

Flood Impact Assessment: A Case Study of Heingang, Imphal East District in 2025

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Abstract

Flood remains one of the most recurrent and destructive natural hazards in the Imphal Valley of Manipur, particularly during the monsoon season. The 2025 flood event caused widespread damage to life, property, and infrastructure, with Imphal East District emerging as one of the worst-affected areas. This study assesses the magnitude and severity of flood impacts in Heingang village using a composite Flood Impact Severity Index (FISI) and evaluates household-level vulnerability through the Household Vulnerability Index (HVI). Primary data were collected from 103 households using a stratified random sampling method, supplemented by secondary data from government reports and published sources. Results reveal a moderate level of flood impact (FISI = 0.468), primarily driven by high floodwater depth and extensive structural damage. Household vulnerability analysis indicates extremely high exposure (E = 0.961), moderate sensitivity (S = 0.300), and limited adaptive capacity (AC deficit = 0.430), resulting in an overall HVI score of 0.276. The findings highlight the critical role of physical exposure and inadequate preparedness in shaping flood vulnerability. The study underscores the need for integrated flood management strategies emphasizing embankment strengthening, early warning systems, and community-based preparedness to enhance resilience in flood-prone areas of the Imphal Valley.

Keywords: Flood impact, vulnerability assessment, Impact Severity Index (FISI), Household Vulnerability Index (HVI)

Introduction

“Flood is a flow of water above the natural runoff channel” (Chow, 1956). The word ‘flood’ is originated from the old English word ‘flod’ akin to the German word ‘flut’ and the Dutch word ‘vloed’ seen as inflow and float of water (Ghapar, A. A., et al. 2018 and Adams, A.G. 2008). ‘Flooding is a dangerous natural phenomenon, a possible source of an emergency situation if flooding of an area with water causes material damage, damages the health of the population or leads to the death of people, farm animals and plants’ (Miroshnikova, 2021). The Oxford Reference Dictionary (ORD) defines flood as an overflowing or influx of water beyond its normal confines. Floods are described as the overflowing of the normal confines of a stream

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Published: 17 January 2026

DOI: <https://doi.org/10.70558/COSMOS.2026.v3.i1.25436>

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or other body of water, or the accumulation of water over areas that are not normally submerged. This includes river/fluvial floods. They can be very high-impact events. “Floods cannot be completely prevented, their impacts can be reduced through appropriate measures” (Abujam et al., 2023). “An integrated assessment of socioeconomic and environmental impact looking at both direct and indirect can be a contributing factor that can help to enhance the affected stakeholders’ response and recovery phase” (Samsuddin et al., 2021). There are two major kinds of floods, which include inundation (slow, builds up over hours or days) and flash floods (there are no streams in the area, usually six hours following a rainstorm, or due to dam or levee breakages). ‘A flash flood is a form of a flood that occurs suddenly and travels rapidly through the landscape with little notice’ (Priyanka et al., 2022).

Flood is a primary natural hazard in the valley during monsoon season damaging crops and properties of people. “Globally, flooding is one of the most dangerous disasters for economic loss and human fatalities” (Lavanya Sivan and Anitha, 2024). Flood hazard assessments results can be adopted by land use and development planners as part of an integrative approach to improve flood preparedness that can improve future land developments and raise community awareness (Bipinchandra et al., 2018). During the last decade of the 20th century, floods washed out 100,00 lives and impacted more than 1.4 billion people (Jonakman, 2005). In Manipur Valley, flash flood occurred every year during the rainy season due to the poor drainage condition. The primary causes of flood in Manipur Valley are heavy run off and less infiltration in degraded watershed in the upper reaches in the rivers during the rainy season (Final Report of MSTC).

In the flood occurred in 2025 at the Imphal Valley, over 56,000 people have been affected by flash floods in Manipur following the overflow of rivers and breaches in embankments, officials said on Tuesday. The floods have destroyed 10,477 houses, with 2,913 people evacuated from the worst-hit areas, mainly in Imphal East district. A new embankment breach occurred at Bashikhong after Kongba (TOI, 3-06-2025). The flood has affected over 1.66 lakh people and damaged 35,429 houses and 115.59 hectares of crop land across the state’s 706 villages, mostly in two districts of the valley such as Imphal West and Imphal East (Economic Times, June 7 2025).

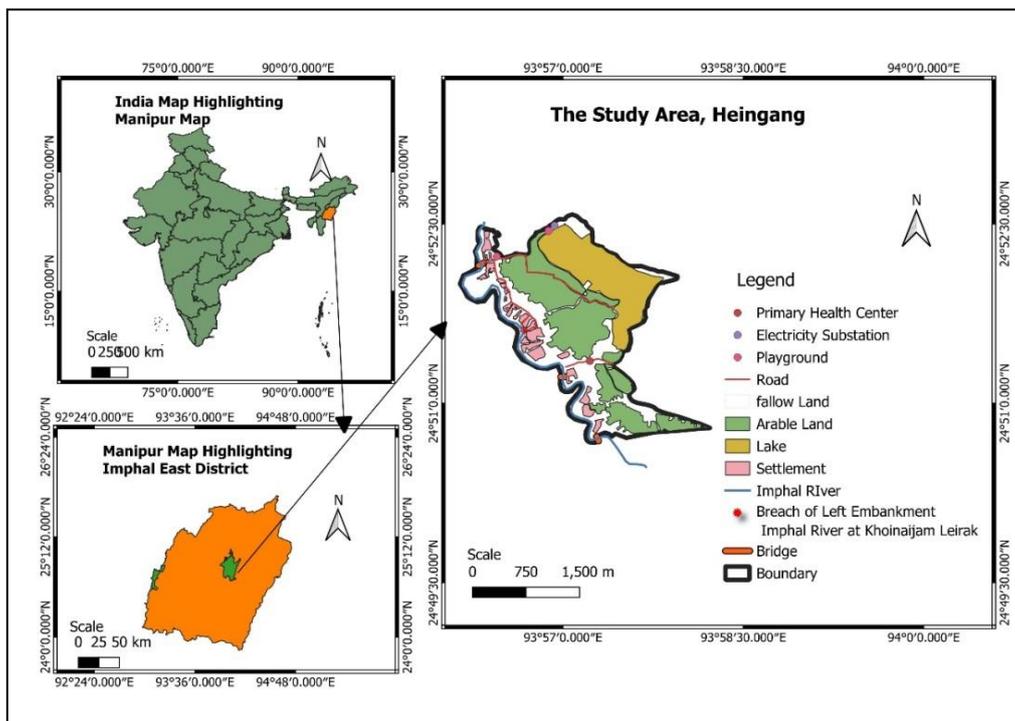
Imphal East district is one of the most affected areas of the last flood occurred in Manipur in 2025. Most parts of the Porompat Sub-division of Imphal East district where study area - Heingang is located are inundated during the flood. Heingang is one of the major spots of the flood where left river bank of the Imphal River is broken. Therefore, it is highly necessary to assess the impact of the flood on economic attributes, health condition, and other related infrastructure.

Study Area

The present study covers the Heingang which is affected by last flood in Manipur. The study area is located at the Porompat, sub-division of Imphal East District, Manipur. It is situated approximately 10 km north of the district headquarters at Porompat and 3 km from Imphal. The village is also part of the Heingang Assembly Constituency. It is surrounded by nearby villages namely Haraorou Tangkham, Kangla, Waiton, Kontha Ahallup, Keirang etc.

According to the 2011 Census the Heingang Census the Heingang town has population of 6115, male population is 3042 and female population is 3073 as per the Census 2011 data. Population of Children under the age of 0-6 is 726, male child population under the age of six is 375 and female child population under the age of six is 351. Total literacy rate of Heingang city is 84.93 percent that is higher than state average of 76.94 percent. Male literacy rate is 91.53 percent and that of female is 78.47 percent. In Heingang, female sex ratio is 1010 per 1000 male persons. Child sex ratio is 936 per 1000 male child under the age of six. Total number of house hold in Heingang is 1320. The area of Heingang is 4.41 hectare (0.0441 sq. km). The population density of the area is observed as 1387 per sq. hectare. In the religious attribute, Hindu accounts 5221 population out of the total population with 85.38 percent.

Figure 1: Flood Affected Area of Heingang, Imphal East District



Source: Prepared by Authors, Based on UTM Projection Zone 46 N and Datum-WGS 84 using QGIS

Objectives of the study

The primary objective of the study is:-

1. To assess the impact of flood in Heingang in 2025.

Materials and Methods

Sources of Data: The study is based on both primary and secondary sources of data. The report published by Manipur Science and Technology Council, government of Manipur, Economic Survey Manipur 2012-13 and 2017-18 published by Directorate of Economics and Statistics, government of Manipur are used. 103 samples were collected through household survey at the study area which is determined by Cochran's formula of sample size determination with interview scheduled on the basis of stratified random sampling.

Techniques: The Flood Impact Severity Index (FISI) is used to assess and quantify the severity of flood impacts by integrating physical, socio-economic, and environmental damage indicators into a single composite value. Flood Impact Severity Index (FISI) is expressed as

$$FISI = \frac{\sum_{i=1}^n (W_i \times S_i)}{\sum_{i=1}^n W_i}$$

Where, S_i = Severity score of the i^{th} indicator, W_i = Weight assigned to the i^{th} indicator and n = Number of indicators. The FISI is ranged from 0 to 1 where, 0–0.33, 0.34–0.66 and > 0.66 represent low, moderate and high respectively.

The Household Vulnerability Index (HVI) is also applied to measure how susceptible a household is to flood impacts based on exposure, sensitivity, and adaptive capacity.

$$HVI = \frac{E+S-AC}{3}$$

Where, **E** = Exposure Index, **S** = Sensitivity Index and **AC** = Adaptive Capacity Index. Sub-indices are computed with following formula

$$\text{Exposure (E)} = \frac{\sum E_i}{n}$$

$$\text{Sensitivity (S)} = \frac{\sum S_i}{n}$$

$$\text{Adaptive Capacity (AC)} = \frac{\sum AC_i}{n}$$

Table 1: Indicators and variable of The Household Vulnerability Index (HVI)

Indices	Sub-indices (Components)	Variables (Parameters)
Flood Impact Severity Index (FISI)	Structural impact	It is measured in percentage of houses impact
	Water depth	It is measured by dividing average depth in feet by severe benchmark (6 feet)
	Health problems	It is measured in percentage of families with diseases
	Infrastructure disruption	It is measured in percentage of households reporting damage to electricity, water, education, health, religious, communication, and transport.
	Exposure Index, E	<ol style="list-style-type: none"> 1. houses inundated 2. households saying vulnerable months May–July 3. households citing riverbank destruction / overflow as cause

The Household Vulnerability Index (HVI)	Sensitivity Index, S	<ol style="list-style-type: none"> 1. Dependency ratio proxy: % aged <15 or 60+ 2. Primary-sector households (more climate-sensitive livelihoods) 3. Non-workers (economic fragility)
	Adaptive Capacity Index, AC	<ol style="list-style-type: none"> 1. timely warning 2. know what to do 3. received assistance 4. evacuation shelter provided

Maximum minimum normalization technique is also employed to measure the value of each indicator and variability used in FISl and HVI.

$$X' = \frac{X - X_{min}}{X_{max} - X_{min}}$$

Each value of sub-indices is ranged from 0 to 1. Higher the HVI indicates more vulnerable.

Analysis Tools: For analysis of the study, SPSS and MS excel were used for the tabulation and statistical calculation. QGIS and Google Earth Pro were used to prepare the study area map.

Result and Discussion

Flood Impact Severity Index (FISI)

Table 2 illustrates the severity of flood impacts experienced in Heingang, Imphal East District, during the flood event of 2025. The index amalgamates weighted indicators that encompass structural damage, floodwater depth, health repercussions, and infrastructure disruption to formulate a comprehensive measure of flood severity. The overall Flood Impact Severity Index (FISI) value of 0.468 signifies a moderate flood impact level, in accordance with the classification threshold that categorizes values ranging from 0.34 to 0.66 as indicative of moderate severity. This observation intimates that, although the flood did not attain catastrophic proportions, it nonetheless inflicted extensive and significant disruption upon the physical, social, and functional systems within the study area. Among the discrete components, water depth (D) exhibited the highest index value (0.613) with a weightage of 0.25, rendering it the most significant contributor to the aggregate FISI score. This elevated value mirrors the considerable depth of floodwater recorded during the event, with average water levels nearing the severe threshold of six feet. Heightened floodwater depth possesses direct ramifications for the magnitude of damage sustained by residential structures, household assets, and essential services. Extended inundation at such depths not only jeopardizes structural integrity but also prolongs recovery times and escalates economic losses. The preeminence of water depth in ascertaining flood severity aligns with antecedent flood impact research, which recognizes depth and duration of inundation as salient determinants of damage intensity and loss magnitude.

The structural impact (S) component, assigned the highest weightage (0.30), recorded an index value of 0.534, indicating that more than half of the housing structures in Heingang were affected by the flood. The moderate-to-high structural damage observed can be ascribed to the breach of the left bank of the Imphal River and the settlement's proximity to the floodplain. The findings indicate that the existing residential structures exhibit insufficient flood resilience, potentially attributable to the prevalence of non-engineered edifices, low plinth heights, and the lack of flood-resistant construction materials. Given its heightened weightage, the structural impact exerted a significant influence on the composite FISl value, accentuating the pivotal role of physical infrastructure vulnerability in delineating overall flood severity.

Table 2: Flood Impact Severity Index (FISI), Heingang, Imphal East District, in 2025

Components with code	Weightage	Variables Measurement	Index Value
Structural impact (S)	0.30	Houses impact	0.534
Water depth (D)	0.25	Average depth	0.613
Health problems (H)	0.20	Families with diseases	0.466
Infrastructure disruption (I)	0.25	Mean of percentage households reporting damage to electricity (34.95), water (65.04), education (4.85), health (0.97), religious (8.73), communication (12.62), transport (45.63)	0.247
Overall FISl			0.468

Source: Computed from field survey, 2025

The health problems (H) component produced an index value of 0.466 with a weightage of 0.20, signifying a moderate level of health-related impacts. This value denotes the proportion of households reporting flood-induced illnesses, inclusive of waterborne diseases, skin infections, and respiratory ailments. Although the index value is inferior to those of water depth and structural impact, it nonetheless reflects substantial public health strain in the aftermath of the flood. The accumulation of stagnant water, contamination of potable water sources, and disruption of sanitation facilities are likely contributing factors to these health outcomes. Nevertheless, the relatively moderate value suggests that either the duration of exposure was restricted or that some degree of healthcare access and coping mechanisms mitigated the onset of widespread health crises.

In contrast, infrastructure disruption (I) recorded the lowest index value (0.247), despite being assigned a relatively high weightage of 0.25. This component was derived from the mean percentage of households reporting damage across various infrastructure sectors, including electricity, water supply, educational institutions, health facilities, religious establishments, communication networks, and transportation systems. While damage to specific services—most notably water supply (65.04%) and transport (45.63%)—was considerable, other sectors such as health (0.97%) and education (4.85%) encountered minimal physical damage.. The

lower composite index value indicates that, although essential services were disrupted, complete infrastructure failure was not widespread. This suggests a degree of resilience in public infrastructure or rapid post-flood restoration efforts, which helped reduce the overall severity score for this component.

The combined effect of these four components resulted in an overall FIS I score of 0.468, firmly placing the 2025 Heingang flood in the moderate impact category. This composite score reflects a balance between high-impact physical factors, such as water depth and housing damage, and relatively lower impacts on social infrastructure and public facilities. The results highlight that flood severity in Heingang was not uniform across sectors; instead, it was characterized by intense physical exposure and housing vulnerability, accompanied by moderate health impacts and comparatively lower infrastructure disruption.

From a planning and policy perspective, the FIS I analysis highlights the need to prioritize structural mitigation measures, particularly in flood-prone residential zones. Strengthening river embankments, enforcing flood-resilient building codes, and elevating housing plinth levels could substantially reduce structural damage in future flood events. Additionally, the prominent role of water depth in determining flood severity suggests the importance of improving drainage capacity and floodwater management systems to reduce inundation depth and duration. The moderate overall severity masks critical sector-specific vulnerabilities, particularly in housing and exposure to deep floodwaters.

Household Vulnerability Index (HVI)

Table 3 presents the results of the Household Vulnerability Index (HVI) for Heingang, Imphal East District, during the 2025 flood event. The HVI integrates three interrelated dimensions of vulnerability—exposure, sensitivity, and adaptive capacity—into a composite index that reflects the degree to which households are susceptible to flood impacts. The overall HVI value for the study area is 0.276, indicating a low to moderate level of household vulnerability. However, a closer examination of the sub-indices reveals substantial internal variation, emphasizing that vulnerability in Heingang is unevenly distributed across its components.

The Exposure Index (E) records an exceptionally high value of 0.961, making it the most significant contributor to household vulnerability. This reflects the near-universal physical exposure of households to flooding. The index value for houses inundated (0.981) demonstrates that almost all surveyed households experienced direct floodwater intrusion, underscoring the severe spatial exposure of the settlement. Heingang’s location in a low-lying floodplain near the Imphal River and the breach of river embankments played a critical role in intensifying flood exposure.

Table 3: Flood: Household Vulnerability Index (HVI), Heingang, Imphal East District in 2025

Sub-indices with code	Variables measurement	Index value of variables	Sub-indices index value
	Houses inundated	0.981	

Exposure (E)	Households saying Vulnerable months May–July	0.932	0.961
	Households citing riverbank destruction/overflow	0.971	
Sensitivity (S)	Dependency ratio proxy	0.404	0.300.
	Primary-sector households (more climate-sensitive livelihoods)	0.311	
	Non-workers (economic fragility)	0.184	
Adaptive Capacity “deficit” (AC)	Timely warning	0.311	0.430
	Know what to do	0.369	
	Received assistance	0.350	
	Evacuation shelter provided	0.689	
Overall HVI			0.276

Source: Computed from field survey, 2025

Additionally, the elevated index value for households recognizing the months of May to July as vulnerable periods (0.932) underscores the seasonal and recurrent characteristics of flooding within the region. This temporal exposure suggests that floods should not be perceived as singular catastrophes but rather as predictable annual phenomena, thereby exacerbating cumulative risk over time. The variable pertaining to riverbank erosion or overflow (0.971) further accentuates the underlying structural determinants of exposure, indicating that failures in embankment integrity and insufficient flood management infrastructure serve as principal catalysts for flood hazards. Collectively, these indicators validate that the exposure experienced in Heingang is fundamentally rooted in structural conditions and geographically delineated, thereby limiting households' capacity to mitigate the impacts of flooding.

In contrast, the Sensitivity Index (S) registers a relatively modest value of 0.300, implying that socio-demographic and economic attributes exert a moderate influence on household vulnerability. The dependency ratio proxy (0.404) signifies the presence of minors and elderly individuals within certain households, which may exacerbate caregiving responsibilities and restrict adaptive responses during flooding events. Nevertheless, this factor in isolation is inadequate to significantly amplify sensitivity at the community level.

The fraction of households engaged in the primary sector (0.311)—those reliant on climate-sensitive economic activities such as agriculture—remain comparatively low, thereby diminishing sensitivity related to livelihood disruptions from flood shocks. Furthermore, the non-worker index value (0.184) is the lowest among sensitivity indicators, suggesting minimal economic vulnerability and a degree of income stability or livelihood diversification. These observations indicate that while specific households encounter demographic and occupational vulnerabilities, the overall sensitivity in Heingang remains moderate and does not exacerbate flood-related impacts to a critical extent.

The Adaptive Capacity “deficit” Index (AC) presents a value of 0.430, signifying moderate constraints in preparedness, response, and recovery mechanisms. Among the indicators of adaptive capacity, the provision of evacuation shelters (0.689) demonstrates the highest index value, reflecting the availability of temporary refuge during flooding events. This implies the existence of certain institutional arrangements for emergency response, which have contributed to alleviating immediate displacement risks.

However, the lower index values for timely warning (0.311) and awareness of appropriate actions (0.369) unveil considerable deficiencies in the dissemination of early warnings and disaster preparedness knowledge. The lack of effective warning systems diminishes households’ capacity to implement precautionary measures, such as timely evacuation or asset safeguarding. Similarly, the moderate index value for received assistance (0.350) suggests that post-flood relief and institutional support were either inadequate or unevenly allocated, thereby hindering recovery efforts.

The composite HVI value of 0.276 encapsulates the cumulative effects of extreme exposure, moderate sensitivity, and constrained adaptive capacity. Although the comprehensive vulnerability score does not classify as high, this should not obscure the structural vulnerabilities stemming from persistent and widespread exposure. The relatively diminished sensitivity and partial adaptive capacity have functioned as buffering elements, preventing the escalation of vulnerability. Nonetheless, in the absence of substantial reductions in exposure and enhancements in preparedness, households remain at considerable risk in light of prospective flooding events. The finding of study demonstrates that household vulnerability in Heingang is primarily driven by physical exposure rather than socio-economic sensitivity. The HVI framework thus provides a comprehensive understanding of flood vulnerability and offers a valuable analytical basis for planning targeted flood mitigation and resilience-building interventions in the Imphal Valley.

Conclusion

The current investigation presents a thorough evaluation of the repercussions of flooding and the susceptibility of households in Heingang, located in the Imphal East District, during the flood event of 2025, employing both the Flood Impact Severity Index (FISI) and the Household Vulnerability Index (HVI) in its analysis. The findings suggest a moderate degree of flood impact (FISI = 0.468), predominantly driven by significant floodwater depth and extensive destruction of residential buildings. Although the damage inflicted on public infrastructure was comparatively minimal, the disruption of essential services, including water supply and transportation, substantially influenced the daily lives of residents. The analysis of household vulnerability indicates an exceedingly high level of exposure (E = 0.961), attributable to the area's low-lying topography and breaches in the embankments along the Imphal River. Conversely, sensitivity levels remained moderate (S = 0.300), indicating relatively stable socio-economic conditions, whereas deficits in adaptive capacity (AC = 0.430) underscore inadequacies in the dissemination of early warnings, preparedness measures, and post-flood support. Collectively, the study underscores that the vulnerability to flooding in Heingang is predominantly a consequence of physical exposure rather than socio-economic instability. Mitigating future flood risks necessitates the fortification of embankments, the enhancement

of drainage systems, the improvement of early warning systems, and the fostering of community-based preparedness initiatives. The integrated FISI–HVI framework offers a valuable paradigm for assessing flood risk and planning for resilience in flood-prone areas of the Imphal Valley.

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