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Geographical Analysis of Flood in Bhagalpur District, Bihar (India)

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Abstract

Migration, whether temporary or permanent, refers to the movement of individuals or groups from one location to another across a certain distance. Such movements are caused by natural, social, economic, and political factors, among which disasters play a particularly significant role. Geophysical and meteorological events are often categorized as disasters. According to the Internal Displacement Monitoring Centre (IDMC), in 2020 alone, 30.7 million people across the globe were displaced due to disasters, with floods accounting for 14 million of these cases. Bihar is one of the most flood-prone states in India, where millions of people are displaced annually. The geographical setting of the state makes it highly vulnerable to floods. Floods bring not only excessive water but also multiple challenges, including the loss of human lives, destruction of houses, devastation of farmlands, threats to livestock, and widespread displacement. The present study focuses on Bhagalpur district of Bihar, which lies along the Ganga River. The district covers 2,569 sq. km, comprising 2,499.90 sq. km of rural and 69.10 sq. km of urban area, with a population of 3,037,766—80.17% rural and 19.83% urban. Like the state itself, the history of Bhagalpur has been shaped by floods, as all its 16 blocks remain flood-affected. Every year during June to August, people from low-lying floodplain villages migrate to higher grounds such as Ravindra Bhavan, T.N.B. Collegiate, and Champanala Bridge, where they construct temporary shelters for survival. The Farakka Barrage also intensifies the flood situation in Bhagalpur. Within 47 years of its construction, silt deposition has raised the riverbed of the Ganga by 40–45 feet, reducing its depth from 40–45 meters to only 20–25 meters. This drastic change has significantly aggravated flood risks, resulting in recurrent displacement of the population.

Keywords: Flood-Induced Migration, Disaster Displacement, Bhagalpur District, Bihar, Ganga River, Farakka Barrage

Introduction

Migration is one of the three fundamental components of demography, alongside birth and death, and plays a crucial role in shaping the socio-economic profile of populations (Lee, 1966; Skeldon, 2012). Migration is driven by multiple factors—natural, social, economic, and political—among which natural disasters are often the most decisive. Each year, millions of people are displaced worldwide due to disasters. According to the Internal Displacement Monitoring Centre (IDMC, 2021), nearly 30.7 million people were displaced globally in 2020 alone as a result of disasters. Out of these, 0.65 million people were displaced by geophysical events such as earthquakes, volcanic eruptions, and landslides, while 30 million people were displaced by weather-related events, including floods, wildfires, droughts, and extreme atmospheric conditions. Among these, floods accounted for 14 million displacements, ranking as the second-largest cause after storms (14.6 million displacements).

India's geomorphological conditions make it highly vulnerable to floods. Of the country's total geographical area of 329 million hectares, more than 40 million hectares are classified as flood-prone (National Disaster Management Authority [NDMA], 2020). Bihar, in particular, is one of the worst-affected states, with 6.88 million hectares of flood-prone land, accounting for nearly 16.5% of India's flood-prone area and 22.1% of the country's flood-affected population (Government of Bihar, 2019). Almost every year, Bihar experiences devastating floods caused by heavy rainfall in the catchment areas of major rivers such as the Gandak, Kosi, and tributaries of the Ganga.

The Kosi River, often referred to as the *"Sorrow of Bihar"* due to its unpredictable shifts in course, plays a central role in recurring floods (Mishra, 2002). The river's tendency to change its path has historically displaced thousands of people, devastating villages, farmland, and infrastructure. The repeated cycle of flooding and displacement highlights the intricate relationship between natural disasters and migration in Bihar. This makes the state a critical case for studying flood-induced migration in India.

Literature Review

Migration induced by disasters has been widely studied within demographic and geographical scholarship, with floods consistently identified as one of the leading drivers of displacement worldwide. Theoretical frameworks emphasize that disaster-induced migration is shaped not only by environmental hazards but also by social vulnerability and governance (Lee, 1966; Black et al., 2011). According to the Internal Displacement Monitoring Centre (IDMC, 2021), nearly 30.7 million people were displaced globally in 2020 due to disasters, of which floods alone accounted for 14 million cases, ranking second after storms. In India, recurrent floods have caused large-scale livelihood disruptions and forced migration, particularly in agrarian communities with weak coping capacities (Senapati, 2022; Sheldon et al., 2022). Bihar, with 6.88

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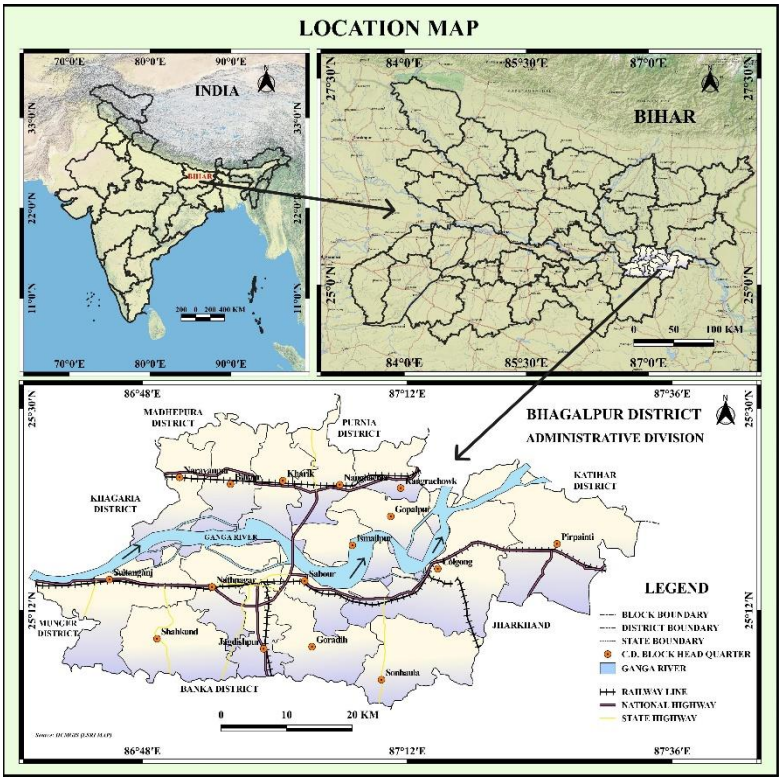
million hectares of flood-prone land, is among the most affected states, and the Kosi River—famously termed the "Sorrow of Bihar"—has been documented for its unpredictable course changes and devastating impacts on settlements (Mishra, 2002; Kumar, 2025). In addition, studies highlight the role of infrastructure such as the Farakka Barrage in aggravating floods in downstream regions like Bhagalpur through excessive silt deposition and reduced river depth, which increases inundation risks (Hasanuzzaman et al., 2024). Local research on Bhagalpur district further reveals recurring riverbank erosion, seasonal migration to higher grounds, and socio-economic distress among displaced populations, though these studies often critique the inadequacy of state relief and rehabilitation measures (Research on Bhagalpur Resettlement, 2024). While previous research has advanced understanding of the global, national, and regional dimensions of flood-induced migration, there remains a significant gap in micro-level, district-focused studies that integrate geomorphological changes with household migration dynamics. The present study aims to address this gap by examining flood-induced migration in Bhagalpur district, combining spatial, demographic, and socio-economic perspectives.

Study Area

The present study has been conducted in Bhagalpur district, located in the state of Bihar, India. Geographically, the district extendsfrom 25°34′ N to 24°45′ N latitude and 84°32′ E to 84°25′ E longitude. It is the 17th largest district of Bihar in terms of area, covering a total of 2,579 sq. km (Government of Bihar, 2021). The district comprises both rural and urbanareas, with rural settlements occupying the dominantshare of land.



The Ganga River is the principal river of Bhagalpur, which bifurcates the district into two unequal parts and plays a centralrolein shaping its physical and socio-economic landscape (Singh,2018). Administratively, Bhagalpur forms

part of the Bhagalpur Division, one of the nine divisions of Bihar, and along with Banka district, it serves as an important regional hub. The district is subdivided into three sub-divisions—Bhagalpur Sadar, Kahalgaon, and Naugachia—further comprising 16 community development blocks and 1,515 villages (Census of India, 2011).

From a demographic perspective, the district has a total population of 3,037,766, including 1,615,663 males and 1,422,103 females (Census of India, 2011). Of this, 19.83% constitutes the urban population, while the remaining 80.17% resides in rural areas, reflecting the predominantly agrarian character of the region. The population density is 1,182 persons per sq. km, which is significantly higher than the state average. The sex ratio of Bhagalpur district is 880 females per 1,000 males, indicating a demographic imbalance. The literacy rate is 63.14%, which, though improving, still lags behind the national average, thereby influencing the socio-economic development indicators of the district (Census of India, 2011).

Thus, Bhagalpur represents a region where geographical, hydrological, and demographic characteristics intersect, making it highly vulnerable to recurrent floods and associated migration. Its strategic location along the Ganga River, coupled with high population density and socio-economic vulnerabilities, underscores its importance as a case study for flood-induced migration in Bihar.

Aims and Objectives

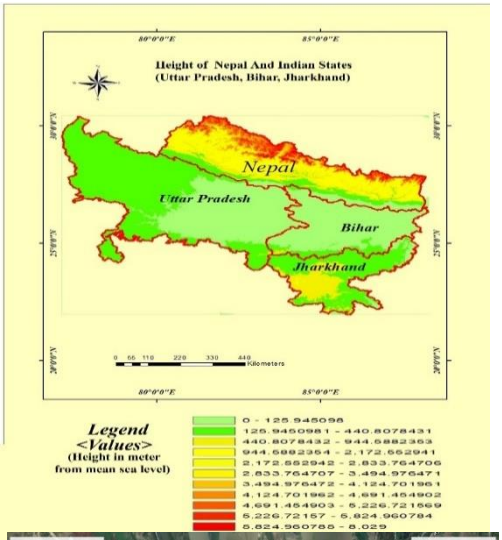
- To analyze the causes of migration.
- To establish the relationship between migration and floods.
- To examine the role of floods in migration.
- To provide significant suggestions for reducing migration.

Data Source and Methodology

This study is entirely based on secondary data sources. The required information has been obtained from the Census of India (2001, 2011), official reports of the Government of Bihar, publications of the Internal Displacement Monitoring Centre (IDMC), and research articles, books, and journals related to migration and flood studies.

For analysis, descriptive statistical methods such as percentage, ratio, and growth rate have been used to interpret demographic and migration-related data. Spatial information regarding flood-prone areas of Bhagalpur has been compiled from government reports and previous studies. The findings are presented through tables, charts, and maps to illustrate the relationship between floods and migration in the district.

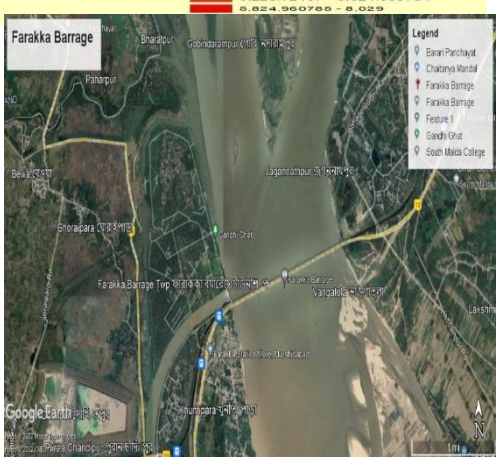
Causes of Flood in Bihar State



The primary reason for recurrent floods in Bihar lies in its geographical setting. The state is bounded by the Himalayas in the north, Uttar Pradesh in the west, and Jharkhand in the south. Compared to these surrounding regions, Bihar's average elevation above mean sea level is relatively low. As the gradient from eastern Uttar Pradesh towards Bihar becomes extremely gentle, water stagnation is common, thereby contributing to flood conditions.

Furthermore, the monsoon branch originating from the Bay of Bengal brings heavy rainfall to the foothills of the Himalayas. As a result, rivers descending from the Himalayan Terai region flow rapidly into the plains of Bihar, causing widespread inundation. The major tributaries of the Ganga originating from the Himalayas are perennial rivers, which swell significantly during the monsoon season and carry large volumes of water. The extensive catchment areas of these northern rivers further intensify flood risks in Bihar.

In addition, the construction of the Farakka Barrage in West Bengal has aggravated the problem by increasing silt deposition in the Ganga River. This has raised the riverbed and reduced its carrying capacity, making floods in Bihar more severe and destructive.



Floods in Bhagalpur District

The history of floods in Bhagalpur district is as old and recurrent as that of Bihar as a whole. All 16 administrative blocks of the district are affected by floods in varying degrees. In 2003, Bhagalpur witnessed a historic flood when the highest flood level (HFL) surpassed the previous record of 34.18 meters set in 1978. Again, in 2016, the district recorded an even higher flood level of 34.72 meters, which caused widespread devastation. The severity of this flood was such that the ring embankment between Ismailpur and Bind Toli collapsed, leading to large-scale inundation.

According to the Disaster Management Department, between 1987 and 2010, blocks such as Naugachhia, Gopalpur, Sabour, Jagdishpur, and Bihpur experienced floods almost every year, highlighting their extreme vulnerability. In contrast, blocks such as Rangra Chowk, Goradih, Ismailpur, Kharik, and Narayanpur showed relatively fewer occurrences. However, in catastrophic years like 2000, 2003, 2004, 2005, 2007, and 2008, all 16 blocks were severely affected, reflecting the widespread nature of flood disasters in Bhagalpur.

A block-wise analysis of flood frequency reveals that Naugachhia and Gopalpur (17 years each) were the most flood-affected blocks, followed closely by Sabour (16 years), Jagdishpur (15 years), and Bihpur (15 years). On the other hand, Rangra Chowk, Goradih, Ismailpur, Kharik, and Narayanpur faced floods less frequently (6–8 years), though they too suffered severe impacts during major flood years. This clearly indicates that flood vulnerability is spatially uneven across the district, with certain blocks chronically exposed to recurrent floods while others experience episodic but high-intensity inundation.

Block Name	Years	Frequency
Naugachhia	87,88,90,91,94,96,98,99,2000,01,02,03,04,05,06,07,08	17
Gopalpur	87,88,89,90,91,94,96,97,98,99,2000,01,03,05,06,07,08	17
Sabour	87,88,89,91,94,95,96,98,99,2000,03,04,05,06,07,08	16
Jagdishpur	87,89,91,93,94,95,96,98,99,2000,01,04,05,06,07	15

Bihpur	87,88,89,90,91,94,96,98,99,2000,03,04,05,07,08	15
Kahalgam	87,91,93,94,95,96,98,99,2000,03,06	11
Sanhaonla	87,91,94,95,96,98,99,2000,01,03,06	11
Nathnagar	88,91,94,95,96,98,99,2000,03,04,05,07,08	13
Sultanganj	87,91,94,95,96,98,99,2000,03,06,07,08	12
Pipainti	87,88,89,91,93,94,96,98,2000,03	10
Sahkund	87,91,94,95,96,98,2000,03,06,07	10
Rangra chowk	2000,01,02,03,04,05,06,07,08	8
Gaura dih	2000,03,04,05,06,07	6
Ismailpur	2000,01,03,05,06,07,08	7
Kharik	2000,01,03,04,06,07,08	7
Narayanpur	2000,03,04,05,07,08	6

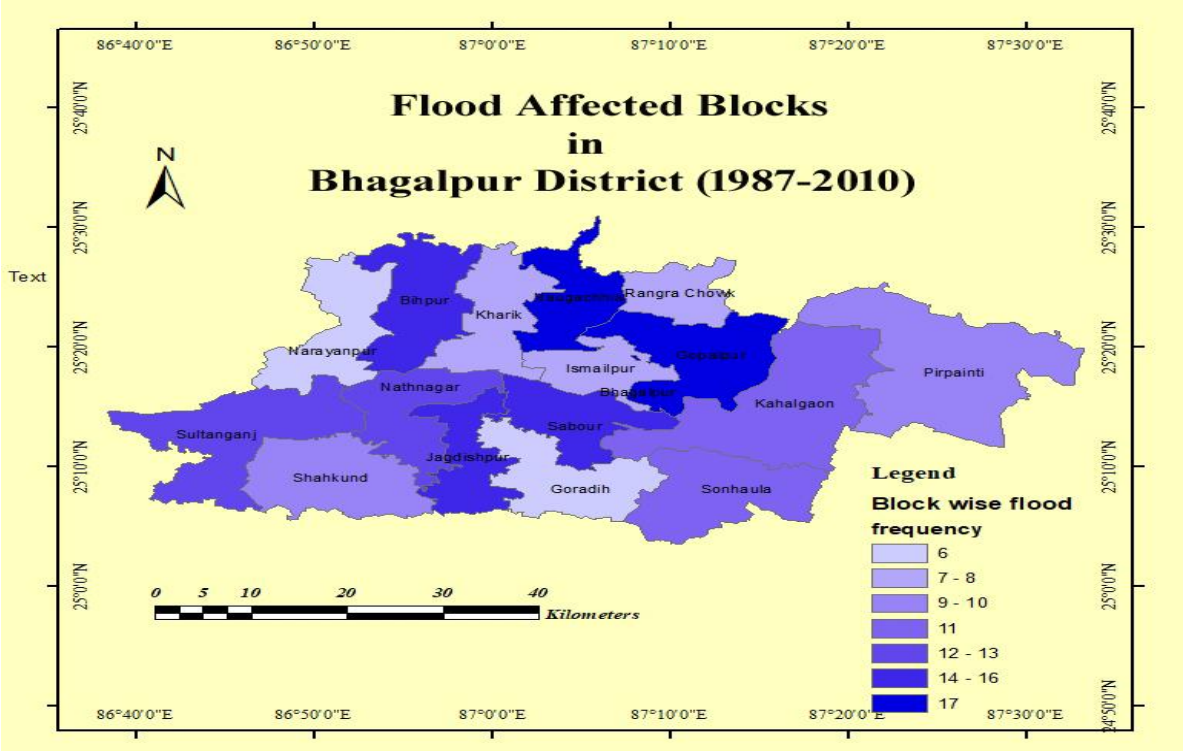
Table 1: Flood Affected Blocks (1987-2010)

Source- Disaster Management Bihar

This table highlights that flood frequency varies significantly across the district, with some blocks like Naugachhia and Gopalpur consistently exposed, while others like Narayanpur and Goradih face floods occasionally. The high recurrence in certain blocks reflects their geographical position along the Ganga and Kosi river systems, while the lower recurrence areas are relatively better protected but still at risk during extreme flood years.

Fig: Flood Affected Blocks (1987-2010)

Source- Disaster



Management Bihar

Impact of Floods in Bhagalpur District

Floods in Bhagalpur have caused severe damage to residential structures over the decades, with both pucca (permanent) and kuccha (semi-permanent or temporary) houses being affected. The data highlights the magnitude of destruction and economic loss, showing fluctuations across years depending on the severity of floods.

Table 2: Table: Year-wise Damage to Houses Due to Floods in Bhagalpur District

Year	Pucca Fully	Pucca Partly	Kuccha Fully	Kuccha Partly	Huts	Total Houses	Value (Rs. Lakh)
2020	52	0	96	0	0	148	140.70
2019	93	6	289	92	324	804	276.30
2018	3	–	30	–	33	66	–
2017	2	0	15	–	314	331	50.25
2016	–	137	997	210	5376	6720	–
2015	–	–	2	5	–	7	–

2014	2	–	410	–	18	430	96.00
2013	10	90	420	427	445	1392	97.84
2011	248	105	1012	773	1378	3516	157.91
2008	137	35	1256	630	762	2820	–
2006	5	228	3690	5039	–	8962	–
2004	512	1000	4000	3500	–	9012	–
2003	132	119	2672	4374	–	7297	–
2002	–	–	33	289	–	322	4.25
2001	24	–	1600	75	–	1699	–
1999	154	342	1048	428	–	1972	92.46
1997	–	–	140	–	–	140	3.00
1996	–	–	6358	5195	–	11553	8.00
1995	100	450	37585	16740	–	54875	641.00
1994	–	15	1400	2062	–	3477	84.95
1993	14	88	235	302	–	639	3.67
1991	10	15	878	369	–	1272	9.61

Source: Department of Disaster Management, Government of Bihar

Floods in Bhagalpur district have caused widespread destruction of houses over the years, with the impact varying in intensity across different flood events. The data clearly shows that kuccha houses have been the most severely affected, as their weak structures are highly vulnerable to inundation, while pucca houses have sustained relatively less damage. The year 1995 stands out as the most disastrous, with more than 54,875 houses damaged and economic losses estimated at ₹641 lakh. Similarly, the years 1996, 2004, and 2006 also witnessed large-scale destruction, with over 8,000 to 11,000 houses affected in each year. In recent times, the 2016 flood caused severe damage, destroying over 6,700 houses, mainly kuccha dwellings and huts. Comparatively, years like 2015 and 1997 recorded minimal damage, highlighting the irregularity in flood intensity. Despite this variability, the overall trend reveals that major floods in Bhagalpur have consistently resulted in thousands of houses being destroyed and significant economic losses, underlining the chronic vulnerability of rural households in particular.

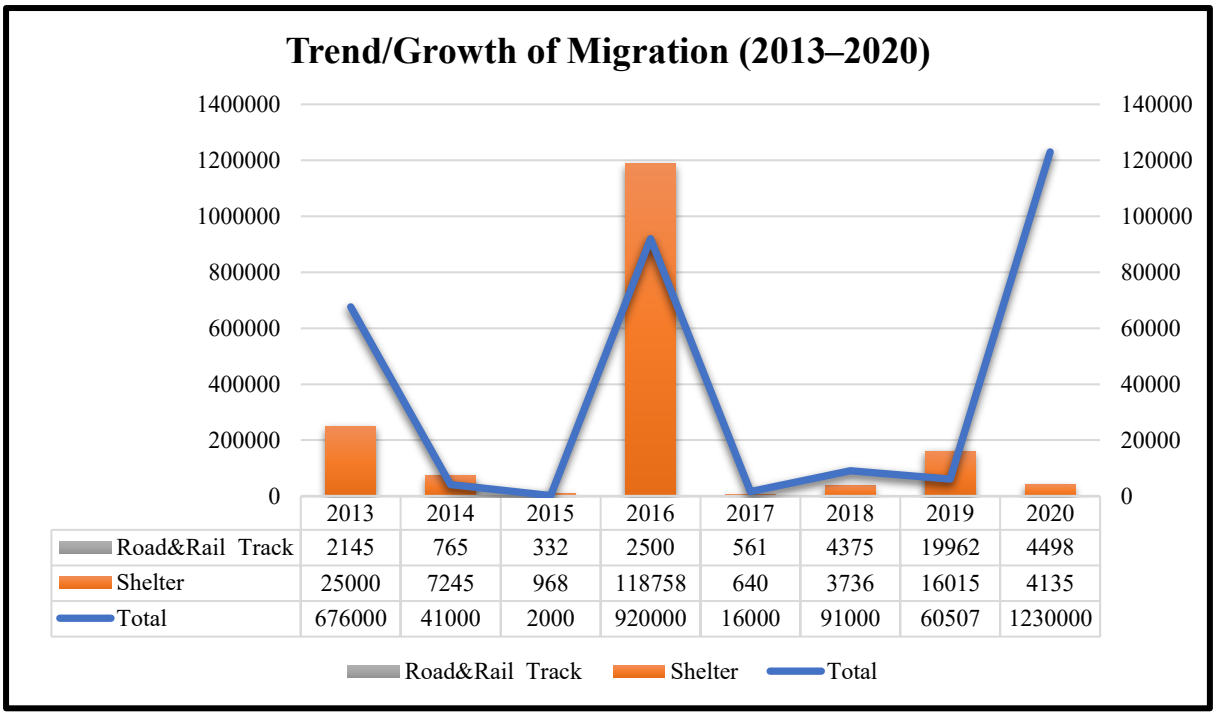
Displacement due to Floods

Flood-induced migration in Bhagalpur district has shown extreme fluctuations between 2013 and 2020, reflecting the irregular but severe nature of flooding in the region. In 2013, around 676,000 people were displaced, with 25,000 taking shelter in relief camps and disruptions reported on 2,145 road and rail tracks. The following years witnessed lower levels of displacement, with only 41,000 migrants in 2014 and 2,000 in 2015, though localized shelter requirements and transport damage persisted. A major flood in 2016 triggered massive migration of about 920,000 people, of whom 118,758 were accommodated in shelters, while 2,500 transport routes were affected. Similarly, in 2020, the district recorded the highest displacement of the decade at 1.23 million people, alongside 4,135 in shelters and damage to 4,498 road and rail tracks. Other years such as 2017 (16,000 migrants), 2018 (91,000 migrants), and 2019 (60,507 migrants) reflect the recurring though varied scale of migration. Overall, the data demonstrates that while minor floods displace tens of thousands, major flood events such as 2013, 2016, and 2020 result in mass displacement running into hundreds of thousands to over a million, causing immense pressure on temporary shelters and widespread disruption of transport infrastructure.

Table 3: Table: Flood-Induced Migration, Shelter Requirement, and Infrastructure Damage in Bhagalpur (2013–2020)

Year	Total	Shelter	Road&Rail Track
2013	676000	25000	2145
2014	41000	7245	765
2015	2000	968	332
2016	920000	118758	2500
2017	16000	640	561
2018	91000	3736	4375
2019	60507	16015	19962
2020	1230000	4135	4498

Source: Disaster Management Department, Government of Bihar



	2013	2014	2015	2016	2017	2018	2019	2020
Road&Rail Track	2145	765	332	2500	561	4375	19962	4498
Shelter	25000	7245	968	118758	640	3736	16015	4135
Total	676000	41000	2000	920000	16000	91000	60507	1230000

Source: Disaster Management Department, Government of Bihar

Compound Annual Growth Rate (CAGR)

CAGR is used in this study because it provides a smoothed long-term growth rate of flood-induced migration, avoiding distortions from yearly fluctuations. While annual migration varies sharply due to irregular flood intensity, CAGR summarizes the overall trend between 2013 and 2020 into a single, comparable figure. This makes it easier to interpret long-term migration pressure and supports policy analysis for sustainable flood management.

$$\textbf{CAGR} = (\textbf{Beginning Value/Ending Value})^{1/n} - 1$$

Where:

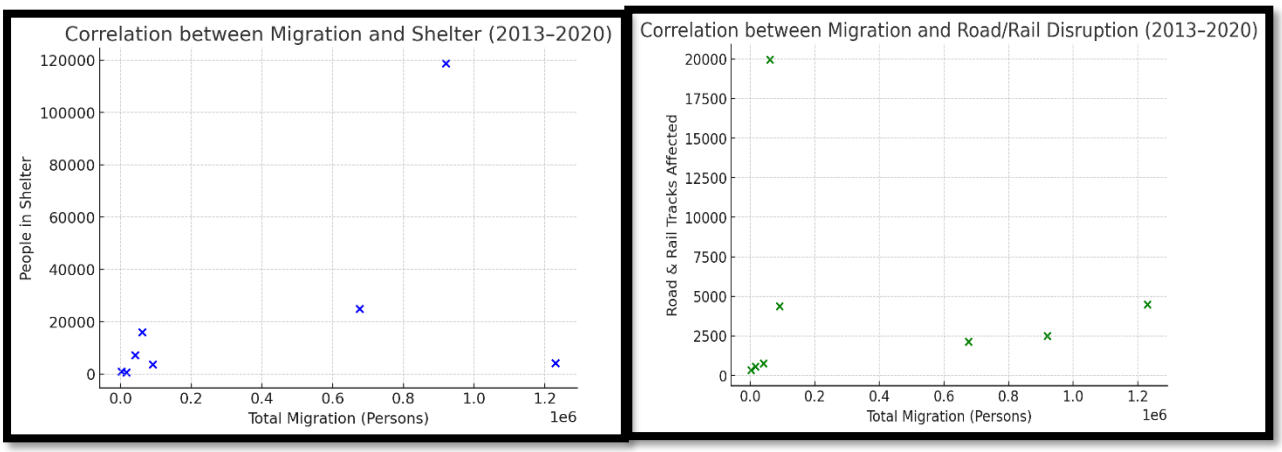
- Beginning Value = 676,000 (in 2013)
- Ending Value = 1,230,000 (in 2020)
- N = 7 years (2020–2013)

CAGR = **8.9%** per year

This means that on average, flood-induced migration in Bhagalpur grew by 8.9% annually between 2013 and 2020.

Correlation analysis

Correlation analysis is applied in this study to examine the relationship between migration, shelter requirements, and infrastructure disruption during floods. Since migration is influenced by multiple factors, correlation helps in quantifying the degree of association between these variables. For example, the moderate positive correlation (r = 0.48)



between migration and shelters indicates that higher migration generally leads to greater demand for relief shelters, though not always in equal proportion. On the other hand, the weak negative correlation ($r = -0.11$) with road and rail disruption shows that infrastructure damage does not consistently correspond to migration levels. Thus, correlation is justified as it highlights the strength and direction of relationships, providing deeper insights into how different aspects of floods interact with population displacement.

Socio-Economic Impact of Flood-Induced Migration

Flood-induced migration in Bhagalpur has severe socio-economic consequences that extend far beyond temporary displacement. One of the most significant impacts is the loss of livelihoods, as agricultural land, standing crops, and livestock are repeatedly destroyed by recurring floods. Many marginal farmers and daily wage laborers are left without income, forcing families into short-term migration in search of alternative work. Housing is another major area of concern, as large numbers of displaced people are forced to take shelter in temporary camps, schools, or roadside areas where conditions are overcrowded and sanitation facilities are inadequate. This often leads to serious health problems, including outbreaks of waterborne diseases such as diarrhea, cholera, and malaria, as well as malnutrition due to food shortages.

Floods also disrupt the education system, as schools are either submerged or converted into relief shelters, resulting in prolonged interruption of children's studies. In many cases, children from displaced families are compelled to engage in labor to support household income, perpetuating the poverty cycle. Women and children remain the most vulnerable during displacement, as they face safety risks, lack of privacy, and greater health challenges in temporary shelters. The repeated loss of property, crops, and homes pushes many households into chronic poverty, making recovery increasingly difficult with each successive flood. Overall, flood-induced migration in Bhagalpur not only causes physical displacement but also entrenches long-term socio-economic vulnerability, weakening the resilience of affected communities and highlighting the urgent need for sustainable flood management and rehabilitation measures.

Government Response and Flood Management Measures

The Government of Bihar, in coordination with the central government, has undertaken several initiatives to mitigate the impacts of floods and reduce migration in highly vulnerable districts like Bhagalpur. The Disaster Management Department of Bihar is the nodal agency responsible for relief, rehabilitation, and preparedness activities. During major flood events, the government establishes temporary relief camps, provides food, drinking water, medicines, and sanitation facilities to displaced populations. Additionally, emergency rescue operations are conducted by the National Disaster Response Force (NDRF) and State Disaster Response Force (SDRF), often with the support of the Indian Army and local volunteers.

Structural measures have also been implemented, including the construction and strengthening of embankments, ring bunds, and flood control reservoirs along vulnerable river stretches. The government has promoted the use of flood forecasting and early warning systems in collaboration with the Central Water Commission (CWC), enabling timely evacuation of people from flood-prone areas. In recent years, emphasis has been placed on community-based disaster risk reduction (CBDRR) programs, where local residents are trained in evacuation, first aid, and disaster preparedness. Financial support is also extended through relief packages and compensation schemes for families that lose homes, crops, or livestock.

Despite these efforts, recurring floods in Bhagalpur reveal limitations in current strategies. Poor maintenance of embankments, delays in relief distribution, inadequate rehabilitation planning, and lack of long-term livelihood restoration measures continue to undermine resilience. Experts argue that flood management in Bihar remains largely reactive rather than preventive, with greater focus on short-term relief instead of sustainable solutions such as river dredging, watershed management, and climate-resilient infrastructure development. Therefore, while government responses provide temporary relief, long-term structural and non-structural interventions are urgently required to reduce flood-induced migration and socio-economic vulnerability in Bhagalpur.

Suggestions for Reducing the Impact of Floods

To minimize the adverse effects of recurrent floods in Bhagalpur district, a combination of structural and non-structural measures is required. The following suggestions may be considered:

1. **Control of Deforestation** – Unregulated deforestation in catchment areas increases surface runoff and sedimentation in rivers, leading to higher flood intensity. Strict enforcement of forest conservation laws and promotion of afforestation programs can significantly reduce flood risks.

2. **Plantation of Vetiver Grass** – Vetiver grass, with its deep and strong root system, is highly effective in controlling soil erosion and stabilizing riverbanks. Large-scale plantation along embankments and vulnerable river stretches can reduce siltation and protect agricultural land from flood damage.

3. **Construction of Pucca Embankments (Example: Dibrugarh)** – Lessons can be drawn from flood-prone regions like Dibrugarh, where strong, permanent embankments have been built to contain river overflow. Similar pucca embankments in Bhagalpur can provide long-term protection against recurring floods.

4. **Adoption of Dozer Sheep Method** – In certain flood-prone regions, controlled grazing methods (locally referred to as "Dozer Sheep") are used to manage vegetation and stabilize embankments. Such innovative practices can be adapted to local conditions in Bhagalpur to reduce flood vulnerability.

5. **Construction of Dams and Reservoirs** – Multipurpose dams and reservoirs in upstream areas can help in flood moderation by storing excess water during heavy rainfall and releasing it gradually, thereby reducing peak flood levels downstream.

6. **Improvement of Technology and Early Warning Systems** – Advanced flood forecasting, GIS-based flood mapping, and real-time monitoring of rainfall and river discharge can strengthen early warning systems. Dissemination of accurate flood alerts through mobile networks and community radios can ensure timely evacuation and preparedness.

Conclusion

Floods in Bhagalpur district represent not only a recurring natural hazard but also a profound socio-economic challenge that continuously disrupts livelihoods, damages infrastructure, and forces large-scale migration. The analysis of historical flood events clearly shows that while the intensity and frequency of floods vary across years and blocks, their cumulative impact has entrenched poverty, weakened resilience, and created cycles of displacement among vulnerable populations. The disproportionate damage to kuccha houses, widespread displacement reflected in migration figures exceeding a million people in certain years, and the severe disruption of transport networks underscore the urgency of addressing this issue through comprehensive planning.

Although government agencies have taken measures such as embankment construction, relief distribution, and rescue operations, the persistence of annual devastation highlights the limitations of current strategies, which remain largely reactive rather than preventive. Sustainable flood management in Bhagalpur requires a shift towards long-term resilience-building through integrated watershed management, afforestation, adoption of erosion-control techniques like vetiver grass plantation, stronger embankments, and improved technological systems for early warning and preparedness. Equally important are socio-economic measures that focus on livelihood restoration, housing security, and community-based disaster management to reduce the compulsion for migration.

In conclusion, flood-induced migration in Bhagalpur is not merely an environmental phenomenon but a multi-dimensional crisis shaped by geography, infrastructure, and governance. Addressing it demands a holistic approach that combines structural measures with socio-economic reforms. Only through such integrated and forward-looking strategies can Bhagalpur move from a cycle of recurrent displacement towards resilience, stability, and sustainable development.

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