



## Need of Multi-Hazard Risk Mitigation in Bihar

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**ABSTRACT:** Disasters are responsible for tremendous loss of life and property in urban as well as rural areas. Disaster prone states like Bihar, with very high vulnerable population, haphazard and unstructured development and weak coping capacity and economic development, are severely impact by the natural and manmade disasters. Vulnerability of Bihar towards the natural disasters is mainly due to its unique geological and geographical situations which make it “home state of hazards”, where nearly every district is prone to the major natural hazards like cyclone, flood and earthquake etc. Direct losses due to disaster events have been estimated about two percent of Indian GDP and about twelve percent of central government revenues. The state of Bihar is one of the top ten states of India in case of lost human lives, cattle loss, crop area damaged and houses damaged. Disaster risk in Bihar is further enhanced by vulnerabilities related to its multi hazard profile of the state, diversified socio-economic condition, unchecked development along vulnerable areas, weak infrastructure and risks of climate change.

Requirement of disaster risk mitigation in Bihar through assessment for disaster vulnerability of various zones against major hazards is identified in this paper. It further elucidates the issues in Bihar regarding its proneness to disaster risk, its mitigation and management.

**Keywords:** Building typologies, Disaster loss, Hazard profile, Multi-hazard , Risk mitigation, Vulnerability profile.

### I. INTRODUCTION

Fast growth rate and development of Bihar have challenges in form of increase in frequency of occurring disaster, magnitude of hazards and negative impact on overall ecosystem. Bihar is a state with complex geological and geographical conditions. Due to its unique geographical and hydro geological conditions due to many fault lines, several low landed areas and rivers with floods and close vicinity from the Bay of Bengal, Bihar is susceptible to several natural disasters. It's exposure towards natural disasters is also accentuating India's critical status as a nation sensitive against climate change. Developing countries like India have faced more damage and loss of life due to their immense geographical diversity and relatively weak institutional framework and preparedness against the risks related to disasters [16]. Global efforts do not seem to be adequate, to cope with rapidly increasing frequency and magnitude of disaster events. During the decade 1991-2000, 66, 59,598 people have loosed their life due to natural disasters, of which 65% are from the developing countries, while developed nations shares only 4% of the reported casualties [18].

In present scenario, there are more than 18.9 million housing units in Bihar state. Out of these 85% are non-engineered building units and most of the urban built-environment in Bihar is delivered by 'owner-builders'. It is important to identify the vulnerability of the houses of Bihar against multi-hazards. Most of the regions of Bihar are facing multi-hazards and the majority of the people are living in the rural areas underneath the buildings made with local knowledge and techniques. Since 2002, India has taken substantive steps towards developing a suitable policy

environment that promotes comprehensive disaster risk management, environmental sustainability and climate resilience [11]. However analysis of recent disaster events in Bihar and recent observations within the state like River Kosi flooding (2008) show that present disaster management and mitigation measures are severely limited financial and skilled resource and face an uphill task in meeting expectations. India's progress report on the Hyogo Framework for Action also highlights that while much is being done to plan and implement DRR measures; there are real challenges in devolving powers and resources at the grassroots level.

Agriculture, infrastructure, transportation, and water sectors are highly sensitive against disasters; hence developing risk mitigation approach addressing specifically these and other areas is needed [12, 13]. As natural & human activity induced disasters are increasing in frequency there is a need for modern approach to address disaster mitigation and management, policy and planning.

### II. DISASTER RISK

Conceptualization of disaster risk includes assessment of the hazards, vulnerability and exposure of communities against any human induced or natural hazard (Eqn. 1). A hazard is an extreme, threatening event which has potential to adversely affect human life, activity, property or the ecosystem that supports them. Risk is expected loss of lives, damage of property and disruption in economic activity due to a particular hazard.

Equation of Disaster Risk:

$$R = F \cdot H \cdot V \cdot E \quad (1)$$

Where R: Disaster Risk; H: Hazard; V: Vulnerability;

E: Exposure, implying risk, hazard and vulnerability are related, but not synonymous. Vulnerability has been as “the degree to which communities or infrastructure are susceptible to harm or loss in the face of a hazard” [21]. While Hazards and vulnerability negatively affect the resilience, exposure is the factors by which thereby the disaster risk is effective on the communities. Different sections of communities respond in a different way to natural calamities and disasters. Marginalized and low income groups of societies are more vulnerable section as they have limited access to safety networks. Risk is characterized by impact, probability, severity, exposure, vulnerability or types of hazards [14, 17].

**Table 1: Top 10 Countries by Number of People Affected due to Disasters (2018) [22].**

S. No.	Country	No. of People Affected
1	India	23,900,348
2	Philippines	6,490,216
3	China	6,415,024
4	Nigeria	3,938,204
5	Guatemala	3,291,359
6	Kenya	3,211,188
7	Afghanistan	2,206,750
8	USA	1,762,103
9	Japan	1,599,497
10	Madagascar	1,472,190

### III. SCENARIO IN BIHAR

The State of Bihar, having predominantly rural population, is a multi-hazard prone state. The geoclimatic conditions of Bihar are responsible for its vulnerability towards several hazards. The livelihood and lives of millions of Bihari people gets affected by different types of disasters from time to time. Natural disasters, which have different origin force from man-made disasters, are those disasters whose principal and direct causes are forces of nature [15].

**Table 2: Loss of Public property in Bihar due to natural disasters during the period 1998-2012 [10].**

Loss Due to Natural Disasters in Bihar				
Year	People affected (million)	Human lives lost	Houses and Buildings damaged (Rs. Crore)	Public property damaged (Rs. Crore)
2012	0.240	15	1.595	1.62
2011	7.143	249	69.04	1.54
2010	0.718	32	7.05	1.69
2009	2.203	97	5.28	5.30
2008	4.995	258	84.51	97.72
2007	2.444	1287	831.45	642.42
2006	1.089	36	12.25	84.56
2005	2.104	58	3.83	3.05
2004	21.299	885	758.1	1030.5
2003	7.602	251	20.32	10.35
2002	16.018	489	526.22	408.92
2001	9.091	231	173.58	183.54
2000	9.018	336	209.34	37.81
1999	6.566	243	53.85	54.1
1998	13.470	381	55.04	92.84
1997	6.97	163	30.57	20.38
1996	6.733	222	14.95	10.36
1995	6.629	291	75.10	21.84
1994	4.012	91	4.95	1.52
1993	5.352	105	88.14	30.41
1992	0.556	4	0.16	0.0075

Natural disasters like Kosi Flood of 2008 and deadly Earthquake of 1934 have been worst disasters in the history of the country and Bihar. In addition, manmade disasters are also threat to the millions of people residing in the state. Disasters with increased frequency, due to environment and climate change issues, are responsible for tremendous life loss of human and public property have been at the centre of it, thus an eco-sensitive approach is required to cope up with them (Table 2) [7-9].

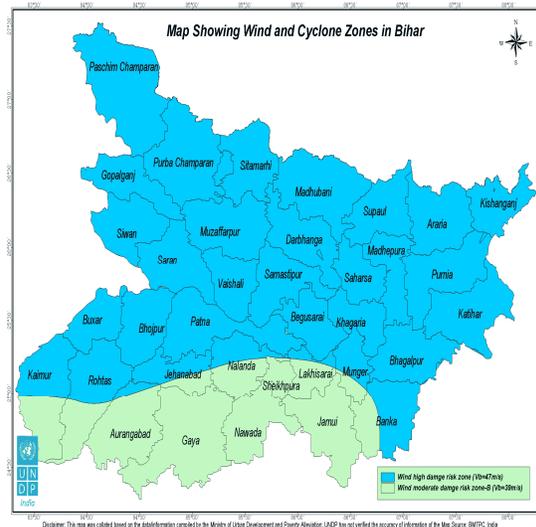
### IV. HAZARD VULNERABILITY PROFILE OF BIHAR

Bihar is highly vulnerable to several hazards mostly due to its geographic complexion, its boundary, the climate, the socio-economic status and, above all, its geological conditions and geographic location which makes it the home state of disasters. Almost every district is prone several major natural hazards i.e. earthquake, floods, and cyclone etc.

#### A. Wind Hazard Profile of Bihar

Twenty seven districts out of thirty eight districts are totally affected by high intensity wind’s speed of 47 m/s alongwith nearly 90% of the district areas of— Arwal, Banka, Jehanabad, and Nalanda and every other district of South Bihar except Nawada is partly affected by the same.

The only district of Bihar which is 100% affected by high intensity winds speed of 39 m/s is, Nawada. Overall eightysix percent of the total area of the state Bihar is susceptible to high speed wind hazard of 47 m/s intensity (Fig. 1).

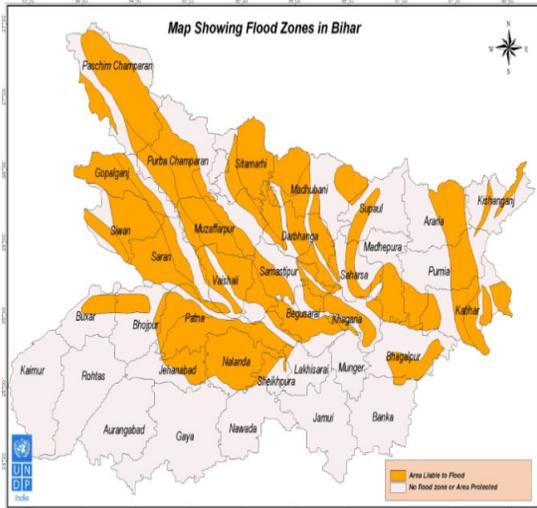


**Fig. 1. Wind Hazard Map of Bihar [2].**

**Vulnerability due to Wind Hazard.** Cyclone or High Speed Wind is one among the most disastrous hazards that can affect society adversely, destroy everything around, which means that almost 8.93 million people are living in a highly vulnerable area [3]. Out of 1.63 million buildings in the state approximately 0.64 million houses made of unburnt brick wall join by mud metrix with lightweight thatched roofs, which are severely at risk to High Speed Winds. Approximately 1.45 million people living in 0.661 million mud houses with light weight roof are in the moderate damage zone.

**B. Flood Hazard Profile of Bihar**

Bihar is a playground of Himalayan Rivers namely Ghaghra, Gandak, BurhiGandak, Bagmati, Kamla, Kosi and Mahanada origins at the Himalaya. During monsoon these rivers receive very high rainfall and there discharge is peaked to 50 to 90 folds higher. This originates frequent and high scale flooding in Northern Bihar. According to *Vulnerability Atlas of India*, about 74% of the total area of North Bihar is prone to floods (Fig. 2). On the other hand, In South Bihar, rivers are primarily rain fed, originating either in the Chotanagpur Hills or in the Vindhyaachal Hills and Sone, Punpun, Karmanasa, Kiul, Chandan etc., are the important rivers flowing in this region. The total flood affected geographical area is 56% of the overall geographical area [11].



**Fig. 2.** Flood Hazard Map of Bihar [2].

Every year because of flood big loss of property, people and infrastructure occurs in almost twenty eight districts. Districts of Sitamarhi, Supaul and Kishanganj are almost 90% and five other districts, Madhepura, Bhagalpur, Khagaria, Saharsa and Darbhanga, are about 70% area are affected by flooding. Rest of 20 districts, this data varies from 25% to 55% of total geographical area.

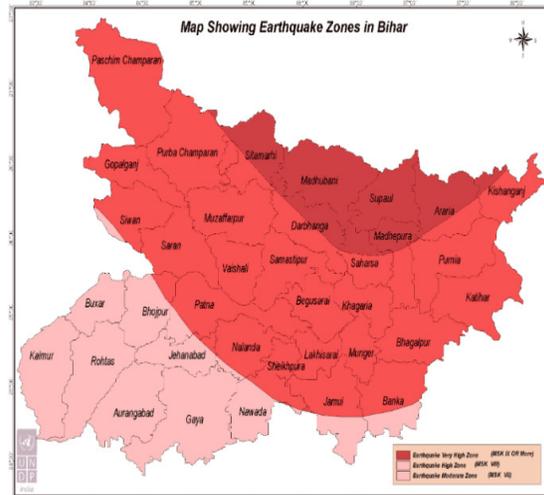
**Vulnerability due to Flood Hazard.** The vulnerability of Bihar is intense from flood point of view on all the most important 5 factors: Density of threshold population, Location, Poverty, Awareness and Preparedness of the people [4].

Out of 38, 15 districts are highly vulnerable and 13 districts are vulnerable to flood hazard. About 31.46 million people are vulnerable to flood hazard in the state of Bihar. Around 1.26 million houses and 27,974 hectares of irrigated land are highly vulnerable for flooding, out of which families living in mud houses are liable to suffer most. Approximately half of the net agricultural land is vulnerable to flooding which originates huge risk for economy and livelihood of Bihar as it is primarily agrarian.

**C. Earthquake Hazard Profile of Bihar**

Bihar lies in the high seismic zone having 6 sub-surface fault lines and at the boundaries of young and highly active Himalayan tectonic plate, which makes it vulnerable to earthquake disaster of near maximum intensity. In all 15.2%, 63.7% and 21.1% area of the

state Bihar is in earthquake risk Zones V, IV and III respectively. eleven districts of Bihar is located in Zone five out of which, Madhubani and Supaul are fully; 2 districts—Araria and Sitamarhi, about 85%; Dharbhanga, Madhepura & Saharsa, more than 45% and the rest 4 districts namely-Purnia, Kishanganj, Muzaffarpur, and Sheohar have about 10% area is in the same zone (Fig. 3). Twenty nine other districts (either fully or partially) of north and south Bihar lies in earthquake risk zone IV which means approximately 79% area of Bihar is in high earthquake risk zones of IV or V.



**Fig. 3.** Earthquake Hazard Map of Bihar [2].

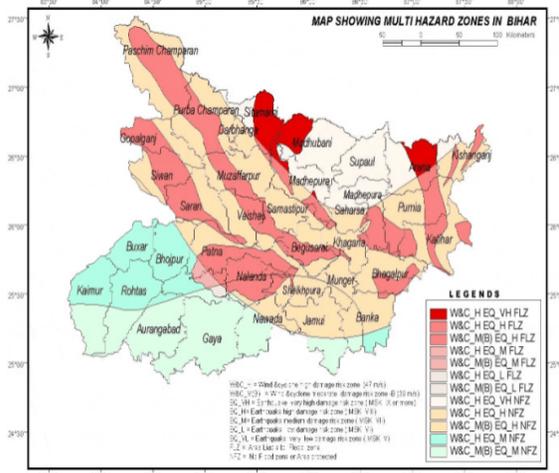
**Vulnerability due to Earthquake Hazard.** As about fifteen percent area of Bihar is in Zone V which means that about 15.78 million people (Census 2011) are leaving in high risk zone [3]. Since these people are living in either 0.77 million kutchha houses or 1.4 million brick walled houses, and 1.1 million in houses of other materials, they vulnerable for losing their life, abode and loss of property. Most of the people residing in about sixtyfour percent area of Bihar falling in earthquake hazard Zone IV and rest about twentyone percent area of Bihar falling in earthquake hazard zone III are also suffering from same kind threat of lower degree of risk against earthquakes.

**V. MULTI- HAZARD VULNERABILITY PROFILE OF BIHAR**

Multi-hazard situation arises when more than one hazard event impacts the same area [14]. When areas are prone to many natural hazards, an effective risk reduction is possible only if all relevant threats are considered and analyzed [19]. Multi hazard risk assessment is an integrated approach to address vulnerability, risk assessment and disasters. The existing risk management approach and methodologies requires a comprehensive understanding of various multi hazard risks. Single hazard result approach is not inclusive and results in focusing management other than mitigating specially areas like Bihar which is inherently vulnerable to multiple natural disasters. Bihar is vulnerable to several hazards, which makes situation more complicated and dangerous. Multi-hazard profiles of the state (Fig. 4) and hazard prone districts are shown below (Table 3).

**Table 3: Multi-hazard Prone Districts of Bihar [10].**

Name of District	Percent Area of Districts					Flood Proneness in %
	Seismic Zone			Wind Velocity		
	V	IV	III	47 m/s	39 m/s	
Madhepura	53	47		100		25.8
Dharbanga	64	36		100		71.2
Sitamarhi	86	14		100		92
Madhubani	100			100		43
Supaul	100			100		81.5
Araria	85	15		100		41.2
Saharsa	45	55		100		79
Muzaffar-pur	7	93		100		22.5
Kishanganj	9	91		100		92
Purnia	4	96		100		31.8
Katihar		100		100		26.5
W.Champaran		100		100		33.7
E.Champaran		100		100		24
Gopalganj		100		100		8.9
Siwan		99	1	100		14
Saran		100		100		22
Samastipur		100		100		31.5
Begusarai		100		100		33.5
Khagaria		100		100		67
Bhagalpur		100		100		68.5
Banka		92	8	87.5	12.5	3
Munger		100		100		7.0
Lakhisarai		100		100		54.5
Sheikhpura		100		52.5	47.5	54
Nalanda		98	2	85.0	15.0	36.7
Patna		88	12		100	55
Nawada		38	62	100		9.8
Jamui		74	26	3.0	97.0	2
Buxar			100	100		5
Rohtas			100	58	42	10.1
Bhojpur		12	88	100		6.8
Jehanabad		19	81	95.7	4.3	13.6



**Fig. 4. Multi Hazard Map of Bihar [2].**

**VI. CONCLUSION**

Very large area of Bihar is prone to natural hazards like flood, earthquake, storms etc. Situation of multi-hazards is common in the region and socio-economic vulnerability of the Bihar is high due to high population and geographical conditions. It can be concluded from the above study that north Bihar has higher multi-hazard vulnerability than the southern part. Some of

the districts of north Bihar, including Supaul, are most vulnerable and they have the highest probable intensity of different hazards by area.

The Vulnerability level of, different types of vernacular buildings depend upon construction material, building form, maintenance etc. [1]. The local construction practices and architecture needs to be modified with respect to the vulnerability but also in context with the socio-economic aspects of the habitants. All new construction of housing needs to have disaster resistant features depending upon the major hazards of the area. The housing constructed without sufficient disaster resistant elements need to be retrofitted.

The multi-hazards scenario makes the situation more dangerous. Combined assessment for different hazards is needed to be done. Transformation of hazards into disaster events is one of the fundamental problems which contribute as a negative catalyst in development of Bihar, which is also responsible for its enhanced vulnerability towards disaster events. The existing policy and institutional framework which is mainly focused on coping with disasters, in place have to focus disaster risk mitigation and prevention [5, 6]. There is requirement to reduce the disaster risk through reducing vulnerability and by strengthening the disaster mitigation framework which includes strengthening of socio-economic, infrastructure and political aspects.

**FUTURE SCOPE**

Disaster vulnerability of various zones against major hazards assessed through this research paper. This assessment can provide appropriate direction to planners and policy makers and can help in decision making while formulating policies for new development as well as transformation of existing infrastructural setup. The study pointed out that relationship between multi hazards, disasters loss and different vernacular building typologies. Further research can be undertaken at micro level in various zones in order to determine suitability of building materials and technologies in order to achieve sustainability in view of disaster risk.

**Conflict of Interest.** There is no conflicts of interest between authors for this research regarding publication or authorship.

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