Journal of Integrated Sciences and Agriculture (JISA)
ISSN: _____
Journal Homepage: http://journals.ageconfrontiers.com/jisa
Vol. 1(1) Open Access

Original Research Article

Climate Change Perceptions and the Adoption of Climate-Smart Agriculture Among Wheat Farmers in Faisalabad, Pakistan: An Exploratory Household Survey

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ARTICLE INFO
Keywords
- Climate change perception
- Climate-smart agriculture
- Technology adoption
- Wheat farmers
- Land tenure
- Agricultural extension
- Faisalabad, Pakistan

Article History
Received: 22 August 2026
Revised: 09 November 2026
Accepted: 11 November 2026
Available online: 17 November 2026
License
CC BY 4.0 – Open Access
DOI
10.66529/jisa.2026.1.1.131

ABSTRACT
Climate change is a major threat to wheat production in Pakistan, yet little district-level evidence exists on how farmers' awareness of the problem translates into adoption of Climate-Smart Agriculture (CSA) practices. This exploratory study surveyed 100 wheat-farming households in Faisalabad district, selected through convenience sampling, to examine climate change perceptions, CSA awareness, adoption behaviour, and the socio-economic factors associated with them. Results show high awareness of climate change (93% had heard of it; 87% believed it negatively affects wheat production) alongside markedly lower engagement with climate-smart solutions: 63% were aware of CSA practices, but only 21% reported adopting any new practice in response to climate change, and 77% expressed willingness to adopt such practices in the future. A chi-square test of independence found that education level was significantly associated with CSA-specific awareness ($\chi^2(3) = 14.80$, $p = .002$, Cramér's $V = 0.38$), with Matric-level respondents least aware; however, education was not significantly associated with general climate change awareness, perceived yield impact, or future willingness to adopt (all $p > .05$). Land ownership and gender were recorded as household characteristics but were not cross-tabulated against adoption outcomes in this analysis and are flagged as priorities for confirmatory follow-up research rather than reported as determinants here. The awareness-adoption gap is attributed, descriptively, to financial constraints, limited technical support, and insecure land tenure reported by respondents. Because the sample is small and non-probability in design, findings should be read as exploratory evidence for Faisalabad rather than as population-representative estimates. The study recommends targeted agricultural extension, accessible financing, and tenure-sensitive outreach to help convert existing awareness into practice, and calls for larger, probability-based follow-up studies to confirm the associations identified here.

Citation: *Saeed, M.H. (2026). Climate Change Perceptions and the Adoption of Climate-Smart Agriculture Among Wheat Farmers in Faisalabad, Pakistan: An Exploratory Household Survey.* ***J. Integ. Sci. Agric.*** *1(1): 33-44. https://doi.org/10.66529/jisa.2026.1.1.131*

1. Introduction

Agriculture is the backbone of Pakistan's economy, contributing approximately 22.9% of national GDP and employing nearly 37.4% of the labour force, with wheat as the country's principal staple and food security crop (Ministry of Finance, 2023). In recent decades, climate change has emerged as one of the most formidable challenges confronting agricultural systems worldwide, and Pakistan, despite contributing less than 1% of global greenhouse gas emissions, ranks among the countries most vulnerable to its effects (Ministry of Finance, 2023).

Global evidence indicates that climate change threatens crop yields, including those of wheat. Lipper et al. (2014) report that global crop yields could fall by up to 2% per decade against a backdrop of rising demand, a pressure that bears heavily on densely populated, agriculture-dependent economies such as Pakistan.

Pakistan's agricultural landscape has been significantly affected by observable climatic shifts over recent decades. In Sialkot district of Punjab, farmers report rising summer and winter temperatures, identify rainfall as a major climate threat, and judge the harvest phase of the wheat crop to be the most affected (Ehsan et al., 2022). Similarly, Abid et al. (2015), using

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data from 450 farm households in three districts across Punjab's agro-ecological zones, examined how farmers perceive climate change and adapt their farming in response, and called for greater investment in farmer education and institutional support for adaptation.

Climate-Smart Agriculture (CSA) has been widely recognized as a promising framework for helping farming communities adapt to these pressures while sustaining productivity and reducing emissions where feasible. CSA integrates practices such as zero tillage, crop diversification, water-efficient irrigation, climate-resilient seed varieties, and integrated soil-fertility management, including soil-amendment approaches such as biochar application, which has been shown to improve soil fertility and crop resilience under environmental stress in arid and semi-arid cropping systems (Osman et al., 2025). Empirical studies from across South Asia and beyond consistently affirm the effectiveness of CSA practices in improving productivity and resilience. In China, Vatsa et al. (2023) found that intensifying CSA adoption significantly increased rice yields, with implications for food security; in Nepal, Gairhe et al. (2021) documented better grain-yield responses to climate-smart interventions in wheat grown under rice-wheat systems; and in India, Kakraliya et al. (2021) reported higher wheat yields, lower greenhouse gas emissions, and better economic efficiency from CSA practice portfolios in rice-wheat systems in Karnal.

However, the relationship between farmers' awareness of climate change and their actual adoption of CSA practices is neither automatic nor straightforward, and reviews of farmers' climate change awareness and adaptation indicate that awareness is only an early step in the adaptation process and that limited information, finance, and institutional support constrain adoption (Ricart et al., 2023; Nguyen et al., 2025). The precise concept of CSA itself has also been applied inconsistently across the literature: a systematic review of 113 CSA-related documents published between 2004 and 2016 found that the framing and operational definition of CSA varied considerably by study and institutional context, limiting direct comparison across settings (Chandra et al., 2018).

1.1. Research Gap and Novelty

Existing Pakistan-focused evidence on climate perceptions and CSA engagement has concentrated on other Punjab districts. Ehsan et al. (2022) examined climate trends and farmer perceptions in Sialkot district, while Abid et al. (2015) surveyed households across three different Punjab districts; neither study reports evidence from Faisalabad, Punjab's largest wheat-producing district and the province's principal agro-industrial hub. Mustafa et al. (2024) analysed the productivity and cost effects of CSA adoption on Pakistani wheat farms but did not examine the awareness-adoption relationship or its socio-economic correlates at household level. A related strand of Punjab-based technology-adoption research, exemplified by Ashfaq and Tehreem (2025) on solar-powered irrigation adoption among rice farmers in Hafizabad, demonstrates that the determinants-of-adoption framework travels well across climate-adaptive technologies in the province, but has not previously been applied to CSA practices specifically in Faisalabad. This study addresses that gap by providing district-specific, household-level evidence on climate change perceptions, CSA awareness, adoption behaviour, and the barriers reported by wheat farmers in Faisalabad, and by examining explicitly whether, and for which outcomes, education level is statistically associated with these outcomes.

1.2. Research Objectives

This study pursues four specific objectives, corresponding to the four dimensions investigated:

1. To assess wheat farmers' perceptions of climate change and its observed effects on wheat yield in Faisalabad district;
2. To measure farmers' awareness of Climate-Smart Agriculture practices, and to examine whether this awareness differs by education level;
3. To assess farmers' actual adoption of, and future willingness to adopt, climate-responsive farming practices, and to examine the association between education and these adoption outcomes; and
4. To identify the principal barriers farmers report to adopting CSA practices, as a basis for targeted policy recommendations.

2. Problem Statement and Significance of the Study

Wheat is Pakistan's principal staple crop and a cornerstone of national food security, yet its productivity is increasingly threatened by rising temperatures, erratic rainfall, and more frequent extreme weather events. Climate-Smart Agriculture offers a recognized pathway for farmers to adapt to these pressures while sustaining yields, but adoption depends on more than awareness alone: it requires access to information, finance, secure land tenure, and effective extension support. Where farmers are aware of both climate risk and CSA solutions but do not adopt them, the resulting gap represents a

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policy-relevant failure of the support system surrounding farmers, rather than a failure of farmer knowledge or motivation. Faisalabad, as Punjab's largest wheat-producing district, is a critical site for understanding this gap: if awareness is not translating into adoption even in a relatively well-connected agricultural hub, the implications for less-resourced districts are likely to be more severe.

This study is significant for three reasons. First, it provides district-specific, household-level evidence from Faisalabad, filling a gap in a literature that has so far concentrated on other Punjab districts (Ehsan et al., 2022; Abid et al., 2015). Second, by examining climate perceptions, CSA awareness, and adoption behaviour within a single household survey, it allows the awareness-adoption relationship to be assessed directly rather than inferred across separate studies. Third, by explicitly testing, rather than assuming, the association between education and each outcome measured, the study offers a more precise basis for targeting extension and policy interventions than descriptive reporting alone would provide.

3. Literature Review

3.1. Climate-Smart Agriculture: Concept and Global Evidence

The conceptual foundations of CSA were articulated by Lipper et al. (2014), who defined it as an approach to sustainably increasing agricultural productivity, strengthening farmers' resilience, and reducing or removing greenhouse gas emissions where possible. A systematic review of 113 CSA-related documents published between 2004 and 2016, however, found that the concept has been framed inconsistently across institutional and geographic contexts, with definitions ranging from narrow technical practice sets to broad sustainable-intensification agendas (Chandra et al., 2018). This conceptual variability matters for empirical research, since studies measuring "CSA adoption" may not be measuring strictly comparable practice sets. Subsequent systematic reviews have nonetheless reported that CSA practices, when adopted, generally raise crop productivity and improve household welfare (Tadesse & Ahmed, 2023; Nguyen et al., 2025).

3.2. Evidence from South Asia

Within South Asia, several studies document both the productivity benefits of CSA and the socio-economic factors shaping its adoption. In India, Kakraliya et al. (2021) found that CSA practice portfolios raised wheat yields, lowered greenhouse gas emissions, and improved economic efficiency in rice-wheat systems in Karnal, while Ramadas et al. (2018), in a survey of 500 wheat farmers in India, found that awareness of most adaptation practices was very low apart from organic manure, new varieties, crop insurance, and irrigation management, and called for targeted extension programmes. In Bangladesh, Moniruzzaman et al. (2023), surveying 600 wheat farmers, reported that farmers' perceptions of changing temperature and rainfall were corroborated by meteorological data, but that adaptation centred on changing planting dates (23%) and short-duration varieties (17%), with about 19% of farmers adopting no adaptation measure, and that access to climate information and credit increased the likelihood of adoption; Akter et al. (2022) examined the income and yield effects of CSA adoption among farmers in flood-prone areas of Bangladesh. In Nepal, Gairhe et al. (2021) documented better grain-yield responses to climate-smart interventions in wheat grown under rice-wheat systems in the southern plains, and in China, Vatsa et al. (2023) found that intensifying CSA adoption raised rice yields by about 1,410 kg per hectare, with implications for food security.

3.3. Evidence from Pakistan

Pakistan-specific evidence reinforces the pattern that awareness of climate change is now widespread among farmers, but that adoption of adaptive practices lags behind. Ehsan et al. (2022) found, in Sialkot district, that literate farmers and those with broad farming experience were more knowledgeable about the climatic effects on wheat production, and that farmers attributed limited adoption of climate-smart practices to lack of knowledge and skills (86%), economic constraints (78%), and lack of modern technologies (74%). Abid et al. (2015), surveying 450 households in three districts across Punjab's agro-ecological zones, examined how farmers perceive climate change and adapt their farming in response, and concluded that greater investment in farmer education and institutional support was needed. Imran et al. (2018) examined CSA practices among cotton farmers in Punjab and found that they had a significant positive impact on the gross value of cotton production. Mustafa et al. (2024) found that CSA adoption improved wheat productivity and cost efficiency among Pakistani farmers, reinforcing the economic case for adoption, while Ashfaq and Tehreem (2025) applied a comparable determinants-of-adoption framework to solar-powered irrigation adoption among rice farmers in Hafizabad district, finding that financial access, farm size, and extension contact were the strongest predictors of adoption, a pattern consistent with the barriers reported qualitatively by wheat farmers in the present study.

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3.4. Evidence from Africa and Other Developing Regions

Evidence from Sub-Saharan Africa shows a broadly similar pattern of constrained adoption despite recognized benefits. In South Africa, Abegunde et al. (2020) found that educational status, farm income, farming experience, farm size, contact with agricultural extension, and exposure to media, among other factors, influenced the adoption of CSA practices among small-scale farming households. In Ethiopia, Belay et al. (2022) found that the adoption of climate-smart adaptation practices among smallholder farmers in the south of the country was significantly influenced by factors including education, landholding size, farming experience, and access to climate information and training, while Alemayehu et al. (2024) found that CSA adoption improved technical efficiency among wheat farmers in the northwest. Broader reviews identify limited access to credit, extension, and secure tenure, together with knowledge, financial, and institutional constraints, as recurring barriers to adoption across the continent (Tadesse & Ahmed, 2023; Wakweya, 2023), and Tesfaye et al. (2015) assess the potential impacts of climate change on maize production and food security across Sub-Saharan Africa.

3.5. Synthesis and Positioning of the Present Study

Three patterns recur across this literature. First, farmer awareness of climate change is now consistently high across the settings reviewed, including Pakistan, India, Bangladesh, and multiple African countries, which is consistent with the high awareness levels reported for Faisalabad in Section 5 below. Second, adoption of CSA practices specifically, as distinct from low-cost behavioural adjustments such as changing sowing dates, remains consistently lower than awareness across most of the studies reviewed, echoing the global finding that awareness does not reliably convert into adoption without institutional support (Ricart et al., 2023). Third, where studies test the socio-economic correlates of adoption using inferential statistics, education, land tenure, extension access, and credit access recur as significant factors (Abegunde et al., 2020; Belay et al., 2022; Tadesse & Ahmed, 2023). The present study extends this literature to Faisalabad specifically, and, within the scope of the data collected, tests the education association directly using chi-square analysis rather than relying on descriptive cross-tabulation alone (Section 5.2).

4. Materials and Methods

4.1. Research Design

This study used a cross-sectional survey design to assess climate change perceptions, Climate-Smart Agriculture awareness, adoption behaviour, and reported barriers among wheat-farming households in Faisalabad district. The design is exploratory rather than confirmatory: its purpose is to generate baseline, district-specific evidence and to identify associations worthy of testing in future, larger-scale research, rather than to produce population-representative estimates for Faisalabad district as a whole.

4.2. Study Population and Sampling

The target population comprised wheat-growing households, including land-owning farmers, tenants, and owner-cum-tenant cultivators, residing in rural union councils of Faisalabad district. Respondents were drawn from multiple rural farming communities across the district rather than a single village, to capture some variation in land tenure and farm size. Data were collected through face-to-face structured interviews conducted during the rabi (wheat-growing) season.

Respondents were selected through convenience sampling: households were approached based on their accessibility and willingness to participate within the rural communities surveyed, rather than through a probability-based sampling frame or a deliberate selection of information-rich cases against pre-specified criteria. This distinction matters methodologically: convenience sampling selects respondents primarily on the basis of ease of access, whereas purposive sampling deliberately selects respondents who meet specific criteria judged relevant to the research question (for example, farmers known to have already adopted CSA practices). The present study used the former. The implications of this choice for the generalizability of the findings are discussed in Section 4.6 and Section 7.2.

4.3. Sample Size

A sample of 100 wheat-farming households was surveyed. This sample size was judged adequate for the study's exploratory objective, descriptive analysis, and bivariate testing of the associations specified in Section 4.5, consistent with general guidance on minimum sample sizes for exploratory social-science surveys (Israel, 1992). It was not derived from a formal probability-sampling calculation (such as Yamane's formula) against a known population total, because a reliable, disaggregated count of wheat-farming households specifically within Faisalabad district was not available to the authors. Consequently, the sample should not be treated as representative of all wheat-farming households in the district, and the findings reported in Section 5 are presented as exploratory, district-level evidence rather than as population estimates. A

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probability-based sample, sized against a verified sampling frame, is recommended for future confirmatory research (Section 7.3).

4.4. Variables

The dependent variables examined were:

- climate change awareness and perceived impact on wheat yield;
- awareness of Climate-Smart Agriculture practices;
- adoption of new farming practices in response to climate change, and willingness to adopt further CSA practices in the future; and
- barriers to adoption, as reported by respondents.

The independent variable examined in the bivariate analysis (Section 5.2) was respondent's highest level of education, coded in four categories: Matric, Intermediate, Bachelors, and Masters. Land ownership status (owner, tenant, owner-cum-tenant) and household size were also recorded descriptively (Section 5.1) but, as discussed in Section 4.6, were not cross-tabulated against adoption outcomes in the present analysis.

The adoption variable requires a specific clarification. The questionnaire item underlying Table 6 asked whether the household had "adopted any new farming practice to cope with climate change", a general adoption question, rather than asking separately whether each specific CSA practice (for example, zero tillage, laser land levelling, or drought-tolerant seed varieties) had been adopted. Respondents who answered affirmatively were asked to name the practice(s) adopted, and the practices most commonly reported (improved/drought-tolerant seed varieties and laser land levelling) fall within standard CSA practice classifications (Lipper et al., 2014). The 21% adoption figure reported in Section 5.1 should therefore be read as adoption of a new, climate-motivated farming practice that is predominantly, but not verified on a practice-by-practice basis to be exclusively, CSA-classified. This measurement distinction is noted as a limitation in Section 7.1 and should be addressed through a practice-specific checklist in future survey instruments.

4.5. Data Analysis Techniques

Data were analysed using descriptive statistics (frequencies, percentages, and cumulative percentages) for all variables. For the four cross-tabulations presented in Section 5.2, a chi-square (χ^2) test of independence was conducted to test whether education level was statistically associated with each outcome, and Cramér's V was calculated as a measure of association strength where the chi-square test indicated a significant relationship. Where more than 20% of cells in a cross-tabulation had an expected count below 5, a standard threshold for chi-square reliability, this is noted explicitly alongside the result, and the test result is interpreted with corresponding caution rather than treated as confirmatory. All descriptive and inferential analyses were conducted using IBM SPSS Statistics.

4.6. Limitations

This study has several limitations that bear directly on how its findings should be interpreted. First, the convenience sampling procedure described in Section 4.2 means the sample is non-probability and may not represent the full diversity of wheat-farming households in Faisalabad district; findings describe the surveyed respondents and should not be generalized to the district population without a confirmatory, probability-based follow-up study. Second, the sample size of 100 was set for exploratory, not population-representative, purposes (Section 4.3), and several cross-tabulated cells, particularly for the Masters-education category (n = 10), have small expected counts that limit the reliability of chi-square tests for some outcomes (noted explicitly in Section 5.2). Third, land ownership status and gender were recorded but were not cross-tabulated against adoption outcomes in this analysis; consequently, this study does not provide statistical evidence that land ownership or gender are determinants of CSA adoption. Fourth, barriers to adoption were recorded through open-ended responses rather than a structured, pre-coded checklist, so barrier frequencies are reported descriptively in Section 5.3 rather than as a quantified table. Fifth, as discussed in Section 4.4, the adoption variable measures general climate-motivated practice change rather than a practice-by-practice CSA checklist. Each of these limitations is carried forward into specific recommendations for future research in Section 7.3.

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5. Results and Discussion

5.1. Descriptive Characteristics and Outcomes

Tables 1 through 6 present the frequency distribution of respondent characteristics and the four principal outcome variables. Throughout this section, education categories are presented in their natural hierarchical order (Matric, Intermediate, Bachelors, Masters) rather than alphabetically, so that cumulative percentages are directly interpretable.

Table 1. Frequency distribution of respondents by education level

Education level	Frequency	Percent	Cumulative percent
Matric	24	24.0	24.0
Intermediate	34	34.0	58.0
Bachelors	32	32.0	90.0
Masters	10	10.0	100.0
Total	**100**	**100.0**	

Table 1 shows that the sample is moderately educated overall. Arranged in hierarchical order, 24% of respondents had completed Matric as their highest qualification, 34% Intermediate, 32% Bachelors, and 10% Masters. Consequently, 76% of respondents had completed at least Intermediate-level education (100% minus the 24% whose highest qualification was Matric). This moderately educated profile is relevant to the education-related associations examined in Section 5.2.

Table 2. Frequency distribution of respondents by land ownership status

Land ownership status	Frequency	Percent	Cumulative percent
Owner	58	58.0	58.0
Owner-cum-tenant	33	33.0	91.0
Tenant	9	9.0	100.0
Total	**100**	**100.0**	

Table 2 shows that land ownership is concentrated: 58% of respondents were outright owners, 33% were owner-cum-tenants who supplement owned land with rented land, and 9% were pure tenants. As discussed in Section 4.6, land ownership status was not cross-tabulated against the adoption outcomes reported below, so Table 2 is presented here descriptively; it establishes the land-tenure composition of the sample rather than a tested association with adoption.

Table 3. Frequency distribution of respondents by number of family members working on the farm

Family members farming	Frequency	Percent	Cumulative percent
1	33	33.0	33.0
2	40	40.0	73.0
3	12	12.0	85.0
4	6	6.0	91.0
5	7	7.0	98.0
6	2	2.0	100.0
Total	**100**	**100.0**	

Table 3 shows that farm labour is typically shared between one and two family members (73% of households), with larger family labour contributions becoming progressively less common.

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Table 4. Frequency distribution of respondents by perceived effect of climate change on wheat production

Response	Frequency	Percent	Cumulative percent
No	13	13.0	13.0
Yes	87	87.0	100.0
Total	**100**	**100.0**	

Table 4 shows that 87% of respondents believe climate change negatively affects wheat production, indicating a strong consensus consistent with farmers' direct field-level experience of climatic stress.

Table 5. Frequency distribution of respondents by awareness of Climate-Smart Agriculture practices

Response	Frequency	Percent	Cumulative percent
No	37	37.0	37.0
Yes	63	63.0	100.0
Total	**100**	**100.0**	

Table 5 shows that 63% of respondents were aware of CSA practices, leaving a substantial 37% knowledge gap that targeted extension could help close.

Table 6. Frequency distribution of respondents by adoption of new farming practices in response to climate change

Response	Frequency	Percent	Cumulative percent
No	79	79.0	79.0
Yes	21	21.0	100.0
Total	**100**	**100.0**	

Table 6 shows that only 21% of respondents reported adopting a new, climate-motivated farming practice, against the operational definition described in Section 4.4. Read together, Tables 4, 5, and 6 establish the central pattern this study investigates: high awareness of both climate change (87%) and CSA practices (63%), alongside markedly lower reported adoption (21%).

5.2. Education and Climate/CSA-Related Outcomes

Four cross-tabulations examine whether education level is associated with climate change awareness, CSA awareness, perceived yield impact, and future adoption willingness. For each, a chi-square test of independence was conducted; results are reported beneath each table, with Cramér's V reported where the association is statistically significant.

Table 7. Education level by whether respondent had heard of climate change

Education level	Had not heard (No)	Had heard (Yes)	Total
Matric	2	22	24
Intermediate	3	31	34
Bachelors	2	30	32
Masters	0	10	10
Total	**7**	**93**	**100**

$\chi^2(3, N = 100) = 1.02, p = .797$. Not statistically significant. Four of eight cells (50%) had an expected count below 5, so this result should be interpreted with caution regardless of significance.

Table 7 shows that 93% of respondents had heard of climate change, and this was true across every education level, including 22 of 24 Matric-level respondents. The chi-square test confirms that this near-universal awareness does not differ significantly by education: climate change awareness in this sample appears to be effectively ubiquitous and education-independent, consistent with the clear perception of changing temperature and rainfall reported in wheat-farming studies elsewhere in South Asia (Ramadas et al., 2018; Moniruzzaman et al., 2023).

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Table 8. Education level by awareness of Climate-Smart Agriculture practices

Education level	Not aware (No)	Aware (Yes)	Total
Matric	15	9	24
Intermediate	14	20	34
Bachelors	8	24	32
Masters	0	10	10
Total	**37**	**63**	**100**

$\chi^2(3, N = 100) = 14.80$, $p = .002$, Cramér's V = 0.38 (medium-to-large association). One of eight cells (12.5%) had an expected count below 5, within the conventional reliability threshold.

Table 8 shows a clear education gradient in CSA-specific awareness: only 9 of 24 (38%) Matric-level respondents were aware of CSA practices, compared with 20 of 34 (59%) Intermediate, 24 of 32 (75%) Bachelors, and all 10 (100%) Masters-level respondents. Unlike the other three outcomes examined in this section, this association is statistically significant and reasonably strong, indicating that education is specifically associated with exposure to, or retention of, CSA-related information, rather than with climate awareness in general. Of the four associations tested, it is the only one supported by inferential evidence; the corresponding associations for general climate awareness, perceived yield impact, and future willingness (Tables 7, 9, and 10) are not statistically significant and are reported descriptively.

Table 9. Education level by perception that climate change has strongly affected wheat yield

Education level	Not strongly affected	Strongly affected	Total
Matric	4	20	24
Intermediate	3	31	34
Bachelors	2	30	32
Masters	1	9	10
Total	**10**	**90**	**100**

$\chi^2(3, N = 100) = 1.74$, $p = .629$. Not statistically significant. Four of eight cells (50%) had an expected count below 5.

Table 9 shows that 90% of respondents perceived climate change as strongly affecting wheat yield, and this perception was consistent across education levels, including 20 of 24 Matric-level and 9 of 10 Masters-level respondents. As with general climate awareness (Table 7), the chi-square test finds no significant association with education, and the high proportion of low-expected-count cells means this non-significant result should be read as inconclusive rather than as definitive evidence of no relationship.

Table 10. Education level by willingness to adopt more CSA practices in the future

Education level	Not willing	Willing	Total
Matric	5	19	24
Intermediate	9	25	34
Bachelors	8	24	32
Masters	1	9	10
Total	**23**	**77**	**100**

$\chi^2(3, N = 100) = 1.32$, $p = .724$. Not statistically significant. One of eight cells (12.5%) had an expected count below 5, within the conventional reliability threshold, so this null result can be read with reasonable confidence.

Table 10 shows that 77% of respondents were willing to adopt more CSA practices in the future, and this willingness did not differ significantly by education level: even among Matric-level respondents, 19 of 24 (79%) expressed willingness, a proportion comparable to or higher than the other education groups. Because this cross-tabulation has only one low-expected-count cell, this null result is more reliable than those in Tables 7 and 9, and indicates that willingness to adopt is broadly shared across education levels, even where current CSA awareness (Table 8) is not. This finding is encouraging from a policy perspective: it suggests that extension interventions targeting less-educated farmers are likely to find a receptive audience rather than needing to first overcome resistance to adoption in principle.

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5.3. Reported Barriers to Adoption

Respondents who had not adopted new CSA-related practices were asked, through an open-ended question, to describe the main obstacles they faced. As noted in Section 4.6, these responses were not captured through a structured, pre-coded checklist, so frequencies or percentages specific to this sample are not available, and no barriers table is presented here. Descriptively, the obstacles raised most frequently in these open responses were limited knowledge of how to implement specific CSA practices, financial constraints in affording improved seed varieties or machinery such as laser land levellers, insufficient contact with agricultural extension staff, and, among tenant respondents in particular, reluctance to invest in land they did not own. These themes are broadly consistent with the barriers reported in comparable studies: Ehsan et al. (2022) report that farmers in Sialkot attributed limited CSA adoption to lack of knowledge and skills, economic constraints, and lack of modern technologies; Belay et al. (2022) find that access to climate information and training significantly influence CSA adoption among smallholders in southern Ethiopia; and reviews identify limited information, credit, extension, and tenure security as recurring constraints (Ricart et al., 2023; Tadesse & Ahmed, 2023). Ashfaq and Tehreem (2025) report a parallel pattern for solar irrigation adoption in Hafizabad, where financial access and extension contact were the strongest predictors. A structured, pre-coded barriers instrument is recommended for future surveys in this district so that these obstacles can be ranked and quantified directly (Section 7.3).

5.4. Summary of the Awareness-Adoption Gap

Read together, Sections 5.1 to 5.3 describe a consistent pattern: awareness of climate change (93%, Table 7) and its effects on wheat yield (87%, Table 4) is close to universal in this sample, CSA awareness is substantial but less complete (63%, Table 5), and actual adoption of new climate-motivated practices is markedly lower (21%, Table 6), despite high stated willingness to adopt in future (77%, Table 10). This pattern mirrors the awareness-adoption gap documented across the South Asian and African literature reviewed in Section 3 (Ricart et al., 2023; Ehsan et al., 2022; Moniruzzaman et al., 2023), and the present study's contribution is to show, with inferential evidence specific to Faisalabad, that this gap is not explained by education differences in general climate awareness or in willingness to adopt, both of which are already high and broadly uniform across education levels; rather, the one significant education-related gap identified here is in CSA-specific awareness (Table 8), pointing to extension and information access, rather than underlying attitude, as the more tractable policy lever.

6. Conclusion and Policy Implications

This exploratory survey of 100 wheat-farming households in Faisalabad district finds that farmers are highly aware of climate change and its effects on wheat yield, and substantially aware of Climate-Smart Agriculture as a response, but that this awareness has not translated into widespread adoption of new practices: only 21% of respondents reported adopting a new, climate-motivated farming practice, against 77% who expressed willingness to do so in future. Chi-square testing shows that this gap is not explained by education differences in general climate awareness, perceived yield impact, or future willingness, all of which are high and statistically indistinguishable across education levels; the one statistically significant education-related difference identified is in CSA-specific awareness, where Matric-level respondents were markedly less likely to be aware of CSA practices than respondents with higher qualifications. Land ownership and gender were recorded but not statistically tested against adoption in this analysis, and their role as determinants is therefore treated as a priority for confirmatory research rather than reported as a finding.

Because the sample was selected through convenience sampling and was sized for exploratory rather than population-representative purposes (Section 4.3), these findings should be read as district-level, exploratory evidence for Faisalabad rather than as generalizable estimates for Punjab or Pakistan as a whole. With that caveat, three policy implications follow, each scaled to the strength of the evidence reported above rather than to the broader ambitions sometimes associated with CSA promotion generally.

6.1. Extension Targeting Less-Educated Farmers

Because CSA-specific awareness, and not general climate awareness or willingness to adopt, is the one outcome significantly associated with education in this sample (Table 8), extension resources in Faisalabad district would be most efficiently directed toward closing the CSA-information gap among Matric-level and less-educated farmers specifically, for example through simplified, visually-oriented extension material and farmer-to-farmer demonstration plots, rather than toward broader climate-awareness campaigns for which this sample shows little room for improvement.

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6.2. Financing and Risk-Sharing Mechanisms for Tenants and Smallholders

Although this study does not provide statistical evidence that land tenure status is associated with adoption (Section 4.6), the qualitative barriers reported in Section 5.3, together with consistent findings from comparable studies in Pakistan and elsewhere (Ricart et al., 2023; Tadesse & Ahmed, 2023; Ashfaq & Tehreem, 2025), indicate that tenant and owner-cum-tenant farmers, who together comprise 42% of this sample (Table 2), face distinct disincentives to investing in practices whose benefits may accrue to landowners rather than to themselves. Targeted, low-collateral financing instruments and input-sharing or leasing arrangements for CSA-related equipment, such as laser land levellers, would directly address a barrier that respondents in this study raised but that this analysis was not designed to quantify, and should be paired with the confirmatory land-tenure analysis recommended in Section 7.3.

6.3. Proportionate Scaling of Interventions

Given the small, non-probability sample underlying this study, the recommendations above are best treated as a basis for a pilot extension and financing intervention in a subset of Faisalabad union councils, evaluated against a larger, probability-based follow-up survey, rather than as a basis for district-wide policy commitment. This proportionate, phased approach is consistent with the exploratory framing of the present study (Section 4.1) and would allow the associations identified here, particularly the education-CSA-awareness link in Table 8, to be confirmed or revised before being scaled further.

7. Limitations and Future Research

7.1. Summary of Limitations

The principal limitations of this study, discussed in full in Section 4.6, are: a non-probability, convenience-sampled study design that limits generalizability; a sample size set for exploratory rather than confirmatory purposes; the absence of cross-tabulated evidence on land ownership and gender as adoption determinants; reliance on open-ended rather than structured barrier reporting; and an adoption measure that captures general climate-motivated practice change rather than a practice-by-practice CSA checklist.

7.2. Implications for Interpreting the Findings

These limitations mean the findings reported in Sections 5 and 6 should be treated as hypotheses generated by an exploratory study rather than as confirmed population parameters for Faisalabad district. The single statistically robust finding, the association between education and CSA-specific awareness (Table 8), is the result best supported for near-term policy use; the remaining descriptive patterns, including the overall awareness-adoption gap itself, are consistent with, and add district-specific detail to, a well-established regional literature (Section 3.5), but warrant confirmation with a larger, probability-based sample before being treated as established facts about Faisalabad specifically.

7.3. Recommendations for Future Research

1. A probability-based follow-up survey, sized against a verified count of wheat-farming households in Faisalabad district, to confirm whether the associations identified here hold at district scale.
2. A dedicated cross-tabulation, or logistic regression, of land ownership status against CSA adoption, to test directly the tenure-related hypothesis this study was not designed to confirm.
3. Collection and analysis of gender-disaggregated data, which this study recorded as a variable of interest but did not analyze.
4. A structured, pre-coded barriers instrument, to allow the obstacles described qualitatively in Section 5.3 to be ranked and quantified.
5. A practice-specific CSA adoption checklist, distinguishing individual practices (for example, laser land levelling, drought-tolerant varieties, zero tillage) rather than a single general adoption question, to refine the measurement clarified in Section 4.4.

Declarations

Funding: The authors declare no specific funding for this work.
Conflict of Interest: The authors declare no conflict of interest.
Research Ethics: Participation in the household survey was voluntary, and respondents were informed of the study's purpose prior to data collection; no personally identifying information is reported in this manuscript.

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Data Availability: The survey dataset underlying Tables 1–10 is available from the corresponding author on reasonable request.

Use of AI: AI-assisted tools were used to support statistical verification, literature and reference checking, and language editing during manuscript revision. The authors reviewed and approved all content and assume full responsibility for its accuracy.

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