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Agricultural Communities' Risk Assessment and the Effects of Climate Change: A Pathway Toward Green Productivity and Sustainable Development

Muhammad Tayyab Sohail[1]*, *Sohaib Mustafa*[2], *Mazurina Mohd Ali*[3]* and *Sidra Riaz*[4]*

[1]School of Public Administration, Xiangtan University, Xiangtan, China, [2]College of Economics and Management, Beijing University of Technology, Beijing, China, [3]Faculty of Accountancy, Universiti Teknologi MARA, Cawangan Selangor, Kampus Puncak Alam, Selangor, Malaysia, [4]Governance and Public Policy Department, National University of Modern Languages, Islamabad, Pakistan

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***Correspondence:**
Muhammad Tayyab Sohail
tayyabsohail@yahoo.com
Mazurina Mohd Ali
mazurina@uitm.edu.my
Sidra Riaz
sidra.riaz@numl.edu.pk

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This study was carried out to assess agricultural communities' understanding of climate change, the adaptation measures being undertaken against climate change, and industrial wastewater irrigation. It was considered important to check agricultural communities' understanding of climate change, as the majority of the study area belongs to the farming and industry sector. This study was based on primary data collected through a survey in the study area. The results of present study showed that agricultural communities with sufficient resources and assets consider themselves to be safer and more capable of coping with the negative effects of climate change. Agricultural communities used different techniques to deal with the impacts of climate change in present study area. This study produced findings about agricultural households' adaptation tactics that are unique and will aid policymakers in assisting agricultural communities in their day-to-day activities and farming practices, as well as in the implementation of proper monitoring and public policies to ensure integration and sustainability. This research is based on the sustainable livelihoods approach (SLA), which investigates how livelihood assets support agricultural communities by combining household adoption/adaptation strategies and livelihood outcomes.

Keywords: agricultural communities, climate change, adaptation techniques, Kasur, Pakistan

INTRODUCTION AND LITERATURE REVIEW

In the agricultural sector, one major challenge is the effect of climate change on agriculture. Inconsistent temperatures have been shown to alter crop respiration requirements, resulting in a shorter maturation period and a decrease in net growth and productivity. Increasingly, lives and livelihoods are being impacted by climate change, particularly in mountainous regions where much of the population may belong to ethnic minorities. A large majority of the population is unable to understand and interpret climate data, making them more vulnerable (Bogner et al., 2009; McDowell et al., 2014; Rehman et al., 2021), despite their best efforts. It is critical to access and implement adaptation measures to better understand farm households' beliefs, mitigation measures, and attitudes toward climate change (Singh et al., 2017; Ozturk et al., 2019). Studies have shown that

climate change has an enormous impact on farmers' lives (Field et al., 2012). The agricultural sectors of many countries face a serious threat from climate change, which necessitates the implementation of adaptation strategies to protect future agricultural production and the livelihoods of agricultural communities (Chandra et al., 2017; Amir et al., 2020; Sohail MT. et al., 2021). Water for irrigation is vital in Pakistan's agricultural sector (Fiaz et al., 2016; Sohail et al., 2019a); without it, the country's food production will be severely limited (Lee et al., 2020). The water used for agriculture is also applied to other uses in many countries; it provides nutrients that increase crop yields without using fertilizer, but it also contains organic compounds and heavy metals that can harm the environment, human health, and agricultural productivity, which must be taken into consideration when deciding what means to use in disposing of wastewater (Mahfooz et al., 2019; Sohail et al., 2019; Sohail et al., 2020). Canal water and wastewater are commonly used by agricultural communities, and wastewater is thought to have beneficial effects on crops (Yamin et al., 2015; Sohail et al., 2022b). Unsuitable wastewater can harm crops, soil, vegetables, and the environment, as well as human health (Hassan et al., 2013; Ullah et al., 2013; Lan et al., 2022). Some agricultural communities do not have or are running low on canal water. As a result, they turn to wastewater pumping as a substitute source of irrigation water (Anwar et al., 2010; Sohail et al., 2022a). This has gravely impacted Pakistan's crop production (Lobell and Gourdji, 2012). Its agricultural output, ecosystems, agricultural livelihoods, and food security have all suffered as a result of the country's growing climate vulnerability in recent years (Saeed et al., 2012; Akhtar et al., 2019). Pakistan is the seventh most vulnerable developing region to extreme weather to extreme weather in the world (Schilling et al., 2013). Because of the increased vulnerability and food insecurity that rural farm households face as a result of environmental hazards such as rising temperatures and irregular precipitation (Ozturk 2016; Fahad and Wang 2018; Jian et al., 2021; Fareed et al., 2022; Sohail et al., 2022b; Zhenyu and Sohail, 2022). The agricultural industry and rural communities will be hit harder by increasingly frequent extreme weather events in the future (Reidsma et al., 2015; Yen et al., 2017; Zhao et al., 2019; Jiang et al., 2021). Hence, timely and innovative adaptation measures and agricultural practices are needed to ensure sustainable development, poverty reduction, and food security (Zabel et al., 2014; Jezeer et al., 2019). It is difficult to find research on how farm households in developing countries like Pakistan are adapting to climate change. This study conducts an investigation into the decision-making processes of agricultural communities regarding climate change adaptation. It takes into account the importance and adverse situation in the study area as well as current research gaps. This research is based on the sustainable livelihoods approach (SLA), studying how livelihood assets support agricultural communities by combining household adoption/adaptation strategies and livelihood outcomes (Shinbrot et al., 2019). Our main research question is the following: How important is it to investigate of agricultural communities' risk assessment and adaptation techniques in response to the effects of climate change? The objectives of this study were to analyze i) agricultural communities' perceptions toward climate change, ii) their adaptation techniques in response to the effects of climate change, and iii) their livelihood assets and life status in the Kasur district of Pakistan.

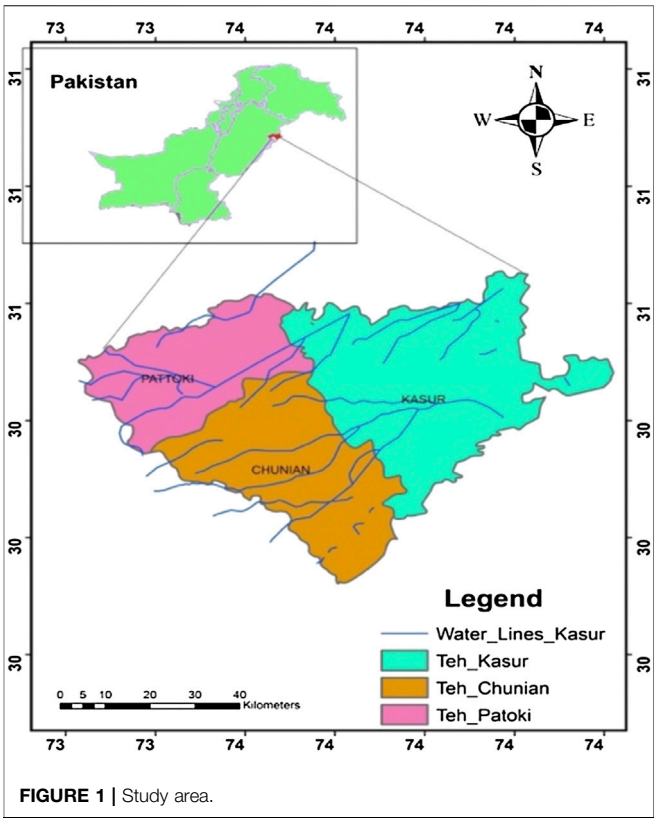

FIGURE 1 | Study area.

METHODOLOGY

Study Area and Data

This study was carried out in one of agriculture area Kasur in Punjab Province Pakistan, Pakistan's most populous and second-largest province. Kasur has a more than 1,000-year history. During the period of the Indus Valley Civilization, the Kasur region was an agricultural region with forests. It had a population of 3,454,881 people at the time of the 2017 census, with 1,788,617 men and 1,666,044 women. The population of this area was 2,564,101 rural and 890,780 urban (Pakistan Bureau of Statistics, 2017). In the Kasur district, the Bambawali-Ravi-Bedian Canal was built, boosting the area's agricultural development. Commercial and industrial development has occurred, but the area remains primarily agricultural. The district's farmland covers 393,000 ha, with about 295,000 ha under cultivation. Rice, cotton, sugarcane, wheat, and fodder are among the main crops grown in the district. The district features a sub-tropical climate and vegetation, making it unsuitable for horticulture development, except for certain areas in the southwest of the district, near Patoki, where a large number of nurseries have sprouted. However, these nurseries do not have a

TABLE 1 | Demographic information/livelihood assets of agricultural communities.

Features	Value	Demographic Information			Livelihood Assets				
		Kasur District			Features	Value	Kasur District		
		Kasur %	Chunian %	Patoki %			Kasur %	Chunian %	Patoki %
Gender	Male	83	70	85	Tractor/plow	No	84	55	60
	Female	17	30	15		Yes	16	45	40
Age (years)	18–25	10	12	8	Bicycle	No	25	19	12
	26–35	40	39	42		Yes	75	81	88
	36–45	25	18	19	Motorbike	No	35	55	45
	46 and above	25	31	31		Yes	65	45	55
Education (years)	0–5	10	8	5	Tube well	No	25	35	70
	6–10	71	24	45		Yes	75	65	30
	11 and above	19	68	50	Spraying device	No	10	14	65
Family members	0–2	16	7	4	Yes	90	86	45	
	3–5	27	28	30	Electric generator	No	100	92	97
	6–8	32	44	46		Yes	0	8	3
	9 and above	25	24	19	Automobile	No	90	86	100
Farming experience (years)	1–5	30	28	35	Yes	10	14	0	
	6–10	46	60	63	Air conditioner	No	100	88	85
	11 and above	26	12	2		Yes	0	12	15
Ploughing technique	Tractor	80	100	84	Gas generator	No	99	94	92
	Bullocks	16	0	6		Yes	1	6	8
	Both	4	0	10	Television (TV)	No	4	1	2
Information bases	Social Media/TV	22	16	29	Yes	96	99	98	
	Friends	60	70	72	Livestock	No	0	0	0
	Own views	10	11	20		Yes	100	100	100
	Do not know	8	3	0	Pests	No	15	0	20
Awareness of climate change	Yes	60	75	55	Yes	85	100	80	
	No	40	25	45	Number of respondents (Total = 800)		280	350	170

market within the district and primarily serve the needs of Lahore (**Figure 1**). The results of this study may be of use for other agricultural countries. In this study, agricultural communities' experiences with climate change, the use of wastewater irrigation, and climate change adaptation techniques were examined (Sohail M. et al., 2021). Based on existing literature, a semi-structured questionnaire was developed and adapted to collect data in Kasur Punjab Pakistan (Teh. Kasur, Teh. Chunian, and Teh. Patoki) (Fahad and Wang, 2018; Fahad et al., 2020; Sohail et al., 2022a). Ethics in basic research were taken into account when defining the research goals and collecting data from agricultural communities, and the research goal was clearly explained to agricultural communities (Resnik et al., 2015). Furthermore, agricultural communities were made aware that the information they provided would only be used for research and that they were not obligated to provide any answers (Bell et al., 2005; Rasool et al., 2017; Mustafa et al., 2022; Rehman et al., 2022; Ullah et al., 2022; Atchike et al., 2022). This instrument contained a brief introduction to the study's purpose, followed by a demographic questionnaire to determine the participants' ages, occupations, and other relevant information. The remainder of the questionnaire is focused on irrigation methods and agricultural communities' livelihoods. As part of this research, a pre-test was performed on all 800 completed questionnaires to ensure that the data was accurate and free of inconsistencies. SPSS 25 was used to analyze the data that had been gathered (regression).

RESULTS AND DISCUSSION

Table 1 shows the 800 agricultural communities sampled in this study from the District Kasur Punjab Province of Pakistan (in Teh. Kasur, Teh. Chunian, and Teh. Patoki). Personal characteristics, circumstances, and farming practices define individual agricultural communities' responsiveness and adaptation potential (Bryan et al., 2013; Qasim et al., 2015; Sohail et al., 2022b). **Table 1** also presents demographic information on the agricultural communities in these three tehsils of the Kasur District in Punjab province: the participants from Tehsil Kasur were 83% male and 17% female, those from Tehsil Chunian were 70% male and 30% female, and those from Tehsil Patoki were 85% male and 15% female. Most members of agricultural communities in the selected tehsils of the Kasur District were young, experienced, and energetic in agriculture. The majority of respondents were

TABLE 2 | Industry waste water use (irrigation).

Features	Value	Kasur District		
		Teh. Kasur (%)	Teh. Chunian (%)	Teh. Patoki (%)
Irrigation (water use)	Fresh	20	15	25
	Industry wastewater	60	65	65
	Both	20	20	10
Industry wastewater cheaper fertilizer than conventional fertilizer	Yes	70	60	55
	No	30	40	45
	Increase crop production	10	15	10
	All of the above	61	65	50
Potential hazards caused by industry wastewater (knowledge)	Yes	45	70	25
	No	55	30	75
Family members suffering from any disease?	Yes	18	9	15
	No	82	91	85

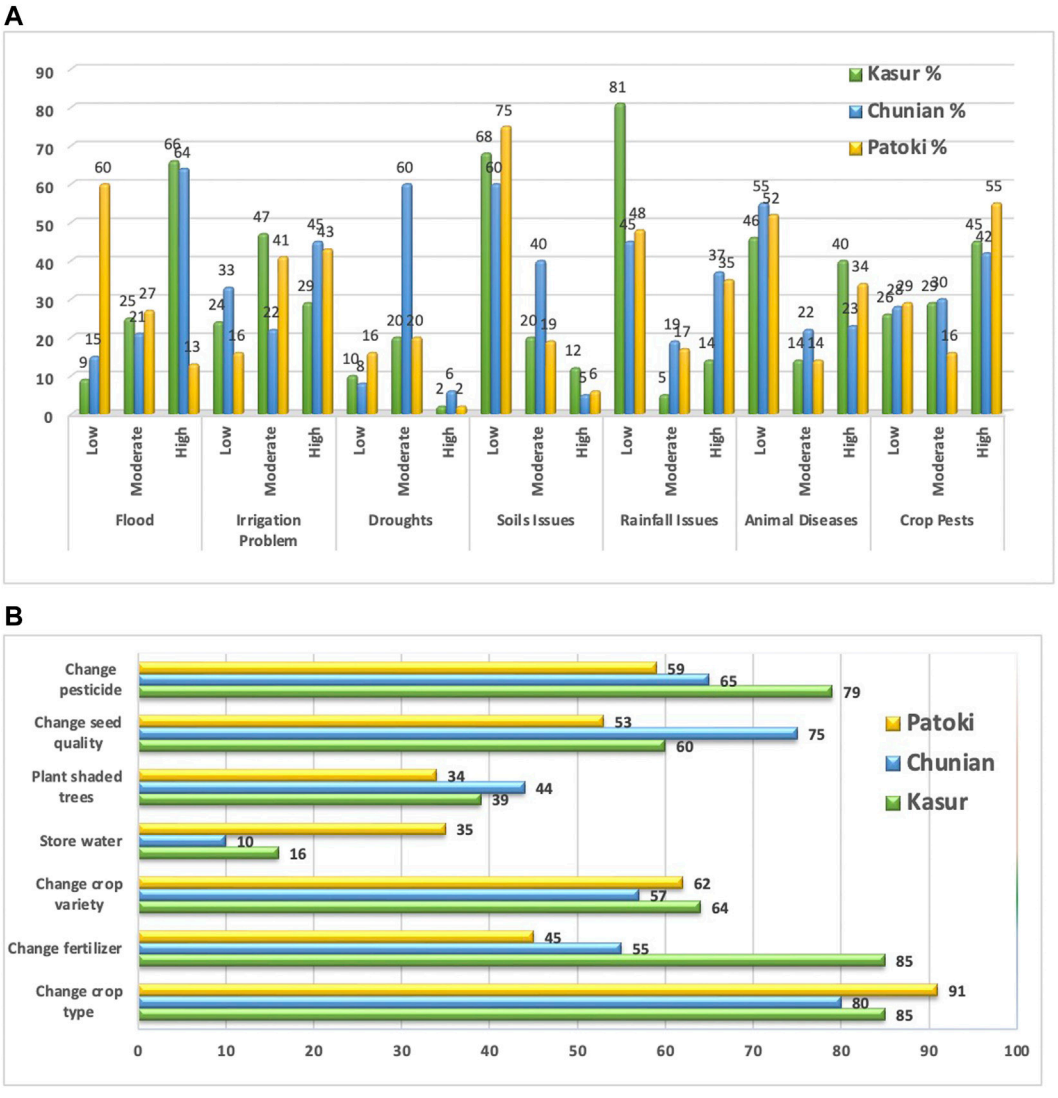

FIGURE 2 | (A) Agricultural Communities' Determining factor of Climate Change (%) **(B)**: Adaption strategies/measures (%) by Agricultural Communities'.

TABLE 3 | Linear regression.

Coefficients			
Variables	**Standardized Coefficients**	**t**	**Sig**
	Beta		
Animal disease	0.153	2.341	0.003***
Soils issues	0.044	4.245	0.000***
Droughts	0.132	7.632	0.000***
Flood	0.073	3.122	0.045**
Crop pests	0.035	0.644	0.000***
Storage water for irrigation	0.124	5.464	0.000***
Potential hazards caused by industry wastewater irrigation	0.178	5.662	0.000***

*Dependent variable: agricultural communities' adaptation strategies; significance levels: *p ≤ 0.10; **p ≤ 0.05; ***p ≤ 0.01.*

uneducated, and their level of education was low; the majority had only primary education, while some had more than 6 years of education. The majority of the agricultural communities were seasoned, with some having about 10 years of experience in the field. According to Mehmood et al. (2021), farmer's awareness has a significant relationship with education and farming experience. Most families in agricultural communities in the Kasur District are large. The majority of respondents plowed their land with a tractor, while some used bullocks, and a small group used both methods. The majority of people in the agricultural communities received information about farming from their friends, particularly from older agricultural communities in the area. The awareness of climate change in agricultural communities was also identified in a survey item. The results showed that 60%, 75%, and 55% of respondents in Kasur, Chunian, and Patoki, respectively, were well aware of climate change (**Table 1**). Agricultural communities' perceptions of climate change and its effects are mediated by farmland features and demographic assets, according to the literature (Bhadwal et al., 2019). Agricultural communities benefit from knowledge, information sharing, and communication in their decision-making, and are adopting proper measures against climate change and associated factors (Drafor and Agyepong, 2005; Deressa et al., 2009). The literature also indicates the importance of agricultural communities' demographic and socioeconomic characteristics in relation to the climate change adaptation they used. **Table 1** depicts the lifestyles and assets of agricultural communities, for example. Tractor/plow, bicycles, motorcycles, tube wells, spraying devices, electric generators, automobiles/jeeps, air conditioners, gas generators, televisions, and livestock (Sohail et al., 2022a). The majority of agricultural communities in these three tehsils of district Kasur feature all of the above-mentioned assets related to their farming and daily life. Although some agricultural communities own tractors, the majority use bullocks and may rent a tractor for land preparation. Many other secondary types of luxuries, such as automobiles, air conditioners, generators, and tube wells, were not available to all agricultural communities in the study area, indicating a less luxurious lifestyle and demonstrating the need to mitigate climate change (Ullah et al., 2022). Better access should be provided to cutting-edge farming technology and agricultural assets to promote agricultural progress and reduce poverty (Fahad, et al., 2018). Some expert have found that agricultural communities that desired to reduce climate change risk had sufficient resources to adapt (Deressa et al., 2009). Natural calamities such as severe rain, droughts, and floods threaten small agricultural settlements. Agricultural communities with sufficient resources and assets feel safer and can better withstand climate change (Goh, 2012).

The climate in Pakistan ranges from semiarid to arid, which impacts its water resources and leads to a scarcity of freshwater (Shah et al., 2019). The agricultural communities examined in this study used canal water, freshwater, and industrial waste water for irrigation. Groundwater in many parts of Pakistan is of poor quality due to high levels of soluble salts and hazardous metals (Murtaza et al., 2019; Hussain et al., 2020). Industrial wastewater is used for irrigation in some areas, and due to prevailing water scarcity, its use may increase in the coming years (Afzal et al., 2014). Many industrial companies discharge their wastewater to nearby waterways or into fields (Hussain et al., 2020; Shahid et al., 2020; Sohail et al., 2022a). The infrastructure for collecting and treating wastewater in Pakistan is inadequate (Kanwal et al., 2020; Khan et al., 2020). Residents in this research region used drains or combined drains and freshwater for irrigation. According to some studies, low-quality irrigation water can have an impact on soil and groundwater quality, as well as human health (Bruvold and Crook, 1981). As some individuals used industrial wastewater for irrigation, the following question was posed: "Is industrial wastewater a cheaper fertilizer than conventional fertilizer?" The majority of respondents, 70%, 60%, and 55% in Kasur, Chunian, and Patoki, respectively, responded "yes." The majority of agricultural communities identified three key benefits to the use of drain water: 1) lower water prices, 2) lower fertilizer costs, and 3) increased crop yield (Sohail and Ehsan, 2022). The majority of rural communities were unaware of the dangers of using drain water. While some agricultural communities were aware of potential threats, 55%, 30%, and 75% in Kasur, Chunian, and Patoki, respectively, were unaware of possible hazards due to industrial wastewater irrigation, while 45%, 70%, and 25% in Kasur, Chunian, and Patoki, respectively, reported awareness of this (Carr et al., 2011). Agricultural communities prefer to use wastewater for irrigation when it is freely available and usually they were unaware of its impacts on human health and on environment (Shahid et al., 2020). Many farmers in agricultural communities prefer to use wastewater because of its good effects and the presence of nutrients for crops, although the level of nutrients in the wastewater they use has not been extensively investigated (Khalid et al., 2020; Sohail et al., 2022a). Studies have shown the potential health risks associated with toxic metal deposition in wastewater-irrigated topsoil (Kanwal et al., 2020, Shahid et al., 2020). Many farmers say that no one in their families experience any ill effects, although some report that they do (McCusker and Gunaydin, 2015; Shahid et al., 2020) (**Table 2**). Heavy metals in

wastewater, soil, and vegetables should be tested regularly to avoid accumulating in the food chain and human health risks (Hussain et al., 2020). Kasur's leather industry, according to M. Afzal, damages soil, agriculture, and groundwater (Afzal et al., 2014).

Figure 2A depicted agricultural communities' views on climate change in the Kasur. Over the past few decades, the effects of climate change have become increasingly evident (Patt and Schröter, 2008; Sohail et al., 2022b; Liu et al., 2022). The primary indicators used to measure perception were drought, flooding, soil issues, irrigation, animal diseases, rainfall issues, and crop pests. The agricultural communities in Kasur and Chunian reported flood rates of 66% and 64%, respectively, while the rest of the tehsils put it at a moderate or low rate. The lives of members of agricultural communities have been adversely affected by high temperatures and floods (Douglas, 2009). For the most part, people in Pakistan's rural areas, particularly those who are agricultural communities, continue to live in substandard conditions, despite the country's efforts to improve their lives in many different areas (Fahad, et al., 2018). Pakistan has experienced several devastating floods, including in 2010 and 2011, which resulted in the loss of approximately 250,000 (numbers) farm households and 1 million cultivated land, as well as the destruction of forests, fisheries, infrastructure, fertilizers, and animal sheds (Holt et al., 2006; Harvey. 2014; NDMA, 2014). Many agricultural communities in Pakistan are concerned about soil issues (Irfan and Husnain, 2022). In this study area, most respondents report low to moderate soil issues, but some face larger challenges (Sohail et al., 2014; Javed et al., 2020). Animals have always been a valuable resource for agricultural communities around the world, and the threat of animal disease adds another layer of complexity to their already taxing lives (Musungu, 2020; Sohail et al., 2022a). Some agricultural communities were facing animal diseases problem in District Kasur. Most of district Kasur is dry, and rainfall is always a severe challenge for farming. Pests are expected to be severe in south Punjab for several years (Iqbal et al., 2022). Many respondents indicate a high level of pests in the study area, 45%, 42%, and 55% in Kasur, Chunian, and Patoki, respectively. Adaptation techniques for climate change were also examined in this study (**Figure 2B**), Many families deal with choosing their own crop varieties, adjusting fertilizer, finding agricultural finance, and facing livelihood risks regularly (Kuang et al., 2020). Agricultural communities in Pakistan have been reported to use similar adaptation measures such as changing planting dates, crop types, variety changes, and input mix changes (Gorst et al., 2015; Maqbool et al., 2020). Agricultural communities occasionally face pest-related attacks on crops, which have been comparatively high in the Kasur District for many years and have the potential to affect production, so they use different techniques to reduce risk at different times (Ishtiaq et al., 2020). In recent years, crop production has fallen due to plant diseases, climate change, poverty, or irrigation concerns (Sohail et al., 2022a). Small agricultural communities are more vulnerable to climate change adoption than larger ones (Jamshidi et al., 2019), and climate hazards have a greater influence on low-resource farming populations' income, food, and security (Shukla et al., 2019). The literature describes climate change's effects on crop output and affecting Pakistan's crop production, which accounts for a substantial amount of its GDP (Hay and Mamura, 2010; Tingju et al., 2014; Kuang et al., 2020). Climate risk and adaptation methods can assist agricultural communities in minimizing risk and boosting crop yield (Sohail et al., 2022b). Physical, environmental, and social assets influence agricultural communities' adaptation strategies (Singh et al., 2022).

Table 3 shows the results of linear regression for the research variables. Explanatory factors, including animal disease, have a significant relationship with adaptation strategies (p-value of 0.003 and coefficient of 0.153). Agricultural communities can safe animal from different diseases if they adopt suitable strategies (Musungu, A. L. 2020). Animal illnesses are managed in different ways by agricultural communities in different areas. Soil issues are highly significant as well (with a p-value of 0.000 and a coefficient of 0.044). With proper resources and measurement, soil issues can be resolved. Droughts and floods have a substantial association with adaptation measures (p-value 0.000 and coefficient 0.132) and (p-value 0.045 and coefficient 0.073) respectively, which indicates that adoption measures can help with droughts and floods. Pests have a significant relationship with the dependent variable as well (p-value 0.000 and coefficient 0.035). This demonstrates that agricultural communities can control pests using reasonable methods. Adaptation measures and storage of water for irrigation showed statistical significance (p = 0.000, positive correlation of 0.124). The dependent variable has a considerable link with potential dangers induced by industry wastewater (p-value 0.000 and coefficient 0.178). More effective adoption strategies can help lessen the negative effects of industrial wastewater on human health and increase access to information about the dangers of industrial wastewater use.

CONCLUSION

Pakistan is largely an agricultural country, and the vast majority of its population is engaged in farming. A majority of our respondents had no idea that industrial wastewater could pose a health risk. A variety of statistical methods were employed to examine the correlation between various variables. Agricultural communities with a sufficient amount of assets and resources believe that they are secure enough to withstand the negative effects of climate change. In this study, correlation values of selected variables are significant across all variables. The study's findings will help policymakers support agricultural communities' daily activities and farming techniques and provide adequate monitoring and public policies to ensure integration and sustainability. In the context of Pakistan, the findings of this study on agricultural households' adaptation tactics are unique. They offer information on adaptation measures and their advantages, as well as the value of change awareness programs delivered by extension workers in the Kasur District. Risk-mitigating investment measures can aid impoverished farming households. Climate-related

endowments, such as access to services and alternative livelihood opportunities, must be prioritized by policymakers.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

ETHICS STATEMENT

Ethics review and approval/written informed consent was not required as per local legislation and institutional requirements.

AUTHOR CONTRIBUTIONS

MTS: conceptualization, methodology, software, and writing—original draft. SM: visualization, and investigation. All authors contributed to the article and approved the submitted version. MMA: supervision and final draft approval. SR: data collection and analyzing, editing and data collection.

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