Mysore J. Agric. Sci., 58 (4) : 111-122 (2024)

Farmers Vulnerability to Climate Change in Telangana State - A Critical Analysis

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Received : July 2024
Accepted : September 2024

Abstract

Vulnerability in the context of climate change refers to the degree to which a system is susceptible and unable to cope with adverse climate effects. Farmers' vulnerability to climate change is a critical issue, especially in countries like India, where a substantial portion of the population relies on agriculture for their livelihood. In India, the excessive pressure on natural resources, coupled with inadequate coping mechanisms, has aggravated this vulnerability. The study was conducted in two districts of Telangana state to analyse the vulnerability level of farmers to climate change. A total of 240 farmers were selected by using simple random sampling technique from twenty four villages from two districts. Personal interview method was used to collect data and appropriate statistical tools were applied to analyse the data. The findings revealed that nearly half (45.00 %) of the farmers belonged to moderately vulnerable category followed by severe (31.67 %) and least (25.84 %) vulnerable level category. The major problems related with adaptative capacity of farmers to climate change was limited access to information regarding long-term climate change, insufficient awareness about suitable adaptation measures (climate resilient crop varieties, soil-moisture conservation techniques etc.), inadequate transportation facilities, challenging to engage in fieldwork due to extreme temperatures, absence of credit or loans from banking institutions. Provision of incentives and support for increased use of green manure, promotion of awareness and providing support for the adoption of organic farming technologies, crop diversification were some of the major suggestions given by farmers to overcome adverse effects of climate change.

Keywords : Climate change, Vulnerability, Challenges

Climate change and its variability have become significant concerns for Indian agriculture in recent years. Global climate change projections indicate an increase in extreme events such as heat waves, cold waves and flooding, along with higher atmospheric carbon dioxide and ground-level ozone concentrations. Additionally, a rise in sea levels is expected to inundate coastal areas, among other impacts (Raghavan *et al.,* 2020).

Developing countries like India are particularly vulnerable to climate change, facing large-scale climate variability and heightened risks. India's susceptibility is exacerbated by its agrarian economy, expansive coastal areas and regions like the Himalayas. Climate change poses significant trade-offs with economic growth and social development. With 2.4 per cent of the world's surface area, India supports around 17.5 per cent of the global population, housing 30 per cent of the world's poor and significant proportions of the global population lacking electricity, clean cooking resources and safe drinking water (Anonymous, 2015). India has a diverse ecology and some regions have evolved and adapted practices over time to tackle vagaries. Judicious use of some of these practices

has the potential to mitigate the effects of climate change. Proper management and implementation of practices that have resulted in an increased agri-produce in unfavourable conditions can also be used to adapt to climate change (D. V. Srinivas Reddy *et al.,* 2023).

Vulnerability in the context of climate change refers to the degree to which a system is susceptible to and unable to cope with adverse climate effects. It is a function of the exposure to climatic hazards, the sensitivity of the system to these hazards and the adaptive capacity of the system (IPCC, 2007a). In India, the excessive pressure on natural resources, coupled with inadequate coping mechanisms, has exacerbated this vulnerability.

Studying farmer's vulnerability is essential for several reasons. Firstly, it provides insights into the specific climatic risks faced by different agricultural regions, helping to tailor adaptive measures effectively. Secondly, it aids in understanding the socio-economic factors that influence farmer's capacity to adapt, such as access to resources, knowledge and technology. Thirdly, it supports the development of policies and programs that enhance the resilience of the agricultural sector, ensuring food security and economic stability. In summary, understanding and addressing the vulnerability of farmers to climate change is imperative for sustaining agricultural productivity and ensuring the livelihoods of millions in India.

To cope with climate change and enhance agricultural resilience, planned approaches in agricultural practices and development are essential. India's diverse ecology has led to the evolution and adaptation of various practices over time, which can effectively address climate variability. The judicious application of these practices has the potential to mitigate the impacts of climate change.

Climate-resilient crops and crop varieties, designed to withstand biotic and abiotic stresses, play a crucial role in maintaining or increasing crop yields under extreme weather conditions. These crops offer a viable solution to counter diminishing yields caused by droughts, higher average temperatures and other climatic challenges (Maricelis Acevedo *et al.,* 2020).

The collaboration among farmers, extension professionals, and scientists is pivotal in managing crises induced by climate change. Active interaction among them is necessary to accelerate agricultural development in concerned areas. However, research in this area has been primarily focused on investigating farmer's adjustment patterns and simultaneously study the crisis-mitigating strategies of government organizations and research systems.

Methodology

Ex-post facto research design was adopted for the study. The study was conducted in the Northen Zone of Telangana. Bodhan and Armoor taluks from Nizamabad district, Boath and Ichoda from Adilabad district were selected purposively for the study. The district and taluks with higher degree of climate change were purposively selected for the study. Villages from each of the taluks were selected randomly and the list of the villages from each of the *taluks* so selected was collected from the Revenue Department and then the six villages from each of the *taluk* were selected randomly for the study. In each of the village, 10 farmers were selected Thus, totally 60 farmers from each Taluk and totally 240 respondents constituted sample for the study.

The independent variables selected for the study were age, education, land holding, experience in farming, annual income, social participation, mass media exposure, farm mechanisation, extension participation, extension contact, credit orientation, risk orientation, management orientation, innovative ness, risk orientation, scientific orientation cosmopoliteness, deferred gratification and knowledge about climate smart technologies.

The scale for assessing the vulnerability level of farmers to climate change was developed and standardized consisting of 89 statements was administered on the respondents along with five point continum representing 'Strongly Agree (SA)', 'Agree (A)', 'Undecided (UD)', 'Disagree (D)' and

'Strongly Disagree (SDA)' with weightage of 5, 4, 3, 2 and 1, respectively. The statements were carefully formed by consulting subject matter specialists of University of Agricultural Sciences, Bangalore along with review of related literature. The statements were subjected to thorough scrutiny and editing to avoid ambiguity of meaning, eliminate duplication of ideas and to achieve clarity and specificity of question. The vulnerability score of a respondent was worked out by adding the scores obtained by him/her on all final statements considered for the measurement.

Results and Discussion

Overall Comparison of Farmers Based on Vulnerability Level to Climate Change

Table 1, indicates the comparison of farmers based on vulnerability level to climate change. The data revealed that among farmers of Nizamabad district, slightly less than half (49.16%) of the farmers belonged to moderate vulnerability level, followed by slightly more than one-fourth (26.67%) were under severely vulnerable level and nearly one-fourth (24.17%) belonged to least vulnerable level category. Among farmers of Adilabad district, the trend observed was that 40.83 per cent of them were under moderate vulnerability level category followed by severely vulnerable level (36.67%) and least vulnerable level category (22.50%). In the case of overall farmers, more than two-fifth (45.00%) of the farmers were categorized under moderate vulnerability level followed by severely vulnerable level (31.67%) and least vulnerable level category (23.33%). The trends reveal that while many farmers are moderately vulnerable to climate change, a significant portion, especially in Adilabad, faces severe risks. The results are inline with results of Shankar (2019) where majority of the respondents were under medium level of vulneralibility followed by severe and low vulnerable category. This situation underscores the need for targeted interventions, such as improving access to resources, enhancing adaptive capacity and promoting sustainable practices to reduce vulnerability levels across both districts. Understanding these dynamics is crucial for developing effective agricultural policies and climate resilience strategies tailored to the specific needs of each community.

Classification of Farmers based on Exposure, Sensitivity, Attitude, Egalitarianism

In the study area data collected on different dimensions of vulnerability level such as exposure, sensitivity, attitude and egalitarianism were analyzed separately for all farmers to know the extent of exposure, sensitivity attitude and egalitarianism. The farmers were grouped and presented in the Table 2. The data in the table reveals that, two-fifth (45.00%) of the farmers were fall in medium level of exposure to climate change (rainfall and temperature) followed by 30 per cent were in low level exposure and one-fourth (25.00%) of them belongs to high exposure category among farmers of Nizamabad district, whereas in Adilabad, slightly less than half

Table 1

Comparison of farmers based on vulnerability level to climate change

(n=240)

Vulnerability level of farmers to climate change	Farmers of Nizamabad district (n_1=120)		Farmers of Adilabad district (n_2=120)		Overall farmers (n=240)	
	Number	Percentage	Number	Percentage	Number	Percentage
Least vulnerable (< 2.94)	29	24.17	27	22.50	56	23.33
Moderately vulnerable (2.94 -4.26)	59	49.16	49	40.83	108	45.00
Severely vulnerable (>4.26)	32	26.67	44	36.67	76	31.67

TABLE 2

Classification of farmers based on exposure, sensitivity, attitude, egalitarianism

(n=240)

Indicators	Classification	Farmers of Nizamabad district (n_1=120)		Farmers of Adilabad district (n_2=120)		Overall farmers (n=240)	
		Number	Percentage	Number	Percentage	Number	Percentage
Exposure	Less exposure (<2.54)	36	30.00	33	27.50	69	28.75
	Moderate exposure (2.54-3.82)	54	45.00	59	49.17	113	47.08
	High exposure (>3.82)	30	25.00	28	23.33	58	24.17
Sensitivity	Less sensitive (<2.49)	17	14.17	16	13.33	33	13.75
	Moderately sensitive (<2.49-3.77)	61	50.83	57	47.50	118	49.17
	Highly sensitive (>3.77)	42	35.00	47	39.17	89	37.08
Attitude	Unfavourable (<2.53)	37	30.83	42	35.00	79	32.92
	favourable (2.53-3.79)	49	40.84	56	46.67	105	43.75
	Most favourable (>3.79)	34	28.33	22	18.33	56	23.33
Egalitarianism	Poor (<2.50)	43	35.83	48	40.00	91	37.92
	Good (2.50-3.78)	51	42.50	53	44.17	104	43.33
	Better (>3.78)	26	21.67	19	15.83	45	18.75

(49.17%) of the farmers were fall in medium level of exposure to climate change (rainfall and temperature) followed by 27.50 per cent were in low level exposure and 23.33 per cent of them belongs to high exposure category.

Overall results with respect to exposure revealed that less than half (47.08%) of the farmers were fall in medium level of exposure to climate change (rainfall and temperature) followed by 28.75 per cent were in low level exposure and slightly less than one-fourth (24.75%) of them belongs to high exposure category. The high proportion of farmers with medium to high exposure to climate change (rainfall and temperature) indicates the need for targeted adaptation strategies to help them cope with the changing climatic conditions. Interventions should focus on improving farmer's access to weather information, early warning systems and climate-smart agricultural practices to enhance their preparedness and resilience.

With respect to sensitivity, half (50.83%) of the farmers were moderately sensitive to climate change and 35.00 per cent of them were highly sensitive to climate change followed category of low level of sensitivity with 14.17 per cent among farmers of Nizamabad district, whereas in Adilabad, less than half (47.50%) of farmers were moderately sensitive to climate change and 39.17 per cent of them were highly sensitive to climate change followed category of low level of sensitivity with 13.33 per cent.

Overall results with respect to sensitivity revealed that slightly less than half (49.17%) of farmers were moderately sensitive to climate change and 37.05 per cent of them were highly sensitive to climate change followed category of low level of sensitivity with 13.75 per cent. The significant share of farmers with moderate to high sensitivity to climate change underscores the vulnerability of the agricultural sector in the study area. Efforts should be made to strengthen the adaptive capacity of farmers, particularly those highly sensitive, through capacity building, access to resources and the promotion of diversified livelihood options.

With respect to attitude, two-fifth (40.84%) of the farmers were under favourable attitude, followed by unfavorable attitude (30.83%) and most favourable attitude (28.33%) among the farmers of Nizamabad district, whereas in Adilabad, 46.67 per cent of farmers were under favourable, followed by unfavorable attitude (35.00%) and most favourable attitude (18.33%). Overall results with respect to attitude revealed that, 43.75 per cent of farmers were under favourable attitude, followed by unfavorable attitude (32.92%) and most favourable attitude (23.33%). The prevalence of favorable and unfavorable attitudes towards climate change among farmers suggests the need for targeted awareness campaigns and educational programs. Improving farmer's understanding of climate change impacts and the importance of adaptation measures could foster more favorable attitudes and encourage proactive engagement in climate-resilient practices.

With respect to egalitarianism, more than two-fifth (42.50%) of the farmers belongs to good level of egalitarianism followed by poor (35.83%) and better level (21.67%) egalitarianism category among the farmers of Nizamabad district, whereas in Adilabad, more than two- fifth (44.17%) of the farmers belongs to good level of egalitarianism followed by poor (40.00%) and better level (15.83%) egalitarianism category. Overall results with respect to egalitarianism, more than two-fifth (43.33%) of the farmers belongs to good level of egalitarianism followed by poor (37.92%) and better level (18.75%) egalitarianism category. The relatively low levels of egalitarianism among farmers, with a significant proportion in the poor and better categories, indicate the need to address socio economic disparities and promote inclusive climate change adaptation strategies. Interventions should aim to enhance equitable access to resources, information and decision-making processes, ensuring that all farmers, regardless of their socioeconomic status, can benefit from climate change adaptation efforts. The findings are inline with results of Chetri (2017), where majority of the respondents were under medium exposure, moderately sensitive category, favourable attitude and good to poor egalitarianism category.

The findings highlight the multidimensional nature of vulnerability to climate change among farmers in the study area. Addressing these vulnerabilities will require a comprehensive approach that combines targeted interventions, capacity building and the promotion of inclusive and equitable climate change adaptation strategies. By addressing the identified vulnerabilities, policymakers and stakeholders can enhance the resilience of the agricultural sector and improve the livelihoods of farmers in the face of a changing climate.

Association of Independent Variables with Vulnerability of Farmers to Climate Change

The chi-square test was used to find out the association between profile characteristics and overall vulnerability of farmers to climate change among farmers of Nizamabad district. It was observed from the data in the Table 3 that, the variables such as age, social participation, economic motivation and

Table 3

Comparison of association of independent variables with vulnerability level of farmer

(n=240)

Independent variables	Farmers of Nizamabad district (n_1=120)	Farmers of Adilabad district (n_2=120)	Overall farmers (n=240)
Age	9.658 **	10.896 **	12.698 **
Education	11.12 *	12.49 *	11.236 *
Family size	0.569 NS	0.428 NS	0.496 NS
Land holding	1.596 NS	2.263 NS	2.168 NS

Continued....

Table 3 Continued....

Independent variables	Farmers of Nizamabad district (n_1=120)	Farmers of Adilabad district (n_2=120)	Overall farmers (n=240)
Experience in farming	8.021 *	7.085 *	7.862 *
Annual income	8.263 *	8.120 *	8.189 *
Social participation	8.467 **	8.866 **	8.662 *
Mass media exposure	7.369 *	7.985 *	7.729 *
Extension contact	8.109 *	7.863 *	8.000 *
Extension participation	8.010 *	8.197 *	8.000 *
Farm mechanisation	3.259 NS	2.968 NS	3.189 NS
Innovativeness	7.210 *	7.928 *	7.762 *
Risk orientation	8.061 *	8.163 *	8.102 *
Scientific orientation	7.296 *	7.000 *	7.169 *
Economic motivation	14.329 **	13.728 **	13.926 **
Management orientation	7.320 *	7.892 *	7.518 *
Credit orientation	8.169 *	8.012 *	8.129 *
Cosmopoliteness	7.139 *	7.368 *	7.261 *
Deferred gratification	1.635 NS	2.356 NS	1.539 NS
Knowledge about climate smart technologies	26.367 **	25.936 **	26.296 **

NS- Non-Significant, *- Significant at 5 per cent level, **- Significant at 1 per cent level

knowledge about climate smart technologies at 1 per cent level of significance. The other variables such as education, farming experience, family income, mass media exposure, innovativeness, extension participation, social participation, extension contact, cosmopoliteness, credit orientation, management orientation, risk orientation, scientific orientation at 5 per cent level of significance and family size, land holding, farm mechanisation and deferred gratification had non-significant association with vulnerability of farmers to climate change. The chi-square test was used to find out the association between profile characteristics and overall vulnerability of farmers to climate change among farmers of Adilabad district.

It was observed from the data in the Table 3 that, the variables such as age, social participation, economic motivation and knowledge about climate smart technologies at 1 per cent level of significance. The other variables such as education, farming experience, family income, mass media exposure, innovative ness, extension participation, social participation, extension contact, cosmopoliteness, credit orientation, management orientation, risk orientation, scientific orientation at 5 per cent level of significance and family size, land holding, farm mechanisation and deferred gratification had non-significant association with vulnerability of farmers to climate change. With respect to overall farmers, same trend of association of variables with vulnerability was found.

Age and Vulnerability Level of Farmers to Climate Change

The study revealed that age is positively and significantly associated with the vulnerability of farmers to climate change. This association can be attributed to several factors. Younger farmers often lack the extensive experience needed to manage climate-related challenges effectively, which increases their vulnerability. Additionally, those with lower

educational levels may struggle to understand the impacts of climate variability, making them more susceptible to adverse effects. Farmers who have not built strong community networks may find it difficult to access resources and support during climate crises. Moreover, some older farmers might resist adopting new technologies or practices, further heightening their vulnerability to climate impacts. Economic constraints also play a significant role, as farmers with limited financial resources may struggle to invest in necessary adaptations, leaving them exposed to climate risks. A reliance on traditional farming methods without considering climate change can increase vulnerability to extreme weather events.

Environmental degradation resulting from unsustainable practices further contributes to this issue. Social isolation can prevent farmers from receiving timely support or knowledge about coping strategies, while older farmers may face physical limitations that hinder their ability to implement necessary changes, ultimately increasing their vulnerability to climate change impacts.

Education and Vulnerability Level of Farmers to Climate Change

Education plays a crucial role in shaping farmer's vulnerability to climate change. Studies have shown that education is significantly associated with the vulnerability of farmers, highlighting the importance of knowledge acquisition and critical thinking skills. Farmers with lower levels of education may struggle to understand climate variability and the associated risks, leading to increased susceptibility to adverse effects. Additionally, less educated farmers may have limited access to new technologies and practices, which can further heighten their vulnerability. With out the ability to plan and organize effectively, these farmers are less equipped to identify challenges and opportunities, ultimately impacting their overall farm management. Consequently, a lower level of education often correlates with a higher vulnerability to climate change, as it limits farmer's capacity to adapt and respond to shifting agricultural conditions.

Mass media and Vulnerability Level of Farmers to Climate Change

Mass media plays a crucial role in raising awareness, increasing knowledge and influencing the vulnerability of farmers to climate change. Research has shown that exposure to mass media is significantly associated with farmer's vulnerability, as those with higher levels of media exposure gain important insights into the risks associated with climate change and the need for sustainable practices. Additionally, increased awareness can lead to complacency if farmers do not have the resources or support to implement new technologies, thereby heightening their vulnerability. The study also revealed that extension participation and contact are positively and significantly associated with farmer's vulnerability to climate change. More frequent interactions with extension personnel and participation in activities like field days and trainings can help farmers understand adaptation strategies, but those who are less engaged may struggle to access this vital information. This limited contact can leave farmers ill-equipped to respond effectively to climate challenges, ultimately increasing their vulnerability and jeopardizing their agricultural sustainability.

Social Participation, Cosmopoliteness and Vulnerability Level of Farmers to Climate Change

Both social participation and cosmopoliteness were found to have a significant impact on the vulnerability of farmers to climate change. Social participation fosters community engagement, but those lacking involvement in local organizations may miss out on critical knowledge sharing and resource access, increasing their vulnerability during climate-related challenges. Without strong community ties, farmers may struggle to adapt effectively to changing conditions. Similarly, cosmopoliteness, or openness to external ideas, can help farmers learn about broader agricultural trends, but farmers who are isolated from these influences may fall behind in adopting necessary practices, further heightening their vulnerability. Additionally, limited social connections can result in a lack of support during difficult times, leaving farmers without essential resources or assistance.

Credit Orientation, Management Orientation Risk Orientation and Vulnerability Level of Farmers to Climate Change

Furthermore, credit orientation, management orientation and risk orientation significantly influence farmer's vulnerability to climate change. Farmers with low credit orientation may find it challenging to secure funding for new technologies, limiting their ability to invest in climate-resilient strategies. Similarly, a lack of risk orientation can prevent farmers from experimenting with innovative practices, making them less resilient in the face of climate variability. Without effective management, farmers may fail to assess operational challenges and respond strategically, increasing their susceptibility to climate impacts. Additionally, farmers who lack access to credit may miss out on vital training and support services that equip them to adapt their practices. Overall, insufficient social participation, cosmopoliteness and orientations towards credit, management and risk contribute significantly to the vulnerability of farmers in the face of climate change.

Scientific Orientation and Vulnerability Level of Farmers to Climate Change

The study revealed that scientific orientation is positively and significantly associated with the vulnerability of farmers to climate change. Farmers lacking a strong scientific orientation may struggle to understand climate-related challenges, making them more susceptible to adverse impacts. Without the ability to adopt innovative practices, these farmers are less equipped to navigate changing conditions, increasing their vulnerability. Limited access to education and information further compounds this issue, preventing farmers from making informed decisions that support sustainable farming and effective resource management.

Moreover, insufficient participation in social networks and extension programs can lead to isolation, reducing opportunities for collaboration and knowledge sharing, which are vital for resilience. Farmers who do not diversify their practices are more reliant on single crops or methods, heightening their vulnerability to climate variability. Additionally, without adequate training and support from extension services, farmers may fail to implement necessary climate-smart practices. Ultimately, a limited scientific mindset can lead to stagnant thinking and a failure to critically evaluate existing methods, resulting in practices that do not promote biodiversity or ecological balance, which are essential for long-term sustainability in the face of climate change.

Knowledge about Climate Smart Technologies and Vulnerability Level of Farmers to Climate Change

Knowledge about climate-smart technologies is positively and significantly associated with vulnerability of farmers to climate change because farmers who lack understanding of these technologies may be ill-equipped to implement effective strategies to combat climate change. Without this knowledge, farmers are more likely to rely on traditional practices that may not be resilient to shifting climatic conditions, increasing their susceptibility to adverse impacts. Additionally, limited awareness of innovative techniques can lead to poor decision-making, resulting in reduced crop yields and heightened vulnerability. Furthermore, farmers without access to information about climate-smart options may miss out on opportunities for adaptation, leaving them unable to respond effectively to climate-related challenges and further exacerbating their vulnerability.

Challenges in Adaptation Experienced by Farmers Due to Climate Change

The data projected in the Table 4 reveals that one of the major challenges expressed by farmers of Nizamabad district was to insufficient awareness about suitable adaptation measures was ranked first with mean score of 2.53 as most important challenge, followed by shortage of labour availability with mean score of 2.49 (Rank II) and limited access to information regarding long-term climate change and lack of timely availability of inputs such as seeds, pest control chemicals and fertilizers were with mean score of 2.48 (Rank III), reduced market prices for agricultural produce and inadequate processing units capacity within the village were with mean score of

TABLE 4

Challenges expressed by farmers for adaptation in response to climate change

(n=240)

Challenges	Farmers of Nizamabad district (n_2=120)		Farmers of Adilabad district (n_2=120)		Overall Farmers (n=240)	
	Mean score	Rank	Mean score	Rank	Mean score	Rank
Challenging to engage in fieldwork due to extreme temperatures.	2.44	VII	2.43	VI	2.43	VII
Increased expenses for agricultural inputs.	2.42	XII	2.43	VI	2.42	IX
Lack of timely availability of inputs such as seeds, pest control. chemicals, and fertilizers	2.48	III	2.48	III	2.48	III
Reduced market prices for agricultural produce.	2.40	XIV	2.44	V	2.42	IX
Shortage of labour availability.	2.49	II	2.40	IX	2.45	IV
Elevated labour wage rates.	2.46	V	2.40	IX	2.43	VII
Inconsistent supply of reliable electricity.	2.38	XVI	2.40	IX	2.39	XVI
Limited access to information regarding long-term climate change.	2.48	III	2.48	III	2.45	IV
Absence of irrigation facilities	2.43	IX	2.37	XII	2.42	IX
Insufficient awareness about suitable adaptation measures.	2.53	I	2.52	II	2.51	I
Absence of credit or loans from banking institutions.	2.43	IX	2.46	IV	2.44	VI
Inadequate storage capacity within the village	2.44	VII	2.36	XIII	2.40	XV
Inadequate processing units capacity within the village	2.40	XIV	2.42	VII	2.41	XIII
Limited understanding of a. Processing b. Gradingc. Storage	2.43	XI	2.30	XV	2.39	XVI
Considerable distance of the regulated market from the village.	2.45	VI	2.33	XIV	2.39	XVI
Inadequate transportation facilities.	2.48	III	2.54	I	2.51	I

2.40 (Rank XIV each) and inconsistent supply of reliable electricity was with mean score of 2.38 (XVI) respectively, whereas among farmers of Adilabad, inadequate transportation facilities was ranked first with mean score of 2.54 followed by insufficient awareness about adaptation strategies with mean score of 2.52 (Rank II) and limited access to information regarding long-term climate change and lack of timely availability of inputs such as seeds, pest control chemicals and fertilizers were with mean score of 2.48 (Rank III). With respect of overall farmers, inadequate transportation facilities and insufficient awareness about suitable adaptation measures was ranked first with mean score of 2.51, followed by limited access to information regarding long-term climate change, shortage of labour availability and lack of timely availability of inputs such as seeds, pest control chemicals, and fertilizers were with mean score of 2.45 (Rank III) and Inadequate storage capacity within the village with mean score of 2.40 (Rank XV) and considerable distance of the regulated market from the village, irregular electricity, limited understanding of processing, grading and storing weres with mean score of 2.39 (Rank XVI) respectively. The probable reasons for the difficulties faced by farmers include small-scale farming with low per capita land availability, low income and a lack of cosmopolitan influence. These factors make it highly challenging for them to adapt suitable technologies in their fields. This aligns with the findings of Banafar and Chandrakar (2016), who identified major socio-economic constraints in

pigeon pea production, such as the unavailability of improved and high-yielding variety seeds, cattle grazing issues, lack of irrigation, insufficient knowledge of agricultural practices, poor economic conditions of small farmers and problems with insect pests and diseases. Similarly, Muhammad *et al.* (2015), reported that limited water availability, high levels of poverty and a weak local government role in providing proper infrastructure exacerbate farmer's sensitivity to climate-related risks. They highlighted constraints such as a lack of resources, limited information, insufficient finances and inadequate institutional support, which all limit the adaptive capacity of farm households. Chinwendu *et al.* (2017), found that inadequate education, limited access to resources (including land, labour supply and traditional knowledge/information), poor local institutional capacity and services and gender disparities are key factors shaping vulnerability.

Expectations of Farmers to Overcome the Adverse Effects of Climate Change

The data projected in the Table 5 reveals that one of the major expectations expressed by farmers of Nizamabad district was to provide subsidies or compensation for crops to offset cultivation costs due to weather aberrations and incentives and support for increased use of green manure and raising awareness regarding appropriate measures for adapting to climate change were ranked first with mean score of 2.94 as most important suggestion, followed by Farmers should receive early alerts about environmental changes with mean score of 2.44 (Rank IV), whereas among farmers of Adilabad, provide subsidies or compensation for crops to offset cultivation costs due to weather aberrations was ranked first with mean score of 2.52 followed by raising farmer's awareness regarding appropriate

TABLE 5

Expectations of farmers to overcome adverse effects of climate change

(n=240)

Expectations	Farmers of Nizamabad district (n_2=120)		Farmers of Adilabad district (n_2=120)		Overall Farmers (n=240)	
	Mean score	Rank	Mean score	Rank	Mean score	Rank
Farmers should receive early alerts about environmental changes.	2.44	IV	2.48	II	2.46	IV
Raise farmers' awareness regarding appropriate measures for adapting to climate change.	2.49	I	2.48	II	2.48	II
The development department must ensure timely supply of production inputs to villages.	2.43	V	2.43	VIII	2.43	VI
Provide subsidies or compensation for crops to offset cultivation costs due to weather anomalies.	2.49	I	2.52	I	2.50	I
Extend insurance coverage to encompass all crops.	2.39	IX	2.44	VII	2.42	X
Offer financial assistance for enriching soil nutrients.	2.41	VII	2.43	VIII	2.42	X
Provide incentives and support for increased use of green manure.	2.49	I	2.46	V	2.48	II
Establish a support price for all crop produce based on cultivation costs.	2.39	IX	2.46	V	2.43	VI
Promote awareness and provide support for the adoption of organic farming technologies.	2.41	VII	2.47	IV	2.44	V
Increase the number of drip/sprinkler irrigation facilities to cover a larger number of farm families.	2.43	V	2.43	VIII	2.43	VI

measures for adapting to climate change and receiving early alerts were with mean score of 2.48 (Rank II) and promote awareness and provide support for the adoption of organic farming technologies with mean score of 2.47 (Rank IV). With respect of overall farmers, provide subsidies or compensation for crops to offset cultivation costs due to weather aberrations was ranked first with mean score of 2.50, followed by incentives and support for increased use of green manure and raising awareness regarding appropriate technologies were with mean score of 2.48 (Rank II) and receiving early alerts about environmental changes was with mean score of 2.46 (Rank IV). Based on the extensive experience of farmers, several key suggestions have been identified to address the challenges posed by climate change. Government and development departments must consider these suggestions to meet farmer's needs and reduce vulnerability caused by climate change. The present study aligns with Deepa and Shiyani (2016) highlight the need for unique strategies in dryland areas like Kutch that consider their uncertain dynamics. Strategies such as rainwater harvesting, livestock development and techniques to enhance dryland agriculture can help overcome many constraints. Implementing policies to promote efficient irrigation systems is essential. Water management strategies should include deepening wells, properly utilizing water supply systems, constructing check-dams and focusing on integrated watershed management and rainwater harvesting. Strengthening insurance coverage (crop, livestock, etc.) and micro-financing facilities is also crucial. Investments in dryland agriculture should include addressing climate change. The results were also supported by the findings of Pooja *et al.* (2022) where various adaptation techniques like awarness about fertilizer management, crop diversification etc., lead to increase in livelihood and income of farmers.

Climate change and agriculture are globally interrelated, with climate change affecting agriculture through shifts in temperature, rainfall, climate extremes, pests, diseases, atmospheric carbon dioxide, ozone concentrations and sea levels. India is particularly vulnerable due to its large population dependent on agriculture. Ensuring food and nutritional security amidst climate change is crucial for India. Climate change poses a significant threat to millions of livelihoods in India, making timely and relevant information vital for farmers to adapt their practices. Providing weather trends and best management practices helps farmers make informed decisions about crop choices, sales and inputs. Crop diversification was also found to be essential not only for achieving higher yields and returns but also for maintaining soil health and providing other benefits (Siddique *et al.,* 2012). Understanding farmer's vulnerability and adaptation strategies is essential for developing effective measures to manage farms and implement agri-environmental policies. The findings revealed that nearly half (45.00%) of the farmers belonged to moderately vulnerable category followed by severe (31.67%) and least (25.84%), vulnerable level category. The chi-square test was used to find out the association between profile characteristics and overall vulnerability of farmers to climate change among farmers of Adilabad district. It was observed from the data that, the variables such as age, social participation, economic motivation and knowledge about climate smart technologies at 1 per cent level of significance with overall vulnerability of farmers. The other variables such as education, farming experience, family income, mass media exposure, innovativeness, extension participation, social participation, extension contact, cosmopoliteness, credit orientation, management orientation, risk orientation, scientific orientation at 5 per cent level of significance.

Bridging the gap in addressing the vulnerability of farmers to climate change requires a strategic and multifaceted approach. Conducting surveys and field studies can identify specific areas of vulnerability, such as water scarcity, pest outbreaks, soil degradation and crop failure. Customized extension strategies are essential, involving mass media campaigns, workshops and seminars to raise awareness about climate change and adaptive measures. Sharing success stories and organizing motivational sessions with experts can build confidence among farmers.

Collaboration with government agencies, NGOs and private organizations can provide resources like drought-resistant seeds, efficient irrigation systems, and climate-smart technologies at subsidized rates. Community resource centers can offer continuous support and information.

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