ADVANCE SOCIAL SCIENCE ARCHIVE JOURNAL
Available Online: https://assajournal.com
Vol. 04 No. 01. July-September 2025.Page#.315-332
Print ISSN: 3006-2497 Online ISSN: 3006-2500
Platform & Workflow by: Open Journal Systems

Agriculture Practices responsible for Climate change and the step taken for mitigation

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Abstract
The present research was carried out in Pakistan, and it focuses on the contribution of agricultural activities to climate change and mitigation efforts, which are dependent on the socio-economic and institutional factors like climate change awareness, education level, size of landholding, farming experience, and access to information. A mixed-method was used where quantitative item responses were analyzed using t-tests, ANOVA, correlation, and chi-square statistics, whereas a thematic analysis was used to explore qualitative data in the form of narrative responses of farmers. The results show that awareness and education have significant effect in enhancing the knowledge base of the farmers on major drivers of climate change such as the utilization of chemical fertilizers, deforestation, burning of crop residues and methane emissions by livestock. The size of landowning and access to the extension services and mobile/social media are positively correlated to such perceptions. Moreover, there is a strong correlation between awareness and the practice of climate-smart agriculture (CSA), including organic composting, rotation of crops, integrated pest management (IPM) and drip irrigation. Thematic analysis reveals that the biggest challenges of farmers include economic strains, environmental depreciation, pesticide dependence, institutional failures and short-term adaptation measures. These findings support the necessity of specific training, development of infrastructure and favorable policies that would enhance climate resiliency and sustainable agriculture in the region.

Key Words: *Climate, Adaptation, Mitigation, Sustainability*

Introduction

In 2025, Pakistan's agriculture sector registered its lowest annual growth in nearly a decade—just 0.56% in FY 2024–25, down sharply from 6.3% the previous year. The dramatic decline was driven by a contraction in the crops sub-sector, where key staples like cotton (–30.7%), wheat (–8.9%), maize (–15.4%), sugarcane (–3.9%), and rice (–1.4%) all suffered due to reduced sowing, climate volatility, and disrupted planting cycles. Meanwhile, livestock (+4.72%), forestry (+3%), and fisheries (+1.4%) provided some cushioning (Brun et al., 2025). Adding to the woes, Pakistan faced a severe heatwave and drought conditions in early 2025, with rainfall falling 40% below normal during Rabi season and water at "dead" levels in key reservoirs—partially due to India's April suspension of the Indus Waters Treaty—jeopardizing Kharif irrigation and intensifying water scarcity concerns. In response, the government allocated Rs 400 billion in the FY 2025–26 budget toward agriculture and livestock, alongside a targeted 4.5% growth objective. Key reforms include digitization through the Land Information and Management System (LIMS), regulatory advances under the Prime Minister's Agri-Innovation Plan, and large-scale infrastructure such as the controversial Cholistan Canal Project—aimed at irrigating nearly 4.8 million acres but opposed by Sindh stakeholders. For the sector to recover sustainably, Pakistan must adopt climate-resilient strategies, enhance irrigation efficiency, accelerate digitized farming, diversify crop production, and improve water governance amid regional tensions and environmental challenges (Ahmad et al., 2025., Ahsan et al., 2023 and Hassan, 2025).

Climate change is one of the most important challenges affecting the globe with long term impacts on the agricultural system. It has threatened food security, the livelihood of rural dwellers and the economy, hence the need to launch more rigorous responses (Shafeeque and Bibi, 2023).

Climatic change is a long-term change of the average weather conditions that contribute to the formation of climate on the planet, and its effect on an agricultural system is significant and extensive (Pérez-Lucas et al., 2024). Agriculture is a casualty and an implementer of climate change. Though imminent to global food security, most mainstream farming activities play a major role in releasing greenhouse gases (GHGs), forest clearing, and loss of soil and water contamination. Intensive farming has a number of adversarial effects on the ecology with nutrient bypass, too great the employment of chemical pesticides, biodiversity misfortune, and augmented passive gas release being a few of them (Yang et al., 2024). Pesticides have become increasingly used across the globe because of the increasing food demand created by the human population that is increasing very rapidly (Rashid et al., 2022). The first adoption of pesticides in agriculture across the world occurred in the 1950s as a significant protection against pests. World rice, wheat, and maize output had increased more than two-fold since 1960s, partly due to fifteen- to twenty-fold increase in pesticide use (Silva et al. 2019). Other activities including over-application of the artificial fertilizer, animal farming, rice growing, and conversion of land contribute high concentrations of methane (CH_4), nitrous oxide (N_2O) and carbon dioxide (CO_2) into the atmosphere. The emissions enhance global warming and ecological imbalance, and this endangers the sustainability of the agricultural systems, in itself

(Verma et al., 2025). With the continued industrialization of agriculture, environmental concerns have emerged as a global issue. Carbon dioxide (CO_2) remains the most persistent and significant long-lived greenhouse gas in the Earth's atmosphere. The rise in CO_2 levels from 2016 to 2017 was roughly consistent with the average annual increase observed over the past decade (Balogh, 2020).

A significant portion of agricultural CO_2 emissions originates directly from activities involved in agricultural production. Unsustainable practices—such as improper land use, over application of chemical fertilizers, and excessive use of pesticides—can result in substantial greenhouse gas (GHG) emissions, which have harmful effects on the environment (Lenka et al., 2015). In 2010, agriculture and related land use changes were responsible for around 17% of total anthropogenic greenhouse gas (GHG) emissions worldwide (Richards et al., 2018). During 2001-2010 crop and livestock production led to an average amount of 5 billion tonnes of CO_2 equivalent emissions (Lenka et al., 2015). While during 1994 to 2012, this emission raise from 71.6 to 162.8 Mt of CO_2, that is 127% increase in the production (Ijaz and Goheer, 2021).

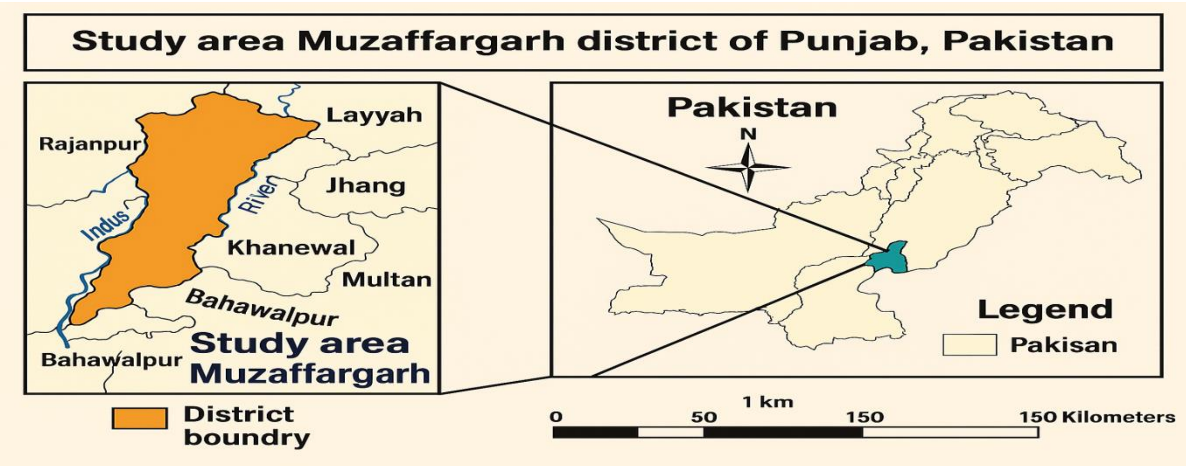
Over the past couple of years the distribution and solution of water resources within most developing countries have been dwindling. Accessibility to enough water is a very significant component in agricultural production (Mahadevan et al. 2024). Nonetheless, the recent environmental crisis involving climate change is posing a danger to the agricultural sector, especially by the increased incidences of soil salinity, which impacts heavily on the crops under irrigation. These are the crops, which receive irrigation and are able to supply the world about 40 percent foods (Anbumozhi et al., 2012).

Livestock is also one of the major emission sources of methane (Petersen et al., 2023). Another contributing factor especially in Punjab and Sindh is rural rice culture which produces anaerobic conditions in the flooded rice paddies leading to emission of methane. These emissions are aggravated by the conventional methods of farming like continuous flooding (Blackburn and Stanley, 2021). The use of excessive artificial fertilizers in farm/s like wheat and rice also contributes greatly to the changes in climate. The fertilizers, urea, and diammonium phosphate (DAP) decompose releasing nitrous oxide that has global warming potential 300 times higher than carbon dioxide (CO_2). The clearing of trees to make room to expand the agricultural land lead to fewer carbon sinks and let the stored CO_2 out, which will make the climate crisis even more severe (Abbas, 2022). Poor farming practices such as flood irrigation and intensive grazing promote soil degradation and thereby lessens the land capability to store carbon. The joint effect of these practices and climate change that manifests through heat waves, irregular monsoons, and glacial melt is a vicious circle that poses a threat to the food security of Pakistan (Fahad and Wang, 2018).

Agricultural production the primary source of livelihood for over half of South Asia's population. Therefore, adopting effective adaptation strategies is crucial to strengthen resilience and adaptive capacity at the farm level and ensure the sustainability of rural livelihoods. Farmers' willingness and ability to adapt agricultural systems depend on their knowledge about changes in climate and perceived risks of extreme events. Climate change has become widely recognized as an issue, which can have a far-reaching impact on the whole globe with possible escalation of events of extreme weather. Some of the most likely to be affected by these climatic shifts are the agricultural communities in the developing nations, especially the those who dwell in poverty.

Methodology

For the purpose of study, Southern Punjab intentionally preferred owing to consecutive facing raising risks of floods with regional critical location of flowing two major rivers particularly Chenab and Indus River. Moreover, there is the severity of climate change especially during the summer. The sudden change climate change affected a lot to the crop production and fruit production. Moreover, from the south Punjab district Muzaffargarh that was selected purposively as it is the main district of south Punjab, where majority of population rely on agricultural sector directly and indirectly for their livelihoods. Muzaffargarh is one of the top districts of cotton production in Punjab. Cotton crop is the only cash crop in the category of major crops and a vital source of raw material for huge textile industry of Pakistan. The district is located in the southern Punjab. It has four tehsils (Muzaffargarh, Ali Pur, Jatoi, Kot Adu) and district is considered high flood risk vulnerable district regarding to floods occurrence and disasters destruction. This is just because of climate change.



From the selected district 60 farmers were selected randomly from 4 tehsil (15*4) for the purpose of data collection. Moreover from each tehsil one focus group discussion was also conducted to know the views of the farmers about the climate.

Comparison of Climate Change Perceptions Based on Awareness

Perception Variable	Heard (Mean ± SD)	Not Heard (Mean ± SD)	T-Value	Sig. (2-tailed)
Chemical fertilizer use causes climate change	4.21 ± 0.74	3.55 ± 0.88	3.16	0.002 **
Deforestation increases climate risks	4.38 ± 0.62	3.89 ± 0.91	2.47	0.015 *
Burning residues causes pollution	4.52 ± 0.50	4.03 ± 0.71	2.93	0.005 **
Livestock releases methane	3.81 ± 0.76	3.25 ± 0.92	2.85	0.006 **

Comparative statistics between the respondents who have heard about climate change, and the respondents who have not gives a sign of tremendous differences in several variables of perception. The results indicate that awareness is imperative in defining the perceptions of individuals concerning climatic issues.

First, participants who knew (Mean = 4.21) that climate change was happening were more inclined to the idea that were chemical fertilizers used, climate change would be contributed by them than participants who had not any idea of climate change (Mean = 3.55). The disparity is significant, statistically (p = 0.002), which means that awareness improves knowledge about the effects of fertilizer application on the environment. The awareness of the influence of synthetic inputs on the health of soil and release of greenhouse gasses seems to be more evident in the informed group.

Likewise, deforestation was recognized more among those who had heard about climate change (Mean = 4.38) than those who had not (Mean = 3.89) and the difference was significant at the 5 % level (p = 0.015). This implies that awareness initiatives can enhance increased awareness about the role of forest loss in heightening the threat of climate change, including increased temperatures, changes in the rainfall patterns, and loss of biodiversity.

Burning of crop residue was accepted generally as a source of pollution especially by the two groups, but the respondents who knew about climate change rated the practice higher (Mean = 4.52) than the unaware group(Mean = 4.03) with and p-value of 0.005. This indicates that the general awareness on residue burning could be widespread but climate awareness adds more insight on the development of their understanding on the impact on the environment, which could connect it to larger concerns like smoke pollution and carbon output.

Finally, there was a greater perception that livestock produces a potent greenhouse gas (methane) by the aware group (Mean = 3.81) when compared to the unaware group (Mean = 3.25); p-value 0.006. The identified fact is especially valuable, as the emissions caused by livestock remain unseen and sometimes unaccounted. Consciousness apparently is significant in the realization of more technical elements of climate change.

Effect of Education Level on Climate Change Perceptions

Perception Variable	**F-Statistic**	**Sig.**
Chemical fertilizer use causes climate change	4.52	0.006 **
Deforestation increases climate risks	3.75	0.011 *
Burning residues causes pollution	4.98	0.003 **
Livestock releases methane	3.42	0.018 *

Note: Education groups: 1=Primary, 2=Middle, 3=Secondary, 4=Above Secondary

The data reveals the effect of the education level on the perception of people about the climatic change and causes. There were four major areas of perceptions which were analyzed and the results indicate a great difference in regard to the amount of education that people have acquired. Education levels are categorized into; Primary, middle, secondary and above secondary.

To begin with, there was a great difference between educated people in the level of affirming that "use of chemical fertilizers catalyzes climate change" and thus the result was dictated to be significant p = 0.006. This is to imply that highly educated people are in a better position to be aware that too much usage of fertilizer will generate climate issues, probably due to the increased exposure to scientific explanations or science in general.

On the same note, the perception that "deforestation makes the climate risky" also varied by the level of education (p = 0.011). The more educated you are the more informative you know about the effect of cutting trees on climate and rise in temperatures, uneven rainfall, loss of biodiversity, etc. This indicates that education makes human beings cognizant of the environmental effects in general of deforestation.

The assumption that "the burning of crop residues would lead to pollution" elicited one of the significant contrasts between the highest and low levels of education (p = 0.003). Higher educated people felt better to associate this practice with pollution and environmental degradation. Perhaps, this is in terms of the fact that they are more acquainted with health warnings or environmental campaigns which talk of how bad it is to burn refuse in the fields.

Finally, the impression that "livestock emits methane" which is a greenhouse gas, and an agent of climate change, also recorded substantial disparities by education levels (p = 0.018). This is a more technical idea and individuals who are not well educated can not know about greenhouse effects caused by animals. On the other hand, the people with higher education might have heard or read this information in science classes, the press, or even in awareness campaigns.

Relationship Between Landholding Size and Climate Change Perceptions

Variables	Pearson r	Sig. (2-tailed)
Chemical fertilizer use causes climate change	0.28	0.014 *
Deforestation increases climate risks	0.33	0.007 **
Burning residues causes pollution	0.26	0.019 *
Livestock releases methane	0.31	0.009 **

Note: r > 0.3 = moderate correlation

Findings indicate that there is positive correlation between land size and perception of farmers to climate change causes. This implies that the larger the size of land that the farmers have the greater their awareness and knowledge is concerning issues related to climate.

As an illustration, attitude that use of chemical fertilizers causes climate change entails correlation coefficient of 0.28(p = 0.014). Although this represents weak to moderate positive correlation, it, nonetheless, shows that the bigger the farmers landholding the more disposed they will be to acknowledge the environmental effects of fertilizers.

The view that deforestation poses more risks of increased climate is moderately and positively correlated (r = 0.33, p = 0.007). This means that more-land farmers might be exposed or experienced with land clearance and they understand what that activity is doing to the environment badly.

In the same way, the notion that burning crop residues leads to pollution correlates positively with the size of landholdings ($r = 0.26$, $p = 0.019$). This is an indication that bigger owners are more aware of the role played by residue burning as one of the sources of pollution since they might be having a larger area of crops.

Last but not least, the perception that livestock emits methane a greenhouse gas contributing to climate change also reveals a moderate correlation ($r = 0.31$, $p = 0.009$). This could be attributed to the fact that larger landholders have tendency to possess more livestock and thereby have greater knowledge of living stock related environmental problems.

Association Between Awareness (Heard Climate Change) and Adoption of Mitigation Practices

Practice	χ^2	Df	Sig. (2-sided)
Use of organic compost	6.31	1	0.012 *
Minimum or zero tillage	4.29	1	0.038 *
Agroforestry / tree planting	9.57	1	0.002 **
Drip or sprinkler irrigation	5.81	1	0.016 *
Crop rotation	7.44	1	0.006 **
Integrated pest management	6.99	1	0.008**

The evidence indicates a statistically considerable and definitive “relationship between the consciousness of climate changes on the part of farmers and the use of mitigation behaviors”. The result of the Chi-square (x 2) test indicates that there was a striking difference in the likelihood of adopting sustainable and climate-resilient of farming techniques of those who had not versus those who had heard about climate change.

As an example, the “use of organic compost” (x 2 = 6.31, p = 0.012) was found more frequently in the eyes than in the ignorant farmers. The practice lessens the use of chemical fertilizer and enhances the equilibrium of the soil crucial in climate adaptation. Just as well, “minimum or zero tillage” (x 2 = 4.29, p = 0.038) also correlated with awareness. The technique contributes to soil moisture conservation, lower erosion, and carbon emission caused by soil disturbance.

There was a very high correlation with “agroforestry or tree planting” (2 = 9.57, p = 0.002), indicating that the farmers who were aware of climate change are more active in the provision of nature-based solutions. Trees do not only sequester carbon, but also better microclimates by cutting the effect of extreme weather conditions.

Climate change awareness was also prominently associated with the usage of “drip or sprinkler irrigation systems” (4.81, p = 0.016). These are important water-saving technologies that can be applied in regions where there is water shortage and this practice is commonly encouraged in climate-smart agricultural practices.

Similarly, crop rotation (x 2 = 7.44, p = 0.006), the method of increasing soil fertility and interrupting pests, and integrated pest management (IPM) (x 2 = 6.99, p = 0.008) that limits relying on chemical pesticides was more common among individual who heard about climatic change. The two practices are helpful in terms of long term sustainability and protection of the environment.

Source of Information vs. Practice Adoption

Practice	Heard from Mobile (Yes)	Heard from Mobile (No)
Adopted Crop Rotation	78%	53%
Adopted Organic Compost	69%	44%
Practicing IPM	65%	39%

Farmers' Support Needs to Adopt Climate-Smart Practices

Variable	Yes (%)	No (%)
Training	91%	9%
Subsidy	89%	11%
Equipment support	85%	15%
Improved seed varieties	92%	8%
Technical advice	88%	12%
Market access	76%	24%

The information underscores the importance of mobile phones as a source of information about the climate in stimulating the drive toward climate-smart agricultural activities. Significantly, farmers who accessed the information using mobile phones were considerably prone to adopting sustainable practices as opposed to their counterparts who did not access the information. As an example, out of these farmers who learned of climate practices through mobile, 78 percent engaged in crop rotation as compared to 53 percent among farmers without mobiles. The use of organic compost was also found in 69 per cent mobile-informed farmers against only 44 per cent in others. Integrated Pest Management (IPM), in this instance, had seemingly been practiced by 65% of mobile users compared to 39% of those who were not using it. These data are clear evidence that mobile-based extension programs have a positive effect on climate awareness, the promotion of sustainable agriculture practices to farmers in rural environment.

Besides access to information, the information also shows what farmers require to enable the climate-smart practices to be adopted. Most (91 per cent) said that they require training, demonstrating that knowledge development and capacity building are essential to implement.

Subsidies (89%) and equipment support (85%) were found necessary also, which suggested the financial and technical constraints of many smallholders. Moreover, 92% of farmers demanded better types of seeds, 88 percent demanded technical guidance, which is an indication of the need of practical products and technical expertise. The importance of market access to 76 percent of farmers may indicate that sustainable practices could become more common as the farmers have the profitable and secure markets to sell their farms.

Experience Level vs. Awareness

Variable	F-Statistic	Sig.
Heard from Extension Officer	3.25	0.023 *
Heard from Radio/TV	2.81	0.041 *
Heard from Mobile/Social Media	4.16	0.008 **
Heard from NGO	1.95	0.096**

Factor = Experience (4 groups); DV = info sources (1=Yes, 2=No)

The data analyses the “level of experience in a farmer and the extent to which he/she is conscious about climate change” depending on the various “sources of information”. ANOVA (F-test) is applied in the analysis by contrasting four groups (e.g., low to high experience in farming) to their chance of getting climate information about several sources. Dependent variable (awareness) is made into a binary response with Yes =1 and No = 2 recorded and considered as scale.

The findings indicate that there is “a profound connection between farming experience and a variety of sources of climate information”. In an example, the awareness of the different activities by “extension officers” varied greatly by the levels of experience (F = 3.25, p = 0.023**). This implies that more mature farmers could be in a good relationship with government/agricultural officers or engage in formal extension work.

Equally, the difference in awareness as a result of exposure to “radio or television” is large enough to suggest experience as a factor determining the levels of attention to traditional sources of the message by the farmers (F = 2.81, p = 0.041**). Probably, even those farmers who have moderate or higher levels of experience may still rely on the radio and TV in order to get the updates on agriculture and other information concerning the climatic conditions.

The highest correlation was determined with “mobile phones and social media” as information source (F = 4.16, p = 0.008**). This indicates that digital engagement depends on experience and can be explained by the fact that younger less experienced farmers are more acquainted with mobile and online services, or maybe the opposite is true to the extent that the experienced farmers with large farms may invest in mobile advisory services.

Nevertheless, “either NGO outreach is even across farmers of different experience levels or that outreach tends to reach the entirety of the agriculture population or none at all” since the NGO awareness was not significantly different among the groups based on experience level (F = 1.95, p = 0.096**).

Themes Identified

1-Economic Viability: This is the predominant issue in every section. According to farmers, the main reasons so as to quit cotton and fruit trees include low profitability, high fruition expense (seeds, pesticides, labour), erratic markets and exploitation by middlemen.

2-Environmental Stress: Droughts, Climatic variation (irregular rain, warm summers), and pests/disease pressure are the key factors affecting farming choices.

3-Pesticide Dependency: The commercial and regulatory pressures lead to this dependency, which traps itself in a vicious circle of health, soil, and environmental degradation.

4-Systemic Failures: Strangely missing government assistance (extension services, technical advice, market access, price regulation, infrastructure such as cold storage) makes all other problems even more problematic.

5-Adaptation strategies: Actual changes Being short-term focused, farmers switch to less water consuming crops (maize, vegetables), faster-return crops, or give up long-term investments (orchards) to be able to produce in the short term.

Detailed Thematic Analysis & Supporting Evidence

Theme	**Sub-Theme**	**Key Findings from Data**	**Representative Farmer Perspectives/Concerns**
I. Economic Drivers	**Declining Profitability (Crops)**	With extreme input expenditures (fertilizer, pesticide, seeds, labor) and a low/irregular cotton price, consistent losses are regrettable.	“The cotton is no longer profitable; the cotton loses money in spite of months of work; cotton is enslaved by the middle men and ginners.”
	Market Access & Exploitation	Low access to markets, lack of market transparency, and manipulation of prices by intermediaries, and slow payment. Shortage of storage of perishable goods (fruits).	Low prices... pay no time"; "skim by middle men"; "it cost high to transport"; "must sell off in a hurry at a loss."

Theme	**Sub-Theme**	**Key Findings from Data**	**Representative Farmer Perspectives/Concerns**
	Labor Costs & Shortages	Cotton picking manually requires hard labour. The urban migration and competition in other industries have contributed to the scarcity and the high rate of labor.	There is no cotton labor, it is costly"; refused the transactions in cotton cultivating.
	Orchard Economics	Due to climate effects, market changes, low prices, high transport costs and no storage, fruit orchards (mango, citrus) become unprofitable.	“Not economically productive; not safe to invest; yields cut out drastically; had to cut out fruit trees at threat.”
II.Environmental & Climate Stressors	**Water Scarcity**	Canal water supply is not always guaranteed (particularly at the tail-ends) and ground water is getting over. Affects crops that consume a lot of water (such as cotton, sugarcane and fruits).	“Scarcity of water; poor and late delivery; insecure supply; decrease of groundwater; difficulty of irrigation.”
	Climate Change Impacts	Higher temperatures, heatwaves, unstable (highs	“Climate change; Variability of weather; Heatwaves; Premature flowering; Boll drop; Fruit

Theme	Sub-Theme	Key Findings from Data	Representative Farmer Perspectives/Concerns
		and lows) rain patterns (droughts and floods). Causes harm directly to flowering/ fruiting.	drop; Reduced fruit size.”
	Increased Pest/Disease Pressure	Pests (whitefly, bollworm, fruit flies) and diseases are well favored by warm, humid conditions. Resistance to chemicals is on the increase.	“Pest pressure out of control"; white flies and pink Bollworms; bollworms; fruit flies and bacteria; resistant pests”
III. Pesticide Crisis	**Causes of High Use**	The notion of a need to fight hard-core pests eruptions (related to climatic change), ignorance of IPM measures and anti-dote advertisement by pesticide sources.	“Use high dose to assure crops; ignorance of integrated pest management (IPM) tension towards an over spray".
	Negative Consequences	Damage to helpful insects (bees, pollinators), soil/water/air contamination, health hazards, production expenses, generation of GHG, increases.	“Destroying the natural balance; dwindling useful insects; pollution of soil, air and water; costly and unhealthy; emit GHGs”

Theme	Sub-Theme	Key Findings from Data	Representative Farmer Perspectives/Concerns
	Vicious Cycle	Excessive use of pesticides →thinning of the good bugs/ resistance or non resistance → more pesticides used → degrades environment → makes crops weak to attacks of the pests → multiplies.	“Vicious cycle/reduces the ability to withstand shock; it is devastating to the environment... health and pocket”
IV. Systemic & Institutional Failures	**Lack of Extension/Support**	High levels of inadequacy in agricultural greening services by the government, technical advice and training in pest management, problems in climate resilience information.	“There exist no efficient agricultural extension services; access to professional advice is limited; there is lack of technical assistance.”
	Input Quality Issues	Low availability and quality of important input, particularly of certified seeds with high rate of germination.	Problem about seed quality; problem of non-availability of high germination seed; all these effects show poor produce as there is unevenness in planting.
	Infrastructure Deficits	Absence of crucial infrastructure like cold storage facilities for fruits,	"Absence of cold storage... compels farmers to remove fruit trees."

Theme	Sub-Theme	Key Findings from Data	Representative Farmer Perspectives/Concerns
		exacerbating market losses.	
V. Farmer Adaptation & Coping Strategies	**Crop Switching**	Switching to sugarcane, maize, vegetables, pulses, or fodder because of low water requirements, faster pay back or net reduced risk..	“Transform them to more water resistant... crops; to crops... more water resistant, and less remunerative”
	Deforestation/Orchard Removal	Felling fruit trees in order to: convert land to annual crops, to save in water/labor, to evade risk of climatic/market fluctuation with orchards.	“Extend crop growing areas"; "solve the domestic needs of the income"; "take out money-losing trees."
	Resource Reallocation	Water, labor and capital, in limited supply, are put towards crops that are considered more trustworthy or those on which immediate subsistence is based.	" Instead of growing wheat, cotton or vegetables... grows quicker"; crops which are short-run are more adaptable”

I. Economic motivations

The poor profitability of traditional crops such as cotton and fruits has caused serious challenges in the economic aspect of farmers in Muzaffargarh. The Cotton cultivation has become economically unviable due to high inputs (fertilizers, pesticides, labour) low-stable markets prices as well as exploitation by the middlemen. Equally, fruit orchards that used to be lucrative are being regarded as a risky venture because fruit markets are very mushy, transportation costs are high and there is a shortage of cold storage. The problem is being worsened by the scarcity of labor particularly in cotton picking where the rural labour has migrated into urban employment.

II. Environmental Climate Stressors

Climate change became an important source of stress. Increasing scarcity of water was reported by farmers caused by unreliability of canal supply and depreciating groundwater, which refer to water-intensive crops, such as sugarcane, fruits, and cotton. Temperatures are rising, irregular rainfalls, and even premature flowering is increasing due to extreme weather events which in turn are causing the reduction of yields and quality. Also, crop destruction by pest and diseases is on the rise due to rising climatic changes and this makes crop management not only tricky but also expensive.

III. Pesticide Crisis

Climate stress is both a direct and indirect outcome of heightened utilization of pesticide. Due to increased rainfall making areas warm and humid, farmers usually use high dosages to control aggressive pests attacks. Nevertheless, the outcome of this activity is environmental degradation in the form of killing the helpful insects, polluting the air and water as well as greenhouse emission. The resultant effect is a vicious cycle of resistance building by the pests that demand an increase in the use of the chemicals that further antagonize the ecosystem and the resilience of the farms.

IV. Institutional and Systemic Fiascos

Farmers were highly dissatisfied with the non-existence of government extension program and technical assistance, especially in the facet of pest management and climate resilience plans. Quality of input is also among concerns faced by them including the unavailability of certified seeds which have high rates of germination. This leads to farmers having to sell their produce at a loss or even chop orchards, exacerbating both the economic and environmental consequences further due to the lack of infrastructure, in particular, the cold storage facilities of perishable fruits.

V. Farmer Adaptation Coping Strategies

In reaction, farmers are diversifying by changing the crops to less water intensive crops and those which give fast returns like vegetables, fodder, or pulses. Many are chopping fruit trees, and taking water and labor out of long-cycle crops to opt for short-cycle crops in order to save risk and resources. Such measures might provide the short-term solution, but that is symptomatic of underlying structural problems that require systemic changes in order to stand the test of time.

Conclusion

The current paper discusses the role played by the factors of awareness, education, landholding size, farming experience, and institutional support to influence farmers perception and engagement with climate change mitigation behavior. It concludes that with increased awareness and level of education there will be improved comprehension of causes of climate change, such as the use of fertilizers, deforestation, burning of residues and livestock

emissions, and that increased adoption of practices considered to be climate-smart will include composting, agro-forestry, drip irrigation, and IPM. Mobile technology access is essential to the dissemination of climate knowledge and institutions of sustainable action.
According to thematic analysis, agriculture in Muzaffargarh is severally subjected to economic restriction, environmental pressure, excess use of pesticides, and poor institutional attention. As the survival strategy of a farmer, farmers are changing the high-input, long-term crops to short-cycle and low-risk crops. Though these adaptations provide solutions that can ease the pressures in the short term, they threaten to exacerbate environmental and economic weaknesses in the long term.

Recommendations

A range of interventions on sustainable agriculture needs to be adopted to ensure it helps in overcoming climatic changes. Awareness creation toward climate-smart agriculture (CSA) ought to be conducted through local extension servicemen, radio, television and mobile educators and inform the farmers about climate change and sustainable agricultural practices. Younger and tech-savvy farmers should be targeted by using a range of digital solutions such as mobile phones and social media, whereas an older and less connected to the Internet population needs to be reached using more traditional channels (radio and field visits). Comprehensive training on CSA methods, which involves composting, integrated pest management (IPM) system, drip irrigation and agroforestry should be done and local-language materials should be issued to cover different levels of education. Availability of certified seeds, ecofriendly fertilisation material and pest control provisions should be made available when farmers want them and investment in agricultural infrastructure like cold storage, water conserving irrigation systems and agro- connectivity roads will be important to eliminate postharvest losses and hike up in profitability. The smallholders should be given financial incentives such as subsidies that are specific, easy credit together with equipment sharing schemes as incentives to adopt the sustainable practice. The cooperation and closer multi-sectoral coordination between the government agencies, research, and NGOs can be strengthened in order to provide new tools to enhance effective provision of extension services and farmer-oriented innovative policies. The community level systems of water management and farmer cooperative should be encouraged to increase access collectively to market and inputs. Lastly, planting of low stress plants and investing in research of high payoffs depending on the region of interest will also help the farmer to adjust well to climatic difficulties.

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