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What shapes grape growers' attitude towards climate-smart agriculture? Evidence from Maharashtra

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Abstract

Climate change has intensified the need for agricultural approaches that can enhance resilience while sustaining productivity. Climate-Smart Agriculture (CSA) is increasingly promoted as a viable strategy for addressing climatic risks; however, its effectiveness depends largely on farmers' perceptions and attitudes towards such practices. In this context, the present study examined the relationship between the attitude of grape growers towards CSA and selected independent variables in Ahilyanagar district of Maharashtra. An ex-post facto research design was adopted, and data were collected from 120 grape growers selected through a multistage sampling procedure. Pearson's correlation coefficient was employed to determine the relationship between attitude towards CSA and selected farmer characteristics.

The findings revealed that education, annual income, experience in grape cultivation, risk orientation, mass media exposure and awareness of climate change were positively and significantly associated with attitude towards CSA. Among the variables studied, annual income ($r = 0.266^*$) and awareness of climate change ($r = 0.263^{**}$) exhibited comparatively stronger associations with attitude, highlighting the importance of economic capability and climate literacy in shaping farmers' perceptions. In contrast, age, total landholding and area under grape cultivation did not show significant relationships with attitude. The results indicate that favourable attitudes towards CSA are influenced more by access to information, awareness of climate-related challenges and behavioural readiness than by demographic or farm-size-related characteristics. The study suggests that extension efforts aimed at strengthening climate awareness, information access and adaptive capacity among grape growers can contribute to the development of favourable attitudes towards climate-smart agricultural practices and facilitate their wider acceptance.

Keywords: Climate smart agriculture, grape growers, attitude, climate change awareness, risk orientation, mass media exposure

1. Introduction

Climate change has emerged as one of the most pressing challenges affecting agricultural sustainability across the world. Increasing temperatures, erratic rainfall patterns, prolonged dry spells and the growing frequency of extreme weather events are disrupting agricultural production systems and threatening the livelihoods of farming communities (IPCC, 2023) [8]. The impacts of climate change are particularly severe in developing countries where agriculture remains highly dependent on weather conditions and natural resources. In India, changing climatic patterns have resulted in increased production risks, reduced resource-use efficiency and greater uncertainty in farm income, necessitating the adoption of resilient and sustainable agricultural practices (FAO, 2021) [5].

In response to these challenges, Climate-Smart Agriculture (CSA) has gained considerable attention as an approach for addressing the interlinked concerns of food security and climate change. The Food and Agriculture Organization (FAO) defines CSA as an approach that aims to sustainably increase agricultural productivity, strengthen resilience and adaptive capacity to climate change, and reduce greenhouse

gas emissions wherever possible (FAO, 2013) [4]. Climate-smart interventions such as efficient water management, precision nutrient application, weather-based advisories, integrated pest management and protected cultivation are increasingly being promoted to enhance the sustainability and resilience of agricultural production systems.

The need for climate-smart approaches is particularly important in horticultural crops due to their sensitivity to climatic fluctuations. Among fruit crops, grape (*Vitis vinifera* L.) occupies an important place in the Indian horticultural economy because of its high commercial value and export potential. India is one of the leading grape-producing countries in the world, while Maharashtra contributes nearly 70 per cent of the country's total grape production (NHB, 2024). Districts such as Nashik, Sangli, Solapur, Pune and Ahilyanagar constitute major grape-growing regions of the state. The area under grape cultivation in Ahilyanagar district has increased substantially during the last decade, reflecting the growing economic importance of the crop in the region.

Grape cultivation is highly sensitive to weather variability. Temperature, rainfall, humidity and sunshine hours directly

influence vine growth, flowering, fruit development, yield and fruit quality (Keller, 2020) ^[10]. Unseasonal rainfall, temperature fluctuations and increased incidence of pests and diseases have become major concerns for grape growers in recent years. Under such conditions, climate-smart agricultural practices offer opportunities to improve production efficiency, reduce climate-related risks and enhance the sustainability of grape cultivation.

However, the successful promotion of climate-smart agriculture depends not only on the availability of technologies but also on farmers' willingness to accept and use them. Farmers differ considerably in their perceptions and evaluation of agricultural innovations. Their attitude towards a technology often influences information seeking, decision-making and eventual adoption behaviour. According to Rogers (2003) ^[16], favourable attitudes towards innovations generally facilitate their acceptance, whereas unfavourable attitudes may hinder adoption even when technologies offer clear advantages. Therefore, understanding farmers' attitudes towards climate-smart agriculture is important for designing effective extension and developmental interventions.

Attitude towards climate-smart agriculture is likely to be influenced by several personal, socio-economic and psychological characteristics of farmers. Factors such as education, farming experience, income, risk orientation, access to information sources and awareness of climate change may shape how farmers perceive and respond to

climate-smart practices. Identifying these factors is particularly important in grape cultivation where production decisions involve substantial investment and risk. Information on the variables associated with favourable attitudes can help extension agencies formulate targeted strategies for promoting climate-smart agricultural practices among grape growers.

Objective

To ascertain the relationship between Attitude of Grape growers towards Climate Smart Agriculture and selected independent variables

2. Methodology

The study was conducted in Ahilyanagar district of Maharashtra during 2024-25. An ex-post facto research design was adopted to examine the relationship between attitude of grape growers towards Climate Smart Agriculture (CSA) and selected independent variables. Ahilyanagar district was purposively selected owing to its increasing area under grape cultivation. Three major grape-growing talukas, namely Shrigonda, Kopergaon and Rahata, were selected for the study. From each taluka, four villages having substantial area under grape cultivation were selected, resulting in a total of 12 villages. Ten grape growers were randomly selected from each village, constituting a sample of 120 respondents.

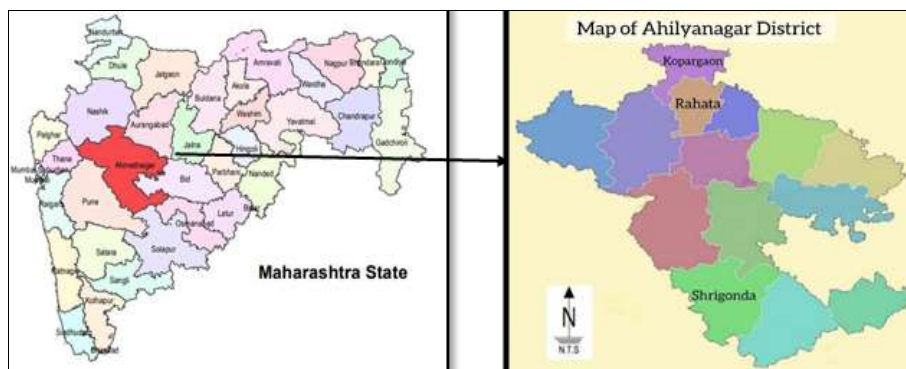


Fig 1: Locale of the study

Primary data were collected through personal interviews using a pre-tested structured schedule. The independent variables selected for the study were age, education, annual income, total landholding, area under grape cultivation, experience in grape cultivation, risk orientation, mass media exposure and awareness on climate change, whereas attitude towards Climate Smart Agriculture served as the dependent variable. Attitude towards Climate Smart Agriculture was measured using a structured attitude scale consisting of statements related to climate-smart agricultural practices. Responses were obtained on a five-point continuum ranging from strongly agree to strongly disagree and the cumulative attitude score was used for analysis.

To ascertain the relationship between attitude towards CSA and selected independent variables, Pearson's correlation coefficient was computed. The significance of the relationship was tested at 5 and 1 per cent levels of probability.

3. Results and Discussion

3.1 Relationship between attitude of grape growers towards Climate Smart Agriculture and selected independent variables

The relationship between attitude of grape growers towards Climate Smart Agriculture (CSA) and selected independent variables was analysed using Pearson's correlation coefficient. The results are presented in Table 1.

The correlation analysis revealed that the attitude of grape growers towards Climate Smart Agriculture (CSA) was influenced primarily by informational, economic and behavioural characteristics. Variables associated with knowledge acquisition, access to information, economic capability, and adaptive preparedness exhibited positive and significant associations with attitude, whereas demographic and farm-structural characteristics showed limited influence.

Table 1: Relationship between attitude of grape growers towards Climate Smart Agriculture and selected independent variables

Sr. No.	Independent variables	Correlation coefficients
1.	Age	0.158 NS
2.	Education	0.221**
3.	Annual income	0.266*
4.	Total land holdings	-0.035 NS
5.	Area under grape cultivation	0.110 NS
6.	Experience in grape cultivation	0.113*
7.	Risk orientation	0.201**
8.	Mass media exposure	0.221*
9.	Awareness on climate change	0.263**
*Significant at 5 per cent level of probability **Significant at 1 per cent level of probability NS = Non-significant		

These findings suggest that favourable perceptions towards climate-smart interventions are shaped more by farmers' ability to understand climatic challenges, evaluate adaptation options and respond proactively to emerging risks than by age or physical resource endowment alone. Similar observations have been reported by Aryal *et al.* (2018) [2] and Naik *et al.* (2024) [11], who found that knowledge-related and behavioural factors played a greater role in shaping farmers' responses towards climate-resilient agricultural interventions than structural farm characteristics.

3.1.1 Education and attitude towards CSA

Education exhibited a positive and highly significant relationship with attitude towards CSA ($r = 0.221^{**}$). The finding suggests that educational attainment plays an important role in shaping farmers' perceptions and evaluation of climate-smart agricultural practices. Education enhances an individual's ability to comprehend technical information, analyse alternative courses of action and make informed decisions regarding farm management. Climate-smart agriculture encompasses a range of knowledge-intensive practices involving weather-based decision-making, efficient resource management, precision application of inputs and adaptation to climate variability. Farmers possessing higher levels of education are generally better equipped to understand these concepts and appreciate their potential benefits.

Education also improves farmers' access to information sources and strengthens their interaction with extension agencies, research institutions and digital advisory platforms. Such exposure often contributes to a broader understanding of climate-related risks and the necessity of adaptation measures. Consequently, educated grape growers may develop stronger confidence in the effectiveness of CSA interventions and demonstrate greater willingness to embrace innovative practices. In regions where climate variability increasingly affects crop productivity and profitability, education enables farmers to move beyond traditional production approaches and consider scientifically recommended alternatives.

Another possible explanation lies in the cognitive dimension of attitude formation. Attitudes are influenced by knowledge and awareness regarding a particular object or practice. Farmers with higher educational attainment generally possess greater analytical ability to evaluate the long-term consequences of climate change and the role of climate-

smart interventions in mitigating production risks. This may explain their favourable disposition towards CSA. Similar findings have been reported by Islam *et al.* (2015) [9], Naik *et al.* (2024) [11] and Harikrishna *et al.* (2021) [7], who observed that education significantly contributed to favourable attitudes towards climate-resilient and climate-smart agricultural practices.

3.1.2 Annual income and attitude towards CSA

Annual income was found to have a positive and significant relationship with attitude towards CSA ($r = 0.266^{*}$). Among the significant variables studied, annual income exhibited one of the strongest associations with attitude, indicating the importance of economic capacity in shaping farmers' perceptions towards climate-smart technologies.

Many climate-smart interventions involve initial investments in infrastructure, equipment or management practices. Technologies such as drip irrigation systems, weather monitoring devices, protected cultivation structures, soil moisture sensors and improved crop management practices often require financial resources beyond routine cultivation expenses. Farmers with higher annual income generally possess greater economic flexibility and may therefore perceive such technologies as feasible and beneficial investments rather than financial burdens.

Economic security also influences farmers' willingness to experiment with innovative practices. Farmers facing severe financial constraints often prioritise short-term survival and may be reluctant to adopt unfamiliar technologies due to fear of economic losses. In contrast, economically better-off growers are more capable of absorbing potential risks associated with innovation and are therefore more likely to develop positive attitudes towards new technologies. In grape cultivation, where production is capital-intensive and market-oriented, financial capacity often determines the extent to which farmers can invest in adaptive and resource-efficient technologies.

Furthermore, higher income levels may be associated with greater market exposure, stronger institutional linkages and increased access to information, all of which can reinforce favourable attitudes towards climate-smart interventions. The present findings are in agreement with the observations of Below *et al.* (2012) [3] and Islam *et al.* (2015) [9], who reported a positive association between annual income and farmers' attitude towards climate adaptation measures.

3.1.3 Experience in grape cultivation and attitude towards CSA

Experience in grape cultivation exhibited a positive and significant relationship with attitude towards CSA ($r = 0.113^{*}$). Although the magnitude of association was relatively modest, the result indicates that farming experience contributes to the development of favourable perceptions towards climate-smart practices.

Experience represents accumulated practical knowledge acquired through repeated interaction with farming systems over time. Experienced grape growers are likely to have observed changes in weather patterns, disease incidence, water availability and crop performance across different production seasons. Such observations provide first-hand evidence of the challenges posed by climate variability and may enhance awareness regarding the need for adaptive management strategies.

Grape cultivation is particularly sensitive to climatic fluctuations. Unseasonal rainfall, temperature extremes and increased pest and disease pressure can significantly affect yield and fruit quality. Farmers with longer experience are more likely to have encountered these challenges repeatedly and may therefore appreciate the relevance of climate-smart interventions designed to reduce production risks. Their favourable attitude towards CSA may stem from practical recognition of the limitations of conventional management approaches under changing climatic conditions.

Experience also facilitates learning through trial, observation and continuous interaction with extension personnel, fellow farmers and market actors. Growers who have spent many years in grape cultivation often develop the ability to evaluate innovations on the basis of practical field realities rather than assumptions. Their accumulated experiential knowledge enables them to assess the effectiveness of different management strategies under varying climatic situations. As a result, experienced growers may be more receptive to practices that enhance resilience, productivity and sustainability under changing climatic conditions. Similar observations have been reported in studies on climate adaptation and climate-smart agriculture, which indicate that farming experience contributes to better understanding of climatic risks and greater receptiveness towards adaptive agricultural practices (Below *et al.*, 2012; Aryal *et al.*, 2018) ^[3, 2].

3.1.4 Risk orientation and attitude towards CSA

Risk orientation demonstrated a positive and highly significant relationship with attitude towards CSA ($r = 0.201^{**}$). This finding highlights the importance of psychological factors in influencing farmers' perceptions towards climate-smart agricultural innovations.

Climate-smart agricultural practices often require behavioural and managerial adjustments. Adoption of new technologies invariably involves uncertainty regarding outcomes, costs and benefits. Farmers differ considerably in their willingness to face such uncertainty. Individuals with higher risk orientation are generally more open to experimentation, innovation and change. They tend to view uncertainty as manageable and are more likely to explore alternatives capable of improving farm performance.

Climate-smart agriculture frequently promotes practices that differ from traditional cultivation methods. Farmers possessing greater risk-taking ability may therefore be more inclined to evaluate these practices positively and consider their adoption. In contrast, risk-averse farmers may perceive climate-smart interventions as uncertain or complex, leading to less favourable attitudes.

The positive association observed in the present study suggests that growers with stronger risk orientation recognise climate-smart practices as opportunities for enhancing productivity and resilience rather than sources of uncertainty. Similar findings have been reported by Aryal *et al.* (2020) ^[2], Patel and Sharma (2022) ^[15], and Naik *et al.* (2024) ^[11], who documented positive relationships between risk orientation and favourable attitudes towards climate-smart agricultural interventions

3.1.5 Mass media exposure and attitude towards CSA

Mass media exposure was positively and significantly

related to attitude towards CSA ($r = 0.221^{*}$). Information and communication play a crucial role in the dissemination of agricultural innovations, particularly those associated with climate adaptation and sustainability.

Mass media channels such as television, radio, newspapers, agricultural magazines, mobile applications and social media platforms provide farmers with access to current information regarding weather conditions, emerging technologies, government programmes and climate adaptation strategies. Continuous exposure to such information contributes to awareness creation and knowledge enhancement, both of which influence attitude formation.

Farmers with greater exposure to mass media are more likely to encounter success stories, expert recommendations and demonstrations related to climate-smart agriculture. Such information may strengthen confidence in the effectiveness of CSA practices and reduce uncertainty regarding their implementation. Mass media also facilitates indirect learning by allowing farmers to observe experiences and outcomes beyond their immediate social environment.

In the contemporary agricultural scenario, digital communication platforms have further expanded farmers' access to climate-related information. Consequently, mass media exposure serves as an important mechanism through which favourable perceptions towards CSA are developed and reinforced. Similar findings were reported by Harikrishna *et al.* (2021) ^[7], Patel and Sharma (2022) ^[15], and Naik *et al.* (2024) ^[11].

3.1.6 Awareness on climate change and attitude towards CSA

Awareness on climate change exhibited a positive and highly significant relationship with attitude towards CSA ($r = 0.263^{**}$). This finding is particularly important because climate-smart agriculture is fundamentally intended to address challenges arising from climate variability and change.

Farmers who possess greater awareness regarding climate change are more likely to understand the causes and consequences of changing climatic conditions. They may recognise trends such as increasing temperatures, irregular rainfall patterns, water scarcity and heightened pest and disease incidence. Such awareness enables them to connect observed environmental changes with their implications for agricultural productivity and livelihood security.

Awareness also influences risk perception. Farmers who recognise the potential consequences of climate change are more likely to perceive adaptation as necessary and urgent. Consequently, they may evaluate climate-smart agricultural practices more favourably because such interventions offer practical solutions for reducing climate-related vulnerabilities.

Awareness of climate change also contributes to the development of adaptive thinking among farmers. Individuals who are conscious of climatic risks tend to pay greater attention to weather information, technological advisories and extension recommendations. They are more likely to recognise that conventional production practices may not be sufficient to address emerging climatic challenges and therefore become more receptive to innovative adaptation strategies. In this sense, awareness

functions not only as a source of knowledge but also as a motivating force that shapes behavioural intentions and favourable attitudes towards climate-smart agricultural practices.

From an extension perspective, awareness creation often represents the first step in the process of behavioural change. Farmers generally adopt risk-reducing practices only when they recognise the existence, seriousness and potential consequences of a threat. Studies on climate change adaptation have similarly emphasized that awareness and risk perception serve as important precursors to adaptive decision-making and behavioural responses among farming communities (Grothmann and Patt, 2005; Arbuckle *et al.*, 2013) ^[6, 1].

Therefore, improving climate change awareness among grape growers may not merely enhance their knowledge regarding CSA but may also strengthen the perceived necessity of adopting such practices. The present finding thus underscores the importance of climate literacy programmes, awareness campaigns and climate information services in promoting favourable attitudes towards climate-smart agriculture. Similar observations were reported by Okoro *et al.* (2016) ^[14], Rupan *et al.* (2017) ^[17], and Ojo *et al.* (2025) ^[13].

3.2. Age, farm size and area under grape cultivation in relation to attitude towards CSA

The analysis revealed that age ($r = 0.158$ NS), total land holding ($r = -0.035$ NS) and area under grape cultivation ($r = 0.110$ NS) were not significantly related to attitude towards CSA.

The non-significant relationship of age suggests that favourable attitudes towards climate-smart agriculture are not confined to a particular age category. Both younger and older grape growers appear capable of developing positive perceptions towards climate-smart interventions when provided with adequate information, technical guidance, and awareness. Grape cultivation in the study area is highly commercialised and information-intensive. Farmers, irrespective of age, are regularly exposed to extension personnel, input suppliers, market information and climate-related advisories. Such exposure may have reduced age-related differences in perception and contributed to a relatively uniform attitude towards CSA across different age groups. Similar non-significant relationships between age and attitude towards climate-resilient agricultural practices have been reported by Harikrishna *et al.* (2021) ^[7], suggesting that access to information may be more influential than age in shaping farmers' perceptions.

Similarly, total land holding did not exert a significant influence on attitude towards climate-smart agriculture. This finding indicates that ownership of larger land resources does not automatically translate into favourable perceptions towards climate-smart interventions. Climate-related risks such as erratic rainfall, pest outbreaks, disease incidence and temperature fluctuations affect both small and large farmers. Consequently, awareness of climatic challenges and access to relevant information may play a more decisive role in shaping attitudes than the quantity of land owned by an individual grower. Aryal *et al.* (2018) ^[2] also observed that farm size alone was not always a reliable predictor of farmers' perceptions regarding climate-smart

agricultural interventions.

The non-significant relationship between area under grape cultivation and attitude further supports this interpretation. Farmers cultivating relatively larger grape areas may not necessarily exhibit more favourable attitudes than those managing smaller vineyards. Since climate variability affects grape cultivation across farm sizes, the perceived usefulness of climate-smart practices may be influenced primarily by farmers' understanding of climate-related risks rather than by the extent of area cultivated. This finding suggests that attitudinal differences are more closely associated with cognitive and informational variables than with enterprise size, a pattern also observed in studies on climate adaptation behaviour among farming communities (Arbuckle *et al.*, 2013) ^[1].

A notable pattern emerging from the present investigation is that variables associated with climate literacy, information access and adaptive preparedness exhibited stronger relationships with attitude towards CSA than structural farm characteristics. Education, mass media exposure and awareness on climate change were all positively associated with attitude, suggesting that cognitive and informational factors play a central role in shaping farmers' perceptions towards climate-smart practices. Similarly, annual income and risk orientation were significantly related to attitude, indicating that both economic capability and behavioural readiness influence the acceptance of climate-resilient agricultural interventions.

The findings imply that favourable attitudes towards CSA are not determined merely by resource ownership or farm size. Rather, they appear to be shaped by farmers' ability to access information, interpret climatic challenges and evaluate adaptation options within their farming systems. This observation reinforces the importance of knowledge-centred extension approaches that strengthen climate awareness, improve access to reliable information and enhance farmers' confidence in climate-smart technologies. This observation is in agreement with the findings of Arbuckle *et al.* (2013) ^[1] and Aryal *et al.* (2018) ^[2], who emphasized the importance of knowledge, awareness and adaptive capacity in shaping farmers' responses to climate-related challenges.

4. Conclusion

The findings of the study indicate that favourable attitudes towards Climate Smart Agriculture among grape growers are influenced largely by factors that enhance farmers' understanding of climatic challenges and their capacity to respond to them. Education, annual income, farming experience, risk orientation, mass media exposure and awareness of climate change were found to be associated with positive attitudes towards CSA, whereas farm size and age did not appear to influence farmers' perceptions significantly. This suggests that the acceptance of climate-smart agricultural practices is shaped more by access to knowledge, information and adaptive capacity than by demographic or resource-related characteristics.

Among the variables studied, awareness of climate change emerged as an important factor associated with favourable attitudes towards CSA. Farmers who possess a better understanding of climate-related risks are more likely to appreciate the relevance of adaptive and resilient farming

practices. Similarly, access to information through education and mass media, coupled with the confidence derived from experience and risk-taking ability, contributes to the development of positive perceptions towards climate-smart interventions.

The findings indicate that efforts aimed at promoting Climate Smart Agriculture among grape growers should go beyond the mere dissemination of technologies. Greater emphasis needs to be placed on strengthening climate awareness, improving farmers' access to relevant information and building their capacity to understand and respond to changing climatic conditions. Creating an enabling informational environment may play an equally important role as technological advancement in encouraging the acceptance of climate-smart agricultural practices. The results provide useful insights for extension agencies, development organisations and policy planners working towards enhancing climate resilience in grape-based farming systems.

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