beta_7 LSIZE + \beta_8 LOWNER + \beta_9 LQI + \beta_{10} NLAI + \beta_{11} INC \\ & + \beta_{12} ASI + \beta_{13} CCI + \beta_{14} FSI + \varepsilon \end{aligned} \quad \textbf{(4.8)}$$

Model 5: Determinants of Mobility Adaptation Strategy

This model aims to predict the mobility adaptation strategy based on several socio-demographic and economic variables.

$$MA = f\left(AGE, MH, JF, DB, FEXP, YOS, LSIZE, LOWNER, LQI, NLAI, INC, CCI, FSI\right) \quad \textbf{(4.9)}$$

The econometric form of the model is:

$$\begin{aligned} MA = {} & \beta_0 + \beta_1 AGE + \beta_2 MH + \beta_3 JF + \beta_4 DB + \beta_5 FEXP + \beta_6 YOS \\ & + \beta_7 LSIZE + \beta_8 LOWNER + \beta_9 LQI + \beta_{10} NLAI + \beta_{11} INC \\ & + \beta_{12} ASI + \beta_{13} CCI + \beta_{14} FSI + \varepsilon \end{aligned} \quad \textbf{(4.10)}$$

Table 3 provides an overview of the variables used in our study, including their abbreviations, descriptions, and measurement methods.

Table 3: Variables: Abbreviation, Description and Measurement

Variables	Abbreviation	Description of Variables	Measurement
Dependent Variables			
On-Farm Adaptation	OFA	It represents the mean of two factors, with values ranging between 0 and 1.	Continuous
Storage Adaptation	SA	It represents the mean of two factors, with values ranging between 0 and 1.	Continuous
Diversification Adaptation	DA	It represents the mean of two factors, with values ranging between 0 and 1.	Continuous

Common Pooling Adaptation	CPA	It represents the mean of two factors, with values ranging between 0 and 1	Continuous
Mobility Adaptation	MA	It represents the mean of two factors, with values ranging between 0 and 1	Continuous
Independent Variables			
Age	AGE	Age of farmer (in years)	Continuous
Male Headed	MH	Either the farmer is the head of the family or not.	0 for No, 1 for yes
Joint Family	JF	Either the farmer live in a joint family or not.	0 for No, 1 for yes
Dependency Burden	DB	It is calculated by dividing the total numbers of non-earner to the total members of the household.	Continuous
Farming Experience	FEXP	How long a famer has been involved in farming activities.	Continuous
Years of Schooling	YOS	Number of years of schooling.	Continuous
Land Size	LSIZE	The physical size or area of land that is owned by farmer.	Continuous
Land Owner	LOWNER	Either the farmer is the owner of the land or not.	0 for No, 1 for yes
Land Quality Index	LQI	It represents the mean of four factors, with values ranging between 0 and 1.	Continuous
Non-Land Assets Index	NLAI	It represents the mean of four factors, with values ranging between 0 and 1.	Continuous
Income	INC	Monthly income of household measured in rupees	Continuous
Access to Service Index	ASI	It represents the mean of four factors, with values ranging between 0 and 1.	Continuous
Climate Change Index	CCI	It represents the mean of four factors, with values ranging between 0 and 1.	Continuous
Food Security Index	FSI	It represents the mean of four factors, with values ranging between 0 and 1.	Continuous

5. Results and Discussion

In this section, we present the comprehensive analysis and insightful discussions on the results obtained from our study. We delve into the key findings and their implications, shedding light on the significant patterns, trends, and relationships that emerged during our research.

Table 4 shows the factors that effect on-farm adaptation in Multan division and its four districts (Multan, Vehari, Khanewal, and Lodhran). The first variable is age that is positively associated with on-farm adaptation in all places except Multan district which is statistically significant in all areas expect Lodhran district, it means that if the age increases, the farmers adopt the climate tolerant varieties and shift to new crops or new method of cultivation. But in the Multan district, the farmer age is increase and they are not shifting for new crops and climate tolerant varieties because they adopted the old method of cultivation. The reason of positive association is that the old farmers are more experiences so that they are able to take the strong decisions about improving the cultivation methods so they shift their crops for the better growth of production. Old farmers have better access to financial resources and supportive labor, which can facilitate the adoption of climate- tolerant varieties and crop shifting practices. They are capable of investing in new seeds and modifying infrastructure or seeking advice from agricultural extension service (Enete and Anyekuru, 2011). While the reasons behind negative influences are, the older farmers have followed the old family traditions and have less believed on the latest techniques so

that avoid the method of shifting the crops (Brown et al., 2018).The old farmers have not aware about the recent techniques and innovations in agricultural methods so they are not adopting the high quality of seeds in the farm growth (Ali and Erenstein, 2017). The old age farmers are also risk- averse because they followed smooth and traditional methods (Funk et al., 2019). The other studies by (Ali and Erenstein, 2017; Brown et al., 2018; Funk et al., 2019) also found positive and negative relationship.

Table 4: Determinants of On-Farm Adaptation in Multan Division, Multan, Vehari, Khanewal and Lodhran Districts

Variables	Multan Division	Multan District	Vehari District	Khanewal District	Lodhran District
Constant	-.181 (.525)	-.283 (.000)	1.059 (.151)	-1.290 (.032)	-1.517 (.075)
Age	.003 (.003)	-.042 (.030)	.160 (.029)	.016 (.000)	.106 (.246)
Male Headed	.082 (.448)	-.089 (.528)	.071 (.096)	.455 (.067)	.109 (.252)
Joint Family	.169 (.000)	-.010 (.042)	.121 (.108)	.061 (.347)	.118 (.032)
Dependency Burden	.619 (.000)	-.009 (.041)	.122 (.042)	.045 (.762)	.117 (.083)
Farming Experience	.010 (.000)	.024 (.005)	.012 (.025)	.020 (.000)	.245 (.018)
Years of Schooling	.708 (.000)	.023 (.045)	.004 (.058)	.007 (.022)	.516 (.001)
Land Size	-.292 (.006)	-.037 (.085)	.017 (.007)	.019 (.044)	.242 (.097)
Land Owner	.101 (.069)	.050 (.055)	.283 (.067)	.173 (.007)	.465 (.040)
Land Quality Index	.166 (.032)	.148 (.087)	.317 (.064)	.128 (.089)	.353 (.039)
Non-Land Asset Index	.244 (.059)	.058 (.008)	.323 (.053)	.165 (.028)	.281 (.000)
Log of Income	.047 (.042)	.045 (.007)	.029 (.030)	.118 (.025)	.455 (.041)
Access to service Index	.064 (.088)	.057 (.006)	.058 (.009)	.362 (.023)	.657 (.025)
Climate Change Index	1.395 (.020)	.463 (.017)	.088 (.076)	.264 (.028)	.449 (.044)
Food Security Index	.313 (.000)	.179 (.058)	.051 (.085)	.284 (.042)	.239 (.000)
Model Summary					
R-Squared	.285	**.**208	.217	.234	.281

The male headed indicate that being in a male-headed household has a positive impact on on-farm adaptation excluding in Multan district. However, the coefficient is statistically insignificant in all areas expect Vehari and Khanewal district, it means that farmer is the male head in the family, farmer adopt the climate change tolerant varieties and shift to new crops strategies. In the Multan district, the farmer is the head of the family but they are not using the climate tolerant varieties and new method of cultivation because they have followed the culture and traditional method of cultivations. The reasons that provide incentive for positive association of the male head of the house hold have increased to adopt the adaptive strategies for climate shock so famers understand to shift their crops in adverse situation

(Abid et al., 2019). While the reasons that encourage negative association is that the famers as the male head, they use the traditional farming method and have been growing the same crop for generations may resist changing their practices. They may view crop shifting as unnecessary or risky (Brown et al., 2018). Our results are in line with the following studies (Brown et al., 2018; Abid et al., 2019).

The joint family defines that it has a positive impact on on- farm adaptation excluding in Multan district. The coefficient is statistically insignificant in Vehari and Khanewal district while in all area of Multan and Lodhran district, it means that if the family lives in the joint family system, the farmers adopt the climate tolerant varieties and shift to the new cultivation method. In the Multan district, the famer lives in joint family and they are not shifting the crops and climate tolerant varieties because they are not risk taker and also follow the smooth method for cultivation. The reasons that provide incentive for positive association are, in the joint family system, knowledge and experience about agricultural are often passed down through generations. Old family members who have experience with farming, they share their wisdom with younger farmers. So they share the information about crop shifting and the benefits of climate- tolerant varieties (Adzawla and Kane, 2019). In joint family system, there is often a larger labor available within the family. By adopting climate- tolerant varieties and practicing crop shifting, farmers are using new method of cultivation (Enete and Anyekuru, 2011). Farmer in a joint family system may be the more risk- averse as compared the individual farmers. They may prefer to stick to familiar crops and varieties that they have use to be successful in the past, rather than taking risk with new crops or adopting new varieties of crops. They have fear to losses the past benefit (Enete and Anyekuru, 2011). Our result is line with the following study (Enete and Anyekuru, 2011; Adzawla and Kane, 2019).

The next variable is dependency burden. The dependency burden has a positive impact on on- farm adaptation excluding in Multan district. However, the coefficient is statistically insignificant in Khanewal district expect all areas are significant. The dependence burden increases, the farmers adopt the climate tolerant varieties and shifting to the crops because they meet the family expense and achieves the better standard of living. But in the Multan district, they are not shifting the new crop and climate tolerant verities because they followed the cultural and traditional methods. The reasons that provide incentives for positive association is that farmers with high dependence burden, such as those who rely heavily on agriculture as their primary source of income or those with larger household to support, they feel stronger economic pressure to adopt strategies that can help ensure a stable crop production. Crop shifting and tolerant varieties are contributing to reduce the risk that is associated with climate change (Mardy et al., 2018). While the reason that encourages the negative association is, may be the farmers have limited resources and information and they are not financially strong to adopt the climate tolerant varieties and shifting the new crop strategy. Our result is line with the following study (Adzawla and Kane, 2019). Our result is line with the following study (Mardy et al., 2018; Adzawla and Kane, 2019).

The farming experience is the important variable. The farming experience has a positive impact on on-farm adaptation in all the areas. The coefficients are statistically significant in all the areas. The farmer experience increases, the farmers adopt the climate tolerant varieties and shift to new crops method for cultivation. The reasons that provide incentive for positive association are, experience farmers have spent many years in agricultural field so framers have great knowledge and skills in agricultural sector. This knowledge helps them to understand the benefits and risks associated with crop shifting and the use of climate tolerant varieties, making them more likely to adopt these practice (Kom et al., 2020). Framer with experience are more likely to have established relations and access to resources such as research and challenges related to crop shifting and climate tolerant varieties. These resources provide them with information, access to improve seeds related to crop shifting and climate- tolerant varieties. These resources help to enhance their adaptation of these practices (Savari and Zhoolideh, 2020). Our results are line with the following studies (Kom et al., 2020; Savari and Zhoolideh, 2020).

The year of schooling is relates to farmer education. The year of schooling has a positive impact on on-farm adaptation in all the areas. The coefficients are statistically significant in all the areas. In the family

year of schooling increases, so the farmers adopt the climate tolerant varieties and shift to the new crops. The reasons that provide incentive for positive association are, education provides farmers with access to information and knowledge about sustainable agricultural practices, climate change, and the benefits of crop shifting and climate- tolerant varieties. Farmers with higher levels of education, to be aware of the challenges about the climate change and understand the importance of adopting their farmer practices accordingly (Enete and Anyekuru, 2011). Our results are line with the following studies (Enete and Anyekuru, 2011).

The land size is important variable on on-farm adaptation. The land size has a positive impact on on-farm adaptation in all the areas except Multan division and Multan district. The coefficients are statistically significant in all the areas. It means that if the land size increases, the farmers adopt the climate change tolerant varieties and shift to the new crops or new method of cultivation. But in the Multan division and Multan district, the year of schooling increase but they are not adopting the old and traditional method of cultivation. The reasons that provide incentive for positive association is, the size of land increases, so the farmer has more space for the experiments. The farmer is using crop shifting activity and reduces the vulnerability of their agricultural system. Large land size provides the more portions of their land to various crops. And farmer is using the climate tolerant varieties such as high quality seed, water management system so it increases the crop productivity (Savari and Zhoolideh, 2021).While the reason that encourages the negative association is, the land size is larger so the farmer have not adopt the crop shifting activity due to less farming experience and they are not take risk to change the cultivation method (Bro, 2020). Our results are line with the following studies (Bro, 2020; Savari and Zhoolideh, 2021).

The land owner play important role in managing the land resources under the ownership. The land owner has positive impact on on-farm adaptation in all areas. The coefficients are statistically significant in all the areas. It means that if the land owner increases the farmers adopt the climate tolerant varieties and shift to the new crops. The reason is that landowners typically have great financial stability and investment capacity compared to farmers who do not own land. This financially stability and investment in new seeds, technologies for implementing crop shifting and adopting climate tolerant varieties (Tran et al., 2020). The land owners, who have a significant investment in their land, they manage the risk that is associated with climate change. The crop shifting and the use of climate tolerant varieties can help landowners the potential impacts of climate vulnerability on their agricultural production and protect the long-term productivity and also value their land (Bro, 2020).Our results are line with following studies (Tran et al., 2020; Bro, 2020).

The variable of land quality index is a comprehensive measure used to assess the quality of the land. The land quality index has positive impact on on- farm adaptation in all areas. The coefficients are statistically significant in all the areas. The land quality index increases that the farmer shifts to new crops for cultivation method and adopt climate tolerant varieties. The reason that provides incentive for positive association is that a higher land quality index better soil fertility, which is useful for successful crop cultivation. Fertile soils provide the necessary nutrients and organic matter that support healthy plant growth. When the farmers have access to high-quality land with fertile soils, they are more likely to have successful crop production and can consider shifting crop maximize productivity and adapt to changing climatic conditions (Ali and Erenstein, 2017).Our results are line with following study (Ali and Erenstein, 2017).

The tenth variable is non- land asset index. The non- land assets index has positive impact in the all the areas. The coefficients are statistically significant in all the areas. It means that if the non- land assets index increases that they are adopting the climate tolerant varieties and shift to the new crops for cultivation. The reasons that provide incentive for positive associations are, the non- land assets index means famer have own car, tube well, tractor and livestock that these facilities provide farmers financial capacity to invest in new agricultural practices. The Crop shifting and the adoption of climate tolerant varieties may initial investment in seeds, infrastructure and equipment's. Having a higher non-land assets

index allows farmers to allocate the resources that they make it easier for them to adopt these practices (Ali and Erenstein, 2017). The non- land assets can contribute to farmers overall risk management capabilities. Having a diverse set of assets can provide a safety during the periods of crop failure due to the climate change. The Farmers have with higher non-land assets to absorb shocks and enabling them to adopt the crop shifting and climate tolerant varieties that contribute the long term benefits (Abid et al., 2019). Our results are line with following studies (Ali and Erenstein, 2017; Abid et al., 2019).

The variable log of income is a fundamental aspect of financial well-being and refers to the earnings received by individuals. The log of income has positive impact in all areas. The coefficients are statistically significant in all the areas. It means that if the log of income increases that they are adopting the climate tolerant varieties and shift to the new crops. The reason is that higher income levels provide farmers with the financial capacity to invest in new crops and varieties. Shifting to different crops or adopting climate tolerant varieties often involves additional costs, such as purchasing seeds, new equipment's or implementing improved farming practices. With increased income, farmers can afford these investments and make the necessary changes in their farming systems (Ali and Erenstein, 2017).Our results are line with following studies (Ali and Erenstein, 2017).

The access to service index is used to access the availability and equality of essential services. The access to service index has positive impact in all areas. The coefficients are statistically significant in all the areas. It means that access of service index increases that farmers are shifting to new crops and adopt the climate tolerant varieties. The reasons that provide incentive for positive associations are that having access to well –maintain surfaced roads allows farmers to transport their products to markets more efficiently and at a lower cost. It reduces the transportation time, minimizes the product damage and expands the reach of their produce. This increased market access enables farmers to sell their products to a wider customer base, potentially leading to higher sale and profitability (Abid et al., 2019). Availability of information plays a important role in empowering farmers with knowledge about best practices market trends, weather patterns and government policies. This leads to improved farm management, pricing and market opportunities (Sujakhu et al., 2019).

The thirteenth variable is climate change index. The climate change index has positive impact in all areas. The coefficients are statistically significant in all the areas. The reason is that provide incentive for positive association is that the climate change index provides farmers with valuable information about the risks and impacts of climate change on their farming systems. It helps raise awareness about the need for adaptation and encourages farmers to understand the importance of crop shifting and ado[ting climate- tolerant varieties to reduce these risk (Kom et al., 2020).Our result is line with following study (Kom et al., 2020).

The last variable is food security index. The food security index has positive impact in all areas. The coefficients are statistically significant in all the areas. It means if the food security index increases that farmers are adopting climate tolerant varieties and shift to new crops for cultivation method. The reasons that provide incentive for positive association is that food security fulfill the basic necessities of poor people. The house hold encouraged the activities that reduced the level of poverty (Ndiritu and Muricho, 2021). In the barter activity system, farmers fulfill their need in the small scale level (Kom et al., 2020). Our results are line with following studies (Kom et al., 2020; Ndiritu and Muricho, 2021).

The value of R- square in Multan division model is 0.28 which means that about 28 percent variation in on-farm adaptation is explained by independent variables. In the Multan district model is 0.20 which means that about 20 percent variations in on-farm adaptation. In the Vehari district model is 0.21 which means that about 21 percent variations in on farm adaptation. In the Khanewal district model is 0.23 which means that about 23 percent variations in on-farm adaptation. In the Lodhran district model is 28 which means that about 23 percent in on farm adaptation.

Table 5 shows the factors that affect storage adaptation in Multan division and its four districts (Multan, Vehari, Khanewal, and Lodhran). The first variable is age that is positively associated with storage adaptation in all the areas. The coefficients are statistically significant in all the areas. It's meant that if the age increases that the farmers adopt the home-saved seeds and store their crops. The possible reasons of positive association are that older farmers often possess a wealth of traditional knowledge and experience accumulated over years of farming. They may have learned traditional practices of seed saving and crop storage from previous generations. This knowledge can be passed down and utilized to adopt home-saved seeds and effective crop storage techniques (Ali and Erenstein, 2107). Older farmers may have developed skills and technique for preserving seeds over time. They understand the importance of selecting, collecting and storing seeds from healthy and productive crops for future planting. Their experience and expertise in seed preservation can positively influence the adoption of home-saved seeds among younger generations of farmers (Funk et al., 2019). Our results are lines with following studies (Ali and Erenstein, 2107; Funk et al., 2019).

The male head in the important pillar of family refers to a situation where a male individuals assumes the primary leadership role within the family. The male head is positively associated with on storage adaptation in all the areas. The coefficients are statistically significant in all the areas except the Lodhran district. Its mean that if male as the head of the family that they are using home-saves seeds and storing their crops. The possible reason of positive association is that male head farmers may have greater access to information and training programs related to seed saving and crop storage. They can share this knowledge to implement improved techniques and share best practices within their farming community. By actively seeking and disseminating information, male head farmers can positively impact the adoption of these practices (Kom et al., 2020).

Table 5: Determinants of Storage Adaptation in Multan Division, Multan, Vehari, Khanewal and Lodhran Districts

Variables	Multan Division	Multan District	Vehari District	Khanewal District	Lodhran District
Constant	.600 (.036)	.599 (.091)	.487 (.050)	.271 (.063)	.932 (.091)
Age	.003 (.094)	.001 (.006)	.109 (.052)	.001 (.724)	.538 (.204)
Male Headed	.263 (.015)	.473 (.030)	.038 (.011)	.376 (.055)	.502 (.181)
Joint Family	.079 (.035)	.068 (.360)	.079 (.231)	.151 (.004)	.776 (.078)
Dependency Burden	1.395 (.020)	.076 (.008)	.044 (.004)	.133 (.255)	.960 (.000)
Farming Experience	.007 (.000)	.003 (.002)	.011 (.019)	.007 (.029)	.520 (.009)
Years of Schooling	.003 (.459)	.008 (.074)	.009 (.074)	.002 (.087)	.588 (.008)
Land Size	.012 (.017)	.021 (.040)	.004 (.043)	.003 (.089)	.647 (.108)
Land Owner	8.103 (.002)	.042 (.027)	.082 (.047)	.021 (.011)	.767 (.084)
Land Quality Index	.252 (.001)	.082 (.027)	.301 (.046)	.047 (.089)	.008 (.087)
Non-Land Asset Index	.380 (.000)	.500 (.000)	.038 (.093)	.048 (.056)	.434 (.071)
Log of Income	.065 (.000)	.030 (.017)	.067 (.005)	.120 (.005)	.400 (.001)

Access to service Index	.029 (.004)	.184 (.018)	.082 (.043)	.191 (.027)	.214 (.003)
Climate Change Index	-.034 (.007)	-.397 (.076)	-.100 (.088)	-.190 (.076)	-.555 (.004)
Food Security Index	.917 (.000)	.134 (.028)	.441 (.009)	.082 (.063)	.034 (.000)
Model Summary					
R-Squared	0.348	0.346	0.358	0.363	0.366

The joint family is essential variable because family members live together and share resources. The joint family is positively associated with storage adaptation in all the areas. The coefficients are statistically significant in all areas excluded Multan and Vehari district. It means that if the farmer's family lives in the joint family system that they are using home-saves seeds and storing their crops. The possible reasons of positive association are that in joint family system, different family members often bring diverse knowledge and skills to farming activities. Older generations may possess traditional knowledge of crops storage techniques, while younger members may have exposure to modern farming practices. The exchange of knowledge and skills within the family can enhance the understanding and implementation of effective crops storage and home- saving seeds methods (Tran et al, 2020)

The fourth variable is dependency burden. The dependency burden is positively associated with on storage adaptation in all areas. The coefficients are statistically significant in the entire areas excluded Lodhran district. It means that if the dependency burden increases that they are storing their crops and use their home-saved seeds. The possible reasons of positive association are that when farmers depend heavily on their own crops for income, they have a strong incentive to maximize the value of their harvested crops. This encourages them to invest time and effort in proper storage techniques to prevent spoilage, pest and quality degradation. By effectively storing their crops, farmers can ensure a steady supply of food for their households and maintain the availability of seeds for future planting (Tran et al., 2020). When farmers are heavily dependent on storing crops and using home- saved seeds, they are more likely to possess knowledge and skills related to proper storage techniques and seed selection. This knowledge can be passed down through generation, ensuring the continuity of traditional practices within farming household and community (Ali and Erenstein, 2017). The other studies by (Ali and Erenstein, 2017; Tran et al., 2020) also found positive relationship.

The farming experience encompasses the knowledge, skills and practical how-know gained through hands- on involvement in agricultural activities. The farming experience is positively associated with on storage adaptation in all areas. The coefficients are statistically significant in the entire areas. It's means that if the farming experience increases that they are storing their crops and use their home-saved seeds. The possible reasons of positive association are that with experience, farmers become better equipped to make informed decisions regarding crop storage, like weather pattern and pest prevalence. So they allocate resources effectively and make informed choices regarding when and how to store their crops and save seeds for future use (Kom et al., 2020). Experienced farmers often have a wider network of fellow farmers, agricultural experts or agricultural extension service. Through these networks, they can exchange information, share experiences and learn about new and innovative techniques for crop storage and seed saving (Emran et al., 2014). Our results are lines with following studies (Emran et al., 2014; Kom et al., 2020).

The years of schooling are essential variable. The year of schooling is positively associated with on storage adaptation in all areas. The coefficients are statistically significant in the entire areas except Multan division. Its mean that the year of schooling increases that farmer is storing their crops and using home-saved seeds. The possible reasons of positive association is that education enhances critical thinking and skills, enabling farmers to make informed decisions about seed selection, storage

techniques and post- harvest management. Farmers with higher level of education can evaluate different options, assess the benefits and risk of various practices and choose the most suitable method of storing their crops and utilizing home-saved seeds (Bro, 2020).

The land size plays a crucial role in determining the potential for various activities such as farming and land development. The land size is positively associated with on storage adaptation in all areas. The coefficients are statistically significant in all areas. The coefficients are statistically significant in the all areas except Multan division. It shows that if the land size increases that farmers are using their home-saved seeds and storing their crops. The possible reason of positive association is that farmers with larger land sizes often have access to more resource, including storage facilities and land for seed production. They can allocate a space for crop storage, such as ware houses, soils which helps ensure proper conditions for storing crops. Moreover, with more land size, farmers can allocate specific areas for seed production, allowing them to save and select high- quality seeds for future planting (Abid et al, 2019).

The variable of land owner plays crucial role in storage adaptation. The land owner is positively associated with on storage adaptation in all areas. The coefficients are statistically significant in all areas. The coefficients are statistically significant in all areas. It shows that if the land owner increases in the area so that farmer are using their home-saved seeds and storing their crops. The possible reasons of positive associations are that landowners typically have a long-term perspective on farming. Owning the land provides stability and security, allowing farmers to plan and invest infrastructure and storage facilities. With ownership, farmers are more likely to make long term commitments to their farming operations, including the adoption of practices that support proper crop storage and seed saving (Abid et al., 2019). Landowners have a direct stake in the profitability and sustainability of their land. They are motivated to implement practices that maximize the productivity and value their land. They are motivated to implement practices that maximize the productivity and value of their land over the long term. Storing crops properly and utilizing home-saved seeds aligns with this goal, as it reduce costs, maintains the availability of quality seeds and ensures a consistent supply of produce(Akinnagbe and Irohibe, 2014).Our results are lines with the following studies (Akinnagbe and Irohibe, 2014;Abid et al., 2019).

The land quality index is essential for storage adaptation. The land quality index is positively associated with on storage adaptation in all areas. The coefficients are statistically significant in all areas. It shows that if the land quality index increases so that farmer is storing their crops and using home-saved seeds for cultivation. The possible reason of positive association is that land quality directly affects are crop productivity. The high- quality land with fertile soil and adequate nutrients have support the better crop growth. When farmers have access to such type of land, they are more likely to have successful harvests, producing abundant crops for seed- saving purpose (Abid et al., 2019). The high- quality land often encourages the adoption of sustainable agriculture practices, such as organic farming. These practices promote of soil health and fertility. Farmers on land with good quality may be more inclined to implement sustainable practices, which align with the principles seeds- saving and proper crop storage (Akinnagbe and Irohibe, 2014). Our results are lines with the following studies (Akinnagbe and Irohibe, 2014; Abid et al., 2019).

The non- land assets index is a measure used to evaluate the assets possessed by individuals. The non-land assets index is positively associated with on storage adaptation in all the areas. The coefficients are statistically significant in all areas. It shows that if the non-land assets index increases so the farmers are storing their crops and use the home- saved seeds. The possible reason of positive associations is that the non- land assets index means farmer have own car, tube well, tractor and livestock that the ownership of tube well or other irrigation infrastructure enables farmers to have better control over water availability for their crops. Reliable irrigation systems contribute to consistent crop growth and yield, adequate water supply supports crop health and quality, making the stored crops and home-saved seeds more resilient (Ali and Erenstein, 2017).

The log of income is essential for the storage adaptation. The log of income is positively associated with on storage adaptation in all the areas. The coefficients are statistically significant in all areas. It means that log of income increases that the farmers are using their home-saved seeds and storing their crops. The possible reason of positive associations is that the higher income allows farmers to invest in infrastructure and facilities for crop storage. They can afford to build or purchase storage structures such as warehouses and cold storage facilities. Income enables farmers to maintain and improve these storage facilities over time, supporting effective crop storage practices. (Abid et al, 2019).

The access to service index is used to assess the availability, availability, quality and affordability of essential services. The access of service index is positively associated with on storage adaptation in all areas. The coefficients are statistically significant in all the areas. It means that if the service index increases so that farmers are storing their crops and using home-saved seeds because they are adopting the climate change strategies. The possible reason of positive associations is that a higher service index shows better access to knowledge and information related to seed saving and crop storage practices. Farmers have benefits from the organizations that gives the workshops and advice that provide them valuable information on effective seed- saving techniques and proper crop storage method (Abid et al, 2019).

The climate change index plays crucial role in storage adapttaion. The climate change index is negatively associated with on storage adaptation in all areas. The coefficients are statistically significant in all the areas. It means that if the climate change index increases so that farmers are not storing their crops and not using home-saved seeds because they are not adopting the climate change strategies. The possible reasons of negative associations is that that climate change can lead to increased temperatures and altered humidity pattern, which can negatively affect crop storage. The weather changes can create conditions to the growth of mold and fungi that is leading to spoilage and loss of seed viability (Kom et al., 2020).

The food security index is important variable in the storage adapttaion. The food security index is positively associated with on storage adaptation in all areas. The coefficients are statistically significant in all the areas. It shows that if the food security index increases so the farmers are using their home-saved seeds and storing their crops. The possible reason of positive associations is that home saved seeds play a vital role in maintaining seeds play a vital role in maintaining seeds security, which is essential for sustainable agriculture. A higher food security index shows that farmers have the resources and capacity to store and utilize home-saved seed security and reducing dependency on external seed sources (Ndiritu and Muricho, 2021).

The value of R-square in the Multan division model is 0.34 which means that about 34 percent variations in storage adaptation. In the Multan district model is 0.34 which means that about 34 percent variations in storage adaptation. In the Khanewal district model is 0.35 which means that about 35 percent variations in the storage adaptation. In the Lodhran district model is 0.36 which means that about 36 percent variations in the storage adaptation.

Table 6 shows the factors that affect diversification adaptation in Multan division and its four districts (Multan, Vehari, Khanewal, and Lodhran). The variable of age that is negatively associated with diversification adaptation in all the areas. The coefficients are statistically significant in all the areas except Khanewal and Lodhran district. It means that if the age increases, the farmers are not adopting the non-farm activities and they are not engaging in multiple income- generating activities. The possible reasons of negative association are that older farmer may experience reduced physical ability and energy compared to younger farmers. This can limit their capacity to engage in non-farm activities or income generating activities that require physical strength (Brown et al., 2018). Non – farm activities and certain income – generating activities often require the adoption and use of modern technologies. Old farmer may face challenges in adapting to new technologies due to limited familiarity (Funk et al., 2019). The other studies by (Brown et al., 2018; Funk et al., 2019) also found negative relations.

The male head can vary in different cultures and it increases the decision power. The male head is positively associated with on diversification except Multan division adaptation in all the areas. The coefficients are statistically significant in all the areas except the Multan district, Khanewal district and Lodhran district. Its mean that if the male is the head of the family so that they are engaging in non-farm activities. Farmers are also starting multiple income generating activities. The possible reason of positive association is that the male head farmer typically holds decision making authority within the household and farming operations. This authority allows him to allocate resources to income- generating activities and non- farm activities (Adzawla and Kane, 2019). Our result is line with the following study (Adzawla and Kane, 2019).

The third variable is joint family. The joint family is positively associated with diversification adaptation in all the areas. The coefficients are statistically significant in all areas excluded Multan and Vehari district. Its mean that if the farmer is living in joint family system so that they are engaging the non-farm activities and farmer engages in multiple income-generating activities. The possible reasons of positive association is that farmer in a joint family ensure that there is expertise and knowledge available to effectively manage agricultural activities. The farmer can employ modern farming techniques, crop selection and resources utilization to maximize agricultural productivity. So the family allocates their resources to other income generating activities (Adzawla and Kane,2019).

The dependency burden is decisive variable in the diversification adaptation. The dependency burden is positively associated with on diversification adaptation in all areas. The coefficients are statistically significant in the entire areas excluded Multan district. It means that if the dependency burden increases so that the farmers are engaging non-farm activities and farmers engages in multiple-generating activities to spread the risk across different products. The possible reason of positive association is that dependency burden means there is available labor force that can be utilized for both farming and non-farming activities. This labor availability enables the family to engage in diverse income- generating activities without the need to hire external workers. The farmer and other family members can contribute the skills and efforts to various sectors, expanding the scope of income generation (Mardy et al., 2018).Our result is line with the following study (Mardy et al., 2018).

Table 6: Determinants of Diversification Adaptation in Multan Division, Multan, Vehari, Khanewal and Lodhran Districts

Variables	Multan Division	Multan District	Vehari District	Khanewal District	Lodhran District
Constant	1.298 (.000)	-.283 (.071)	3.130 (.001)	.815 (.004)	-.294 (.056)
Age	-.004 (.084)	-.004 (.004)	-.206 (.006)	-.001 (.760)	-.001 (.842)
Male Headed	.161 (.191)	.133 (.017)	.226 (.000)	.256 (.334)	.023 (.271)
Joint Family	.331 (.084)	.010 (.893)	.112 (.216)	.033 (.033)	.118 (.000)
Dependency Burden	.066 (.186)	.177 (.003**)**	.101 (.063)	.015 (.023)	.088 (.018)
Farming Experience	-.085 (.017)	-.231 (.008)	-.005 (.081)	-.001 (.036)	-.003 (.092)
Years of Schooling	.129 (.092)	.002 (.004)	.007 (.023)	.763 (.002)	.025 (.046)
Land Size	-.236 (.028)	-.142 (.005)	-.002 (.075)	-.872 (.002)	-.005 (.011)
Land Owner	-.168 (.069)	-0.36 (.000)	-.124 (.013)	-.153 (.093)	-.122 (.062)

Land Quality Index	-.097 (.002)	-.123 (.042)	-.519 (.012)	-.401 (.014)	-.181 (.071)
Non-Land Asset Index	.050 (.000)	.020 (.005)	.290 (.049)	.462 (.002)	.102 (.090)
Log of Income	.124 (.041)	-.016 (.022)	.175 (.017)	.085 (.034)	.083 (.098)
Access to service Index	-.005 (.026)	-.084 (.053)	-.082 (.061)	-.068 (.087)	-.035 (.009)
Climate Change Index	.437 (.000)	.325 (.045)	.829 (.001)	-.575 (.003)	.796 (.016)
Food Security Index	-.319 (.000)	-.346 (.009)	-.142 (.030)	-.449 (.004)	-.589 (.020)
Model Summary					
R-Squared	0.247	0.265	0.286	0.266	0.278

The farming experience is essential for the diversification adaptation. The farming experience is negatively associated with on diversification adaptation in all areas. The coefficients are statistically significant in the entire areas. The possible reasons of associations are that farming requires significant time and effort, particularly during crucial seasons or when unexpected situations arise. The demands of farming can limit the time and resources available for pursuing non-farms activities. This could potentially hinder the family's ability to fully engage in or expand their non-farm activities (Kom et al., 2020). While farming experience with specialized knowledge and skills in agriculture, it may not directly translate to expertise in non-farm activities. Engaging and other income generating activities often requires skills set, market knowledge and management approach. The lack of expertise in non-farm sectors may create the challenges (Savari and Zhoolideh, 2020). Our results are line with the following studies (Kom et al., 2020; Savari and Zhoolideh, 2020).

The years of schooling plays important role in diversification adaptation. The year of schooling is positively associated with on diversification adaptation in all areas except Multan division. The coefficients are statistically significant in the entire areas. Its show that if the year of schooling increases so that the farmers adopts the non- farming activities and farmers engages in multiple income-generating activities to spread the risk across different products. The possible reason of positive association is that farmer education enhances the farmer's basic business and management skills. This includes skills related to budgeting, record-keeping and risk assessment. With these skills, farmers can better manage their finances, allocate resources effectively, and market strategic decision to maximize profitability in both farm and non- farm activities (Savari and Zhoolideh, 2020).

The land size is important role in determining land use and development potential. The land size is negatively associated with on diversification adaptation in all areas. The coefficients are statistically significant in all areas. Its mean that if the land size increases so that the farmers are not increasing to adopt the non-farming activities, farmers are not engaging in multiple income- generating activities. The possible reason of negative association is that farmer managing a larger land size requires more time, effort and resources. Farmers with larger landholding may need to prioritize their focus and allocate a significant portion of their resources to farming activities alone. This may limit their ability to diversify their income sources or invest in non-farmer activities due to resource constraints (Bro, 2020).

The land owner is a unique position of ownership and responsibility for a specific piece of land. The land owner is negatively associated with on diversification adaptation in all areas. The coefficients are statistically significant in all areas. Its mean that if the land ownership increases so that the farmers are not increasing to adopt the non-farming activities, farmers are not engaging in multiple income-generating activities. The possible reason of negative association is that farmers who own land may have specialization may benefit their farming activities; it may limit their expertise in non-farm sectors.

Engaging in diverse income generating activities often requires sill set, market knowledge, and management approaches. The lack of expertise in non-farm sectors may create challenges of such activities (Ali and Erenstein, 2017). Our results are lines with the following study (Ali and Erenstein, 2017).

The land quality index is a comprehensive tool that evaluates the quality of a piece of land for specific purpose. The land quality index is negatively associated with on diversification adaptation in all areas. The coefficients are statistically significant in all areas. It shows that the land quality index increases that the farmers are not increasing to adopt the non-farming activities; they are not engaging in multiple income- generating activities. The possible reasons of negatively associations is that land that is not suitable for farming, this can directly affect the income generated from farming activities, which in turn can impact the economic condition of the farming community. It reduced the agricultural income can then directly impact non- farming activities, as farmers may have less disposable income to spend on goods and services provided by non- farming sector (Ndiritu and Muricho, 2021).

The non- land assets index plays crucial role in diversification adaptation. The non- land assets index is positively associated with on diversification adaptation in all the areas. The coefficients are statistically significant in all areas. It means that if the non-land assets increases so that farmers are engaging the non- farm activities, they also engaging in multiple income generating activities. The possible reasons of positive associations are the non- land assets index means famer have own car, tube well, tractor and livestock that the non-land assets often involves gaining specialized knowledge and skills. Farmers with more education and training related to the non-farming activities such as machinery operation. This knowledge can be shared with other farmers, contributing to the overall agricultural development and facilitating the adoption of innovation practices (Ali and Erenstein, 2017).

The log of income plays essential role in the diversification adaptation. The log of income is positively associated with on diversification adaptation in all the areas except Multan division. The coefficients are statistically significant in all areas. It means that if the log of income increases so that the farmers are adopting the non-farm activities and they are also engaging multiple income- garneting activities. The possible reason of positive association is that higher farmer income can lead to increased demand for labor in non-farming sectors. As farmers spend more on goods and services, business in those sectors experience higher sale and growth. So it leads to the creation of new job opportunities reducing unemployment rates and providing additional income sources for the local community (Mardy et al., 2018).

The access to service index is provides the objective to measure to access the services that are vital for their well-being and quality of life. The access of service index is negatively associated with on diversification adaptation in all areas. The coefficients are statistically significant in all the areas. Its means that if the access the service index increases so that they are not adopting the income- garneting activities and they are also not engaging the non- farming activities. The possible reasons of negatively associations is that farmer take loan form the banks but that they high level of interest rate and other side farmers have less knowledge to get the loan opportunity. The different organizations are giving the advice about agricultural sectors. So, the farmers have no accessed to get this type of knowledge because these types of organization stats up their set up in the urban areas (Iwasaki et al., 2009).

The climate change index is a powerful tool for assessing the impacts of climate change on various aspects of the economy. The climate change index is negatively associated with on diversification adaptation in all areas except Khanewal district. The coefficients are statistically significant in all the areas. It means that if the climate change index increases so that farmers are adopting the non-farms activities and they are also engaging multiple income- garneting activities. But in Multan they are not adopting the income- garneting and non- farming activities. The reason is that farmers use the old and traditional methods of cultivation. The possible reasons of positive associations is that climate change can negatively affect agricultural productivity by altering temperature and patterns, causing shifts I pests

and diseases and impacting soil fertility. It reduces the crops yields and livestock productivity can directly impact farmer income, leading to decreases spending in non- farming sector (Kom et al., 2020).Our result are line with following study (Kom et al., 2020).

The food security index is a vital tool for measuring the availability, accessibility and affordability of food. The food security index is negatively associated with on diversification adaptation in all areas. The coefficients are statistically significant in all the areas. It means that if the food security index increases so that the farmers are not engaging the non-farms activities and not engaging the income- garneting activities. The possible reason of negative association is that in the situations where farmers struggle to attain food security, they may need to dedicate a significant amount of time and labor to agricultural activities. This leaves them with limited time and resources to engage in no- farming activities. The focus on food production and subsistence can reduce their ability to explore additional economic activity (Zurovec and Vedeld, 2019).

The value of R-square in the Multan division model is 0.24 which means that about 24 percent variations in diversification adaptation. Whereas in the Multan, Vehari, Khanewal, Lodhran districts it is 0.26, 0.28, 0.24, 0.26 percent variations in diversification adaptation.

Table 7 shows the factors that affect common pooling adaptation in Multan division and its four districts (Multan, Vehari, Khanewal, and Lodhran). The variable of age that is positively associated with common pooling adaptation in all the areas except Multan division and Multan district. The coefficients are statistically significant in all the areas. Its means that if the age increases so that the farmers use common resources such as forests, water or labor. The possible reason of positive association is that the older farmers often uses valuable traditional knowledge and practices that have been passed down through generations this knowledge can include sustainable land management techniques, water conservation methods or traditional forest management practice. Their experience and wisdom can contribute to sustainable utilization and preservation of common resources (Mardy et al., 2018).Our results are lines with following study (Mardy et al., 2018).

The variable of male head is essential in common pulling adaptation. The male head is positively associated with on common pooling adaptation in all the areas. The coefficients are statistically significant in all the areas except the Khanewal district and Lodhran district. It shows that if the male is the head of the family so that they are using common resources such as water, forest and labor. The possible reason of positive association is that the male head is valuable knowledge and skills related to resource management. It recognizing and valuing this diversity can contribute to more comprehensive and effective approaches to utilizing common resources sustainability (Ali and Erenstein, 2017). Our results are lines with following study (Ali and Erenstein, 2017).

Table 7: Determinants of Common Pooling Adaptation in Multan Division, Multan, Vehari, Khanewal and Lodhran Districts

Variables	Multan Division	Multan District	Vehari District	Khanewal District	Lodhran District
Constant	-.722 (.018)	-.847 (.054)	1.640 (.057)	.818 (.038)	.576 (.084)
Age	.004 (.040)	.006 (.007)	.103 (.060)	.002 (.337)	.021 (.595)
Male Headed	.283 (.015)	.059 (.095)	.702 (.001)	.064 (.689)	.012 (.076)
Joint Family	.007 (.192)	.013 (.068)	.275 (.002)	.027 (.029)	.035 (.343)
Dependency Burden	.099 (.036)	-.024 (.006)	.126 (.071)	.166 (.088)	.055 (.020)

Farming Experience	.004 (.055)	.008 (.082)	.102 (.034)	.104 (.010)	.021 (.085)
Years of Schooling	.010 (.073)	-.001 (.256)	.016 (.016)	.202 (.090)	.011 (.072)
Land Size	.088 (.000)	.013 (.041)	.005 (.063)	.405 (.035)	.023 (.048)
Land Owner	.062 (.048)	.022 (.037)	.283 (.235)	.460 (.002)	.046 (.035)
Land Quality Index	.002 (.066)	.210 (.044)	.292 (.042)	.031 (.052)	.013 (.077)
Non-Land Asset Index	.008 (.029)	.068 (.041)	.259 (.082)	.572 (.021)	.012 (.055)
Log of Income	-.044 (.071)	-.029 (.053)	-.098 (.060)	-.011 (.000)	-.017 (.036)
Access to service Index	-.257 (.001)	-.454 (.005)	-.236 (.091)	-.118 (.000)	-.010 (.027)
Climate Change Index	.368 (.001)	.517 (.007)	.046 (.052)	.084 (.008)	.407 (.001)
Food Security Index	.418 (.000)	.354 (.021)	1.111 (.000)	.021 (.008**)**	.125 (.046)
Model Summary					
R-Squared	.246	.245	.255	.265	.296

The joint family is essential variable. The joint family is positively associated with common pooling adaptation in all the areas. The coefficients are statistically significant in all areas excluded Multan division and Lodhran district. It shows that if the farmer is living in the joint family system so that they are using common resources such as water, forest and labor. The possible reason of positive associations is that in a joint family system, family members can share the labor and workload linked with resources management. This can transfer the burden on individual farmers and ensure that task related to water management, forest conservation, and labor- intensive activities are distributed among family members the collective effort can lead to more efficient resources utilization and conservation (Kom et al., 2020).

The dependency burden provides the quantitative measures of the non-working person in a family. The dependency burden is positively associated with on common pooling adaptation in all areas except Multan district. The coefficients are statistically significant in the entire areas excluded Lodhran district. Its mean that if the dependency burden increases so that the farmers are using the common resources such as water, forest and labor. The possible reason of positive association is that a non-working person in a farmer family can contribute to labor- intensive activities related to resources management. They can help with task such as maintain water infrastructure, implementing forest conservation measures and engaging in agricultural activities. The workload on other family members and enhance the overall efficiency of resources utilization (Abid et al., 2019).

The farming experience is essential for common pooling adaptation. The farming experience is positively associated with on common pooling adaptation in all areas except Multan division. The coefficients are statistically significant in the entire areas. Its means that if the farming experiences increases so that the farmers are using the common resources such as water, forest and labor. But in the Multan division, farmers are not using common resources because they moves from the technological filed. They are adopting the new technologies and strategies. The possible reasons of positive association is that farmers with experience have a deep understanding of local conditions, including water availability, soil type and climate patterns. This knowledge allows them to make informed decisions regarding water usage, forest conservation practices and labor management that are used to the specific

needs of the area. They can apply their knowledge to optimize resources utilization while minimizing negative impact (Wilson, 2013).

The next variable is years of schooling. The year of schooling is positively associated with on common pooling adaptation in all areas. The coefficients are statistically significant in the entire areas except Multan district. It means that farmers are using the common resources such as water, forest and labor. The possible reason of positive association is that a year of schooling provides individuals with knowledge about the important of resources conservation, environmental sustainability and impacts of human activities on natural system. With a higher level of education, farmers are more likely to be aware of sustainable practices and the potential consequences of sustainable resources use. They can apply this knowledge to make informed decisions regarding water management, forest and labor practices (Abid et al., 2019).

The land size plays crucial role in the common pooling adaptation. The land size is positively associated with on common pooling adaptation in all areas. The coefficients are statistically significant in all areas. It means that if the land size increases so that the farmers are using the common resources such as water, forest and labor. The possible reason of positive association is that farmers with larger land sizes may have more control over resources allocation and management decision. They may have the ability to strategically plan water usage, implement forest conservation measures and organize labor more effectively. However, the positive impact depends on how these resources are managed and sustainable practices are organized (Mubaya and Mafongoya, 2016).

The eighth variable is land owner. The land owner is positively associated with on common pooling adaptation in all areas. The coefficients are statistically significant in all areas except Vehari district. It means that if the land ownership increases so that farmers are using the common resources the water, forest and labor. The possible reason of positive associations is that farmers as the landownership to take a long term perspective and engaging in sustainable resources management. When farmer own land they cultivate, they are more invest in adopt sustainable water management techniques, wellbeing of the land for future generation (Abid et al., 2019).

The land quality index is essential because it is positively associated with on common pooling adaptation in all areas. The coefficients are statistically significant in all areas. It shows that if the land quality index increases so the famers are adopting the water, forest and labor. The possible reason of positive associations is that land ownership provides farmers with security of tenure, which can encourages them to make long term investments in resource management. When farmers have secure rights over their land, they are more likely to invest in soil conservation measures, protect water sources and implement sustainable labor practices. This sense of ownership can foster deeper commitment to responsible resources use (Wichern et al., 2019).

The non- land assets index is necessary because it is positively associated with on common pooling adaptation in all the areas. The coefficients are statistically significant in all areas. It shows that if the non-land assets index increases so that farmers are adopting the water, forest and labor. The possible reason of positive associations is that non- land assets index means famer have own car, tube well, tractor and livestock. So, non- land assets often enhance the farmer knowledge and develop new skills. This process of acquiring technical know-how can enhance farmers understanding of sustainable resources management practices. For using advanced equipment may necessary for training on proper maintains and operation, which can translate into better water and labor management practices (Mubaya and Mafongoya, 2016).

The next variable is log of income. The log of income is negatively associated with on common pooling adaptation in all the areas. The coefficients are statistically significant in all areas. It means that log of income increases so that farmers are not adopting the water, forest and labor. The possible reasons of negatively associations is that higher income farmers have the financial capacity to engage in more

intensive agricultural practices, which can have negative impact on common resources. If increased in water using for irrigation and extensive labor practices without adequate consideration for sustainable resources management can lead to environmental degradation and depletion of resources (Wilson, 2013).

The variable that is access to service index plays important role in the common pooling adaptation. The access of service index is negative associated with on common pooling adaptation in all areas. The coefficients are statistically significant in all the areas. It means that access to service index so that farmers are not adopting the common resources such as water, forest and labor. The possible reasons of negative associations is that farmers have the service capacity to engage in more intensive agricultural practices, which can have negative impact on common resources. If increased in water using for irrigation and extensive labor practices without adequate consideration for sustainable resources management can lead to environmental degradation and depletion of resources (Abid et al., 2019).

The variable climate change index is positively associated with on common pooling adaptation in all areas. The coefficients are statistically significant in all the areas. It shows that if the climate changes index increases so that farmers are using the common resources such as water, forest and labor. The possible reason of positive associations is that the farmer climate change index reflects farmer's ability to adapt to climate change and implement strategies to mitigate its negative effects. Farmers who are more aware of climate change risked and have higher adaptive capacities may more likely to adopt sustainable resource management practices. This can include efficient water usage, reforestation efforts and adopting climate- smart agricultural techniques (Mubaya and Mafongoya, 2016).

The last variable is food security index. The food security index is positively associated with on common pooling adaptation in all areas. The coefficients are statistically significant in all the areas. It means that if the food security index increases so that farmers are using common resources such as water, forest and labor. The possible reasons of positive associations is that farmers who focus on food security are often more connected to their local environment and possess valuable traditional knowledge about resource management. This knowledge can contribute to sustainable practices that promote the efficient use of water, responsible forest utilization and effective labor management (Wichern et al., 2019). The R-square values indicate the percentage of variation in common pooling adaptation explained by the models: 24% for Multan division and district, 25% for Vehari district, 26% for Khanewal district, and 29% for Lodhran district.

Table 8 shows the factors that affect mobility adaptation in Multan division and its four districts (Multan, Vehari, Khanewal, and Lodhran). The variable age is negatively associated with mobility adaptation in all the areas. The coefficients are statistically significant in all the areas except Khanewal district and Lodhran district. It means that if the age increases so that farmers are not resident in the local area. The possible reasons of positive association is that older farmers who are not local residents may have limited knowledge of the specific farming practices, local climate, soil conditions that influence agricultural production in the area. The lack of familiarity can reduce their farming techniques to suit the local context (Abid et al., 2019).

The variable male head is essential because it is positively associated with on mobility adaptation in all the areas. The coefficients are statistically significant in all the areas except the Lodhran district. If the farmer is head of the family so that farmer is local resident. The possible reasons of positive association is that being a local resident often means having a deep understanding of the local environment, climate, soil condition and farming practices. The local knowledge and experience can provide the farmer with valuable insights to the specific needs and challenges of the area, allowing them to make informed practices accordingly (Wilson, 2013).

Table 8: Determinants of Mobility Adaptation in Multan Division, Multan, Vehari, Khanewal and Lodhran Districts

Variables	Multan Division	Multan District	Vehari District	Khanewal District	Lodhran District
Constant	.802 (.011)	.352 (.055)	.914 (.094)	1.191 (.050)	2.691 (.006)
Age	.141 (.010)	-.003 (.002)	-.101 (.027)	-.324 (.331)	-.004 (.529)
Male Headed	.103 (.031)	.343 (.061)	.155 (.069)	.227 (.014)	.023 (.000)
Joint Family	.089 (.031)	.085 (.018)	.034 (.039)	.085 (.196)	.196 (.072)
Dependency Burden	.043 (.075)	.361 (.004)	.074 (.097)	.342 (.024)	.256 (.299)
Farming Experience	-.004 (.098)	-.005 (.003)	-.102 (.063)	-.105 (.013)	-.004 (.013)
Years of Schooling	.120 (.000)	.004 (.118)	.005 (.025)	.005 (.092)	.004 (.019)
Land Size	-.507 (.000)	-.011 (.016)	-.201 (.000)	-.487 (.000)	-.011 (.009)
Land Owner	-.010 (.035)	-.062 (.090)	-.213 (.274)	-.212 (.058)	-.149 (.078)
Land Quality Index	-.510 (.000)	-.428 (.027)	-.009 (.057)	-.612 (.000)	-.878 (.001)
Non-Land Asset Index	.180 (.028)	.197 (.005)	.128 (.019)	.126 (.003)	.005 (.079)
Log of Income	.064 (.012)	.043 (.011)	.015 (.091)	.034 (.003)	.227 (.006)
Access to service Index	-.159 (.020)	-.154 (.061)	-.013 (.032)	-.161 (.005)	-.036 (.006)
Climate Change Index	.300 (.006)	.495 (.046)	.619 (.003)	.296 (.002)	.209 (.017)
Food Security Index	-.054 (.050)	-.079 (.026)	-.757 (.000)	-.248 (.004)	-.130 (.098)
Model Summary					
R-Squared	.253	.251	.269	.245	.240

The next variable is joint family. The male head is positively associated with mobility adaptation in all the areas. The coefficients are statistically significant in all areas excluded Khanewal district. If the farmer is living in the joint family system so that farmer is the local resident. The possible reason of positive association is that in a joint family setup in the local resident have enhance the efficiency of the farmer. Because joint families often share resources such as land, tools and providing access to a boarder rage of agricultural resources (Budhathoki et al., 2020).

The dependency burden is positively associated with on mobility adaptation in all areas. The coefficients are statistically significant in the entire areas excluded Lodhran district. If the dependence burden increases so that farmer is the local resident. The possible reason of positive association is that non-working family members, such as elderly parents or young children, contribute to the emotional and social wellbeing of the family. Their presence provides a support system for the working members, which can positive impact their mental health and satisfaction (Pradhan et al, 2017).

The farming experience is positively associated with on mobility adaptation in all areas. The coefficients are statistically significant in the entire areas. If the farming experience so that farmer is local resident. The possible reason of positive association is that farmers with experience in farming have developed a deep understanding of the local environment, climate and soil conditions. This local expertise allows them to make informed decisions and adapt their farming practices to maximize productivity and sustainability (Abid et al., 2019).

The variable years of schooling plays a important role. The year of schooling is positively associated with on mobility adaptation in all areas except Multan district. The coefficients are statistically significant in the entire areas except Multan division. It means that if the year of school increases so that farmer is the local resident. The possible reasons of positive association is that year of education enhance the farmer skills and practices. If the farmer lives in the local area so the knowledge empowers them to make informed decision and adopt innovative activities (Budhathoki et al., 2020).

The next variable is land size. The land size is positively associated with on mobility adaptation in all areas. The coefficients are statistically significant in all areas. It means that if the land size increases so that the farmer is the local resident. The possible reasons of positive association is that the farmer live in the local area so the land size provides the farmer with increased the opportunities for agricultural production (Wilson, 2013).

The variable land owner is important because it is positively associated with on mobility adaptation in all areas. The coefficients are statistically significant in all areas except Vehari district. It means that if the land ownership increases so that farmer is the local resident. The possible reasons of positive associations is that farmer is the landowner in the local area so the farmers allow them in engage in long-term planning, making investment in their farming operations and access credit or financing (Pradhan et al, 2017).

The land quality index is positively associated with on mobility adaptation in all areas. The coefficients are statistically significant in all areas. It means that if the land quality index increases so that farmer is the local resident. The possible reason of positive associations is that land quality plays important role in enhancing the agricultural productivity. The high- quality land with fertile soil and water availability enhance the agricultural production (Abid et al., 2019).

The non- land assets index is positively associated with on mobility adaptation in all the areas. The coefficients are statistically significant in all areas. It means that if the non- land assets index increases so that farmer is the local resident. The possible reasons of positive associations is that non- land assets index means famer have own car, tube well, tractor and livestock. The farmer is living as a local resident in the area so the non- land assets can generate income through various means. The livestock can provide a regular source of income through sale of milk and related products. Increased the income from non- land assets enhances the farmers livelihood and overall well-being as a local resident (Wichern et al., 2019).

The log of income is positively associated with on mobility adaptation in all the areas. It shows that if the log of income increases so that farmer is the local resident. The coefficients are statistically significant in all areas. The possible reason of positive associations is that higher farmer income allows for increased purchasing power, enabling framers to spend more on goods and services within the local economy (Wilson, 2013).

The access of service index is negatively associated with on mobility adaptation in all areas. The coefficients are statistically significant in all the areas. It means that if the access of service index increases so that farmer is the not local residents. The possible reason of negative associations is that services such as agricultural programs and getting the advice from the organizations and loan facilities

are not access because the farmer is not living in the local area so the impact on farmer activities, income and overall living conditions (Pradhan et al, 2017).

The variable is climate change index is essential because it is positively associated with on mobility adaptation in all areas. The coefficients are statistically significant in all the areas. It shows that if the climate change index increases that farmer is the local resident. The possible reason of positive associations is that farmer who is living in the local area, so the farmer aware the climate change conditions. The farmer is using sustainable farming techniques, adopting water management strategies (Mardy et al., 2018).

The food security index is positively associated with on mobility adaptation in all areas. The coefficients are statistically significant in all the areas. It means that food security index increases so that farmer is the local resident. The possible reason of positive associations is that when farmers have food security, so it shows that farmer produces enough food to meet their own needs. So, the farmer selling their product to generates income. Food security can contribute to increased financial stability and livelihood opportunities for farmer (Abid et al., 2019).

The value of R-square in the Multan division model is 0.25 which means that about 25 percent variations in mobility adaptation. In the Multan district model is 0.25 which means that about 25% variations in the mobility adaptation. In the Vehari District model is 0.26 which means that about 26% variations in the mobility adaptation. In the Khanewal district model is 0.24 which means that about 24% variations in the mobility adaptation. In the Lodhran district model is 0.24 which means that about 24% variations in the mobility adaptation.

6. Conclusions and Policy Implications

6.1. Conclusions

The study aimed to examine the relationship between climate change adaptation, food security, and livelihoods in the context of the Multan division. The study collected the data from the small agricultural farmers of the four district of Multan division namely Multan, Vehari, Khanewal and Lodhran, and used the Ordinary Least Squares (OLS) method to estimate the results. The following five regression models are used, each with the unique dependent variables: on-farm adaptation strategy, storage adaptation strategy, diversification adaptation strategy, common pooling adaption strategy and mobility adaptation strategy. The dependent variables included a wide variety of variables, such as socio-demographic variables (age, male headed, joint family), farmer-related factors (farmer experience, farmer education), land-related determinants (land size, land owner, land quality index), non-land assets index, income, access to services index, climate change index, and food security index.

The findings of this study provide a substantial contribution to our understanding of the dynamics and nature determinants of agricultural adaptation to climate change. This study offers a thorough analysis that highlights the complex nature of farmer's reactions to climate change impacts by taking into account the five different adaptation techniques and their accompanying independent factors.

The results of the study provide several insights. First, the socio-demographic determinants of farmers are playing important role in determining the climate change adaptation strategies. Such as age, male headed and joint family all are the important factors for determining the adaptation techniques. The findings of the study suggest that the decisions of selecting the efficient adaptation methods are influenced by intra-household, age and headed of the household.

Secondly, the framer's related variables like experience of the farmers, and education of the farmers (measured by the years of schooling) are found the significant factors for determining the adaptation strategies. The farmer who has experience and highly educated are more likely to adopt the different adaptation strategies as compared to the uneducated and less experience farmers. It highlights the

importance of education and experience in the agriculture sector that enhances the farmers and empowered them to adopt the climate change adaptation strategies.

Thirdly, the study also used land related variables (such as size of the land, land owner, and land quality index) that play a significant role while deciding the climate change adaptation technique. The farmers who are the owner of the large land and have higher quality of land are more likely to engage in adaptation strategies as compared to those famers who are the owner of small land size and have lower quality land. Similarly, if the farmers are owner of the land then they are more likely to use the climate change adaptation strategies.

Furthermore, the study also indicates that the non-land assets index, income level of the farmers, and access to services index, are important determinants of farmer's climate change adaptation behavior. The farmers with greater non-land assets and higher income are more likely to adopt the diversification, common pooling and mobility adaptation strategies. And the farmers who easily access to services such as financial resources are more likely to adopt the on-farm and storage adaption strategies.

Moreover, the study also shows the role climate change index and food security in deciding the appropriate adaptation strategies. The selection and efficacy of various adaptation techniques is influenced by the climate change index, which quantifies the severity and frequency of climate-related difficulties, similarly, the food security index also plays a significant role for adopting the climate change strategy. The farmers who secure food are more likely to adopt the storage adaptation.

6.2 Policy Implications

The results of the study provide valuable insights for the government, policy makers and researchers to promote agriculture adaptation.

Policies to Promote the Climate Change Adaptation Strategies

The policy makers may have to focus on providing a specialized training and capacity building programs to the various age groups of the farmers.

- The government may implement gender-responsive policies and programs to encourage adaptation strategies by addressing the difficulties and possibilities encountered by faring households with males as the head of the family.
- The policy makers may have to implement the policies to promote the joint family system because on-farm adaptation, common pooling and storage adaptation is more likely to adopt by farmers living in the joint family system.
- In order to encourage farmers with high dependency burdens to embrace adaptation techniques, the government should establish and execute inclusive policies and programs that offer financial and technical support.
- In order to capitalize on farmer experience, the government should set up mentoring programs and knowledge-sharing networks. So that famers can get knowledge and experience to adopt adaptation strategies.
- The government should create and implement thorough education and training programs that improve farmer's expertise in climate-smart agricultural practices, promoting resilience and adaptability on the farm.
- To encourage and facilitate adaptation strategies, the government should create policies that offer incentives and support systems suited to farmers with small land size.
- The policymaker may establish the land quality improvement initiatives to the farmers to improve the quality of the land because famers with high quality land are more likely to adopt the adaptation strategies.
- The government should develop the financial incentives and policy to enhance the farmer's income, access to non-land assets and access to services to promote the adaptation strategies.

- The government should create and implement comprehensive agricultural policies that incorporate adaptation measures with an emphasis on raising food security by promoting sustainable farming methods, expanding market connections, and improving access to resource.

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Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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