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Factors affecting farmers' attitude towards climate smart agricultural technologies in Chhattisgarh, India

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Abstract

Agriculture and climate change are closely interlinked, with increasing climatic variability posing significant threats to agricultural productivity and rural livelihoods. Climate Smart Agricultural Technologies (CSATs) offer a strategic approach to enhance resilience and sustainability; however, farmers' attitude plays a crucial role in shaping their orientation toward such technologies. The present study was undertaken during year 2022–24 to analyse the factors affecting farmers' attitude toward Climate Smart Agricultural Technologies in Chhattisgarh, India. An ex post facto research design was employed for the study. The state was represented through proportional random sampling across three agro-climatic zones Northern Hills, Chhattisgarh Plains, and Bastar Plateau. Total six districts were selected, followed by the selection of two blocks from each district and two villages from each block. A total of 360 farmers were selected through a multistage random sampling procedure. Primary data were collected using a structured and pre-tested interview schedule. Farmers' attitude toward CSATs was treated as the dependent variable, while personal, socio-economic, farm-related, communication and psychological characteristics were considered as independent variables. Data were analysed using descriptive statistics and Karl Pearson's product-moment correlation coefficient. The findings revealed that education, farm size, occupation, family annual income, irrigation facilities, social participation, extension contact, innovative proneness, risk orientation, perception toward climate change, ownership and utilization of ICTs, source of information, information needs and WBAAS showed positive and significant relationships with farmers' attitude. In contrast, farming experience, cropping pattern, livestock possession, and farm mechanization were non-significant. The study highlights the importance of educational, informational and psychological factors in shaping favourable attitudes toward CSATs, which are essential for promoting sustainable agriculture under changing climatic conditions.

Keywords: Climate Smart Agricultural Technologies (CSATs), farmers' attitude, climate change

Introduction

Climate change has emerged as a critical global challenge with far-reaching implications for agricultural production, food security and rural livelihoods. Increasing frequency and intensity of extreme weather events such as heat waves, droughts, floods, and erratic rainfall are exerting severe pressure on land, water and biological resources. Projections indicate that by the 2080s, global agricultural productivity could decline by 3-16 percent (FAO 2010). Agriculture itself contributes nearly 14 percent of global greenhouse gas emissions (IPCC 2007), while land use and land use change account for approximately 23 percent of total global greenhouse gas emissions, including substantial shares of CO₂, methane (CH₄), and nitrous oxide (N₂O) (IPCC 2019). These interlinkages demonstrate that agriculture is both highly vulnerable to climate change and simultaneously part of the emissions pathway, necessitating a transformation toward more resilient and sustainable production systems. The urgency of such transformation is heightened by rapidly increasing food demand. The global population is projected to reach 9.7 billion by 2050, requiring nearly a 70 percent increase in food production to ensure food security (FAO 2013) [5]. Global food demand is expected to increase by 35–56 percent between 2010 and 2050 due to demographic growth and changing consumption patterns. In India, food demand is projected to rise significantly owing to population growth and increasing per capita income (Mittal 2012) [12], while production growth is constrained by low

yield expansion (Kumar *et al.*, 2009) ^[11]. India's share of global food demand stands at 24.3 percent and demographic projections estimate a population of 1.718 billion by 2065, requiring approximately 567 million tons of food. Globally, achieving a 60 percent increase in agricultural productivity by 2050 has been emphasized as essential to balance supply and demand (Fischer 2018) ^[6]. However, climate variability threatens crop yields, livestock productivity, fisheries, and ecosystem stability (Hasegawa *et al.*, 2021) ^[7], rendering agricultural systems increasingly fragile, particularly in developing regions. Beyond yield reductions, climate change affects crop quality, livestock health, and ecosystem sustainability. Elevated CO₂ concentrations are associated with reduced protein and nitrogen content in major crops such as wheat and rice (USGCRP 2018) ^[17]. Heat stress lowers livestock fertility and milk production, while moisture-dependent pathogens may proliferate under changing rainfall patterns (USGCRP 2018) ^[17]. Rising ocean temperatures and acidification threaten fisheries and aquaculture livelihoods. In regions such as South Asia, where nearly 60 percent of the workforce depends on agriculture, these impacts directly affect income, nutrition, and rural stability (Ado *et al.*, 2019; Hasegawa *et al.*, 2021) ^[1, 7]. In India, climate change has contributed to soil degradation, declining soil carbon, micronutrient deficiencies, and reduced water-holding capacity (Elbehri *et al.*, 2017) ^[3], further constraining agricultural productivity.

In response, Climate-Smart Agriculture (CSA) has been advanced as an integrated framework aimed at achieving “triple wins”: enhancing productivity, strengthening resilience, and reducing or removing greenhouse gas emissions (World Bank 2010). CSA encompasses location-specific technological and institutional interventions, including water-smart practices (water harvesting and community water management), weather-smart services (weather advisories and insurance), seed/breed-smart innovations (stress-tolerant varieties), carbon/nutrient-smart practices (cover cropping, efficient fertilizer use, minimum tillage), and institutional/market-smart mechanisms (financial services, market information systems, collectivization, and gender-responsive strategies) (FAO and Care 2019; Aggarwal *et al.*, 2018) ^[2]. These interventions are designed to simultaneously address production, adaptation, and mitigation objectives.

Despite their potential benefits, adoption of climate-smart agriculture technologies (CSAT) remains limited in many developing countries, including India. Conventional top-down dissemination approaches have demonstrated limited success in fostering sustained technological uptake, partly because they inadequately support interactive learning and farmer-centered innovation processes. Evidence suggests that knowledge dissemination strategies, financial incentives, insurance mechanisms and institutional arrangements can influence CSA uptake. However, availability of technology alone does not ensure adoption. The decision to adopt CSAT is fundamentally behavioural and shaped by farmers' attitudes, perceptions and expectations. Attitude toward climate-smart agriculture technologies can be understood as a farmer's overall evaluative disposition toward such technologies, reflecting cognitive assessments (perceived usefulness, productivity benefits, economic returns), affective responses (confidence, fear of risk, uncertainty) and behavioural intentions (readiness to adopt or willingness to invest). Farmers may weigh anticipated gains in resilience and income stability against perceived risks, complexity, compatibility with existing practices, and cost considerations. Willingness to pay (WTP) for CSA interventions

further reflects the strength of favourable attitudes and perceived value. Where attitudes are positive, farmers are more likely to consider adoption; where scepticism, risk aversion or uncertainty dominate, adoption may remain low despite demonstrable technical benefits. Empirical evidence indicates that adoption of climate-smart technologies can enhance rural households' subjective well-being by reducing climate-related risks and improving livelihood security. However, persistent low adoption in developing regions suggests that attitudinal barriers rather than purely technical constraints may limit uptake. Understanding the factors shaping farmers' attitudes is therefore critical for designing effective extension strategies, policy incentives, and institutional support systems. Interventions such as farmer field schools, peer learning, ICT-based advisories, credit access, insurance schemes and collective action mechanisms may influence attitudes by improving knowledge, reducing perceived risk, and strengthening trust (Totin *et al.*, 2018; Schut *et al.*, 2016; Rosenstock *et al.*, 2016) ^[16, 15, 14].

Chhattisgarh, an agriculture-dependent state characterized by climatic variability and resource constraints, provides a relevant context for examining these behavioural dimensions. Given the increasing exposure of farmers to climate stress and the strategic importance of enhancing productivity sustainably, identifying the determinants of farmers' attitudes toward CSAT becomes essential. A systematic analysis of factors such as perceived economic benefits, risk perception, access to information, institutional support and willingness to pay can generate evidence-based insights to promote context-specific and scalable climate-smart interventions. Therefore, the present study aims to examine the factors affecting farmers' attitudes toward climate-smart agriculture technologies in Chhattisgarh, India. By situating attitudinal dynamics within the broader framework of climate change challenges and CSA interventions, the study seeks to contribute to a deeper understanding of how cognitive, affective and behavioural factors influence the acceptance and potential adoption of sustainable agricultural technologies.

Methodology

The present study was conducted in the state of Chhattisgarh during the year 2022–24. The study adopted an ex post facto research design to examine the factors affecting farmers' attitude toward climate smart agricultural technologies (CSAT), as the independent variables had already occurred and were not subject to experimental manipulation. Chhattisgarh comprises three agro-climatic zones, namely Bastar Plateau, Chhattisgarh Plains and Northern Hills. To ensure adequate representation of the entire state, districts were selected from each agro-climatic zone through proportional random sampling, with twenty percent of districts chosen from each zone. Accordingly, one district (Sarguja) was selected from the Northern Hills zone, four districts (Raipur, Rajnandgaon, Bemetara, and Dhamtari) from the Chhattisgarh Plains zone, and one district (Kanker) from the Bastar Plateau zone, resulting in a total of six districts. From each selected district, two blocks were chosen and from each block, two villages were selected, making a total of twenty-four villages. Farmers from these selected villages were chosen through a multistage random sampling procedure to constitute a final sample size of 360 respondents.

Primary data were collected from the selected respondents using a structured and pre-tested interview schedule designed in accordance with the objectives of the study. The schedule included items to measure the dependent variable, namely farmers' attitude toward climate smart agricultural technologies, as well as selected independent variables hypothesized to

influence attitude. A total of nineteen independent variables were included in the analysis, comprising education, farming experience, farm size, cropping pattern, occupation, livestock possession, family annual income, irrigation facility, social participation, extension contact, innovation proneness, risk orientation, farm mechanization, perception toward climate change and related technologies, ownership and extent of utilization of climate smart technologies, sources of information, information needs and WBAAS. These variables represented personal, socio-economic, farm-related, communication and psychological characteristics considered relevant to shaping farmers' attitudinal orientation toward CSAT. The collected data were coded, classified, and tabulated for analysis. Descriptive statistical measures such as frequency, percentage, mean and standard deviation were used to describe the characteristics of

the respondents. Karl Pearson's product-moment correlation coefficient was computed to determine the degree and direction of relationship between the selected independent variables and farmers' attitude toward climate smart agricultural technologies. This systematic analytical approach enabled the identification of key determinants influencing farmers' attitude toward climate smart agricultural technologies in Chhattisgarh.

Results and Discussion

Table 1 presents the correlation analysis between the selected independent variables and farmers' attitude toward Climate Smart Agricultural Technologies (CSATs) in Chhattisgarh state. The findings reveal that several personal, socio-economic, communication and psychological variables exhibit a positive and statistically significant relationship with farmers' attitude.

Table 1: Correlation analysis of independent variables with an attitude of farmers of Chhattisgarh

S. No.	Independent Variable	Correlation (r) Values
1	Education	0.222 **
2	Farming Experience	-0.194 NS
3	Farm size	0.227 **
4	Cropping pattern	0.080 NS
5	Occupation	0.217 **
6	Livestock Possession	0.077 NS
7	Family Annual Income	0.117 *
8	Irrigation facilities	0.137 **
9	Social Participation	0.253 **
10	Extension contact	0.184 **
11	Innovative Proneness	0.263 **
12	Risk Orientation	0.238 **
13	Farm mechanization level	0.055 NS
14	Perception of farmers towards Climate change	0.234 **
15	Ownership and extent of utilization of ICTs by farmers	0.192 **
16	Source of information on Climate Smart Agriculture Technologies (CSATs)	0.261 **
17	Information needs for Climate Smart Agriculture Technologies (CSATs)	0.199**
18	Weather based Agro advisory services (WBAAS)	0.203 **

**Significant at 0.01 level, *Significant at 0.05 level

The results indicate that education ($r = 0.222^{**}$), farm size ($r = 0.227^{**}$), occupation ($r = 0.217^{**}$), irrigation facilities ($r = 0.137^{**}$), social participation ($r = 0.253^{**}$), extension contact ($r = 0.184^{**}$), innovative proneness ($r = 0.263^{**}$), risk orientation ($r = 0.238^{**}$), perception of farmers toward climate change ($r = 0.234^{**}$), ownership and extent of utilization of ICTs ($r = 0.192^{**}$), source of information on CSATs ($r = 0.261^{**}$), information needs for CSATs ($r = 0.199^{**}$), and Weather Based Agro Advisory Services (WBAAS) ($r = 0.203^{**}$) were positively and significantly correlated with farmers' attitude at the 0.01 level of significance. These findings clearly suggest that farmers possessing better educational status, larger farm holdings, diversified occupational engagement, improved irrigation access, higher social participation, stronger extension linkage, greater innovativeness, and higher risk-taking ability tend to develop a more favourable attitude toward CSATs.

Family annual income ($r = 0.117^{*}$) was found to be positively significant at the 0.05 level of significance, indicating that economically better-off farmers are relatively more inclined toward developing a positive attitudinal disposition toward climate smart technologies. This may be attributed to their greater financial capacity to absorb risks and experiment with improved practices. On the other hand, farming experience ($r = -0.194$ NS), cropping pattern ($r = 0.080$ NS), livestock possession ($r = 0.077$ NS), and farm mechanization level ($r = 0.055$ NS) were found to be non-significant with farmers' attitude toward CSATs. The non-significant relationship of

farming experience suggests that mere years of farming do not necessarily translate into favourable perception toward climate smart technologies. Similarly, livestock possession and mechanization level alone do not automatically influence attitudinal orientation unless supported by awareness, information access, and psychological readiness. The strong positive correlations of innovative proneness ($r = 0.263^{**}$) and source of information on CSATs ($r = 0.261^{**}$) indicate that farmers who are more innovation-oriented and better connected to information channels are more likely to hold favourable attitudes toward CSATs. Likewise, social participation and risk orientation emerged as important attitudinal drivers, suggesting that socially active and risk-tolerant farmers are more open to climate-responsive technologies. The significant association of perception toward climate change ($r = 0.234^{**}$) further implies that farmers who recognize climate variability and its adverse impacts tend to develop a stronger positive orientation toward climate smart solutions.

Overall, the findings demonstrate that farmers' attitude toward CSATs is significantly shaped by educational level, economic strength, farm resource base, communication exposure, innovation orientation, risk-bearing capacity and access to climate-related information and advisory services. The results emphasize that attitudinal development toward climate smart technologies is more strongly influenced by cognitive, informational, and psychological factors than by purely structural characteristics such as family type or farming

experience. Thus, the correlation analysis clearly indicates that enhancing educational opportunities, strengthening extension services, improving access to ICT-based information, promoting weather-based advisory services, and encouraging innovation-oriented behaviour may significantly improve farmers' attitudinal orientation toward Climate Smart Agricultural Technologies in Chhattisgarh.

Conclusion

The study systematically analysed the factors influencing farmers' attitude toward Climate Smart Agricultural Technologies (CSATs) in Chhattisgarh. The findings clearly demonstrate that farmers' attitudinal orientation is significantly shaped by educational, economic, communicational and psychological characteristics. Variables such as education, farm size, occupation, family annual income, irrigation facilities, social participation, extension contact, innovative proneness, risk orientation, perception toward climate change, ownership and utilization of ICTs, source of information, information needs and Weather Based Agro Advisory Services (WBAAS) exhibited positive and significant relationships with farmers' attitude. In contrast, farming experience, cropping pattern, livestock possession, and farm mechanization level were not found to significantly influence attitude. The results indicate that favourable attitudes toward CSATs are more strongly associated with cognitive awareness, access to information, innovation orientation, and risk-bearing capacity than with structural farm characteristics alone. Farmers who are better educated, socially connected, innovation-oriented and actively engaged with extension and advisory services tend to exhibit stronger positive attitudinal dispositions toward climate smart technologies. These findings highlight the need for an integrated extension approach focusing on strengthening educational exposure, improving information dissemination through ICTs and advisory services, enhancing innovation capacity and promoting climate awareness. Such targeted efforts can foster favourable attitudes and support sustainable, climate-resilient agricultural development.

Disclaimer (Artificial intelligence)

The author(s) hereby declare that generative AI technologies, such as OpenAI ChatGPT version 4, have been used during the writing or editing of manuscripts for language improvement.

Author Conflict

Authors have declared that no competing interests exist.

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