Environmental Disaster and Human Mobility: A Study of Disaster-Induced Migration in India

Kumar Vineet, Singh Harpreet*, Meena Avadhesh Kumar, Sharma Sanjana and Roychowdhury Ratul
Department of Geography, Institute of Science, Banaras Hindu University, Varanasi, Uttar Pradesh, INDIA
*harpreetsingh@bhu.ac.in

Abstract

Population displacement is a natural response to climatic shocks, particularly when people's livelihoods are devastated. Natural disasters act as significant catalysts for global human migration, compelling millions of individuals to relocate. The 1991 census data in India is the sole available dataset that incorporates natural disasters as a reason for migration. A comprehensive analysis of this data reveals that migration within rural areas represents the most substantial migration stream while migration from urban to rural areas is the least significant. Notably, a greater number of males reported natural disasters as the primary cause for their migration.

Among all Indian States, Uttar Pradesh ranks first in terms of migrants reporting natural disasters as the main cause for migration within urban-rural and urban-urban migration streams. On the other side, Bihar and Tamil Nadu occupy the top positions in rural-urban and rural-rural migration streams respectively. The objective of this study is to present a detailed examination of male and female migration patterns in India resulting from natural disasters, categorized by different migration streams.

Keywords: Natural Disaster, Migration, Human Mobility, Spatial Dynamics, India.

Introduction

Migration is described as migration from one country, place, or area to another. Since more people are moving over currently than at any previous time, migration has been acknowledged as one of the major worldwide challenges of the early twenty-first century[14]. Moreover, over three percent of the worldwide population, or 258 million persons, are now residing outside of their country of origin. According to this, one in every 35 people worldwide is a migrant. International migrant populations have grown by 45 million between 1965 and 1990, a 2.1% annual growth rate[8].

According to the UN Migration Agency (IOM), a migrant is a person who is moving or has moved across an international boundary or within a state away from his or her usual place of residence, independent of a person's authorized identity, whether the migration is either free or forced, what the reasons are for the move around, what the reasons are for the shift, or the duration of the period of stay[8]. A natural catastrophe is the result of a natural hazard such as an earthquake, flood, tornado, hurricane, volcano eruption, or landslip, which adversely affects the environment and causes property damage, loss of life, or other negative effects[6,11]. The world is constantly evolving. Natural disasters are rapid changes in the environment that may harm human life as well as those of creatures that live. Natural disasters include, but are not limited to, earthquakes, typhoons, cyclones, tsunamis, tornadoes, floods, landslides, mudslides, bushfires and volcanic activity[11]. In 2023, approximately 26.4 million individuals were displaced due to disasters, representing an 11% decrease compared to the annual average displacement recorded over the preceding decade[9]. According to the Internal Displacement Monitoring Centre (IDMC) in India, approximately 14 million individuals have been displaced as a result of climate change. Furthermore, between 2008 and 2023, an estimated 56.5 million people undertook internal migration within the country.

Human migration is often understood as a strategic response aimed at securing improved livelihood opportunities in new destinations, driven by the need to escape environmental risks and vulnerabilities present in the place of origin[12]. Migration induced by natural disasters has emerged as a significant global trend, with individuals and communities relocating in search of safety and security amidst growing environmental hazards and the spread of diseases[15].

From hurricanes and floods to wildfires and earthquakes, the impact of natural disasters can result in forced displacement, causing people to leave their homes and migrate to safer regions[6]. Natural disasters possess the capacity to displace substantial segments of the population, often resulting in either temporary displacement or long-term migratory movements[1].

The Internal Displacement Monitoring Centre (IDMC) reports that between 2008 and 2019, disasters caused an average annual displacement of approximately 24.7 million people[7]. This number excludes those displaced by slow-developing calamities like drought and sea level rise. Approximately 3 million individuals were impacted by disasters such as cyclone Idai in 2019, which also led to significant patterns of both internal and cross-border migration[4]. Certain geographical areas face an elevated risk of natural disasters and the resulting migratory movements.

The Asia-Pacific region, due to its geographical location, is especially vulnerable to a range of hazards including typhoons, floods and earthquakes. For example, in 2004 in the Indian Ocean, tsunami resulted in the displacement of

approximately 1.7 million individuals across 14 countries[10]. In addition, small island nations such as the Pacific Islands are threatened by sea level rise, forcing populations to relocate to more stable regions[5]. Migration triggered by natural disasters presents numerous challenges for both displaced populations and host communities. Those who are displaced frequently encounter difficulties in securing essential resources including adequate shelter, safe drinking water, healthcare services and access to education. The pressure exerted on existing infrastructure and resources in host areas can intensify social tensions and deepen economic disparities, necessitating coordinated international interventions for effective assistance and support[10].

Between 1980 and 1991, a significant number of natural disasters took place, leading to widespread loss of life and leaving many individuals homeless, injured, or permanently disabled[5]. Such circumstances compelled numerous male and female migrants to relocate in search of employment and better living conditions. This study aims to provide a thorough examination of the difficulties faced by migrants displaced by natural disasters. Given the absence of prior comprehensive research on this subject, a clear gap in the existing literature has been identified. Addressing this gap will offer helpful advice to policymakers and local authorities in formulating effective policies to address the challenges faced by migrant populations[2,13].

Material and Methods

We used data from the 1991 Indian Census for this research. India had carried out its decennial census fifteen times by 2011. The first systematic and comprehensive census was carried out in 1881 during the tenure of British Viceroy Lord Mayo, initiating a process that has been repeated every ten years since 1872. Following India's independence, the responsibility for conducting the census has been entrusted to the Office of the Registrar General and Census Commissioner under the Ministry of Home Affairs, Government of India, since 1949 (Census of India 1991)[3]. The Census of India has been conducted under the provisions of the Census Act of 1948 since 1951. The most recent enumeration took place in 2011, with the subsequent census originally scheduled for 2021; however, it was postponed primarily due to the COVID-19 pandemic.

This study explores stream-wise migration patterns of male and female migrants across India in response to natural calamities (Figure 1). However, for analytical purposes, the focus has been limited to the top ten States that recorded the highest levels of such migration. Microsoft Word and Excel were employed for drafting the manuscript, generating tables and creating graphs, while ArcGIS was utilized for spatial mapping and visualization (Figure 2).

Table 1
The number of natural disaster and causality between 1941- 1990 in India

Year	Total Number of Fatalities	Recorded Disaster Incidents
1941-1950	1548939	13
1951-1960	5423	30
1961-1970	1518872	44
1971-1980	42169	102
1981-1990	40143	125

Sources: National Institute of Disaster Management

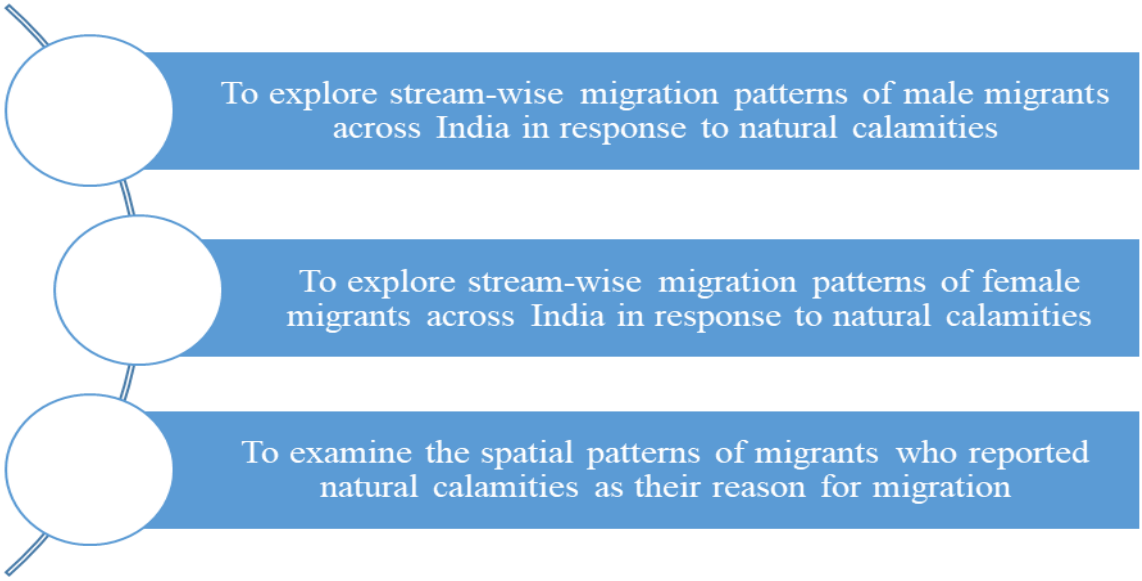

Figure 1: The Framework of the objective for the study

Results and Discussion

Stream-wise migration due to natural calamities in India: In the Indian context, migration predominantly occurs through four primary streams: rural-to-rural, rural-to-urban, urban-to-urban and urban-to-rural. Census data indicates that among individuals who cited natural calamities as the reason for their migration, the majority relocated from one rural area to another. As presented in figure 3, the rural-to-rural migration stream accounts for 56.25% of the total disaster-induced migrant population (Figure 3).

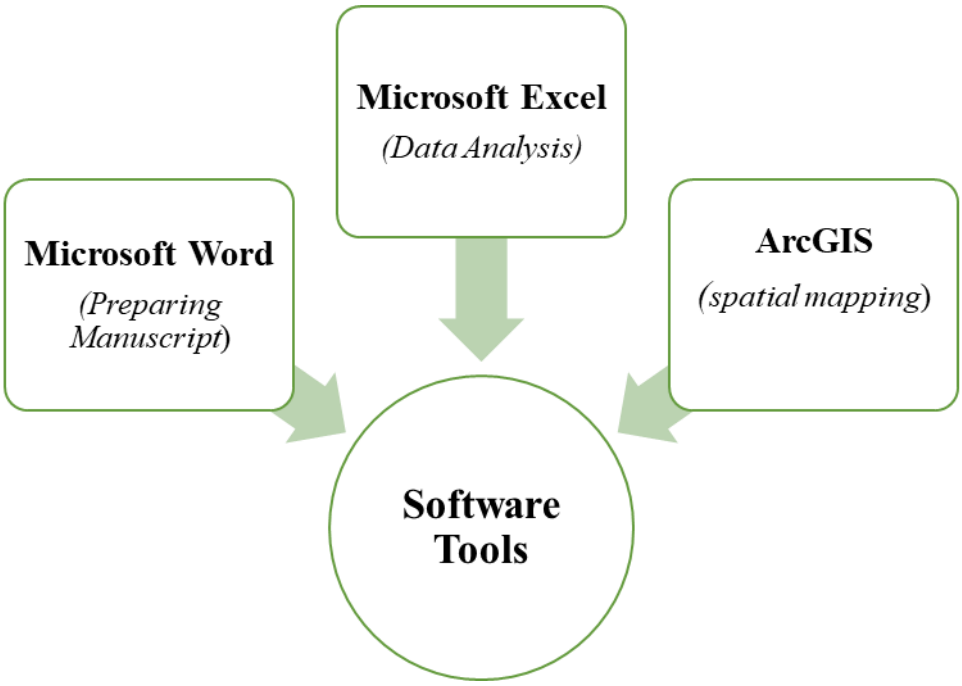

Figure 2: Software tools used for the study

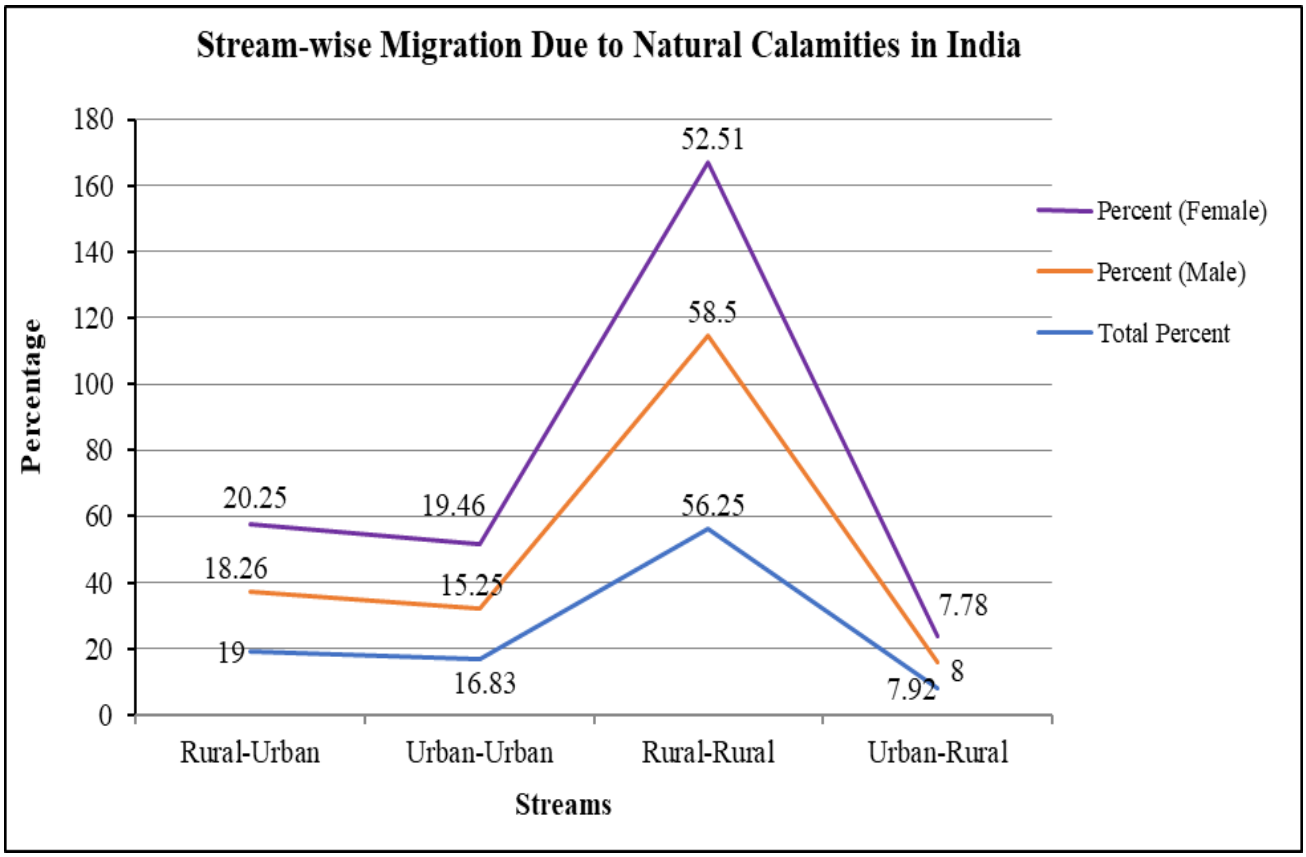

Figure 3: Migrants Reported Natural Calamities as Reason of Migration in India (Stream-wise)
Source: Census of India, 1991[3]

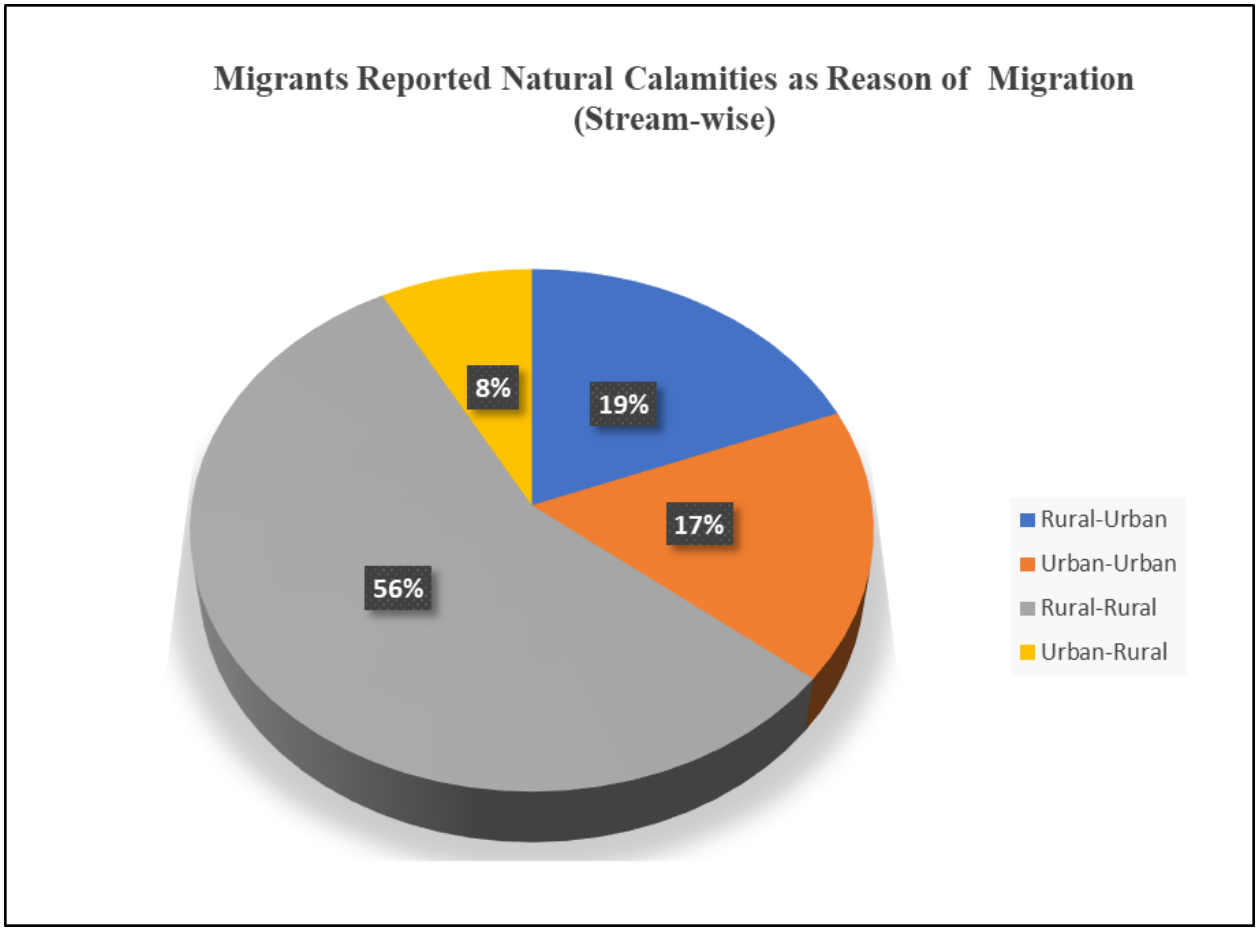

Figure 4: Total Migrants Reported Natural Calamities as Causes of Migration in India (Stream-wise)

The rural-to-urban migration stream represents the second-largest share, comprising 19% of the total migrants. In contrast, urban-to-urban migration accounts for 17%, while the urban-to-rural stream records the lowest proportion of individuals migrating due to natural calamities. The rural-rural migration stream accounted for more than fifty percent of individuals affected by natural calamities. In summary, the census data highlights that the largest proportion of migrants, specifically those impacted by natural disasters, migrate from rural areas to rural places in India. This finding illustrates the importance of the rural-rural migration stream as a response to natural calamities (Figure 4).

Male and female migrants contribute significantly to migration dynamics, particularly in the context of natural disasters. Gender-specific responses to such events reveal distinct patterns of movement. Based on census data, a substantial proportion of male migrants (58.5%) relocated through the rural-to-rural stream, indicating a predominant preference for intra-rural displacement during natural calamities. The rural-to-urban stream accounted for 18.2% of male migrants, representing the second-largest category, while the urban-to-rural stream recorded the lowest percentage (8%). Similarly, female migration patterns reflect comparable trends. Over half of the female migrants (52.5%) moved within the rural-to-rural stream, suggesting a significant impact of disasters on rural communities. The rural-to-urban stream involved 20.2% of female migrants, highlighting a notable shift toward urban centers. Conversely, urban-to-rural migration among women was limited to approximately 8%, reflecting minimal reverse movement. These trends underline the gendered dimensions of disaster-induced migration and the need for targeted policy interventions.

Spatial patterns of migration streams driven by natural calamities: A comparison of male migration patterns across the urban-urban and rural-urban streams reveals a more pronounced difference than that observed among female migrants in the same categories. However, Census data indicates that the proportions of male and female migrants in the urban-to-rural migration stream caused by natural disasters are relatively comparable. Disaster-induced displacement significantly affects both genders, albeit with distinct migration trajectories. The rural-to-rural migration stream emerges as the most dominant pathway for both male and female migrants, highlighting the extensive intra-rural mobility triggered by natural calamities.

These findings underscore the gendered nuances of disaster-related migration and the necessity of incorporating such differences into policy planning and disaster response strategies (Figure 5).

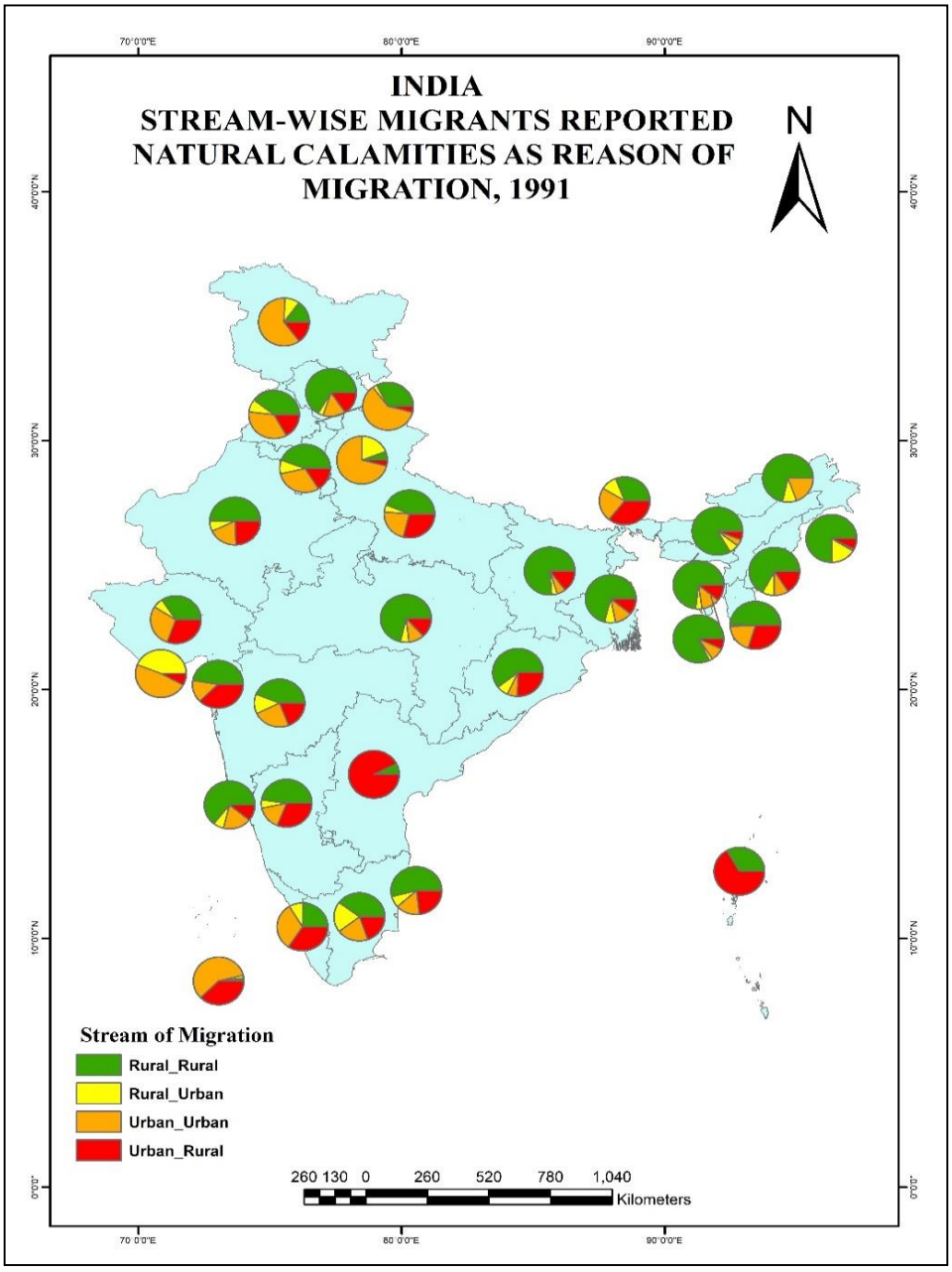

Figure 5: The migrants reported natural calamities as reason of migration in India (Stream-wise)

Migration along the rural-to-rural stream driven by natural calamities: The rural-rural migration stream holds significant importance when considering migrants who reported natural calamities as the reason for their migration. This is primarily because, during the 1991 census, a large portion of the Indian population lived in rural areas. The level of urbanization at that time was only around 26%. Table 3 presents the top ten States with the highest number of male and female migrants who migrated through the rural-rural migration stream due to natural calamities. The total number of male migrants was 41,701 while the total number of female migrants was 22,435. Bihar emerges as the State with the highest number of male migrants (21.2%) and female migrants (22.2%) in the rural-rural migration stream due to natural calamities. Following Bihar, West Bengal accounts for the second-highest number of male migrants (12.1%) and Andhra Pradesh stands in third place with 11.4% of male migrants.

Notably, only four States, Bihar, West Bengal, Andhra Pradesh and Madhya Pradesh, comprise more than fifty percent of male migrants in the rural-rural migration stream due to natural calamities. In summary, the rural-rural migration stream plays a significant role for migrants affected by natural calamities, particularly in States such as Bihar, West Bengal, Andhra Pradesh and Madhya Pradesh. These findings highlight the regional disparities and concentrations of male and female migrants in response to natural disasters within the stream of rural-rural migration.

Bihar stands out as the State with the highest number of female migrants (22.2%) in the rural-to-rural migration

stream due to natural calamities. Following Bihar, Andhra Pradesh and West Bengal both share the second-highest number of female migrants, accounting for 10.3% each. Uttar Pradesh reports the third-highest number of male migrants (7.7%) in the rural-to-rural migration stream due to natural calamities. Notably, only four States account for more than fifty percent of male migrants: Bihar, Andhra Pradesh, West Bengal and Uttar Pradesh. Among the remaining 32 States, the percentage of male migrants is only 13.7%, while the percentage of female migrants is 14.4%. The top ten States account for over 85% of both male and female migrants in the rural-to-rural migration stream. These findings highlight that many male and female migrants are located in certain States, especially Bihar, Andhra Pradesh, West Bengal and Uttar Pradesh, which have been greatly impacted by natural disasters, leading to their movement within the rural-to-rural migration stream (Table 2).

Migration along the urban-to-rural stream driven by natural calamities: The urban-to-rural migration stream holds significant importance as the second most prominent stream of migration when considering migrants who reported natural calamities as the reason for their migration during the 1991 Census. Table 4 presents the top ten States in India with the highest number of both male and female migrants who migrated through the stream of urban-to-rural migration due to natural calamities. The total number of male migrants was 13,015, while the total number of female migrants was 8,651. Andhra Pradesh accounts for the highest proportion of male migrants (12.8%) in the urban-to-rural migration stream resulting from natural calamities. Bihar follows with 12.4%, while Uttar Pradesh occupies the third position, contributing 12.2% of male migrants in this category.

Collectively, five States Bihar, Andhra Pradesh, Karnataka, Uttar Pradesh and Tamil Nadu, constitute over half of the total male migrants who have relocated from urban to rural areas due to natural disasters. This distribution underscores the concentration of environmentally induced male migration in specific regions of the country. In the context of female migration, Uttar Pradesh emerges as the leading contributor, accounting for 16.6% of female migrants in the urban-to-rural stream prompted by natural calamities. Bihar ranks second with 11.6%, while Karnataka follows closely at 11.3%. These trends indicate a similar concentration pattern as observed among male migrants. The same five Sates Bihar, Uttar Pradesh, Karnataka, Tamil Nadu and Andhra Pradesh, comprise more than 50% of the total female migrants within this migration stream. The distribution of migrants across the remaining 32 States is significantly lower with only 17% of male and 19% of female migrants originating from these regions.

The data reveal that more than 80% of both male and female urban-to-rural migrants due to natural disasters are concentrated within the top ten contributing States. This points to a highly uneven geographical distribution of disaster-induced migration, highlighting specific States with greater exposure and vulnerability to environmental risks. These findings emphasize the importance of region-specific interventions and disaster resilience strategies in mitigating the adverse impacts of natural calamities and managing internal migration effectively. Between 1994 and 2010, moderate flooding in Bangladesh primarily resulted in increased internal migration rather than international movement, with the most affected groups being socially and economically vulnerable populations including women and low-income individuals (Table 3).

Migration along the urban-to-urban stream driven by natural calamities: The urban-to-urban migration stream represents a critical dimension in understanding internal migration patterns driven by natural calamities, as reflected in the 1991 Census data. Table 5 highlights the top ten States in India with the highest numbers of male and female migrants who reported natural disasters as the primary reason for their relocation within urban areas.

Table 2
Rural-to-rural stream of migration stated natural calamities as cause of migration in India

Migrants stated natural calamities as reason of migration						
S.N.	**States**	**Male**	**Percentage**	**States**	**Female**	**Percentage**
1	Bihar	8843	21.21	Bihar	4987	22.23
2	West Bengal	5073	12.17	Andhra Pradesh	2323	10.35
3	Andhra Pradesh	4769	11.44	West Bengal	2316	10.32
4	Madhya Pradesh	3336	8.00	Uttar Pradesh	1738	7.75
5	Assam	3004	7.20	Karnataka	1674	7.46
6	Uttar Pradesh	2868	6.88	Tamil Nadu	1520	6.78
7	Tamil Nadu	2755	6.61	Madhya Pradesh	1417	6.32
8	Karnataka	2057	4.93	Assam	1215	5.42
9	Orissa	1781	4.27	Rajasthan	1099	4.90
10	Rajasthan	1481	3.55	Maharashtra	914	4.07
Remaining States		5734	13.75	**Remaining States**	3232	14.41
Total		**41701**	100.00	Total	**22435**	100.00

Source: Census of India, 1991[3]

Table 3
Urban-to-rural stream of migration stated natural calamities as cause of migration in India

Migrants stated natural calamities as cause of migration						
S.N.	**States**	**Male**	**Percentage**	**States**	**Female**	**Percentage**
1	Andhra Pradesh	1666	12.80	Uttar Pradesh	1438	16.62
2	Bihar	1626	12.49	Bihar	1005	11.62
3	Uttar Pradesh	1588	12.20	Karnataka	978	11.31
4	Karnataka	1456	11.19	Tamil Nadu	727	8.40
5	Tamil Nadu	1387	10.66	Andhra Pradesh	701	8.10
6	Rajasthan	740	5.69	Rajasthan	525	6.07
7	West Bengal	649	4.99	West Bengal	469	5.42
8	Orissa	617	4.74	Orissa	406	4.69
9	Punjab	552	4.24	Maharashtra	391	4.52
10	Madhya Pradesh	513	3.94	Punjab	376	4.35
Remaining States		2221	17.06	**Remaining States**	1635	18.90
Total		**13015**	100.00	Total	**8651**	100.00

Source: Census of India, 1991[3]

Table 4
Urban-to-urban stream of migration stated natural calamities as causes of migration in India

Migrants stated natural calamities as cause of migration						
S.N.	**States**	**Male**	**Percentage**	**States**	**Female**	**Percentage**
1	Uttar Pradesh	1381	12.71	Uttar Pradesh	983	11.82
2	Tamil Nadu	1325	12.19	Punjab	856	10.30
3	Andhra Pradesh	1170	10.76	Tamil Nadu	814	9.79
4	Punjab	1050	9.66	Andhra Pradesh	758	9.12
5	Karnataka	658	6.05	West Bengal	575	6.92
6	West Bengal	601	5.53	Maharashtra	559	6.72
7	Bihar	551	5.07	Karnataka	553	6.65
8	Rajasthan	550	5.06	Bihar	437	5.26
9	Maharashtra	517	4.76	Rajasthan	418	5.03
10	Delhi	516	4.75	Delhi	390	4.69
Remaining States		2550	23.46	**Remaining States**	1971	23.71
Total		**10869**	100.00	Total	**8314**	100.00

Source: Census of India, 1991[3]

This migration stream recorded a total of 10,869 male migrants and 8,314 female migrants. Uttar Pradesh emerges as the leading contributor for both male (12.7%) and female (11.8%) migrants in the urban-to-urban migration stream caused by natural calamities. Tamil Nadu ranks second among male migrants (12.1%), followed by Andhra Pradesh (10.7%). Collectively, five States, Tamil Nadu, Uttar Pradesh, Andhra Pradesh, Punjab and Karnataka, account for over 50% of all male migrants in this category. These figures suggest a significant regional concentration of male migration, highlighting the disproportionate impact of environmental disruptions in these States.

With respect to female migrants, Uttar Pradesh again records the highest share (11.8%), followed by Punjab (10.3%) and Tamil Nadu (9.7%). The top five States Punjab, Uttar Pradesh, Tamil Nadu, Andhra Pradesh and West Bengal-constitute more than half of the total female migrants in this stream. In contrast, the remaining 32 States contribute only around 23% of both male and female migrants. Altogether, the top ten states account for over 80% of the total urban-to-urban migration due to natural disasters, underscoring the uneven geographic distribution of such movements. These findings reveal that certain States particularly Uttar Pradesh, Punjab, Tamil Nadu, Andhra Pradesh and West Bengal, are more prone to disaster-induced urban displacement. This emphasizes the value of targeted policy responses and urban resilience strategies in regions experiencing high levels of environmentally driven migration (Table 4).

Migration along the rural-to-urban stream driven by natural calamities: The rural-to-urban migration stream appears to be among the less dominant form of internal migration when analyzing movements driven by natural calamities, as reported in the 1991 Census of India. Table 5 outlines the top ten States with the highest numbers of male and female migrants who relocated from rural to urban areas due to natural disasters.

Table 5
Rural to Urban stream of migration stated natural calamities as cause of migration in India

Migrants stated natural calamities as reason of migration						
S.N.	**States**	**Male**	**Percentage**	**States**	**Female**	**Percentage**
1	Tamil Nadu	1383	24.25	Tamil Nadu	830	24.98
2	Andhra Pradesh	672	11.78	West Bengal	333	10.02
3	Bihar	469	8.22	Madhya Pradesh	251	7.56
4	Maharashtra	452	7.93	Karnataka	243	7.31
5	West Bengal	404	7.08	Andhra Pradesh	222	6.68
6	Uttar Pradesh	348	6.10	Bihar	198	5.96
7	Punjab	287	5.03	Punjab	191	5.75
8	Orissa	253	4.44	Maharashtra	161	4.85
9	Rajasthan	252	4.42	Uttar Pradesh	161	4.85
10	Assam	210	3.68	Rajasthan	115	3.46
	Remaining States	973	17.06	**Remaining States**	617	18.57
	Total	**5703**	100.00	Total	**3322**	100

Source: Census of India, 1991[3]

The total number of male migrants in this category was recorded at 5,703 while female migrants accounted for 3,322. Tamil Nadu emerges as the most prominent contributor, with 24.2% of male and 24.9% of female migrants in this stream, indicating a substantial outflow of individuals from rural to urban settings within the State following environmental disruptions. Andhra Pradesh ranks second for male migrants (11.7%), followed by Bihar with 8.2%. These three States, along with Maharashtra, collectively account for over 50% of male migrants in the rural-to-urban migration stream associated with natural calamities.

For female migrants, Tamil Nadu again leads with nearly a quarter of the total (24.9%), followed by West Bengal at 10% and Madhya Pradesh with 7.5%. Together, Tamil Nadu, West Bengal, Madhya Pradesh and Andhra Pradesh comprise more than half of the total female migrants in this stream. In contrast, the remaining 32 States contribute relatively marginally to the rural-to-urban migration driven by natural calamities, with only 17% of male and 19% of female migrants originating from these regions. The top ten States, however, account for over 80% of both male and female migrants, suggesting a highly concentrated spatial pattern of migration due to environmental shocks. These findings reflect the localized nature of disaster-induced rural-to-urban migration, with States such as Tamil Nadu, Andhra Pradesh, Bihar, Maharashtra, West Bengal and Madhya Pradesh experiencing heightened vulnerability. The prominence of Tamil Nadu across both male and female migration highlights the State's specific exposure to recurring natural hazards and its potential role in shaping internal displacement dynamics during this period (Table 5).

Conclusion

This study was to explore the spatial distribution of different migration streams associated with natural calamities in India, based on data from the 1991 census. A gender-wise and stream-wise analysis revealed important trends in disaster-induced migration across the country. The findings indicate that due to the predominantly rural demographic profile of India at the time, rural-to-rural migration constituted the largest proportion of migrants reporting natural disasters as their reason for relocation. This underscores the significant impact of environmental disturbances on rural populations, who tend to move within similar geographical and socio-economic contexts.

In contrast, rural-to-urban migration emerged as a less dominant stream, reflecting the relatively lower volume of individuals transitioning to urban areas in response to natural calamities. The State-level analysis revealed pronounced regional disparities in migration flows. States such as Bihar, Uttar Pradesh, Tamil Nadu and Andhra Pradesh consistently reported high numbers of both male and female migrants across various streams. These patterns highlight the localized effects of natural disasters and emphasize the need for region-specific policy responses to manage and mitigate the consequences of environmental disruptions on population mobility.

Furthermore, the study highlights the critical gender dimension of migration, emphasizing the necessity of accounting for both male and female migration experiences. While male migrants constituted the majority in certain streams, particularly rural-to-rural and urban-to-rural migrations, the data also revealed a considerable proportion of female migrants, especially within the rural-to-rural stream. This gendered pattern of mobility suggests the importance of inclusive policy frameworks that address the specific vulnerabilities and needs of both genders. The research also points to the geographic concentration of migrants in specific states, reinforcing the need for regionally tailored strategies to mitigate the impacts of natural disasters.

By analyzing spatial migration patterns and their underlying causes, the study offers valuable insights for policymakers

seeking to reduce disaster-related displacement. Overall, the results help to build a deeper understanding of environmentally induced migration and advocate for comprehensive, gender-sensitive disaster risk reduction and migration management policies in the face of climate-related challenges.

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