



# **Adoption Challenges of Climate-smart Practices among Mustard Farmers in Bundelkhand, Uttar Pradesh, India**

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## **Authors' contributions**

*This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.*

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## ABSTRACT

This study was conducted to examine constraints faced by mustard farmers in adopting climate-smart agricultural practices in the Bundelkhand region of Uttar Pradesh. The data were collected from 120 respondents randomly with a structured interview schedule from two groups of villages' namely smart and non-smart villages from four blocks (two each of Banda and Hamirpur districts). The constraints were divided into three categories i.e., economic constraints, socio-personal constraints, and technological constraints. Among socio-personal factors, the communication gap among farmers emerged as the most serious issue in both Smart and Non smart villages followed by lack of trust in CSAP effectiveness, cultural incompatibility, and the inability to take risks. Economic constraints such as high production costs and initial investment in equipment and machinery were the most pressing barriers. Furthermore, it was observed that, while there was not much difference in socio-personal, technical and economic constraints faced by both groups of respondents.

*Keywords: Mustard; agriculture practices; adoption; constraints.*

## 1. INTRODUCTION

Climate change is a great risk to farming especially in susceptible areas such as Bundelkhand which is characterized with irregular rain, occurrence of droughts and degradation of resources. Mustard cultivation in the Bundelkhand region faces significant challenges due to these conditions. The area is prone to erratic and delayed rainfall, frequent droughts, and rising winter temperatures, all of which disrupt sowing schedules, reduce crop yields, and affect oil content (Kumar, et al., 2022, Kalia, et al., 2021). It is quite vulnerable to climatic changes thus Climate Smart Agricultural practices (CSAP) that will advance resilience and productivity must be embraced. CSA entails various strategies, which promote sustainable enhancement of agricultural productivity, adaptation and generation of resilience to climate change, and controlled greenhouse gas generation. Nevertheless, realization of the CSAP among mustard farmers in Bundelkhand is not high. This can mostly be attributed to various socio-economic, technological, institutional and environmental limitations that render the effective implementation to be difficult. The awareness of these challenges is essential with regard to the development of specific interventions targeted at the improvement of sustainable mustard production under the conditions of climatic variability.

Smallholder farmers continue to rely on their own knowledge, experiences, creativities, and ingenuities to build local resilience and enhance food crop production at the household levels. Indigenous knowledge represents the knowledge and experiences of smallholder farmers and it is collectively owned and includes the mental inventories of the characteristics of weather elements, animal breeds, local plants, crops and tree species and belief systems that enhance the livelihood of the people and protection of the environment (Audefroy and Sanchez, 2017). Rural farmers employ traditional farming methods such as the use of manure (animal droppings), intercropping, use of indigenous seed varieties, use of local materials such as ashes, neem leaves and seeds for controlling pests and insects as measures for building resilient farming systems for food production (Bekuma, et al., 2022).

Any crop production puts a lot of pressure on the climate and the environment so it is important that the climate-smart agricultural practices be adopted (Sarkar et al., 2022). Climatic change is still being experienced in poor rainfall pattern and high temperature which results in poor crop production and low food security distribution, production and problems of food security in semi-arid region amongst rural households (Mishra, et al., 2025). Low level of relevant information and expertise on climate smart agricultural practices is one of the greatest limitations encountered among farmers when it comes to using climate

smart technologies (Jasna et al., 2016). There is lot of challenges to adopt Climate Smart Agricultural practices (CSAP). Shortage of financial resources is one of the key factors. Other barriers that hinder the adoption of these practices are institutional: lack of government support, policy inefficiency, and bureaucratic challenges. Such challenges are worsened by such environmental problems as unpredictable rainfall, long-term droughts, and soil degradation (Yadav, et al., 2025). The most essential aspect of imparting knowledge and developing awareness about safe pesticide use in vegetable for Climate Smart Agricultural practices (CSAP) is to trained extension workers for pesticide handling and safety precautions to avoid pesticide-related harms in Bundelkhand region (Pathak, et al., 2024). The major disturbances to adoption of climate smart agricultural practices (CSAP) among the farmers of non- climate smart villages were the technical constraints like lack of awareness on the climate-smart agricultural practices, lack of training and complexity of climate-smart practices whereas the economic constraints like increased cost of paddy production, higher initial investments in inputs and low paddy production were the most critical constraints that the farmers encountered in the climate smart villages (Mishra et al., 2024). There is also a need to disseminate the improved production technologies of mustard cultivation among the farmers to enhance the productivity and profitability (Puniya 2024).

In India, smart village means change the rural regions to a sustainable, self-contained and digitally enabled environment by means of augmented technology, clean energy, and enhanced infrastructure. It is concerned with improving livelihoods, education, health care and improving governance and ensuring environmental sustainability. A number of government programs, such as Sansad Adarsh Gram Yojana, Digital India, and the Climate Smart Village program are contributing to this change. Although Smart Villages that involves climate-oriented interventions assist farmers to adjust to climate change by enhancing more acceptable practices and instruments, such difficulties as unfavorable infrastructure, financial support, and skilled manpower deprive the large-scale application. However, the Smart Villages is a great leap to break the rural-urban gap and make it inclusive.

The study was aimed to find out various constraints faced by mustard farmers of smart and non-smart villages in adoption of climate smart agricultural practices.

## 2. METHODOLOGY

The present study used Analytic research design. Banda and Hamirpur districts were selected purposively because there is the maximum climatic variation in Bundelkhand region of Uttar Pradesh and both are known for mustard crop. Two blocks were selected from each district. And from each block, two villages were selected. Thus, a total of 4 blocks and 8 villages were selected from these districts of the Bundelkhand region of Uttar Pradesh. From each selected village, 15 respondents were selected randomly. Thus, a total of 120 respondents were selected as a sample for the present study. 60 respondents from four smart villages and 60 from non- smart villages were personally interviewed for the study. Structured interview schedule administered to farmers to capture their challenges, and constraints. The constraints were categorized under three categories viz, economic constraints, socio-personal constraints and technological constraints. The responses were obtained on a three-point continuum signifying the degree of that particular constraint, i.e., yes, can't say and no. Also, weighted mean score for each of the constraint. Furthermore, an independent sample t-test was conducted to find out if there was a significant difference in the degree of constraints faced by farmers from smart villages to that of non smart villages. Quantitative data analysed using descriptive statistics and inferential statistics through SPSS software.

## 3. RESULTS AND DISCUSSION

### 3.1 Constraints Faced by Mustard Farmers in the Adoption of Climate Smart Agricultural Practices

The data in Table 1 and Table 2 reveal that the communication gap among farmers is the most serious socio-personal constraint faced by respondents in smart villages followed by a lack of trust in the effectiveness of climate smart agricultural practices, cultural incompatibility and the inability to take risks by the respondents, whereas small and fragmented landholding and inability to accept new practices or technologies were the least serious constraint faced by the respondents in smart villages (SV).

**Table 1. Constraints faced by mustard farmers in the adoption of CSAP in Smart Villages**

S. No.	Constraints	Yes		Can't Say		No		TWS	WMS	Rank
		F	%	F	%	F	%			
<b>A</b>	<b>Socio-Personal Constraints</b>									
1	Inability to take risks	15	25.00	26	43.33	19	31.67	116	1.93	4
2	Inability to accept new practices or technologies	14	23.33	18	30.00	28	46.67	106	1.77	6
3	Small and Fragmented landholding	19	31.67	21	35.00	10	16.67	109	1.82	5
4	Cultural Incompatibility	18	30.00	26	43.33	16	26.67	122	2.03	3
5	Lack of trust in the effectiveness of CSAP	20	33.33	25	41.67	15	25.00	125	2.08	2
6	Communication gap among farmers	24	40.00	22	36.67	14	23.33	130	2.17	1
<b>B</b>	<b>Economic constraints</b>									
1	Increased cost of production in comparison to conventional method	32	53.33	18	30.00	10	16.67	142	2.37	1
2	Higher initial investment in equipment and machinery	31	51.67	18	30.00	11	18.33	140	2.33	2
3	Lack of labour availability	24	40.00	16	26.67	20	33.33	124	2.07	6
4	Lower yield in comparison to the conventional method	29	48.33	16	26.67	15	25.00	134	2.23	3
5	Increased incidence of weeds, pests and diseases after adopting CSAP	25	41.67	18	30.00	17	28.33	128	2.13	4
6	Inadequate financial support from institutions	23	38.33	19	31.67	18	30.00	125	2.08	5
7	Lack of market access	17	28.33	22	36.67	21	35.00	116	1.93	7
<b>C</b>	<b>Technical constraints</b>									
1	Non-involvement of local communities in planning & implementation of CSAP	26	43.33	26	43.33	8	13.33	138	2.30	1
2	Lack of awareness about CSA technologies	18	30.00	23	38.33	19	31.67	119	1.98	4
3	Lack of training on CSAP	21	35.00	22	36.67	17	28.33	124	2.07	2
4	Lack of extension support	16	26.67	26	43.33	18	30.00	118	1.97	5
5	Ineffectiveness of weather-based agro-advisory services	13	21.67	27	45.00	20	33.33	113	1.88	6
6	Inadequate services through custom hiring centers (CHC)	18	30.00	24	40.00	18	30.00	120	2.00	3
7	Complexity of adopting CSAP	19	31.67	14	23.33	27	45.00	112	1.87	7

**Table 2. Constraints faced by mustard farmers in the adoption of CSAP in Non Smart Villages**

<b>A Socio-Personal Constraints</b>										
<b>S. No.</b>	<b>Constraints</b>	<b>No.</b>	<b>%</b>	<b>No.</b>	<b>%</b>	<b>No.</b>	<b>%</b>	<b>TWS</b>	<b>WMS</b>	<b>Rank</b>
1	Inability to take risks	17	28.33	25	41.67	18	30.00	119	1.98	5
2	Inability to accept new practices or technologies	16	26.67	18	30.00	26	43.33	110	1.83	6
3	Small and Fragmented landholding	22	36.67	20	33.33	18	30.00	124	2.07	4
4	Cultural Incompatibility	21	35.00	24	40.00	15	25.00	126	2.10	3
5	Lack of trust in the effectiveness of CSAP	22	36.67	24	40.00	14	23.33	128	2.13	2
6	Communication gap among farmers	27	45.00	21	35.00	12	20.00	135	2.25	1
<b>B Economic constraints</b>										
1	Increased cost of production in comparison to conventional method	33	55.00	19	31.67	8	13.33	145	2.42	1
2	Higher initial investment in equipment and machinery	32	53.33	20	33.33	8	13.33	144	2.40	2
3	Lack of labour availability	25	41.67	16	26.67	19	31.67	126	2.10	6
4	Lower yield in comparison to the conventional method	30	50.00	17	28.33	13	21.67	137	2.28	3
5	Increased incidence of weeds, pests and diseases after adopting CSAP	24	40.00	20	33.33	16	26.67	128	2.13	4
6	Inadequate financial support from institutions	24	40.00	19	31.67	17	28.33	127	2.12	5
7	Lack of market access	17	28.33	22	36.67	21	35.00	116	1.93	7
<b>C Technical constraints</b>										
1	Non-involvement of local communities in planning & implementation of CSAP	25	41.67	26	43.33	9	15.00	136	2.27	1
2	Lack of awareness about CSA technologies	22	36.67	24	40.00	14	23.33	128	2.13	3
3	Lack of training on CSAP	25	41.67	21	35.00	14	23.33	131	2.18	2
4	Lack of extension support	21	35.00	24	40.00	15	25.00	126	2.10	4
5	Ineffectiveness of weather-based agro-advisory services	15	25.00	25	41.67	20	33.33	115	1.92	7
6	Inadequate services through custom hiring centers (CHC)	17	28.33	22	36.67	21	35.00	116	1.93	6
7	Complexity of adopting CSAP	23	38.33	18	30.00	19	31.67	124	2.07	5

For respondents in non-smart villages, communication gap among farmers was also the most serious socio-personal constraint lack of trust in the effectiveness of climate smart agricultural practices was the second most constraints followed by cultural incompatibility and small and fragmented landholding. Inability to take risks and inability to accept new practices or technologies were the least serious constraint faced by the respondents in non-smart villages (NSV).

Economic challenges were perceived as more severe, with the increased cost of production and higher initial investments in equipment and machinery being rated as the most serious barriers faced by the respondents from smart villages. Lower yield in comparison to the conventional method, increased incidence of weeds, pests, and diseases after adopting CSAP and Inadequate financial support from institutions were the next most barriers whereas lack of market access and lack of labour availability were the minor constraints in the adoption of climate smart agricultural practices for the respondents from smart villages.

Increased cost of production and higher initial investments in equipment and machinery were also found major barriers by the respondents of non-smart villages followed by Lower yield in comparison to the conventional method, increased incidence of weeds, pests, and diseases after adopting CSAP. Other notable issues were lower yield compared to conventional methods, inadequate financial support, lack of market access and lack of labour availability. All of which severely impact farmers' economic sustainability.

Technical constraints also posed significant barriers, especially the non-involvement of local communities in CSAP planning, lack of awareness and training on CSAP and inadequate services from custom hiring centers. Lack of awareness about CSA technologies, Lack of extension support, Ineffectiveness of weather-based agro-advisory services and Complexity of adopting CSAP were also found significant barriers by the respondents of smart villages.

In case of the respondents of non-smart villages, constraints such as the non-involvement of local communities in CSAP planning and implementation, lack of training and limited awareness of CSA technologies stood out most important barriers. Additionally, lack of extension support and perceived complexity in adopting CSAP further compounded the issue.

These findings underscore the multifaceted nature of challenges farmers face, highlighting the need for integrated interventions that address social trust, economic feasibility, and technical support systems to enhance CSAP adoption.

### 3.2 Comparison of Constraints Faced in Smart and Non Smart Villages

#### 3.2.1 We want to test the hypotheses

H<sub>0</sub>: there is no significant difference in the degree of socio-personal, economic constraints and technical constraints, faced by the respondents from smart and non-smart villages.

H<sub>1</sub>: there is significant difference in the degree of socio-personal, economic constraints and technical constraints, faced by the respondents from smart and non-smart villages.

The results from the independent sample t-test presented in Table 3 revealed that there was no significant difference found in the degree of socio-personal, economic constraints and technical constraints, faced by the respondents from smart and non-smart villages.

Moreover, it was observed that both groups of respondents from smart villages and non-smart villages showed insignificant variation in terms of socio-personal, technical, and financial constraints. This indicates that despite the infrastructural and informational advantages present in smart villages, farmers across both village types continue to face similar barriers in adopting climate-smart agricultural practices. The persistent nature of these constraints suggests the need for more inclusive, context-specific interventions that go beyond technological access and address underlying issues such as communication, trust, and institutional support.

**Table 3. Comparison of Constraints faced by respondents of smart villages and non- smart villages**

Constraints Category	Mean (SV)	Mean (NSV)	t value	p-val	Hypothesis
Socio-personal	1.96	2.06	1.10	0.29	Accepted
Economic	2.16	2.19	0.39	0.70	Accepted
Technical	2.01	2.08	1.03	0.31	Accepted

#### 4. CONCLUSION

When it comes to the adoption of innovation in agriculture, farmers in the smart villages and non smart villages have varying kinds of challenges to face. Although economic barriers constitute the main challenges facing farmers in smart villages probably because such farmers are exposed to new state of the art techniques which cost money, technical barriers are evident among farmers in non-smart villages. This is mainly attributed to the fact that these farmers have no knowledge of the climate-smart agricultural approaches and have not been subjected to specific skills and competencies training by extension agencies especially the Department of Agriculture and Farmers Welfare. This makes them have dwindling technical expertise and therefore, makes it difficult to embrace sustainable methods of farming.

The findings highlight that while smart villages may offer improved infrastructure and exposure to climate-smart solutions, they are not immune to deep-rooted socio-personal and economic challenges. Communication gaps, trust deficits, and financial constraints continue to hinder CSAP adoption. Non-smart villages, in contrast, are further disadvantaged by technical barriers stemming from inadequate knowledge dissemination and institutional support. Therefore, holistic and village-specific strategies including strengthened extension services, financial incentives, participatory planning, and trust-building measures are essential to overcome these multi-dimensional barriers and ensure the successful adoption of climate-smart agriculture across rural India.

#### DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

#### COMPETING INTERESTS

Authors have declared that no competing interests exist.

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