Research Note

Indian Journal of Extension Education
Vol. 62, No. 3 (July–September), 2026, (323-328)

ISSN 0537-1996 (Print)
ISSN 2454-552X (Online)

Climate-induced Migration, Farmers' Perception and its Determinants in Bundelkhand Region of Uttar Pradesh

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HIGHLIGHTS

- Climate-induced migration is a reality in sampled villages and climate change as a key driver for food insecurity.
- The SEM results show that climate adaptation strategies have restricted food insecurity.
- Limited availability of non-farm employment opportunities in the villages further exacerbated the credit trap.

ARTICLE INFO

Keywords: Climate change, Adaptation strategies, Food insecurity, Migration, Structural equation model.

https://doi.org/10.48165/IJEE.2026.623RN06

Citation: Sarma, H. P., Jatav, S. S., & Ranjan, A. (2026). Climate-induced Migration, Farmers' Perception and its Determinants in Bundelkhand Region of Uttar Pradesh. *Indian Journal of Extension Education*, *62*(3), 323-328. https://doi.org/10.48165/IJEE.2026.623RN06

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ABSTRACT

The study aims to examine the extent and dimensions of climate-induced migration, adaptation strategies, and food insecurity in the Banda district, India. By using a systematic random sampling procedure, a total of 100 samples were collected from two villages (i.e., Banthary and Amlokhar) of Kamasin development block of the Banda district, India, in April 2026. Further, descriptive statistics and the structural equation model (SEM) were applied to analyse the data. The results indicate that climate change-induced migration has increased manifold. About 74.07 per cent of households have reported that due to crop failure, they are unable to pay loans. Limited water resources, a rise in temperature, and a lack of non-farm employment opportunities were major drivers of food insecurity in sampled villages. Therefore, farmers have adopted different adaptation strategies to overcome food insecurity. This study suggested that investment in agriculture and non-farm activities is vital for restricting climate-induced migration. Responsive, well-resourced public institutions must support community-led strategies.

INTRODUCTION

Climate migration can be slow-onset or fast-onset. Rapid-onset natural disasters such as floods and cyclones usually result in immediate evacuation of households. Slow-onset processes such as desertification, soil degradation and rising temperature erode livelihood opportunities over time. Slow-onset results in seasonal or circular migration in which mostly the male members of the household migrate to urban areas for work during agricultural off seasons and stay back in the village with family. Climate induced migration strongly interact with the socio-economic conditions of the community. Climate is seldom a single driver. Instead, it amplifies the already existing vulnerabilities of poverty, landlessness, unemployment and low access to credit or technology. Small and marginal farmers with limited land are more vulnerable to climate shocks because they cannot make investments in irrigation, crop diversification or climate resilient technologies. These households are therefore more prone to use migration as a coping mechanism. In addition, backward social groups and tribal farmers face have structural inequalities that further limit their adaptability (Jena & Kanungo, 2021).

Large scale migration occurs toward urban areas already facing infrastructure stresses, housing and public services crisis. Unplanned rapid growth of cities, strains resources resulting in

Received 25-05-2026; Accepted 09-06-2026

informal settlements and water, sanitation and health systems, a complete set of policies and views on climate-induced migration can be tackled through mitigation, adaptation and development. Investing in climate-resilient agriculture, improving access to irrigation and diversifying income sources help in reducing the vulnerability of rural livelihoods (Pal et al., 2017; Roy et al., 2022). Social protection measures, such as employment guarantee schemes and crop insurance, can help mitigate the impact of crises when they are available during crises. Education, skill development and access to information can increase people's ability to migrate safely and productively when they need to do so (Jena & Aditya, 2022). Urban planning and governance must also prepare for rising numbers of migrants by providing sufficient housing, infrastructure and employment. Migration should not only be viewed as a problem, but also as an adaptive response to climates stresses.

Drought in semi-arid areas has been one of the strongest factors of migration in India (Singh, 2020). Drought is one of the strong causes of migration as the deficiency of soil moisture and water availability do much harm to the farming (Singh et al., 2020; Sreekumar & Sabuj, 2024), as India has 93 per cent of the population and 87 per cent of the districts that are drought moderate to very highly vulnerable. In the semi-arid tropics, around 69 per cent of households are vulnerable to drought, which significantly raises the chances of labour migration (Pradhan & Narayanan, 2020). Moreover, historical data indicated that heat waves and other climate disasters have increased in intensity in India over the years (Moharaj et al., 2025), causing large-scale displacement. In India, a total of 56.23 million internal displacements have occurred from 2008 to 2023 (IDMC, 2023). Most of these migrations are quick and involuntary, which makes handling them even more difficult.

METHODOLOGY

The present study uses systematically collected field survey data from the Banda district of Uttar Pradesh in April, 2026. The district is climatologically in a semi-arid to sub-humid zone. It is characterized by drastic changes in temperature, whereby the hottest summers reach 47°C and the southwest monsoon is very unpredictable. In Banda, the rural poor have made migration an unavoidable part of their livelihood approach due to the mounting pressures of climate change impacts such as escalating temperatures, erratic rainfall, pest attacks, and subsequent economic deprivation. The type of migration which is actually distress migration due to extreme economic deprivation, natural calamities, and intolerable social conditions of the place of origin and not due to "pull" of urban aspirations (Anuja et al., 2018). To capture grassroots information on farmers' perceptions of climate-induced migration and their determinants, Kamasin Development Block was chosen. The Kamasin is plagued by gross infrastructural shortages, especially in water management and connectivity. In the Kamasin Development Block, two villages, namely Banthary and Amlokhar, were chosen for the household survey. Both the villages have very traditional, agrarian characteristics. Lastly, fifty sample farmers were selected from each village for a household-level survey. Thus, one district, one development block, two villages, and 100 samples were collected to capture a comprehensive picture of climate-induced migration in the Bundelkhand region of Uttar Pradesh.

In order to analyse the data, the Structural Equation Model (SEM) was used to investigate whether food insecurity acted as a mediator in the relationship between climate change adaptation strategies and climate migration (Pearl, 2012). Further, SEM is used to examine whether the relationship between an independent variable (X) and a dependent variable (Y) is influenced partially or fully by a third variable called the mediating factor (Z). The model can be expressed through the following equation:

$$X = \beta_0 + \varepsilon_1 \quad \text{... (1)}$$

$$Z = \delta_0 + \gamma X + \varepsilon_2 \quad \text{...(2)}$$

$$Y = \eta_0 + \beta X + \varphi Z + \varepsilon_3 \quad \text{...(3)}$$

Where X represents the climate change adaptation strategies; Z represents the food security; represents the climate migration; β_0, δ_0 and η_0 represents the regression intercepts; γ, β and φ are the estimated coefficients; and ε_1, ε_2 and ε_3 are the uncorrelated error terms with a mean of zero. The study also computed the conditional expectation to assess the total effect, yield and conditional expectation $E(\{Y \mid x, Z\} = \eta_0 + \beta X + \varphi Z)$. In fact, it (E) was used to evaluate the overall causal impact of changing the independent variable (X) from one baseline value (x) to new value (x′) on the dependent variable (Y), while accounting for both direct and indirect effects influence by mediating factor (Z). this compares outcomes when X changes from a baseline value (x) to a new value (x′). From this, study derived the indirect effect as follows:

$$IE(x,x') = \Sigma z(\eta_0 + \beta X + \varphi Z)\ [P(Z \mid x') - P(Z \mid x)] = \varphi[E(Z \mid x') - E(Z \mid x)]) \quad \text{... (4)}$$

Where IE is the indirect effect; and P is the pre-transition distribution. Equation 4 can be simplified as follows:

$$IE(x,x') = \gamma\varphi(x' - x) = (x'-x)\ (t-\beta) \quad \text{...(5)}$$

Where, *t* represents the slope of the total effect, which can be calculated as follows:

$$t = \frac{E(Z \mid x') - E(Z \mid x)}{x' - x} = \beta + \gamma\varphi \quad \text{...(6)}$$

This study derived standard expressions for indirect effects within linear systems, which can be estimated as the difference t - β or as the product $\gamma\varphi$ (Pearl, 2012).

RESULTS

Extent and dimensions of migration in Banda

Figure 1 shows the reasons that motivate sampled households to migrate to nearby urban areas. From post-Green Revolution, it is very visible that the cost of cultivation has been increased manifold. Therefore, farmers needed additional funds and resources to continue farming, and once crop failure occurred due to a rise in temperature, farmers were not in a position to pay loans. This is clearly visible in the sampled villages. About 74.07 per cent of households have reported that due to crop failure, they are unable to pay loans. Limited availability of non-farm employment opportunities in the villages further exacerbated the credit trap. With

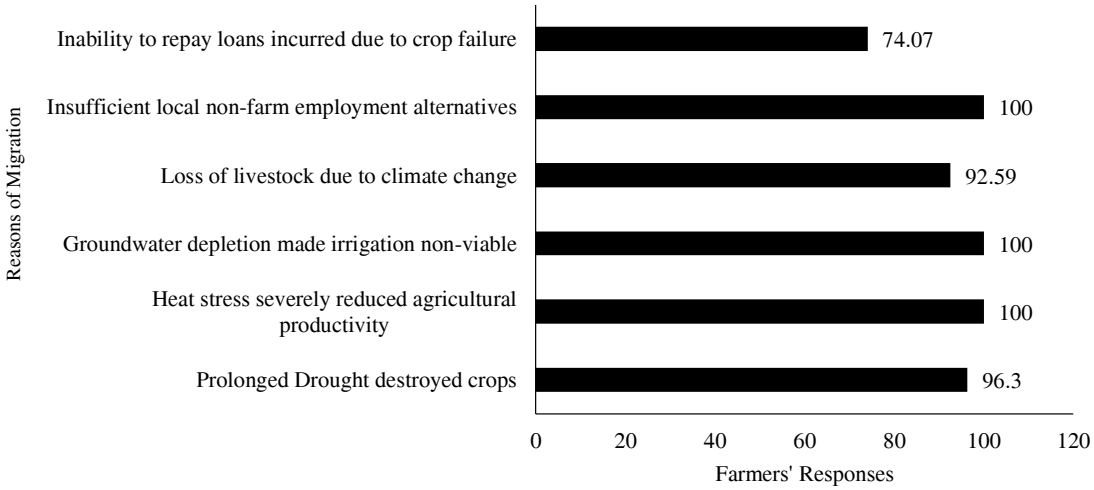

Figure 1. Reasons for Migration in the Surveyed Villages

limited water availability along with grazing land, livestock lost their lives, which are a secondary source of income in the area. Further, the majority of the households have reported that heat stress has depleted both surface and groundwater resources, which is responsible for crop productivity losses in the area.

Extend and dimensions of food insecurity in Banda

Crop failures in the sampled villages were caused by climate change and resulted in food insecurity in the area. In order to understand the depth and breadth of food security, some passive reasons were identified, and the responses of farmers were recorded to understand why food suppliers have become food importers (see Table 1). Responses were rated on a Likert scale ranging from "never", "rarely", "sometimes" and "often". As seen in Table 1, more than half of the sample households reported concerns of food availability resulting in restrictions in their consumption of preferred foods. Around 30 per cent of the surveyed households reported frequently eating a narrow range of food, which is a main factor in nutritional food insecurity. Similar statistics can also be seen in "no food to eat at home" and "eating fewer meals per day."

Climate adaptation strategies adopted by sampled households

Table 2 depicts climate adaptation strategies adopted by the sampled households in surveyed villages. As the Banda district has a dry climatology, most adaptation strategies are about how to conserve soil and water resources. Hence, adopted strategies were classified into three categories, namely economic, irrigation management, and sustainable development-oriented strategies.

Table 2. Identified climate adaptation strategies in surveyed villages

Factors	Positive response
Economic Strategies	
Non-agricultural activity outside the farm	35.25
Non-agricultural employment	20.75
Getting a loan	80.00
Using personal savings	90.25
Reduced household expenses	12.25
Livestock sale	85.25
Irrigation management strategies	
Irrigation pattern change	60.25
Improving the coverage of water transmission channels	75.25
Use of alternative water sources	80.25
Management of irrigation intervals	65.00
Watershed management activities	80.00
Sustainable development-oriented strategies	
Changing the crop cultivation deadline	56.25
Conservation tillage	45.25
Agricultural land levelling	20.25
Changing the time of crop harvest	45.25
Multi-cropping	80.00
Compliance with crop rotation	12.25
Reducing the distance between crop rows	25.00

Source: Field Survey, 2026.

As far as economic strategies were concerned, about 35.25 per cent of households were engaged in non-agricultural employment activities, and among them, 20.75 per cent got employment. About 80 per cent of households have taken out loans for agricultural

Table 1. Food insecurity access in the sampled households

Indicators	Never	Rarely	Sometimes	Often
Worrying about food availability	20.25	16.5	40.5	22.75
Unable to eat preferred food	26.5	19.5	34.5	19.5
Eating a limited variety of food	15.25	17.5	37.75	29.5
Eating unappealing food due to lack of alternatives	10.25	10.5	47.25	32
Eating a smaller meal	5.5	12.5	50.75	31.25
Eating fewer meals in a day	15.75	9.25	50.25	24.75
No food to eat at home	18.5	19.5	50.25	11.75
Not eating for a whole day and night	7.5	45.5	40.25	6.75

purposes, while more than 90 per cent of households have used personal savings, followed by 12.25 per cent who have reduced their expenditure and 85.25 per cent who have sold their livestock to secure their livelihoods and to mitigate adverse effects of climate change.

Further, as water is vital in an agrarian economy, more than 60 per cent of households have adopted various water conservation techniques. About 75.25 per cent of households have improved the coverage of water transmission channels by making concrete canal channels to reduce water loss. In the sampled villages, ponds were constructed under MGNREGA; therefore, households have multiple resources of irrigation, i.e., canals, ponds, and tube wells. Hence, more than 80 per cent of households have used multiple irrigation channels. These multiple irrigation sources enhanced irrigation resilience in the study area.

Lastly, sustainable development strategies were also adopted by the households. For instance, 56.25 per cent of households have changed the crop cultivation deadline by growing early maturing varieties, followed by 45.25 per cent who have adopted tillage conservation techniques, 20.25 per cent who have levelled the field, 45.25 per cent who have changed harvesting time, and 80 per cent who have diversified their cropping pattern within the cropping season.

Relationship between climate adaptation strategies, migration and food insecurity

Table 3 illustrates the substantial direct and indirect consequences of various climate adaptation measures, climate-induced migration, and food insecurity. The research indicates that economic strategies directly influence climate migration, hence affecting migration patterns. Furthermore, an indirect effect is shown, demonstrating that economic strategies influence climate migration via other migration-related processes. The results demonstrate a clear correlation between economic strategies and food insecurity; specifically, improved economic strategies correlate with reduced levels of food insecurity.

The management of irrigation is especially critical in dry locations like Bundelkhand. The structural equation model (SEM) research indicates significant negative direct and indirect effects of irrigation management practices on climate migration. This indicates that effective irrigation management may mitigate climate-induced migration. The research indicated a direct impact of sustainable development initiatives on climate migration, but the indirect effect was negligible.

The cumulative impact of these measures on climate migration was not substantial, suggesting that while a direct negative correlation exists, the overall effect may be minimal. Strategies focused on sustainable development directly impact food insecurity, indicating a significant connection.

Moreover, food insecurity directly influences climate migration, indicating that increased food insecurity correlates with heightened climate migration. These findings underscore the intricate relationship among climate adaption measures, migration, and food insecurity, emphasizing the need for focused interventions in the examined locations.

DISCUSSION

The interplay between food insecurity and migration is intricate, bidirectional, and context-dependent, influenced by a confluence of environmental, economic, and political elements (Bardsley & Hugo, 2010). Climate shocks, like droughts and erratic rainfall patterns, directly jeopardize agricultural output and rural livelihoods, prompting communities to relocate in pursuit of more stable living conditions (FAO, 2016). Simultaneously, migration can exacerbate food insecurity by altering agricultural systems and generating population imbalances in impacted regions. In the Bundelkhand region, climate-induced migration functions as coping strategy. Migration can serve as an adaptive response to food insecurity, allowing households to diversify income sources and receive remittances that improve food purchasing power, healthcare, and education (Mekonnen et al., 2022). Research from West Africa and Uganda which are similar geographical conditions as in Bundelkhand region, indicates that remittances can mitigate the effects of climatic shocks and enhance household resilience (Osei-Amponsah et al., 2023). Involuntary or mismanaged migration can intensify vulnerability in both the origin and host regions. Limited absorption capacity in host communities often leads to competition

Table 3. The structural equation model results

Factors	Factor	Effect pathway	Original sample	Sample mean	t-statistic
Economic strategies	Climate migration	Direct effect	-0.026	-0.027	4.715*
		Indirect effect	-0.009	-0.010	4.68*
		Total effect	-0.050	-0.40	4.52*
	Food insecurity	Direct effect	-0.055	-0.060	4.48*
Irrigation management strategies	Climate migration	Direct effect	-0.191	-0.201	2.45**
		Indirect effect	0.025	-0.025	3.500*
		Total effect	-0.225	-0.235	2.775*
	Food insecurity	Direct effect	-0.180	-0.151	2.275**
Sustainable development-oriented strategies	Climate migration	Direct effect	-0.055	-0.059	3.660*
		Indirect effect	-0.005	-0.005	0.355^{NS}
		Total effect	-0.050	0.060	0.860^{NS}
	Food insecurity	Direct effect	-0.025	-0.029	3.645*
Food insecurity	Climate Migration	Direct effect	0.135	0.130	2.250**

Note: * & ** indicates 1%, 5% level of significance, while NS indicates non-significance.

for scarce resources, higher food prices, and social tension (FAO, 2016).

A holistic food and livelihood policy in an agrarian economy must consider the nexus of climate change, migration and food insecurity. The findings of this study are consistent with the findings of Reza et al. (2025). Their study shows that climate change adaptation strategies can strengthen community resilience but their effectiveness is highly dependent on the level of food insecurity. They also found that climate-related disasters very probably caused displacement. Sabbatasso et al. (2025) studied the situation in Guatemala and highlighted two major concerns: (i) the exacerbation of food insecurity due to climate change and the expansion of monoculture farming, and (ii) the insufficient institutional response to the interlinked crises. Suza et al. (2026) investigated the links between climate, livelihood insecurity and violent conflict in the context of access to fishing in coastal Bangladesh. They found that the climate patterns that affect fish populations and availability are exacerbating existing vulnerabilities, a trend observable across Bangladesh. Climate impacts, poverty, limited access to credit and weak governance interacted to render small-scale fisher livelihoods more vulnerable to stresses.

CONCLUSION

The study highlighted the linkages between climate change, migration and food insecurity in one of the most vulnerable region to climate change. The MGNREGA as the most popular strategy supports as institutional buffer against climate induced collapse of income. Access to institutional credit and direct income support reduces the risk of financial problems and the need to move. The coverage of Kisan Credit Card (KCC) should be extended to all agricultural households and a specific KCC product should be evolved for marginal farmers with lower rates of interest and flexible repayment linked to crop seasons. Priority should be given to self-help group (SHG)-bank linkage programmes for women farmers to enable the poorest to access credit. Policies should shift from trying to eliminate it to managing it to optimize its developmental benefits and to minimize its social costs. Bundelkhand Labor Mobility Program should be established, offering migrant workers portable social security, skills with certification, and housing support in the destination city.

DECLARATIONS

Ethics approval and informed consent: Informed consent was sought from the respondents regarding the study during the course of the data collection.

Conflict of interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

The authors declare that during the preparation of this work, they thoroughly reviewed, revised, and edited the content as needed. The authors take full responsibility for the final content of this publication.

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