Journal of Management Science Research Review
https://jmsrr.com/index.php/Journal/about

Volume 4 Issue No 4 (2025)

Online ISSN: 3006-2047
Print ISSN: 3006-2039

https://doi.org/10.5281/zenodo.17846533

Agricultural Drivers of Climate Change: Adaptation Mitigation Strategies

Muhammad Saleem
Institute of Agricultural Extension, Education and Rural Development, University of Agriculture, Faisalabad

Dr Shahinshah khan
Associate professor, Department of Agriculture Extension, Balochistan Agriculture College, Quetta

Muhammad Adnan Aslam*(Corresponding Author)
Institute of Agricultural Extension, Education and Rural Development, University of Agriculture, Faisalabad
Email: Adnanaslam3835@gmail.com

Abdul Ghaffar
Research Officer, Directorate of Agriculture Research Zhob, Department of Agriculture Research, Balochistan

Shah Alam Mandokhail
Horticulturist, Deputy Director, Department of Agriculture Research, Musakhail, Balochistan

Abstract
Climate change has become an uphill task towards agricultural sustainability especially in developing countries where farmers are dependent on climate sensitive resources. This paper evaluates agricultural causes of climate change and looks at the factors that affect adaptation and mitigation methods used by farmers in the Muzaffargarh district, which is a big agricultural center in South Punjab in Pakistan. The district was selected purposely because of its variety of cropping systems and continuous interventions of governmental and non-governmental organizations that advance the idea of climate-resilient agriculture. Simple random sampling was used to select a sample of 120 farmers and data collected in form of a structured questionnaire by conducting face-to-face interview. Moderate climate change knowledge ($M = 3.26$), adaptation ($M = 2.88$), and mitigation practices ($M = 2.67$) were found, and the perceived climate change impact levels were relatively high ($M = 3.43$). The correlation analysis revealed a positive relationship between the knowledge and adaptation and mitigation behaviors, which is a good indication of the significance of awareness in determining climate-responsive actions. Regression analysis has shown that knowledge was the best predictor of adaptation ($b = 0.36$, $p < .001$) and mitigation ($b = 0.31$, $p < .001$). Perceived impact had a strong effect on adaptation (b

Volume 4 Issue No 4 (2025)
https://doi.org/10.5281/zenodo.17846533
Online ISSN: 3006-2047
Print ISSN: 3006-2039

= 0.21, p =.002) but not mitigation, which indicates that farmers adopt short-term coping mechanisms over long-term emission reduction. Ownership of livestock was found to have a marginal positive impact on adaptation and significant negative impact on mitigation indicating the complexity of livestock-related climate interactions. The size of farms did not make a significant difference so that behavioral responses within the groups of different landholdings were similar. Unreasonable fertilizers application was found to be negatively correlated to mitigation (p =.010), which underscores the unsustainable use of nutrients as a principal cause of agricultural emissions. In general, the results underline the primary position to consider farmer knowledge, perception of risk, and resource management in the formation of climate change adaptation and mitigation behavior. The paper highlights the necessity of reinforced extension services, specialized climate-smart agricultural training, and reinforced assistance to livestock-based farmers in order to develop sustainable agricultural systems that can decrease the effects of climate and increase the resilience.
Key Words: Climate, Adaptation, Mitigation, Agriculture, Sustainability.

Introduction

Agriculture contributes significantly to climate change in the world by the emission of greenhouse gases (GHGs) including carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). Approximately 10% of worldwide GHG emissions are attributed to the sector, and they are mainly achieved through livestock production, use of fertilizers, rice production, and land-use modifications (Moore & Bruggen, 2010; Wojcik-Gront, 2020). The emissions are particularly apparent in the less developed areas, including sub-Saharan Africa, where the effects of increased temperatures and the change in the rainfall patterns complicate the problems of farmers (Omotoso and Omotayo, 2023).

Methane is a major agricultural pollutant and the sector accounts to approximately one-third of all methane emissions in the globe with livestock and rice farming being the primary contributors (Balogh, 2020). Crop residue burning and the growing adoption of artificial fertilizers only raise the levels of emissions and contribute to climate change (Balogh, 2020; Obiora and Madukwe, 2013). Although the overall emissions of agriculture in the world are growing, in the Annex I countries, there has been a slow decrease in emissions, particularly in the fields of enteric fermentation and manure management (Wojcik-Gront, 2020).

Climate change is also affected differently by several major crops. An example is rice, which is one of the most emitting crops, produces large amounts of methane, and occupies almost 48 per cent of the GHG emissions of the croplands in certain areas (Carlson et al., 2017). Maize, which has high nitrogen requirement, is one of the crops that contribute significantly to the production of N_2O, and soybean is a more viable crop option because of its less nitrogen demand and effects on the environment (Ray et al., 2019; Guo et al., 2024). Conversely, millets are known to have a low resource intensity and lower GHG, and thus, they can be used as a climate-smart alternative to sustainable agriculture (Wang et al., 2018).

Volume 4 Issue No 4 (2025)

https://doi.org/10.5281/zenodo.17846533

Online ISSN: 3006-2047
Print ISSN: 3006-2039

The increasing awareness of the climate effect of agriculture has led to the stress on adaptation and mitigation measures. These are climate-sensitive farming methods, better livestock husbandry, low intake of meat, optimization of fertilizers and adopting of sustainable crop alternatives. These measures contribute to the resilience to severe weather, better crop productivity, and the prioritization of economic, social, and environmental aspects (Nunes, 2023; Shuvar et al., 2024).

Methodology

The Muzaffargarh district that has a population of 3,528,567, is an important agricultural area in Punjab. Geographically, it falls between the two main rivers of the subcontinent the Chenab and the Indus. The area is famous in terms of diverse cropping. The main crops are wheat, sugarcane and cotton, and rice, jawar, bajra, moong, mash, masoor, groundnut, maize and different oilseeds (rapeseed, sunflower etc.) are grown on a smaller scale. The key fruit crops are mangoes, dates, citrus, and pomegranate; jaman, pears, phalsa, and bananas are also of small scale.

The research was carried out in the Muzaffargarh district, which was chosen out of the purposive selection based on its central position in agricultural production in South Punjab and its suitability to the aim of the research. The district has been known as having ageing farmers with a high percentage of people being illiterate or having low education levels which affect the agricultural decisions and adoptions of modern practices. Furthermore, a number of non-governmental and state agencies are also operating in the district to foster the welfare of farmers, their awareness, and the use of better and more climate-resistant agricultural practices. This made the district a suitable location of the current study.

A sample of 120 farmers was selected in the district selected out of a simple random sample of 120 farmers. The respondents were contacted on a one-on-one basis to ascertain the right and valid data gathering. A structured questionnaire was used as a data collection tool and was conducted by face-to-face interviews.

Results and Discussion

Table 1. Descriptive Statistics of Demographic Attributes and Climate-Related Scores (Awareness, Resilience, Abatement, and Perceived Risk)

Variable	Mean	SD	Min	Max
Age (years)	44.18	13.75	20	69
Farm Size (ha)	10.92	7.34	1.2	38.6
Fertilizer (kg/ha)	137.44	63.22	14.8	286.1
Income (USD)	5,646	2,948	1,506	17,586
Knowledge Score	3.26	0.59	1.67	5.00
Adaptation Score	2.88	0.65	1.50	4.75
Mitigation Score	2.67	0.63	1.25	4.75
Perceived Impact	3.43	0.90	1.00	5.00

Volume 4 Issue No 4 (2025)

https://doi.org/10.5281/zenodo.17846533

Online ISSN: 3006-2047
Print ISSN: 3006-2039

The descriptive statistics of the respondents and key study variables are presented in Table 1. The average age of the farmers was 44.18 years (SD = 13.75), indicating that most participants were middle-aged and actively engaged in farming activities. The mean farm size was 10.92 hectares (SD = 7.34), with a range of 1.2 to 38.6 hectares, reflecting variability in landholding patterns. Fertilizer use among farmers averaged 137.44 kg/ha (SD = 63.22), while annual income varied widely, with a mean of USD 5,646 (SD = 2,948), suggesting notable differences in economic capacity and resource availability among the respondents.

Regarding climate change-related variables, farmers exhibited a moderate level of knowledge with a mean score of 3.26 (SD = 0.59). The average adaptation score was 2.88 (SD = 0.65), indicating that while some adaptive measures were implemented, overall adoption of climate-resilient practices was limited. Similarly, mitigation practices were less prevalent, with a mean score of 2.67 (SD = 0.63). Farmers' perceived impact of climate change was relatively high, with a mean score of 3.43 (SD = 0.90), suggesting that respondents are generally aware of the consequences of climate change on their agricultural activities.

Table 2 Correlation between different variables

Variable	Know	Adapt	Mitig	Impact	Farm Size	Fertilizer	Income
Knowledge Score	1	0.41	0.38	0.22	0.05	−0.17	0.09
Adaptation Score	0.41	1	0.47	0.33	0.12	−0.09	0.14
Mitigation Score	0.38	0.47	1	0.29	0.02	−0.11	0.07
Perceived Impact	0.22	0.33	0.29	1	−0.03	0.00	−0.05
Farm Size (ha)	0.05	0.12	0.02	−0.03	1	0.16	0.53
Fertilizer (kg/ha)	−0.17	−0.09	−0.11	0.00	0.16	1	0.27
Income (USD)	0.09	0.14	0.07	−0.05	0.53	0.27	1

Table 2 shows the correlation analysis between the important variables of the studying. Adaptation (r = 0.41) and mitigation scores (r = 0.38) had a significant positive association with knowledge score, which proved that farmers possessing better knowledge about climate change have higher chances of using adaptation and mitigation strategies. Adaptation (r = 0.33) and mitigation scores (r = 0.29) also showed a positive correlation, with perceived impact of climate change which indicates that the more farmers perceive the effects of climate change, the more responsive steps they will take.

Farm size was positively and moderately correlated with income (r = 0.53) which indicated that bigger farm is associated with higher income. There was a negative correlation between knowledge (= 0.17) and adaptation (= 0.09) and mitigation scores (= 0.11) and the use of fertilizers which could be attributed to excessive dependence on traditional methods and the need to adopt climate-compatible measures. The rest of the correlations between variables were most often weak, which

Volume 4 Issue No 4 (2025)

https://doi.org/10.5281/zenodo.17846533

Online ISSN: 3006-2047
Print ISSN: 3006-2039

means that besides the resources endowment (farm size and farm income) knowledge and perception are more important in determining the adaptation and mitigation behavior of the farmers.

Table 3 Regression analysis of Human and farm-level drivers which determine the adaptation and mitigation practices3

Predictor	β (Beta)	SE	t	p-value
Knowledge Score	0.36	0.08	4.52	< .001
Perceived Impact	0.21	0.06	3.22	.002
Has Livestock	0.14	0.07	1.96	.052
Farm Size (ha)	0.04	0.03	1.23	.221
Fertilizer (kg/ha)	−0.01	0.00	−1.78	.077

The regression findings offer a valuable understanding of the human and farm-level drivers which determine the adaptation and mitigation practices, which are major factors in dealing with the drivers of climate change, in an agricultural system. Knowledge Score is the most powerful predictor ($b = 0.36$, $p < .001$). This implies that climate change, sustainable practices and environmental impacts are the factors that farmers with more knowledge on them are more likely to engage in adoption of adaptation and mitigation strategies. Capacity building is therefore founded on knowledge that plays a pivotal role in reduction of emission and resilience enhancement as a result of agriculture.

Similarly, Perceived Impact shows a high positive effect ($b = 0.21$, $p = .002$) to suggest that the attitude that farmers hold regarding the severity and relevance of climate change has a huger influence on their willingness to perform. When farmers know how climate change will affect their productivity, soil health and long-term sustainability, they will be more willing to adopt climate-smart action such as resource-efficient irrigation and soil conservation and integrated pest management.

The Has Livestock ($b = 0.14$, $p = .052$) variable is marginally significant, indicating that the owners of the livestock were a little more apt to be more concerned with adaptation and mitigation practices. This may be in the form of the increased exposure of the risk of the climate (such as lack of fodder, heat stress and epidemics) or increased dependence on the sustainable manner of resources management. The livestock production has also contributed to agricultural emissions, therefore, improved livestock management practice by this group would generate massive climate benefits.

The inconsequential variables like Farm Size ($b = 0.04$, $p = .221$) imply that big landholders are not the only ones who are sensitive to climate- both small and large farmers behave similarly as far as adaptation and mitigation are concerned. This is a very important finding because it highlights the reality that climate-smart agriculture interventions should be all-inclusive and should be applicable in all sizes of farms.

Volume 4 Issue No 4 (2025)
https://doi.org/10.5281/zenodo.17846533
Online ISSN: 3006-2047
Print ISSN: 3006-2039

Lastly, the Fertilizer Use correlates with the negative relation with a slight and non-significant correlation (b = -0.01, p =.077). This is not a significant difference, but the negative direction may indicate the ineffectiveness or excessive use of fertilizers which is the primary source of nitrous oxide emissions, one of the primary causes of climate change. This observation highlights the need to have more effective nutrient management systems such as precision agriculture and balanced fertilization to reduce emissions without reducing productivity.

Table 4 Descriptive Statistics of Key Constructs among Farmers

Variable	Mean	SD	Min	Max
Knowledge Score	3.26	0.59	1.67	5.00
Adaptation Score	2.88	0.65	1.50	4.75
Mitigation Score	2.67	0.63	1.25	4.75
Perceived Impact of Climate Change	3.43	0.90	1.00	5.00

The descriptive findings give the general picture of the level of knowledge, adaptation and mitigation behaviors and the perceptions of the farmers towards climate change. The Knowledge Score has a average of 3.26 (SD = 0.59), which is a moderately high level of awareness of the majority of the respondents about climate change and the issues associated with agriculture. Nevertheless, the variation is quite large (1.67-5.00) indicating variability, some of the farmers possess very thin knowledge. This underscores the importance of tailored training and sensitization activities to make sure everyone among the farmers has been well informed to practice climate-smart activities.

The mean score of the Adaptation Score is 2.88 (SD = 0.65) indicating moderate involvement in the adaptation strategies. That means that farmers are not completely eliminating adaptive practices, i.e. conservation of water and the crop diversification, or the use of stress-tolerant varieties, yet there is still a way to improve. The difference in scores suggests the adoption will be dependent on the access to resources, knowledge, and perceived vulnerability.

In a similar manner, the Mitigation Score (M = 2.67, SD = 0.63) shows the rather low level of participation in mitigation activities as opposed to adaptation. This implies that farmers are more concerned with the urgent climate-based issues as opposed to the long-term measures to reduce emissions. Such practices as effective use of the fertilizers, less tillage, and better animal management might not be as broadly adopted yet, perhaps because of cost or lack of awareness, or perhaps technologically.

The peer-reviewed article Perceived Impact of Climate Change presents a relative high mean of 3.43 (SD = 0.90) which illustrates that the majority of the respondents think that climate change is already impacting their farming practices. The wide range (1.00-5.00) indicates that whereas some farmers are quite aware of the effects, there are still those who continue to undervalue or are not fully aware of the severity of the

Volume 4 Issue No 4 (2025)

https://doi.org/10.5281/zenodo.17846533

Online ISSN: 3006-2047
Print ISSN: 3006-2039

threats of climate. Perception is a vital motivation in an action; therefore, the augmentation of awareness can further promote adaptation and mitigation actions.

Table 5 Determinants of Climate Change Adaptation and Mitigation Strategie

Predictor	Adaptation Score		Mitigation Score	
	β (SE)	p-value	β (SE)	p-value
Knowledge Score	0.36 (0.08)	< .001	0.31 (0.07)	< .001
Perceived Impact	0.21 (0.06)	.002	0.08 (0.05)	.118
Has Livestock (Yes=1)	0.14 (0.07)	.052	-0.18 (0.06)	.003
Farm Size (ha)	0.04 (0.03)	.221	-0.02 (0.03)	.512
Fertilizer Use (kg/ha)	-0.01 (0.00)	.077	-0.02 (0.00)	.010
Constant	1.12 (0.25)	< .001	1.45 (0.23)	< .001
Model Fit	R^2 = 0.28, Adj. R^2 = 0.25, F = 8.91, p < .001		R^2 = 0.23, Adj. R^2 = 0.20, F = 6.87, p < .001	

The regression of the adaptation and mitigation behaviors are useful in understanding the motivation of climate-smart farming behaviors. The adaptation model has a statistical significance of 28% in explaining the variation in adaptation behavior and this is statistically significant meaning that the predictors included have a significant role to play in the adaptive behavior of farmers. Knowledge Score comes out as the best positive predictor of adaptation. Farmers that have better understanding of climate change have a high probability of embracing adaptive strategies like better water management schemes, crop diversification, and stronger varieties. This underscores the importance of awareness, education as well as technical training in enhancing agricultural resilience. The other predictor is Perceived Impact, which implies that farmers who perceive themselves more adversely by climate change have more incentive to implement adaptation. The Has Livestock variable presents a marginally significant effect, which means that the owners of livestock might make a little more adaptive actions because the livestock systems are exposed to feed shortages, heat stress, and disease outbreaks. On the other hand, Farm Size does not make any significant impact showing that adaptation behavior is independent of landholding. The Fertilizer Use is slightly negative, which means that farmers who use fertilizers intensively might not be willing to follow the climate-smart practices.

The explanatory power of the mitigation model is also very high and as such, 23 percent of the variation in mitigation behavior is explained by the model. Like the

Volume 4 Issue No 4 (2025)

https://doi.org/10.5281/zenodo.17846533

Online ISSN: 3006-2047
Print ISSN: 3006-2039

adaptation model, the knowledge is still a powerful and important predictor but it states that knowledgeable farmers are in a better position to implement long-term emission-reducing activities, including efficient application of fertilizers, less tillage, and livestock minimization. Nonetheless, Perceived Impact does not have a significant effect on mitigation behavior, indicating that the awareness of the farmers about climate effects can drive them to putting in place preventive actions instead of taking long-term measures on greenhouse gas reduction. It is important to note that the ownership of livestock significantly impacts negatively mitigation behaviors meaning that livestock producers are less likely to undertake activities that reduce the emission. This shows it is a significant discovery since livestock systems have been cited as a major cause of methane emission, and climate-smart livestock technologies can be achieved by applying specific interventions. Similar to the adaptation model, the Size of Farm is not significant, and it proves that mitigation behaviors are not conditioned by the size of landholding. Fertilizer Use has a significant negative impact and this implies that the more the farmers that use more fertilizer, the less likely they are to implement mitigation practices, possibly because of reliance on production systems based on input intensive production.

Table 6: Correlation Matrix of Key Variables

Variable	Know	Adapt	Mitig	Impact	Farm Size	Fertilizer	Income
Knowledge Score	1	0.41	0.38	0.22	0.05	−0.17	0.09
Adaptation Score	0.41	1	0.47	0.33	0.12	−0.09	0.14
Mitigation Score	0.38	0.47	1	0.29	0.02	−0.11	0.07
Perceived Impact	0.22	0.33	0.29	1	−0.03	0.00	−0.05
Farm Size (ha)	0.05	0.12	0.02	−0.03	1	0.16	0.53
Fertilizer (kg/ha)	−0.17	−0.09	−0.11	0.00	0.16	1	0.27
Income (USD)	0.09	0.14	0.07	−0.05	0.53	0.27	1

The correlation matrix offers valuable information on the interaction between various variables in the environment of climate change adaptations and mitigations among the farmers. Knowledge Score forms positive correlations with both Adaptation (r = 0.41) and Mitigation (r = 0.38), which are moderate and positive; hence, farmers who possess higher climate-related knowledge have a higher chance of engaging in adaptation and mitigation practices. This supports the role of awareness and training activities as the basic engines of climate-smart agriculture. There is also a weak positive correlation between Knowledge and Perceived Impact (r = 0.22), where more informed farmers might have a better knowledge of the risks of climate.

Volume 4 Issue No 4 (2025)

https://doi.org/10.5281/zenodo.17846533

Online ISSN: 3006-2047
Print ISSN: 3006-2039

Adaptation Score is positively correlated with Mitigation Score (r = 0.47), which means that farmers that switch to adaptive (e.g., water-saving) strategies are also likely to adopt mitigation (e.g., reducing the use of fertilizers, managing livestock better, etc.). This complementary relationship implies that improving adaptation might indirectly increase the process of mitigation.

The relationships between Perceived Impact and the behavioral outcomes of the Adaptation (r = 0.33) and Mitigation (r = 0.29) variables show that the more climate change influences farmers, the more they act. This highlights the importance of risk perception in developing climate responsive behavior.

There are different patterns of socioeconomic variables. Farm Size Farm Size has low or insignificant correlations with Knowledge, Adaptation, Mitigation, and Impact, suggesting that the size of landholding does not play a major role in climate-related behavior of the farmers. Farm Size is, however, strongly related with Income (r = 0.53) which is not surprising because larger farms tend to bring more income. Farm Size is also positively, but insignificantly related to Fertilizer Use (r = 0.16), which indicates that, larger farms are more likely to use more fertilizer which could be contributing to the higher level of emissions.

There are weak negative correlations between Fertilizer Use and Knowledge, Adaptation and Mitigation. Though insignificant, small negative relationships suggest that more intensive use of fertilizers can be linked with a reduced practice of climate-smart practices, which could be explained by the traditional methods of farming based on inputs. There is a moderate correlation between Fertilizer use and Income (r = 0.27), which demonstrates the purchasing power and the ability to afford it by wealthier farmers.

Table 7 Predictors of Farmers' Adaptation Measures: Regression Output

Predictor	**Unstandardized B**	**Standardized Beta (β)**	**SE**	**t**	**p-value**
(Constant)	1.12		0.25	4.48	< .001
Knowledge Score	0.40	0.36	0.08	4.52	< .001
Perceived Impact	0.15	0.21	0.06	3.22	.002
Has Livestock (Yes=1)	0.14	0.14	0.07	1.96	.052
Farm Size (ha)	0.01	0.04	0.03	1.23	.221
Fertilizer Use (kg/ha)	-0.001	-0.01	0.00	-1.78	.077
Model Summary					
R	0.53		R^2	0.28	
Adjusted R^2	0.25		F-statistic	8.91	
p-value (Model)	< .001				

The outcome of the multiple linear regression analysis shows that the model has a significant amount of variation in the dependent variable with an overall R2 of 0.28.

Volume 4 Issue No 4 (2025)

https://doi.org/10.5281/zenodo.17846533

Online ISSN: 3006-2047
Print ISSN: 3006-2039

This shows that the selected predictors explain about 28 per cent of the variability in the behavior of farmers (or outcome variable) with respect to climate. The significance of the model as indicated by an F-statistic of 8.91 ($p < .001$) is that the joint influence of knowledge, perceived impact, livestock ownership, farm size, and fertilizer use has a meaningful impact in explaining the reaction of farmers to climate change.

Knowledge score was the strongest and most effective of the predictors. The positive and significant coefficient ($B = 0.40$, $p < .001$) is used to show that the farmers who possess better knowledge of climate change are more likely to pursue adaptation or mitigation strategy. The fact that its standardized beta ($b = 0.36$) is relatively high confirms that knowledge is at the center stage of determining climate-sensitive behavior. This underscores the role of awareness programs, training and extension services in enhancing the capacity of the farmers in terms of knowledge of climate risks.

Perceived impact of climate change ($B = 0.15$, $p =.002$) was the second important predictor. Farmers who have a higher perceptions of climate change have more behavioral responses. The correlation indicates that the perceived risk promotes the desire to implement the measures of adaptation. This observation suggests that adaptive capacity can be increased by interventions that assist farmers to appreciate climate variability and its effects.

The ownership of livestock (Yes = 1) had a weak effect ($B = 0.14$, $p =.052$). The positive trend is not very statistically significant but indicates that livestock households could be more vulnerable to climate-related hazards like fodder scarcity or heat stress, which prompts the slight increase in climate-related behaviors. The fact implies that there is the necessity to provide specific assistance to the farmers that rely on livestock as they might be more susceptible.

On the contrary, the farm size ($B = 0.01$, $p =.221$) was not found to significantly predict the dependent variable, meaning that the climate adaptation or mitigation efforts are not related to the size of the landholding. This is an indication that small and large farmers have a relatively the same perceptions on climate challenges as well as responding to the same. Likewise, the use of fertilizers had a very weak negative and insignificant effect ($B = -0.001$, $p = .077$). Even though the coefficient is almost marginal in significance, the value is insignificant, which means that the level of input intensity does not have an effective influence on how farmers respond to climate changes.

Conclusion

Volume 4 Issue No 4 (2025)
https://doi.org/10.5281/zenodo.17846533
Online ISSN: 3006-2047
Print ISSN: 3006-2039

The paper has investigated the agricultural sources of climate change and most critical factors that affect the adaptation and mitigation processes by the farmers in Muzaffargarh district of South Punjab. The results indicate that whereas farmers have moderate information on climatic change, they are not using adaptation and mitigation strategies. Knowledge turned out to be the most powerful factor in adaptation and mitigation practices, which highlights the significance of awareness, education, and information access towards climate-responsive practices. There was a tendency of risk perception to have a stronger effect on farmers who felt more seriously affected by the climate, which is why the use of adaptation strategies was more likely to be adopted in order to take immediate coping responses.

The ownership of livestock had a mixed impact where they somewhat promoted adaptation but had a negative impact on mitigation behavior due to intricacy of livestock-related emissions and management issues. The size of farms did not play a big role in climate action indicating that the small and big farmers have the same constraints and opportunities in their involvement in the climate change. The adverse relationship between the use of fertilizers and mitigation highlights the fact that major inputs-driven agricultural practices persist, and they are fuelling up greenhouse gases and could be a barrier to the migration to climate smart agriculture.

In general, the paper finds that improvement of farmer knowledge, development of climate risk awareness, and management of resources play a central role in supporting sustainable and climate-adaptive agricultural systems. Both behavioral and structural barriers should be addressed by effective interventions to promote the prevalence of climate-smart practices.

Recommendations

Judging by the results of the study, it is suggested that there should be an effort aimed at improving the knowledge and awareness of farmers about the changes in climate by conducting specific training sessions, demonstration plots and farmer field schools. Farmers can make informed and timely decisions by having better communication on climate risks through the use of local advisory services, digital and community-based sources. To enhance resilience, there is a need to promote climate-smart agriculture in the form of crop diversification, drought-tolerant and efficient irrigation, soil conservation, and integrated pest management. Particular focus needs to be made on livestock farmers by introducing livestock management practices that are sustainable, better feeding systems and fodder security practices. The management of nutrient and fertilizers should be promoted to minimize the use of excess inputs and emissions related to them with the help of the soil testing and site-specific recommendations. Adaptive and mitigation measures may be further boosted through strengthening agricultural extension services and enhancing accessibility to resources, credit and technologies that are climate resilient. Lastly, the all-inclusive climate policies that

Volume 4 Issue No 4 (2025)
https://doi.org/10.5281/zenodo.17846533
Online ISSN: 3006-2047
Print ISSN: 3006-2039

encompass farmers of both large and small land holdings and facilitate cooperation among government, nongovernmental organizations and other stakeholders in the private sector are essential to the realization of fair and effective climate-smart agricultural interventions.

References

1. Balogh, J. M. (2020). The role of agriculture in climate change: a global perspective. International Journal of Energy Economics and Policy, 10(2), 401–408.
2. Balogh, J. M. (2020). The role of agriculture in climate change: a global perspective. International Journal of Energy Economics and Policy, 10(2), 401–408
3. Guo, S., Zhao, J., Zhao, C., Guo, E., Liu, Z., Harrison, M. T., Liu, K., Zhang, T., & Yang, X. (2024). Adapting crop land-use in line with a changing climate improves productivity, prosperity and reduces greenhouse gas emissions. Agricultural Systems.
4. Moore, J. N., & Bruggen, V. (2010). Agriculture's Fate under Climate Change: Economic and Environmental Imperatives For Action. Chicago-Kent} Law Review, 86(1), 87.
5. Obiora, C. J., & Madukwe, M. C. (2013). Climate Change Mitigation: The Role of Agriculture. *The Journal of Agricultural Extension*, *15*(1), 51–63. https://doi.org/10.4314/JAE.V15I1.6
6. Omotoso, A. B., & Omotayo, A. O. (2023). The interplay between agriculture, greenhouse gases, and climate change in Sub-Saharan Africa. Regional Environmental Change, 24.
7. Wang, J., Vanga, S. K., Saxena, R., Orsat, V., & Raghavan, V. (2018). Effect of Climate Change on the Yield of Cereal Crops: A Review. *Climate*, *6*(2), 41. https://doi.org/10.3390/CLI6020041
8. Wójcik-Gront, E. (2020). Analysis of Sources and Trends in Agricultural GHG Emissions from Annex I Countries. Atmosphere, 11(4), 392. https://doi.org/10.3390/ATMOS11040392
9. Шувар, I., Brych, V., Shuvar, A., & Borysiak, O. (2024). Agricultural nature management in the context of global climate change. Ekonomìčnij Analìz, 34(3), 133–143.
10. Carlson, K. M., Gerber, J. S., Mueller, N. D., Herrero, M., MacDonald, G. K., MacDonald, G. K., Brauman, K. A., Havlik, P., O'Connell, C. S., O'Connell,

Volume 4 Issue No 4 (2025)

https://doi.org/10.5281/zenodo.17846533

Online ISSN: 3006-2047
Print ISSN: 3006-2039

C. S., Johnson, J. A., Saatchi, S., & West, P. C. (2017). Greenhouse gas emissions intensity of global croplands. *Nature Climate Change*, *7*(1), 63–68.

11. Nunes, L. J. R. (2023). The Rising Threat of Atmospheric CO2: A Review on the Causes, Impacts, and Mitigation Strategies. *Environments*, *10*(4), 66.