

International Journal of Agriculture Extension and Social Development

Volume 8; Issue 2; February 2025; Page No. 381-386

Received: 02-12-2024
Accepted: 08-01-2025

Indexed Journal
Peer Reviewed Journal

Challenges and constraints in farmer's adaptation to climate change: A sectoral analysis

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DOI: <https://www.doi.org/10.33545/26180723.2025.v8.i2f.1662>

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Abstract

This paper explores the constraints faced by farmers in the Banda, Hamirpur, and Mahoba districts of the Bundelkhand region of Uttar Pradesh, India, while adapting to climate variability. Two blocks from each district were selected, and two villages from each block were selected, totalling 6 blocks and 12 villages. Data was collected from 180 randomly selected farmers through a structured interview schedule. The region is highly vulnerable to climate change, primarily relying on rainfed agriculture, which amplifies socio-economic challenges. The study categorizes constraints into personal, institutional, technical, weather-related, crop-variety-related, labour-related, and economic barriers that hinder effective climate adaptation strategies. Among personal constraints, illiteracy (2.88 wms) and fragmented landholdings (1.89 wms) were identified as significant challenges, limiting access to climate-related information and impeding the adoption of adaptive measures such as soil conservation and diversified farming. Institutional constraints, including poor extension services (2.68 wms) and limited access to credit (1.80 wms), further increased the difficulties faced by farmers. Additionally, high input costs and distant agricultural supply centres hinder timely and efficient decision-making. Weather-related constraints, particularly unreliable weather forecasting (2.50 wms) and unpredictable monsoon (1.74 wms), significantly affect agricultural planning. Crop-related constraints such as non-availability of the insect-pest and disease-tolerant varieties (2.40 wms), high input costs (1.96 wms), restrict farmers' capacity to mitigate risks. The paper also highlights labour-related challenges, including high labour costs (2.22 wms) and financial limitations in hiring adequate manpower (2.52 wms) for adaptive agricultural practices. Non-farm income diversification is another crucial adaptation strategy, but low wages (2.52 wms), and poor skills (2.00 wms) restrict its effectiveness. Livestock farming also faces significant obstacles, with feed shortages (2.38 wms), susceptibility of high-yielding breeds (2.33 wms) to climate stress, and breeding issues being major concerns. Statistical analysis suggests that socio-demographic factors such as landholding size, herd size, milk production, and annual income have a strong correlation with the ability to overcome climate adaptation constraints. The findings emphasize the need for improved agricultural extension services, access to institutional credit, better weather forecasting systems, and increased availability of climate-resilient crops. Addressing these challenges is crucial to strengthening the resilience of farmers in the face of climate variability.

Keywords: Adaptation strategies, weighted mean score, constraints, climate variability, resilience

Introduction

Climate variability has emerged as a growing worry for agricultural communities globally, especially in areas where farming is the principal means of subsistence. The erratic nature of precipitation, increasing temperatures, and severe weather phenomena have profoundly affected agricultural output, livestock well-being, and general food security. Although numerous adaptation solutions have been formulated to address these difficulties, farmers frequently encounter certain constraints that hinder their capacity to implement climate-resilient practices efficiently. These restrictions may be socio-economic, institutional, technological, or environmental, resulting in intricate hurdles to adaptation. This study seeks to examine the obstacles encountered by farmers in adjusting to climatic unpredictability and the elements that impede the effective execution of adaptation techniques. The study describes primary obstacles including financial limits, insufficient access to climate-smart agricultural technologies, limited extension services, and policy deficiencies. Moreover, socio-cultural factors, such as reluctance to change and

conventional agricultural practices, significantly affect adaptation choices. Comprehending these obstacles is essential for formulating tailored interventions that can improve climate resilience at the community level. This study examines these problems, contributing to the broader discussion on climate adaptation by offering insights on enhancing policies and support systems for effective responses to climate variability. The research emphasizes the necessity of fortifying institutional frameworks, augmenting agricultural education initiatives, and enhancing access to financial and technical resources. The document is organized to initially examine pertinent literature on climate adaptation limitations, then presenting the research methods. The findings section delineates the primary obstacles mentioned by the respondents, subsequently facilitating a discourse on viable solutions and policy proposals. This study seeks to educate stakeholders, policymakers, and agricultural practitioners on methods to improve adaptive capacity and guarantee sustainable agricultural practices amid climate variability.

Methodology

The Analytic research design was used in the present study. The Banda, Hamirpur, and Mahoba districts were purposively selected as these districts have the most climatic variability in the Bundelkhand region of Uttar Pradesh. Two blocks were selected from each district. And from each block, two villages were selected. Thus, a total of 6 blocks and 12 villages were selected from all these three districts of the Bundelkhand region of Uttar Pradesh. From each selected village, 15 respondents were selected randomly. Thus, a total of 180 respondents were selected as a sample for the present study. Structured interview schedule administered to farmers to capture their challenges, and constraints. Quantitative data analysed using descriptive statistics and inferential statistics through SPSS software.

Results and Discussion

Farmers implement various adaptation measures promptly to address the changing climate in the research area. Throughout this process, farmers encounter multiple constraints affecting their selection of climate change adaptation options, which are classified into personal, institutional, and technological categories. Table (1) delineates the limitations influencing the selection of adaption strategies employed by the respondents in the research area. Illiteracy and the limited extent of fragmented landholdings emerged as the most significant personal constraints affecting the respondents' coping strategies in

response to climate change in the study area, ranked first and second with weighted mean scores of 2.88 and 1.89, respectively. Illiteracy obstructs respondents' access to knowledge from diverse sources regarding the mitigation of climate change risks. The limited educational attainment restricts access to climate change knowledge from diverse sources, and inadequate comprehension heightens these populations' susceptibility to climate risks. The limited size of fragmented landholdings hinders respondents from using diverse coping strategies such as soil and water conservation, varied farming, cultivation of drought-resistant cultivars, and usage of available weather information. The results of the current study align with those of Satishkumar *et al.* (2013) ^[14]. Furthermore, insufficient technical expertise about suitable adaptation tactics and a shortage of labour in the study were the third and fourth principal restrictions, with mean scores of 1.74 and 1.71, respectively. Liang *et al.* (2013) ^[9] discovered that farmers are more aware of local climate variability concerns. Nonetheless, their comprehension of the significance of adaptation to their livelihoods is constrained. They possess insufficient understanding of the appropriate contacts and sources for climate change adaptation information. The lack of labour to implement adaptation strategies for enhancing resistance to climatic variability is a significant barrier encountered by the respondents in the research area.

Table 1: Distribution of respondents according to personal constraints to choice of Climate Change Adaptation Strategies (n=180)

Sl. No.	Personal constraints to choice of climate change adaptation strategies	Most severe constraints		Severe constraints		Least severe constraint		Score	WMS	Rank
		f	%	f	%	f	%			
1.	Illiteracy	163	90.55	14	7.78	3	1.67	520	2.88	I
2.	Small-size fragmented landholding	5	2.77	151	83.89	24	13.34	341	1.89	II
3.	Scarcity of labour	15	8.34	104	57.77	61	33.89	314	1.74	III
4.	Inadequate technical know-how on appropriate adaptation strategies	9	5.00	110	61.12	61	33.88	308	1.71	IV

Institutional constraints to choice of climate change adaptation strategies

Institutional restrictions (Table 2) presented hurdles to responders in executing adaptive capability to climatic variability. In the rainfed region, a significant majority of respondents (72.77%) reported inadequate access to information from state government extension services and informal institutions such as private input traders and non-profit organizations focused on climate risk management, with a weighted mean score of 2.68, ranking first. The extension services in India have extensive reach to the populace, although encountering several challenges in timely access to the agricultural community, particularly in rainfed areas. Institutional credit is a crucial feature that enables farmers to cultivate land and use adaptive measures to mitigate the consequences of climate change, especially in rainfed areas. This is the sole method to obtain credit with the minimal interest rates relative to other disorganized lending industries in India. In the research area, 68.33% of

farmers indicated that the lack of institutional financing was a significant limitation to implementing adaptation measures, with a weighted mean score of 1.80, ranking it second. Farmers indicated that if such facilities were made accessible during or after the cropping season, they would be ineffective, as soil and water conservation measures and other agricultural strategies must be implemented before to the cropping season. The acquisition of necessary resources for land cultivation and the implementation of adaptive measures to climate variability mostly hinges on credit availability.

The results are in conformity with the study of Deressa *et al.* (2008) ^[2], Onyeneke and Madukwe (2010) ^[10], Satishkumar *et al.* (2013) ^[14], and Tambo and Abdoulaye (2013) ^[15]. High cost of fertilizer and other inputs (52.77%), and high distance of agricultural input supply shops (52.23%) were the other institutional constraints reported by the respondents with a weightage mean score of 1.79 and 1.77 and ranked 3rd and 4th, respectively.

Table 2: Distribution of respondents according to Institutional constraints to choice of Climate Change Adaptation Strategies (n=180)

Sl. No.	Institutional constraints to choice of climate change adaptation strategies	Most severe constraints		Severe constraints		Least severe constraint		Score	WMS	Rank
		f	%	f	%	f	%			
1.	Poor extension service on climate risk management	131	72.77	42	23.34	7	8.89	484	2.68	I
2.	Non-availability of institutional credit	11	6.11	123	68.33	46	25.56	325	1.80	II
3.	High cost of fertilizer and other inputs	20	11.11	103	57.22	57	31.67	323	1.79	III
4.	High distance of agricultural input supply shops	23	12.77	94	52.23	63	35.00	320	1.77	IV

Weather related constraints to choice of climate change adaptation strategies

Farmers predominantly depend on their indigenous knowledge for weather information due to its reliability, which has been cultivated over centuries of experience “(Satishkumar *et al.* 2013) ^[14]”. Approximately 56.11% of respondents (Table 3) indicated that insufficient access to information regarding weather forecasting technology and its poor reliability constituted the most significant barriers to implementing adaptive measures for climate change, with a weighted mean score of 2.50, ranking it first. This was followed by the unpredictable monsoon, regarded as the second most critical issue, with a weighted mean score of 1.74. The results align with previous research by Shankar,

which identified the lack of location-specific climate forecasts, inadequate reliability and accuracy of these forecasts, insufficient extension services regarding climate predictions, media forecasts that do not meet operational requirements, and low confidence in climate predictions as significant issues reported by farmers.

The other constraints as reported by the respondents were heavy rainfall and hailstorm in a short period and insufficient funds from Govt. for climate information like early warning systems, automatic weather stations etc. With a weightage mean score of 1.68 and 1.60 and ranked 3rd and 4th, respectively. This corroborates the findings of Fagariba *et al.* (2018) ^[3].

Table 3: Distribution of respondents according to weather-related constraints to choice of Climate Change Adaptation Strategies (n=180)

Sl. No.	Weather-related constraints to choice of climate change adaptation strategies	Most severe constraints		Severe constraints		Least severe constraint		Score	WMS	Rank
		f	%	f	%	f	%			
1.	“Inadequate access to climate information and poor reliability”	101	56.11	68	37.77	11	6.12	450	2.50	I
2.	Unpredictable monsoon	6	2.33	122	67.78	52	28.89	314	1.74	II
3.	“Insufficient funds from Govt. for climate information like early warning systems, Automatic weather stations, etc.”	11	6.11	86	47.77	83	46.12	288	1.60	IV
4.	Heavy rainfall and hailstorms in a short span of time	19	10.55	86	47.78	75	41.67	304	1.68	III

Crop varieties related constraints to choice of climate change adaptation strategies

It was further revealed (Table 4) that non-availability of the insect-pest and disease-tolerant varieties, high cost of the varieties, non-availability of late and early sown varieties, and non-availability of drought, salinity, water-logging/flooding/submergence tolerant varieties were perceived as the major constraints with a weightage mean

score of 2.40, 1.96, 1.76, 1.62 and ranked 1st, 2nd, 3rd and 4th respectively. The high cost, coupled with the unavailability of improved technologies of crop varieties that are resistant to insect pests and diseases, climatic stress, and variability militate against the choice of crop varieties as a coping strategy to combat the effect of climate change in the study area. The study conducted by Otitoju and Enete (2016) ^[11] is in line with the present study.

Table 4: Distribution of respondents according to crop varieties related constraints to choice of Climate Change Adaptation Strategies (n=180)

Sl. No.	Crop varieties related constraints to choice of climate change adaptation strategies	Most severe constraints		Severe constraints		Least severe constraint		Score	WMS	Rank
		f	%	f	%	f	%			
1.	Non-availability of the insect-pest and disease-tolerant varieties	87	48.33	78	43.33	15	8.34	432	2.40	I
2.	High cost of the varieties	33	18.33	107	59.44	40	22.23	353	1.96	II
3.	Non-availability of late and early sown varieties	12	6.66	88	48.89	80	44.45	292	1.62	IV
4.	Non-availability of drought, Salinity, water logging/flooding/submergence tolerant varieties	28	15.55	81	45.00	71	39.45	317	1.76	III

Change in planting and harvesting time of crop related constraints to choice of climate change adaptation strategies

Further, (Table 5) revealed that high input costs due to changes in planting dates followed by in-accurate agro-metrological information to decide the date of harvesting and time of dissemination of agro-meteorological information were the top most constraints as reported by the respondent with a weightage mean score of “2.38, 2.33, 1.84 and ranked 1st, 2nd and 3rd,” respectively. Other constraints faced by respondents in the study area due to changes in

planting and harvesting time of crops were poor storage and processing facilities, difficulties in shifting to different cropping patterns in a short period of time, poor mechanization and other needed machinery, decrease in crop yield, inadequate access to seeds as per change in planting schedule with a weightage mean score of “1.82, 1.77, 1.73, 1.70, 1.61 and ranked 4th, 5th, 6th, 7th and 8th” respectively. Changes in the planting and harvesting time of crops restrict the respondents from take appropriate decisions on time against the choice of climate change adaptation strategies.

Table 5: Distribution of respondents according to change in planting and harvesting time of crops related constraints to choice of Climate Change Adaptation Strategies (n=180)

Sl. No.	Change in planting and harvesting time of crops related constraints to choice of climate change adaptation strategies	Most severe constraints		Severe constraints		Least severe constraint		Score	WMS	Rank
		f	%	f	%	f	%			
1.	High input cost due to change in planting dates	92	51.12	66	36.66	22	12.22	430	2.38	I
2.	"Difficulties in shifting to different cropping patterns in a short period of time"	11	6.11	116	64.46	53	29.44	318	1.77	V
3.	Decrease in crop yield	22	12.22	82	45.55	76	42.23	306	1.70	VII
4.	Inadequate access to seeds as per change in planting schedule	16	8.88	79	43.89	85	47.23	291	1.61	VIII
5.	Inaccurate agro-metrological information to decide the date of harvesting	77	42.77	86	47.78	17	9.45	420	2.33	II
6.	Time of dissemination of agro-meteorological information	19	10.55	114	63.33	47	26.12	332	1.84	III
7.	Poor storage and processing facilities	31	17.23	86	47.77	63	35.00	328	1.82	IV
8.	Poor mechanization and other needed machinery	23	12.78	87	48.34	70	38.88	313	1.73	VI

Labour cost and availability related constraints to choice of climate change adaptation strategies

The results revealed that (Table 6) inadequate finance and credit facilities to meet the labour requirement were the most important constraints faced by respondents in the choice of climate change adaptation strategies followed by the high cost of labour in applying the mulching material and poor family human assets with a weightage mean score

of 2.52, 2.22, 1.68 and ranked 1st, 2nd, and 3rd, respectively. The other constraints which hinder the coping capacity of respondents to choice of climate change adaptation strategies were the low durability of the mulching materials, use of labour to protect the grazing of the crop field, harsh working conditions for labour, low availability and productivity of labour with a weightage mean score of 1.66, 1.50, 1.48, 1.36 and ranked 4th, 5th, 6th, and 7th, respectively.

Table 6: Distribution of respondents according to Labour cost and availability related constraints to choice of Climate Change Adaptation Strategies (n=180)

Sl. No.	Labour cost and availability related constraints choice of climate change adaptation strategies	Most severe constraints		Severe constraints		Least severe constraint		Score	WMS	Rank
		f	%	f	%	f	%			
1.	Inadequate finance and credit facilities to meet the labour requirement	111	61.67	53	29.45	16	8.88	455	2.52	I
2.	Poor family human assets	15	8.33	92	51.11	73	40.56	302	1.68	III
3.	Harsh working conditions for labour	9	5.00	69	38.33	102	56.67	267	1.48	VI
4.	Low availability and productivity of labour	3	1.66	59	32.78	118	65.56	245	1.36	VII
5.	Use of labour to protect the grazing of the crop field	9	5.00	72	40.00	99	60.00	270	1.50	V
6.	High cost of labour in applying the mulching material	67	37.22	86	47.78	27	15.00	400	2.22	II
7.	Low durability of the mulching materials	9	5.00	102	56.66	69	38.34	300	1.66	IV

Mixed cropping, crop rotation and use of inter-cropping related constraints to choice of climate change adaptation strategies

The results (Table 7) revealed that complications of crop management and harvesting practices followed by varying life cycles of the crop grown, vulnerability to insect-pest and diseases of crops were the most significant and important constraints which influence the respondent's choice of climate change adaptation strategies with a weightage mean score of 2.25, 2.14, 2.13 and ranked 1st, 2nd, 3rd, respectively. The other constraints were depletion of the

soil nutrient, problem of separating seed crop yield, inadequate farm input supplies, crops competing for nutrients due to mixed or intercropping, poor extension delivery services on agronomic practices, non-availability of labour, depletion of the groundwater table due to increased cropping intensity with a weightage mean score of "1.96, 1.85, 1.75, 1.72, 1.62, 1.52, 1.45 and ranked 4th, 5th, 6th, 7th, 8th, 9th and 10th", respectively. The studies conducted by "Farauta *et al.* (2011) [4] and Chukwudumebi and Agwu (2013) [1]" also found that a lack of financial resources was the major constraint in adapting to changing climate.

Table 7: Distribution of respondents according to Mixed cropping, Crop rotation, and Use of inter-cropping related constraints to choice of Climate Change Adaptation Strategies (n=180)

Sl. No.	Mixed cropping, crop rotation, and use of inter-cropping related constraints to choice of climate change adaptation strategies	Most severe constraints		Severe constraints		Least severe constraint		Score	WMS	Rank
		f	%	f	%	f	%			
1.	Vulnerability to insect pest and diseases of crops	63	35.00	78	43.33	39	21.67	384	2.13	III
2.	Crops compete for nutrient due to mixed or intercropping	13	7.22	104	57.78	63	35.00	310	1.72	VII
3.	Depletion of the soil nutrient	83	46.11	7	3.89	90	50.00	353	1.96	IV
4.	Poor extension delivery services on agronomic practices	27	15	59	32.77	94	52.23	293	1.62	VIII
5.	Varying life cycle of the crop grown	61	33.88	84	46.67	35	19.45	386	2.14	II
6.	Inadequate farm input supplies	25	13.88	86	47.78	69	38.34	316	1.75	VI
7.	Depletion of the groundwater table due to increased cropping intensity	5	2.77	71	39.45	104	57.78	261	1.45	X
8.	Non-availability of labour	12	6.66	70	38.89	98	54.45	274	1.52	IX
9.	Complications of crop management and harvesting practices	70	38.88	85	47.23	25	13.89	405	2.25	I
10.	The problem of separating seed crop yield	18	10.00	118	65.55	44	24.45	324	1.85	V

Non-farm income diversification related constraints to choice of climate change adaptation strategies

The results revealed (Table 8) that low wages and poor working conditions followed by poor skills to adjust in non-farm income diversification activities and inadequate training were the most important constraints as perceived by the respondents to cope with the choice of climate change

adaptation strategies with a weightage mean score of 2.52, 2, 1.90 and ranked 1st, 2nd and 3rd, respectively. Other constraints as reported by the respondents were looking for an extra job opportunity but being unable to find it and government policies due to taxes with a weightage mean score of 1.87, 1.79 and ranked 4th and 5th, respectively.

Table 8: Distribution of respondents according to non-farm income diversification related constraints to choice of Climate Change Adaptation Strategies (n=180)

Sl. No	Non-farm income diversification related constraints to choice of climate change adaptation strategies	Most severe constraints		Severe constraints		Least severe constraint		Score	WMS	Rank
		f	%	f	%	f	%			
1.	Low wages and poor conditions of work	111	61.67	53	29.45	16	8.88	455	2.52	I
2.	Poor skills to adjust in non-farm income diversification activities	39	21.66	102	56.67	39	21.67	360	2.00	II
3.	Looking for an extra job opportunity but unable to find it	30	16.66	97	53.89	53	29.45	337	1.87	IV
4.	Government policies due to taxes	17	9.44	109	60.56	54	30.00	323	1.79	V
5.	Inadequate training	30	16.66	102	56.67	48	26.67	342	1.90	III

Livestock farming related constraints to choice of climate change adaptation strategies

An in-depth examination of (Table 9) indicated that the primary constraint was the Shortage of feed and fodder, with a weighted mean score of 2.38, followed by the susceptibility of high-yielding breeds to climatic stress/heat stress and repeat breeding, with weighted mean scores of 2.33 and 2.30, ranked 1st, 2nd, and 3rd, respectively. Respondents regarded it as a primary restraint, as it directly impacted animal productivity and their living security.

Repeated breeding diminishes the productive lifespan of animals and reduces farmers' income due to escalating health management costs associated with treating these animals. Additional constraints identified by respondents in the study area included the lack of quality animal breeds, anoestrous issues in animals, and the year-round unavailability of improved fodder seeds, which were ranked as the 4th, 5th, and 6th constraints with mean weight scores of 2.25, 2.18, and 2.15, respectively. The research aligns with the findings of Kant *et al.* (2015) [7, 8].

Table 9: Distribution of respondents according to livestock farming-related constraints to choice of Climate Change Adaptation Strategies (n=180)

Sl. No	Livestock farming related constraints to choice of climate change adaptation strategies	Most severe constraints		Severe constraints		Least severe constraint		Score	WMS	Rank
		f	%	f	%	f	%			
1.	Shortage of feed and fodder	100	55.55	50	27.78	30	16.67	430	2.38	I
2.	Susceptibility of high-yielding breed to climatic stress/heat stress	90	50.00	61	33.89	29	16.11	421	2.33	II
3.	Non-availability of improved fodder seeds round the year	63	35.00	82	45.56	35	19.44	388	2.15	VI
4.	Non-availability of good animal breed	81	45.00	63	35.00	36	20.00	405	2.25	IV
5.	The anoestrous problem in animals	74	41.11	66	36.67	40	22.22	394	2.18	V
6.	Repeat breeding	83	46.11	68	37.78	29	16.11	414	2.30	III

Relationship between socio-demographic profile characteristics and constraints to farmers' choice of climate change adaptation strategies

The findings indicated that (Table 10) "There is no significant correlation between certain socio-demographic characteristics of the respondent and the limitations to the selection of adaptation strategies employed by the respondent." The respondent's landholding, herd size, milk production, and annual income were the sole socio-demographic characteristics that exhibited a strong positive correlation with the constraints to selecting climate change adaptation strategies in the study area. This indicates that constraints to selecting climate change adaptation strategies escalate with larger landholdings, herd sizes, milk production, and annual incomes, suggesting that respondents with more favorable socio-demographic characteristics encountered fewer constraints in choosing climate change adaptation strategies compared to those with less advantageous profiles in the study area.

Table 10: PPMC Correlation between socio-demographic profile characteristics and Constraints to Farmers' choice of Climate Change Adaptation Strategies (n=180)

Sl. No.	Variable	R-value	P-value
1.	Age	-0.028	0.729
2.	Education	-0.047	0.215
3.	Family type	0.122	0.128
4.	Family size	-0.074	0.345
5.	Occupation	-0.037	0.201
6.	Landholding	0.170*	0.034
7.	Herd size	0.189*	0.039
8.	Milk Production	0.113*	0.021
9.	Annual Income	0.121*	0.032
10.	Experience	0.134	0.116

*Correlation is significant at the 0.05 level (2-tailed)

Conclusion

This study examined the limitations faced by farmers in adjusting to climate variability practices, emphasizing the various obstacles hindering effective adaptation. The

findings indicate that financial constraints serve as a principal barrier, limiting access to vital resources, modern technologies, and climate-resilient agricultural inputs. Moreover, a lack of information and awareness regarding climate-smart practices impedes adaptation, compounded by inadequate training programs and extension services. The research also defines institutional obstacles, including insufficient support from governmental bodies, bureaucratic impediments, and suboptimal policy execution, which diminish farmers' ability to apply sustainable practices. Moreover, environmental difficulties such as inconsistent rainfall patterns, extended droughts, and soil degradation hinder the adaption process. Social considerations, including resistance to altering conventional agricultural practices and insufficient community-level collaboration, present considerable challenges. Notwithstanding these limitations, the study emphasizes the significance of focused actions to alleviate these limits. Enhancing financial support systems via subsidies, low-interest loans, and improved insurance programs can bolster resilience. Enhancing information accessibility through workshops, peer-to-peer learning among farmers, and digital platforms can close knowledge gaps. Institutional reforms, encompassing enhanced stakeholder coordination, streamlined policies, and participatory decision-making, are essential for effective implementation. A comprehensive approach that amalgamates financial, educational, institutional, and environmental solutions is crucial for improving adaptation techniques. Cooperative initiatives among farmers, policymakers, academics, and extension agencies can cultivate enduring resilience, guaranteeing sustainable livelihoods and food security amidst climate variability.

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