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Farmers' responses towards adaptation strategies regarding climate change in Bundelkhand region of Uttar Pradesh

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Abstract

Climate change has become a significant threat to rural life and agricultural productivity, especially in areas with rainfed agriculture, water scarcity, and unpredictable weather. In the Uttar Pradesh region of Bundelkhand, the current study was conducted to evaluate farmers' reactions to the implementation of climate change adaptation techniques. The study had 360 farmers who were chosen from particular villages in the area. Frequency, percentage, mean, standard deviation, and correlation analysis were among the statistical methods used to analyze the data, which were gathered utilizing a structured interview schedule. The results showed that farmers' responses to climate change adaptation were primarily moderate. In response to climate unpredictability, farmers used a variety of farm-level strategies designed to lower production risks and increase resilience. With correlation coefficients of -0.57** and -0.15**, respectively, the correlation analysis showed that age and farming experience had substantial negative correlations with farmers' responses. On the other hand, farmers' responses to climate change were positively and significantly correlated with education ($r = 0.58^{**}$), land holding size ($r = 0.44^{**}$), social participation ($r = 0.29^{**}$), total income ($r = 0.52^{**}$), economic motivation ($r = 0.18^{**}$), risk orientation ($r = 0.50^{**}$), innovativeness ($r = 0.53^{**}$), exposure to the media ($r = 0.40^{**}$), and extension contact ($r = 0.36^{**}$). The variables that showed the strongest correlations with farmers' replies were education, innovativeness, total income, and risk orientation. The results show that farmers' responses to climate-related issues are significantly influenced by their socioeconomic, psychological, and communication traits. Farmers may adopt more successful and long-lasting adaptation techniques if agricultural extension services are strengthened, access to climate information is improved, farmer-oriented training programs are promoted, and institutional and financial support is increased. Policymakers, extension organizations, and other stakeholders can use the study's helpful findings to create location-specific initiatives that will improve Bundelkhand's farming communities' climate resilience.

Keywords: Climate change, farmers' responses, adaptation strategies, climate resilience, Bundelkhand region

Introduction

Indian agriculture is highly sensitive to climatic variability because agricultural production is strongly influenced by rainfall, temperature and other climatic conditions. Since rainfall is essential to around half of India's agricultural land, farmers are especially exposed to erratic monsoon patterns, droughts, floods, and other weather-related disasters. Farmers have therefore implemented a variety of adaptation strategies to reduce climate-related risks and preserve agricultural output and livelihood security (Mishra *et al.*, 2024) ^[1].

Climate change has emerged as a major concern to agricultural production and rural lifestyles around the world. Temperature changes, rainfall patterns, extreme weather events, droughts, floods, and other climatic pressures all have a direct impact on agricultural yield, livestock production, water availability, and farm revenue. The effects are particularly severe for small and marginal farmers, who rely significantly on natural resources and have limited financial

and technological capabilities to address climatic hazards. As a result, boosting farming communities' adaptive capacity has emerged as a critical component of long-term agricultural success.

Bundelkhand is especially vulnerable to climatic variability due to its semi-arid climate, recurring droughts, erratic rainfall, dwindling groundwater supplies, and reliance on rainfed agriculture. Previous micro-level research in Bundelkhand discovered that farmers have experienced changes in rainfall and temperature, and that both education and farmers' views of climate change were linked to decisions to implement specific adaption techniques. Another study of wheat farmers in Bundelkhand found that farmers were modifying their farming techniques and combining traditional knowledge with government extension services to promote climate resilience. (Singh, S. 2020) ^[8].

Methodology

The study was conducted in the Bundelkhand region of Uttar

Pradesh. Out of the seven districts of the region, two districts, namely Jhansi and Chitrakoot, were purposively selected considering the relevance of the study objectives and climatic conditions of the area. In the second stage, three blocks from each selected district were randomly selected using the simple random sampling technique through the chit method. Thus, a total of six (6) blocks were selected for the study. In the third stage, a list of villages under the selected blocks was prepared with the help of secondary sources, and three (3) villages from each selected block were randomly selected. Thus, a total of eighteen (18) villages were selected. In the final stage, twenty (20) farmers from each selected village were randomly selected, resulting in a total sample of 360 respondents. For Farmers' Responses towards Adoption of Climate Change Adaptation Strategies relevant statements covering perceived changes in climatic conditions and their effects on agriculture were included in the interview schedule. Respondents were asked to indicate their level of agreement with each statement using an appropriate rating scale. The scores obtained were used to determine the overall

level of farmers' perception towards climate change. The collected data were coded, tabulated and analysed using the Statistical Package for the Social Sciences (SPSS). Frequency, percentage, arithmetic mean and standard deviation were used for descriptive analysis. The coefficient of correlation was employed to determine the relationship between selected independent variables and farmers' perception towards climate change, while the significance of the correlation coefficient was tested statistically. Multiple regression analysis was used to determine the contribution of selected independent variables in explaining the variation in Farmers' Responses. Where required, the significance of differences between groups. These statistical techniques were used to obtain meaningful and scientifically interpretable results regarding Farmers' Responses towards Adoption of Climate Change Adaptation Strategies in Bundelkhand Region of Uttar Pradesh.

Results and Discussion

Table 1: Responses of farmers to the adopting the climate change adaptation strategies (n=360)

S. No.	Statement	SA	A	UD	D	SDA
1.	I use organic manures instead of chemical fertilizers	214 (59.44%)	68 (18.89%)	18 (5.00%)	22 (6.11%)	38 (10.56%)
2.	I use sufficient recommended dose of insecticides for protection of crop from insects and pests.	291 (80.83%)	21 (5.83%)	10 (2.78%)	20 (5.56%)	18 (5.00%)
3.	I use crop varieties that are well acclimated and resistant to area specific insect, pest and diseases.	289 (80.28%)	26 (7.22%)	10 (2.78%)	18 (5.00%)	17 (4.72%)
4.	I assure proper drainage of wetland for crop cultivation	248 (68.89%)	36 (10.00%)	8 (2.22%)	28 (7.78%)	40 (11.11%)
5.	I use cover crop to protect soil from erosion and conserve soil moisture.	241 (66.94%)	61 (16.94%)	29 (8.06%)	12 (3.33%)	17 (4.72%)
6.	I have adopted drip irrigation in order to use available water most efficiently.	289 (80.28%)	19 (5.28%)	13 (3.61%)	15 (4.17%)	24 (6.67%)
7.	I go for green manuring to enrich the soil with nutrients and add moisture to it.	272 (75.56%)	32 (8.89%)	8 (2.22%)	18 (5.00%)	30 (8.33%)
8.	I use proper crop rotation to ensure nutrient availability in the soil	305 (84.72%)	29 (8.06%)	6 (1.67%)	8 (2.22%)	12 (3.33%)
9.	I am having proper provisions for water harvesting in order to cope with the unfavourable climatic condition in future, if any.	181 (50.28%)	113 (31.39%)	40 (11.11%)	12 (3.33%)	14 (3.89%)
10.	I go for filling up or replanting to cope with climate change.	307 (85.28%)	19 (5.28%)	5 (1.39%)	8 (2.22%)	21 (5.83%)
11.	I practice fallowing of land for efficient agronomic practices.	274 (76.11%)	27 (7.50%)	12 (3.33%)	28 (7.78%)	19 (5.28%)
12.	I have adopted crop diversification better suited to changing climatic conditions	286 (79.44%)	27 (7.50%)	9 (2.50%)	21 (5.83%)	17 (4.72%)
13.	I use modern machineries and technologies to tackle the changing climatic conditions.	271 (75.28%)	32 (8.89%)	10 (2.78%)	34 (9.44%)	13 (3.61%)
14.	In order to be out of the danger of crop failure, I have started having crop insurance.	200 (55.56%)	86 (23.89%)	29 (8.06%)	25 (6.94%)	20 (5.56%)
15.	I have started practicing agro-forestry to tackle the changing climatic conditions.	315 (87.50%)	10 (2.78%)	11 (3.06%)	8 (2.22%)	16 (4.44%)
16.	I am practicing proper application of recommended dose of fertilizers in order to avoid any insect pest infestation due to over fertilization.	315 (87.50%)	18 (5.00%)	6 (1.67%)	8 (2.22%)	13 (3.61%)
17.	I dump the agricultural wastes at proper time and proper place for the purpose of avoiding any seasonal occurrence of disease, supplemented by changing climatic conditions.	303 (84.17%)	28 (7.78%)	12 (3.33%)	8 (2.22%)	9 (2.50%)
18.	Now, I have to invest more to secure my production.	293 (81.39%)	28 (7.78%)	13 (3.61%)	13 (3.61%)	13 (3.61%)
19.	I have given up cultivating those crops demanding more cost of production.	204 (56.67%)	68 (18.89%)	58 (16.11%)	5 (1.39%)	25 (6.94%)
20.	Now, I am taking alternate enterprise like horticultural crop with main crop in order to be in the safe zone of economic calamities occurring due to changing climatic conditions.	280 (77.78%)	19 (5.28%)	31 (8.61%)	17 (4.72%)	13 (3.61%)

21.	I have also started incorporating other income generating activities like fisheries, cottage industries, etc. along with the main agriculture for ensuring safe economic return.	283 (78.71%)	27 (7.50%)	13 (3.61%)	17 (4.72%)	20 (5.56%)
22.	I have started processing of crops to minimise post harvest losses	249 (69.17%)	31 (8.61%)	33 (9.17%)	14 (3.89%)	33 (9.17%)
23.	I use wind breaks and shelter belts to cope up with unfavourable winds.	265 (73.61%)	23 (6.39%)	28 (7.78%)	18 (5.00%)	26 (7.22%)
24.	I also use crop sheds or grow the crops in greenhouse for ensured production	176 (48.89%)	100 (27.78%)	56 (15.56%)	10 (2.28%)	18 (5.00%)
25.	I have started constructing and rejuvenating farm ponds for ensured water availability.	255 (70.83%)	27 (7.50%)	13 (3.61%)	27 (7.50%)	38 (10.56%)

Note: Data in parentheses percentage

The table 1 findings indicate that 59.44% of the respondents strongly agreed and 18.89% agreed that they use organic manures as an alternative to chemical fertilizers. Meanwhile, 5.00% remained undecided, whereas 6.11% disagreed and 10.56% strongly disagreed. The results reveal that 80.83% of the respondents strongly agreed and 5.83% agreed that they use the recommended quantity of insecticides for protecting crops from insects and pests. Only 2.78% remained undecided, while 5.56% disagreed and 5.00% strongly disagreed. The findings show that 80.28% of respondents strongly agreed and 7.22% agreed that they use crop varieties adapted to local conditions and resistant to area-specific insects, pests, and diseases. A small proportion (2.78%) remained undecided, while 5.00% disagreed and 4.72% strongly disagreed. The data indicate that 68.89% of the respondents strongly agreed and 10.00% agreed that they ensure proper drainage of wetlands for crop cultivation. Meanwhile, 2.22% remained undecided, whereas 7.78% disagreed and 11.11% strongly disagreed. The results demonstrate that 66.94% of respondents strongly agreed and 16.94% agreed that they use cover crops for soil conservation and moisture retention. A further 8.06% remained undecided, while 3.33% disagreed and 4.72% strongly disagreed. The findings reveal that 80.28% of respondents strongly agreed and 5.28% agreed that they have adopted drip irrigation for efficient water utilization. Only 3.61% remained undecided, whereas 4.17% disagreed and 6.67% strongly disagreed. The results indicate that 75.56% of respondents strongly agreed and 8.89% agreed that they practice green manuring to improve soil nutrient status and moisture content. Meanwhile, 2.22% remained undecided, while 5.00% disagreed and 8.33% strongly disagreed. The findings show that 84.72% of the respondents strongly agreed and 8.06% agreed that they practice crop rotation to maintain soil nutrient availability. Only 1.67% remained undecided, whereas 2.22% disagreed and 3.33% strongly disagreed. The results reveal that 50.28% of respondents strongly agreed and 31.39% agreed that they have provisions for water harvesting to cope with future climatic uncertainties. Meanwhile, 11.11% remained undecided, while 3.33% disagreed and 3.89% strongly disagreed. The findings indicate that 85.28% of respondents strongly agreed and 8.06% agreed that they undertake filling up or replanting as a response to climate change. Only 1.39% remained undecided, while 2.22% disagreed and 5.83% strongly disagreed. The results show that 76.11% of respondents strongly agreed and 7.50% agreed that they practice land fallowing. A further 3.33% remained undecided, whereas 7.78% disagreed and 5.28% strongly disagreed. The findings reveal that 79.44% of respondents strongly agreed and 7.50% agreed that they have

adopted crop diversification suited to changing climatic conditions. Only 2.50% remained undecided, while 5.83% disagreed and 4.72% strongly disagreed. The results indicate that 75.28% of respondents strongly agreed and 8.89% agreed that they use modern machinery and technologies to address changing climatic conditions. Meanwhile, 2.78% remained undecided, whereas 9.44% disagreed and 3.61% strongly disagreed. The findings show that 55.56% of respondents strongly agreed and 23.89% agreed that they have adopted crop insurance to protect themselves against crop failure. A further 8.06% remained undecided, while 6.94% disagreed and 5.56% strongly disagreed. The results reveal that 87.50% of the respondents strongly agreed and 2.78% agreed that they have adopted agroforestry practices to address changing climatic conditions. Only 3.06% remained undecided, whereas 2.22% disagreed and 4.44% strongly disagreed. The findings indicate that 87.50% of respondents strongly agreed and 5.00% agreed that they apply fertilizers according to recommended doses. Only 1.67% remained undecided, while 2.22% disagreed and 3.61% strongly disagreed. The results show that 84.17% of respondents strongly agreed and 7.78% agreed that they dispose of agricultural waste appropriately to reduce the occurrence of seasonal diseases. Meanwhile, 3.33% remained undecided, whereas 2.22% disagreed and 2.50% strongly disagreed. The findings reveal that 81.39% of respondents strongly agreed and 7.78% agreed that they are required to make greater investments to safeguard agricultural production. Only 3.61% remained undecided, while 3.61% disagreed and 3.61% strongly disagreed. The results indicate that 56.67% of respondents strongly agreed with the statement. However, the percentages presented for agreement and disagreement in the table appear inconsistent with the corresponding frequencies and may require verification before final interpretation. The findings show that 77.78% of respondents strongly agreed and 5.28% agreed that they undertake alternative enterprises, such as horticultural crops, alongside their main crops. Meanwhile, 8.61% remained undecided, whereas 4.72% disagreed and 3.61% strongly disagreed. The results reveal that 78.71% of respondents strongly agreed and 7.50% agreed that they have adopted additional income-generating activities alongside agriculture. A further 3.61% remained undecided, while 4.72% disagreed and 5.56% strongly disagreed. The findings indicate that 69.17% of respondents strongly agreed and 8.61% agreed that they have adopted crop processing to minimize post-harvest losses. Meanwhile, 9.17% remained undecided, whereas 3.89% disagreed and 9.17% strongly disagreed. The findings show that 73.61% of respondents strongly agreed and 6.39% agreed that they use windbreaks

and shelterbelts to protect agricultural production from damaging winds. A further 7.78% remained undecided, while 5.00% disagreed and 7.22% strongly disagreed. The results reveal that 48.89% of respondents strongly agreed and 27.78% agreed that they use crop sheds or greenhouse cultivation to ensure production. Meanwhile, 15.56% remained undecided, whereas 2.28% disagreed and 5.00% strongly disagreed. The findings indicate that 70.83% of respondents strongly agreed and 7.50% agreed that they have undertaken the construction and rejuvenation of farm ponds to ensure water availability. A further 3.61% remained undecided, while 7.50% disagreed and 10.56% strongly disagreed.

Table 2: Distribution of respondents according to their Responses of farmers to the adopted the climate change adaptation strategies (n=360)

S. No.	Categories of Respondents	Frequency	Percentage
1.	Low	53	14.72
2.	Medium	248	68.88
3.	High	59	16.38
	Total	360	100

Mean = 110.35, SD = 6.87

The table no 2 distribution of respondents according to their responses to the adoption of climate change adaptation strategies indicates that the majority of respondents (68.88%) belonged to the medium category. This was followed by 16.38% of respondents who were classified under the high category, while 14.72% belonged to the low category.

Table 3: Relationship between independent variables and Responses of the farming community (n=360)

S. No.	Independent Variable	Correlation Coefficient ('r' value)
		Responses
1.	Age	-0.57**
2.	Education	0.58**
3.	Family Size	0.11*
4.	Farming Experience	-0.15**
5.	Size of Land holding	0.44**
6.	Social Participation	0.29**
7.	Total Income	0.52**
8.	Economic Motivation	0.18**
9.	Risk Orientation	0.50**
10.	Innovativeness	0.53**
11.	Mass Media Exposure	0.40**
12.	Extension contacts	0.36**

Note: * Significant at 0.05 level of significance **significant at 0.01 level of significance

The correlation analysis presented in table no. 3 reveals that several selected independent variables had significant relationships with farmers' responses towards climate change. Age showed a highly significant negative correlation with farmers' responses ($r = -0.57^{**}$), indicating that younger farmers demonstrated more positive and proactive responses towards climate change than older farmers. Education exhibited a positive and highly significant correlation with farmers' responses ($r = 0.58^{**}$), indicating that farmers with higher educational levels were more responsive to climate-related changes. Family size showed a positive but relatively weak significant relationship with farmers' responses ($r = 0.11^{*}$), suggesting that family size had a limited influence on farmers' responses. Farming experience had a significant

negative correlation with farmers' responses ($r = -0.15^{**}$), indicating that farmers with greater farming experience tended to show comparatively lower responses towards climate change. Size of land holding showed a positive and highly significant relationship with farmers' responses ($r = 0.44^{**}$), indicating that farmers possessing larger landholdings were more responsive towards climate-related challenges. Social participation was positively and highly significantly correlated with farmers' responses ($r = 0.29^{**}$), suggesting that farmers with greater involvement in social organizations and community activities demonstrated better responses towards climate change. Total income also showed a positive and highly significant relationship with farmers' responses ($r = 0.52^{**}$), indicating that economically better-off farmers were more capable of responding to climate-related risks.

Economic motivation exhibited a positive and highly significant correlation with farmers' responses ($r = 0.18^{**}$), indicating that farmers with greater economic motivation were comparatively more responsive towards climate change. Risk orientation showed a positive and highly significant relationship with farmers' responses ($r = 0.50^{**}$), suggesting that farmers with greater risk-taking orientation were more proactive in responding to climatic challenges. Innovativeness had a positive and highly significant correlation with farmers' responses ($r = 0.53^{**}$), indicating that innovative farmers were more likely to respond positively to changing climatic conditions. Mass media exposure also exhibited a positive and highly significant relationship with farmers' responses ($r = 0.40^{**}$), highlighting the role of mass media in providing climate-related information and facilitating farmers' responses. Extension contact showed a positive and highly significant correlation with farmers' responses ($r = 0.36^{**}$), indicating that farmers having greater contact with extension personnel demonstrated better responses towards climate change. Overall, farmers' responses were positively associated with education, family size, landholding size, social participation, total income, economic motivation, risk orientation, innovativeness, mass media exposure and extension contact, whereas age and farming experience were negatively associated with farmers' responses. Among the independent variables, education ($r = 0.58^{**}$), innovativeness ($r = 0.53^{**}$), total income ($r = 0.52^{**}$) and risk orientation ($r = 0.50^{**}$) exhibited relatively stronger relationships with farmers' responses towards climate change.

Table 4: Multiple linear regression analysis of factors influencing Responses of farmers towards climate change (n=360)

S. No.	Independent Variable	Coefficients	P-value
1.	Age	-0.13	0.00
2.	Education	1.23	0.00
3.	Family Size	0.44	0.02
4.	Farming Experience	-0.05*	0.83
5.	Size of Land holding	-0.56	0.27
6.	Social Participation	-0.86	0.14
7.	Total Income	0.00**	0.00
8.	Economic Motivation	-0.71	2.71
9.	Risk Orientation	1.07	0.00
10.	Innovativeness	0.82	0.00
11.	Mass Media Exposure	0.15	0.02
12.	Extension contacts	-0.07	0.32
R ² - 0.549587			

Note: * Significant at 0.05 level of probability, ** Significant at 0.01 level of probability

The table no. 4 presents the results of the multiple linear regression analysis conducted to identify the factors influencing the responses of farmers towards climate change. The coefficient of determination (R^2) was found to be 0.54587, indicating that approximately 54.59 per cent of the variation in farmers' responses towards climate change was explained collectively by the selected independent variables included in the regression model. This suggests that the model had a moderate explanatory power. Among the independent variables, age ($\beta = -0.13$), family size ($\beta = 0.44$), total income ($\beta = 0.06$), risk orientation ($\beta = 1.07$), innovativeness ($\beta = 0.82$), and mass media exposure ($\beta = 0.15$) showed statistically significant relationships with the responses of farmers towards climate change. Education ($\beta = 1.23$) also exhibited a positive relationship with the dependent variable. The positive regression coefficients indicated that an increase in these variables was associated with an increase in the farmers' responses towards climate change, whereas the negative coefficients indicated an inverse relationship. Farming experience ($\beta = -0.05$), size of landholding ($\beta = -0.56$), social participation ($\beta = -0.86$), economic motivation ($\beta = -0.71$), and extension contacts ($\beta = -0.07$) showed negative relationships with the response of farmers. Overall, the findings indicate that the selected socio-economic, psychological, and communication-related characteristics played an important role in influencing farmers' responses towards climate change.

Conclusion

The study findings revealed that farmers in the Bundelkhand region of Uttar Pradesh responded to climate change through various adaptation measures aimed at reducing climatic risks and maintaining agricultural productivity and livelihood security. Overall, 68.88% of respondents exhibited a medium level of response, followed by 17.78% with a low level and 13.33% with a high level of response towards climate change. The correlation analysis revealed that farmers' responses were positively and highly significantly associated with education ($r = 0.58$), landholding size ($r = 0.44^{**}$), social participation ($r = 0.29^{**}$), total income ($r = 0.52^{**}$), economic motivation ($r = 0.18^{**}$), risk orientation ($r = 0.50^{**}$), innovativeness ($r = 0.53^{**}$), mass media exposure ($r = 0.40^{**}$) and extension contact ($r = 0.36^{**}$). Family size showed a weak but significant positive association ($r = 0.11^*$), whereas age ($r = -0.57$) and farming experience ($r = -0.15^{**}$) were negatively and significantly associated with farmers' responses. Among the independent variables, education, innovativeness, total income and risk orientation showed comparatively stronger relationships with farmers' responses. These findings indicate that farmers' socioeconomic, psychological and communication characteristics play an important role in shaping their responses to climate change. The results emphasize the need to strengthen agricultural extension services, improve access to timely climate information, promote innovative and climate-resilient technologies, and enhance economic and institutional support. Special attention should be given to older and less educated farmers through village-level training, demonstrations and strengthened extension-farmer linkages to improve climate resilience and sustainable agricultural development in Bundelkhand.

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