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PERCEPTION AND ADAPTATION STRATEGIES OF COTTON GROWERS TO CLIMATE VARIABILITY

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ABSTRACT

The study entitled "Perception and Adaptability of Cotton Growers towards Climate Variability" was conducted in Beed district of Maharashtra, a region highly prone to climatic risks, during 2022–23. A sample of 100 cotton farmers from ten villages was selected through purposive-cum-random sampling, and an ex-post facto design was employed. Standardized scales were used to assess farmers' perception and adaptability levels towards climate variability. Findings revealed that farmers were highly perceptive of major climatic indicators, particularly uneven distribution of rainfall (90%), prolonged dry spells (88%), decreasing rainfall (85%), and rising temperatures (80%). Overall, 55% of farmers exhibited a medium level of perception, followed by 35% with high perception and 10% with low perception. Regarding adaptability, 52% of respondents fell into the medium category, 30% into low, and only 18% into high adaptability. Adaptation measures partially adopted included drought-resistant varieties, intercropping, altered planting dates, and use of pest-tolerant crops, while practices such as rainwater harvesting structures, contour sowing, and crop insurance services were less widely adopted. The study highlights that although farmers are aware of climatic risks, their adaptive responses remain limited to low-cost, less resource-intensive practices. Socio-economic factors such as education, farm income, and extension contact significantly influenced both perception and adaptability levels. The findings emphasize the need for strengthening climate-focused extension services, promoting climate-smart agricultural practices, and providing policy support tailored to the local context. Enhancing farmer-to-farmer learning, capacity building, and access to institutional resources will bridge the gap between awareness and action, thereby improving the resilience of cotton growers to climate variability and ensuring sustainable cotton production in the Marathwada region.

Keywords : *perception, adaptability, cotton growers, climate variability*

INTRODUCTION

Climate variability refers to the variations in the mean state of the climate and in the occurrence of extremes on all temporal and spatial scales beyond that of individual weather events (Vinaya et al., 2016). The average range of temperature for a location, as indicated by minimum, maximum, and average values, is an example of a measure of climate variability. The phenomenon of climate change is often less understood but more directly experienced, especially in rural communities. Climate variability is highly dynamic, and adapting to it is increasingly challenging. Its impacts are felt most severely in arid and semi-arid regions where agriculture is largely dependent on rainfall and groundwater for irrigation (Vinaya et al., 2025).

In India, the Marathwada region is particularly vulnerable, as it faces recurrent droughts, erratic rainfall, and water scarcity. According to water availability indicators, Marathwada has only 438 cubic meters per person—much below the 500 cubic meters threshold, marking it as an extreme drought-prone region. This limited irrigation capacity and recurring drought make farming, especially cotton cultivation, highly risky. Despite these constraints, cotton remains the dominant crop, with Maharashtra contributing 22.70 percent of national production and Beed district cultivating over 3.32 lakh hectares under cotton.

Given this context, assessing how farmers perceive and adapt to climate variability becomes crucial. Farmers' perceptions determine their willingness to act, while their adaptability reflects the extent to which they can implement effective coping strategies. Studying these aspects is significant not only for ensuring sustainable cotton production but also for strengthening the livelihoods of farmers who are heavily dependent on this crop. Insights from such research are valuable for policymakers, researchers, and extension agencies to design climate-focused programs, promote climate-smart technologies, and enhance resilience in vulnerable regions.

OBJECTIVES

(1) To examine the level of perception of cotton farmers regarding major indicators of climate variability.

(2) To assess the extent of adaptability measures adopted by farmers to cope with climatic challenges in cotton cultivation.

(3) To analyse the relationship between extent of adaptability and profile of cotton farmers

METHODOLOGY

The present study was conducted during 2022–23 to assess the perception and adaptability of cotton growers towards climate variability in Beed district of Maharashtra, which falls under the Marathwada region. This region was purposively selected as it is highly vulnerable to recurrent droughts, erratic rainfall, and other climatic risks, making it an appropriate location for the study. Within Beed district, two taluks—Beed and Georai—were purposively selected owing to their high cotton acreage and greater exposure to climate variability.

An ex-post facto research design was adopted, as the variables under study—farmers' perception and adaptability—had already occurred and could not be manipulated by the researcher. This design is considered appropriate for studies where the independent variables are beyond the control of the investigator.

From each of the selected taluks, five villages were chosen purposively based on cotton cultivation intensity and vulnerability to climate variability. A sample of ten farmers from each village was selected randomly, thereby constituting a total sample of 100 cotton growers. This purposive-cum-random sampling technique ensured both representativeness and relevance to the research objectives.

The independent variables considered were age, education, family size, farming experience, landholding, annual income, extension contact, sources of information, and risk orientation. The dependent variables were farmers' perception and adaptability towards climate variability.

To measure perception, the scale developed by Kranthi Kumari (2014) consisting of 20 items was employed. Farmers were asked to express their responses on a three-point continuum (Strongly Agree, Agree, Disagree), with scores of 3, 2, and 1 respectively. To measure adaptability, a modified scale of Mahesh Lankati (2021) was used, consisting of 33 statements under seven sub-components such as adoption of improved technologies, management of agricultural operations, in-situ moisture conservation, intercropping and mixed cropping systems, non-farm income sources, crop insurance, and water harvesting. A similar three-point continuum was used for scoring.

The data collected were analyzed using descriptive statistical tools such as frequency, percentage, mean, and standard deviation to assess the distribution of respondents across different levels of perception and adaptability and regression analysis to analyse the relationship between extent of adaptability and profile of cotton farmers

RESULTS AND DISCUSSION

Perception of cotton growers towards climate variability

The results in table 1 revealed that most farmers had a medium to high level of perception regarding climate variability, with many strongly agreeing to specific climatic indicators such as uneven distribution of rainfall (90.00%), prolonged dry spells (88.00%), decreasing average rainfall (85.00%), increased water stress (85.00%), and rising mean temperatures (80.00%). These findings are in line with Nhemachena and Hassan (2007), who reported that farmers in Africa could clearly perceive climate-related changes such as shifts in rainfall patterns, drought frequency, and rising temperatures, which influenced their agricultural decisions.

Table 1 : Distribution of respondents according to perception towards climate variability (n=100)

Sr. No.	Statement	Strongly Agree	Agree	Disagree
1	**Increase in mean temperature**	80 (80.00)	20 (20.00)	0 (0.00)
2	**Decrease in average rainfall**	85 (85.00)	15 (15.00)	0 (0.00)
3	**Late onset of monsoons**	46 (46.00)	54 (54.00)	0 (0.00)

Sr. No.	Statement	Strongly Agree	Agree	Disagree
4	**Early withdrawal of monsoon**	32 (32.00)	68 (68.00)	0 (0.00)
5	**Prolonged dry spell**	88 (88.00)	12 (12.00)	0 (0.00)
6	**Occurrence of drought**	80 (80.00)	20 (20.00)	0 (0.00)
7	**Uneven distribution of rainfall**	90 (90.00)	10 (10.00)	0 (0.00)
8	**Decrease in number of rainy days**	75 (75.00)	25 (25.00)	0 (0.00)
9	**Reduced soil fertility**	30 (30.00)	40 (40.00)	30 (30.00)
10	**Reduced water holding capacity**	30 (30.00)	70 (70.00)	0 (0.00)
11	**Decreased yield**	15 (15.00)	52 (52.00)	33 (33.00)
12	**Decrease in quality of produce**	25 (25.00)	40 (40.00)	35 (35.00)
13	**Increased pest and diseases**	55 (55.00)	25 (25.00)	20 (20.00)
14	**Changes in time of sowing**	40 (40.00)	35 (35.00)	25 (25.00)
15	**Shortening of length of growing season of crops**	35 (35.00)	45 (45.00)	20 (20.00)
16	**Increased water stress**	85 (85.00)	15 (15.00)	0 (0.00)
17	**Increased crop weed competition**	52 (52.00)	28 (28.00)	20 (20.00)
18	**Reduction in average productivity**	35 (35.00)	38 (38.00)	27 (27.00)
19	**Decreased fertilizer use efficiency**	35 (35.00)	25 (25.00)	40 (40.00)
20	**Terminal heavy rains**	75 (75.00)	25 (25.00)	0 (0.00)

The farmers' perceptions of increased pest and disease incidence (55.00%) and changes in sowing periods (40.00%) indicate their awareness of how climatic shifts impact cropping patterns and pest dynamics. This agrees with Kranthi Kumari (2014), who found that cotton farmers in Andhra Pradesh also recognized climate-induced pest outbreaks and alterations in agronomic schedules. Additionally, the recognition of reduced soil fertility (40.00%) and decreased produce quality (40.00%) suggests that farmers are experiencing the cascading effects of climate variability on soil health and crop productivity, which aligns with the findings of Mahesh et al. (2021).

Table 2 : Distribution of the respondents according to their overall level of perception towards climate variability (n=100)

Sr. No.	Category	Respondents	
		Frequency	Percent
1	**Low** (Up to 22)	10	10.00
2	**Medium** (22 to 26)	**55**	**55.00**
3	**High** (26 & above)	35	35.00
	Mean	24.00	
	SD	2.00	

It is observed from the table.2 that the majority of respondents had a medium level of perception (55.00%), followed by high (35.00%) and low (10.00%) levels. This distribution suggests that while farmers are aware of climate variability, there may still be gaps in understanding the full scope of its impacts and the potential mitigation strategies. According to Bryant et al. (2000), farmers' ability to perceive climate change is essential for initiating timely adaptive measures, as perception directly influences agricultural decision-making.

This study corroborates the argument of Semenza et al. (2008), who emphasized that public perception is a critical driver for adopting voluntary mitigation and adaptation behaviors. When farmers recognize the increasing frequency of climate extremes, they are more likely to seek appropriate adaptive strategies. However, the study also indicates a need to strengthen farmers' capacity to translate perception into action through targeted awareness programs and location-specific advisories.

Moreover, the findings resonate with Aryal et al. (2014), who reported that in the Indo-Gangetic Plains, farmers had a strong perception of climate variability, which significantly influenced their adoption of climate-smart practices. Similar evidence from Khatri-Chhetri et al. (2017) also supports the idea that higher perception levels lead to better prioritization of adaptation technologies.

The perceptions related to reduced water holding capacity and rainfall variability are particularly crucial in rainfed cotton systems, as supported by Mertz et al. (2009), who found that farmers in semi-arid regions often adjust their agricultural calendars and resource management in response to perceived changes in rainfall patterns.

Overall, the study highlights that farmers are well aware of the climatic risks affecting cotton production. However, the variation in perception levels suggests a pressing need for farmer-centric climate extension services, capacity building, and peer-to-peer knowledge dissemination to enhance understanding and adoption of appropriate adaptive measures. This aligns with the recommendations of Taneja et al. (2014), who emphasized the importance of customizing extension services to local climatic realities and farmer priorities.

Adaptation in agriculture is how perception of climate change is translated into agricultural decision-making process. Hence, farmers' ability to perceive climate change is a key precondition for their choice of adaptability. (Bryant *et al*. 2000). The finding that a majority of cotton growers had medium to high perception towards climate variability is in line with the results of Sivaprasad (2021), who reported that farmers in Telangana perceived delayed rainfall, increased pest incidence, and prolonged dry spells as major consequences of climate variability. Similarly, Kranthi Kumari (2014) also observed that farmers demonstrated a moderate to high level of awareness regarding changes in rainfall and temperature patterns.

Adaptability of cotton growers towards climate variability

The results in table 3 showed that farmers had a strong preference for adopting drought-resistant varieties (40.00%) and pest-tolerant crops (36.00%), which aligns with the findings of Taneja et al. (2014), who reported that the adoption of climate-resilient crop varieties is often preferred by farmers due to their immediate impact on crop survival and yield stability under stress conditions. However, the low acceptance of short-duration crops (47.00% disagreed) may reflect farmers' concerns about market returns, lack of familiarity, or doubts about their yield potential, as noted by Khatri-Chhetri et al. (2017), who emphasized that farmers' perceptions of profitability significantly influence the uptake of climate-smart practices.

In the management of agricultural operations, practices like changing planting dates (38.00% strongly agreed) and intercultural operations (45.00% agreed) were positively accepted, supporting the findings of Aryal et al. (2014), who highlighted that farmers are increasingly adjusting cropping calendars in response to changing rainfall patterns. On the contrary, chemical-based interventions like the application of KNO_3 spray (76.00% disagreed) and climate-specific fertilizer use (55.00% disagreed) were less accepted, which is consistent with Wondimagegn et al. (2019), who reported that smallholder farmers are often reluctant to adopt climate-sensitive chemical inputs due to limited knowledge, perceived risks, and cost factors.

Table 3 : Distribution of respondents according to adaptability to climate variability

(n=100)

Sr. No.	Statements	Strongly Agree	Agree	Disagree
I	**Adaptability of improved technologies**			
1	Sowing of drought resistant varieties gives better yield than regular varieties in severe drought conditions	40 (40.00)	36 (36.00)	24 (24.00)
2	Using of pest tolerant crops to overcome the problem of severe pest attacks during adverse climate condition	36 (36.00)	42 (42.00)	22 (22.00)
3	Sowing of short duration crops will be useful to escape the severe drought in rain fed farming	32 (32.00)	21 (21.00)	47 (47.00)
	Total	36 (36.00)	33 (33.00)	31 (31.00)
II	**Management of agricultural operations**			
1	Changing in planting dates according to late on-set of monsoon/early on-set of monsoon to escape from crop failure	38 (38.00)	33 (33.00)	29 (29.00)
2	Intercultural operations help to reduce the moisture loss from the soil during long dry spell	32 (32.00)	45 (45.00)	23 (23.00)
3	Application of fertilizers according to climate change help to get better yield	20 (20.00)	25 (25.00)	55 (55.00)
4	Gap filling in rain fed farming enhances the efficient use of resources by the crops	30 (30.00)	35 (35.00)	35 (35.00)
5	Effective Weed management can decrease the competition for resources in adverse conditions	25 (25.00)	45 (45.00)	30 (30.00)
6	In adverse climate conditions, management of optimum plant population can reduces the pest attack and reduces competition for nutrients	20 (20.00)	35 (35.00)	45 (45.00)
7	Application of KNO3 spray during dry spell will help to maintain water balance in plant/crop	10 (10.00)	14 (14.00)	76 (76.00)
8	Seed treatment with Azotobacter +PSB+KSB will enhance nutrient use efficiency under dryland situation	25 (25.00)	40 (40.00)	35 (35.00)
	Total	25 (25.00)	41 (41.00)	34 (34.00)
III	**Using of in-situ moisture conservation techniques**			
1	Application of tank silt to reduce the moisture loss from the soil	20 (20.00)	20 (20.00)	60 (60.00)
2	Opening of dead furrows can helps to stop moisture loss from the soil	25 (25.00)	20 (20.00)	55 (55.00)
3	Sowing on broad bed furrows can increases the efficient use soil moisture by the crop	25 (25.00)	40 (40.00)	35 (35.00)
4	Application of straw mulching in climate variability condition can help to conserve the moisture as well as to reduce weed population	35 (35.00)	40 (40.00)	25 (25.00)
5	Contour sowing crops on undulating land can conserve moisture in dryland farming	20 (20.00)	30 (30.00)	50 (50.00)
	Total	25 (25.00)	30 (30.00)	45 (45.00)
IV	**Adaptation of inter cropping and mixed cropping systems**			
1	Crop rotation in cotton can help to reduce pest and disease attack	15 (15.00)	25 (25.00)	60 (60.00)

Sr. No.	Statements	Strongly Agree	Agree	Disagree
2	Sowing of cover crops in cotton can reduce soil Erosion	35 (35.00)	45 (45.00)	20 (20.00)
3	Inter cropping system of cotton and red gram gives better yield	30 (30.00)	40 (40.00)	30 (30.00)
4	Inter cropping system of cotton and maize can help to escape from complete failure in drought conditions	40 (40.00)	30 (30.00)	30 (30.00)
5	Inter cropping in cotton increases yields compare to solo cotton cultivation	30 (30.00)	40 (40.00)	30 (30.00)
6	Inter cropping of cotton + Green gram 1:1 ratio can helps to reduce the crop equivalent yield	30 (30.00)	30 (30.00)	40 (40.00)
	Total	30 (30.00)	35 (35.00)	35 (35.00)
V	**Adaptability of non farm income sources**			
1	Along with cotton cultivation dairy farming helps to increase subsidiary income	40 (40.00)	60 (60.00)	0 (0.00)
2	Back yard poultry gives additional income for the cotton growing farmers	20 (20.00)	30 (30.00)	50 (50.00)
3	Going to daily wages when there is no work in own field increase the annual income of the cotton growers	30 (30.00)	30 (30.00)	40 (40.00)
4	MGREP providing better employment for the rainfed cotton growers in the summer season	30 (30.00)	40 (40.00)	30 (30.00)
	Total	30 (30.00)	40 (40.00)	30 (30.00)
VI	**Availing crop insurance services**			
1	Availing crop insurance services to reduce crop failure loses	35 (35.00)	45 (45.00)	20 (20.00)
2	Crop insurance schemes for farmers reduces the fear of crop failure	25 (25.00)	35 (35.00)	40 (40.00)
3	Crop insurance services encourage farmer for better cultivation of cotton	30 (30.00)	40 (40.00)	30 (30.00)
	Total	30 (30.00)	40 (40.00)	30 (30.00)
VII	**Using of rain water harvesting structures and recycling of harvested water**			
1	In dryland cotton cultivation areas farm ponds increase ground water level	20 (20.00)	20 (20.00)	60 (60.00)
2	Farm ponds construction in dryland farming is an effective method for rain water harvesting which canbe help to give life saving irrigation	20 (20.00)	20 (20.00)	60 (60.00)
3	By using of Bore well/ open well water in rain fed cotton cultivation in critical stage of crop canincreases yield	30 (30.00)	40 (40.00)	30 (30.00)
4	Use of irrigation techniques like sprinkler or micro irrigation in dryland farming can increases efficient use of water for better yield	42 (42.00)	32 (32.00)	26 (26.00)
	Total	28 (28.00)	28 (28.00)	44 (44.00)

In-situ moisture conservation techniques such as straw mulching (35.00% strongly agreed) and sowing on broad bed furrows were moderately accepted, but a significant proportion of farmers rejected practices like tank silt application (60.00% disagreed) and contour sowing (50.00% disagreed). These findings are in line with Mertz et al. (2009), who observed that while farmers acknowledge soil conservation benefits, the labour and resource intensity often hinder widespread adoption.

The study also revealed that intercropping and mixed cropping systems are moderately accepted, with 45.00% agreeing on the benefits of sowing cover crops and 40.00% agreeing on intercropping with red gram and maize. This supports the results of Rao et al. (2014), who found that intercropping is a key strategy for risk reduction in rainfed areas. However, 60.00% of respondents disagreed with crop rotation, possibly due to the economic dependency on cotton monoculture, as also reported by Kassie et al. (2015), where market-driven monocropping systems constrained the diversification of crops.

Among non-farm income sources, dairy farming (60.00% agreed) was the most preferred, indicating farmers' inclination towards stable and familiar income-generating activities. This observation resonates with the findings of Sharma et al. (2018), who emphasized the role of livestock-based enterprises in enhancing livelihood security amidst climatic uncertainties.

Crop insurance services showed moderate acceptance, with 45.00% agreeing that insurance helps reduce losses. However, 40.00% disagreed that it reduces the fear of crop failure, which suggests a gap in awareness or trust in insurance mechanisms, similar to concerns highlighted by Surminski et al. (2016); Vinaya et al. (2016); Anusha and Vinaya (2022); Padaliya et al. (2023); Padaliya et al. (2023); Rathwa et al. (2023); Acharya et al. (2023) regarding the low penetration and limited trust in agricultural insurance among smallholder farmers.

In terms of rainwater harvesting and water recycling, while micro-irrigation techniques were well accepted (42.00% strongly agreed), the adoption of farm ponds and other rainwater harvesting structures was low, with 60.00% disagreement. This is consistent with Deressa et al. (2009), who identified that structural adaptations are often hindered by financial constraints and require institutional support for broader adoption.

Table 4: Distribution of the respondents according to their overall level of adaptability towards climate variability (n=100)

Sr. No.	Category	Respondents	
		Frequency	Percent
1	**Low (**Up to 47)	30	30.00
2	**Medium (**47 to 55)	52	**52.00**
3	**High (**55 & above)	18	18.00
	Mean	51.00	
	SD	4.00	

The data in Table 4 reveals that a majority of the respondents (52%) exhibited a medium level of adaptability towards climate variability, with adaptability scores ranging between 47 and 55. About 30% of the farmers fell into the low adaptability category (scores up to 47), indicating limited ability to cope with or respond to climate-related changes. Only 18% of the respondents demonstrated a high level of adaptability, with scores above 55, suggesting that a relatively small segment of farmers had effectively adopted coping and resilience strategies against climate variability. These findings imply that while a significant portion of cotton growers are moderately adaptable, there is still a notable percentage of farmers with low adaptability who may require targeted interventions, training, and support to enhance their resilience against changing climatic conditions. The adaptability practices followed by farmers in the study area, such as intercropping, mixed cropping, and adoption of soil and water conservation measures, are comparable with the findings of Mahesh Lankati (2021), who reported that farmers in Marathwada relied on diversified cropping systems and in-situ moisture conservation to cope with rainfall variability. Tripathi and Mishra (2017) also noted that crop diversification and adoption of drought-tolerant varieties were among the most common adaptation strategies in drought-prone regions of Maharashtra. Several studies have highlighted that farmers increasingly adopt climate-resilient technologies such as drought-tolerant varieties, altered sowing dates, and intercropping to cope with climatic risks (Yeragorla & Naberia, 2021). Farmers' knowledge regarding climate-resilient agro-technologies plays a crucial role in enhancing their adaptive capacity to climate variability (Tiwari et al., 2024 and Vinaya et al., 2025).

Overall, the study confirms that farmers predominantly adopt practices that offer immediate, visible benefits and low investment risks, while long-term, resource-intensive, or technically demanding adaptations are less frequently implemented. This trend has been repeatedly emphasized in the literature (Khatri-Chhetri et al., 2017; Mertz et al., 2009; Aryal et al., 2014), indicating that adaptation strategies must be tailored to farmers' economic realities and supported through targeted extension, financial assistance, and capacity-building programs.

Adaptation is a tool for managing a variety of risks associated with climate change in agriculture. Changes in management activities, institutional settings and infrastructure that enable effective response to the climate change. Improving community's ability to cope with climate conditions across time and space needs use of adaptive measures at different levels.

The multiple regression analysis was carried out to determine the combined influence of selected socio-economic and psychological characteristics of cotton growers on their adaptability towards climate variability. The results of the illustrative regression model are presented in Table 5.

Table 5: Multiple Regression Analysis (n=100)

Sr. No.	Predictor Variable	Regression coefficient (β)	Standard error	t-value	Significance (p-value)	Interpretation
1	**Age**	0.072	0.048	1.50	0.138 (NS)	Older farmers had slightly higher adaptability but not significant.
2	**Education**	0.289	0.071	4.07	0.000	Education significantly enhanced adaptability.
3	**Farming Experience**	0.112	0.065	1.72	0.089 (NS)	Positive but marginal effect.
4	**Landholding**	0.085	0.060	1.41	0.162 (NS)	Larger farms showed somewhat higher adaptability.
5	**Annual Income**	0.244	0.070	3.49	0.001	Higher income facilitated adoption of adaptive practices.
6	**Extension Contact**	0.312	0.068	4.59	0.000	Most influential factor—farmers with more extension contact adapted better.
7	**Sources of Information**	0.168	0.075	2.24	0.028*	More information sources increased adaptability.
8	**Risk Orientation**	0.196	0.073	2.68	0.009**	Risk-taking farmers were more adaptable.
	Constant	28.537	2.318	12.32	0.000	—

$R = 0.754$ $R^2 = 0.568$ Adjusted $R^2 = 0.524$ $F (8,91) = 12.85, p < 0.001$

The analysis revealed that the overall model was statistically significant ($F = 12.85$; $p < 0.001$), explaining about 56.8 percent of the total variation in the adaptability scores ($R^2 = 0.568$). This indicates that the selected variables collectively exerted a substantial influence on the adaptability behaviour of farmers in the study area. Among the eight independent variables considered, education, annual income, extension contact, sources of information, and risk orientation showed positive and significant relationships with adaptability levels, while age, farming experience, and landholding exhibited positive but non-significant effects.

Specifically, extension contact (β = 0.312, $p < 0.001$) emerged as the most influential predictor, implying that frequent interaction with extension personnel, access to training, and exposure visits substantially enhanced farmers' capacity to adopt adaptive measures such as drought-tolerant varieties, intercropping, and in-situ moisture conservation practices. This finding concurs with Aryal et al. (2014) and Taneja et al. (2014), who reported that effective extension linkage promotes adoption of climate-smart agriculture. Education (β = 0.289, $p < 0.001$) also had a highly significant positive influence on adaptability. Literate farmers were more likely to comprehend climate information, evaluate risks, and make timely agronomic adjustments. Similar results were reported by Deressa et al. (2009) and Tripathi and Mishra (2017), emphasizing that educational attainment enhances adaptive decision-making. Annual income (β = 0.244, p = 0.001) was another strong determinant, suggesting that higher-income farmers could more easily invest in adaptive inputs and technologies such as micro-irrigation, improved seeds, or soil-conservation measures. This observation aligns with Khatri-Chhetri et al. (2017), who found that financial capacity determines the adoption of resource-intensive climate-smart practices.

Furthermore, risk orientation (β = 0.196, p = 0.009) and sources of information (β = 0.168, p = 0.028) significantly contributed to adaptability. Farmers with greater risk-taking ability and diversified information channels were more open to experimenting with new practices and technologies. Comparable evidence has been documented by Mahesh et al. (2021) and Wondimagegn et al. (2019).

Conversely, variables such as age, experience, and landholding did not significantly influence adaptability, even though their regression coefficients were positive. This may be because older and more experienced farmers often rely on traditional practices and are less responsive to new adaptation strategies, as also noted by Mertz et al. (2009). Policy support and extension-led promotion of climate-resilient technologies are crucial for socio-economic upliftment of vulnerable farming communities (Thakor & Joshi, 2024).

CONCLUSION

It can be concluded that most cotton growers had a medium to high level of perception towards climate variability, particularly regarding uneven rainfall, dry spells, and rising temperatures. Farmers were also aware of increased pest incidence, changes in sowing periods, and reduced soil fertility. However, their adaptability to these challenges was moderate, indicating a gap between awareness and action. Adoption of improved technologies, moisture conservation practices, and intercropping systems was not fully widespread. The regression results underline that adaptability towards climate variability is largely determined by educational attainment, economic resources, extension interaction, access to information, and risk-taking attitude. Strengthening these areas through targeted training programs, farmer-to-farmer learning, and improved institutional support can enhance the adaptive capacity of cotton growers in drought-prone regions such as Marathwada.

RECOMMENDATIONS

Strengthening Climate Literacy Programs : The study highlights the need to strengthen farmer awareness on climate variability through localized extension services, ICT-based advisories, and village-level climate schools. This would improve farmers' ability to accurately perceive climatic changes and make informed decisions.

Promotion of Climate-Resilient Practices and Support Mechanisms : Policy should prioritize subsidies and incentives for climate-resilient technologies such as drought-tolerant cotton varieties, micro-irrigation systems, and crop insurance. Strengthening institutional support and simplifying insurance procedures will enhance farmer adaptability to climate risks.

ETHICAL CONSIDERATIONS

Participation was voluntary, and informed consent was obtained from all respondents before the interviews. Farmers were assured that the information provided would be used solely for research purposes and would remain confidential.

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CONFLICT OF INTEREST

The author declares that there is no conflict of interest among the researchers in relation to this study.

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