Risk Factors Associated with Earthquake in Sikkim

Depesh Subba*[1]

Abstract

Disaster is a sudden catastrophic event caused by natural hazards or human-induced or sometimes from a combination of both which results in substantial loss of lives, damage and destruction of property and environment. With the advancement of science and technology, there has been some progress in prediction, preparedness and management of natural hazards. However, such progress has been negligible in case of earthquake which is a sudden and unpredictable geophysical events.

Disasters are prevalent worldwide and India is no exception to disasters. India is one of the most vulnerable countries in the world and 59% of its land area is vulnerable to seismic hazards. The entire Himalayan region is considered as vulnerable to high-intensity earthquakes. This article is based on Sikkim- an Eastern Himalayan State which falls under the seismic Zone IV. The earthquake of 18 September 2011 of 6.8 RS is the most devastating in Sikkim history which caused huge loss. The paper tries to comprehend the risk factor associated with earthquake due to recent surge in urban growth and industrial units/development projects.

Keywords: *Eastern Himalaya, Sikkim, Urbanization, Industrial Units, Development Projects.*

1. Introduction

The United Nations International Strategy for Disaster Reduction (UNISDR 2009) defines disaster as "A serious disruption of the functioning of a community or a society involving widespread human, material, economic or environmental losses and impacts, which exceeds the ability of the affected community or society to cope using its own resources." Likewise, the Disaster Management Act of 2005 of India defines disaster as

[1] **Depesh Subba,** Assistant Professor (Environmental Studies) at Sikkim Institute of Higher Nyingma Studies(SIHNS/ Sheda), Government of Sikkim.
* Corresponding Author Email: depeshsubba11@gmail.com

"a catastrophe, mishap, calamity or grave occurrence in any area, arising from natural and man-made causes, or by accident or negligence which results in substantial loss of life or human suffering or damage to, and destruction of, property, or damage to, or degradation of, environment, and in of such a nature or magnitude as to be beyond the coping capacity of the community of the affected area". In simple, disaster is caused by natural hazards or human-induced or sometimes from a combination of both which damages lives and properties.

Generally, the natural hazards are classified into five major categories viz., meteorological, geophysical, climatological, hydrological, and biological (National Disaster Management Plan 2016). In last decade (2010-2019), there have been 2,850 disasters triggered by natural hazards where 83% were caused by climate and weather-related extreme events. These disasters affected 1.8 billion people approximately. In 2019, 308 disasters were triggered by natural hazards affecting 97.6 million people where floods (127), storms (59), disease outbreaks (36), earthquakes (32) and hydrological-related landslides (25) were the most frequent (World Disaster Report 2020).

Over the years, some progress has been made in prediction, preparedness, evacuation, recovery, management of hazards with the advancement in science and technology. However, there are some hazards like earthquake where progress has been negligible. The earthquake is a geophysical event which is sudden and unpredictable in nature and can trigger a huge disaster.

Table 1: Earthquakes from 1960 to 2019

Geophysical	Since 1960		2010-2019		2019
	Total	Annual Average	Total	Annual average	Total
Earthquake	1021	17	131	13	32

(Source: World Disaster Report 2020: Come Heat or High Water, IFRC.)

From 2010 to 2019, our world had experienced total of 131 earthquakes. In the year 2019 alone, world had experienced 13 incidents of earthquakes. It shows that earthquake is an inevitable event and has been great threat to human civilization considering its unpredictable nature and intensity. Therefore, preparedness by limiting vulnerabilities is the best option we have to mitigate the effect of earthquakes.

2. Earthquake in India

India with diverse physiographic and climatic settings is exposed to various natural and anthropogenic hazards. Factors like climate change and population growth further make India one of the most vulnerable countries in the world (Nambiar 2015). India's 59% of land area is vulnerable to seismic hazard (National Disaster Management Plan 2016) and the Indian subcontinent has experienced high number of devastating earthquakes in last decade (Mohapatra and Mohanty 2010). The entire Himalayan region is considered as vulnerable to high intensity earthquakes with magnitude exceeding 8 Richter Scale (RS) (National Disaster Management Guidelines: Management of Earthquakes 2007).
Given the regional threat of earthquake, the small Eastern Himalayan State of Sikkim falls under the seismic Zone IV; i.e. high damage risk zone or destructive in nature. As per National Centre for Seismology (NCS), twenty nine cities and towns in India are categorized highly vulnerable to earthquakes which also include Gangtok - capital city of Sikkim[2]. So, considering the location and risks factors, the article tries to put light on vulnerability aspects of earthquakes in Sikkim.

3. A Brief Seismic Background of Sikkim

Sikkim is situated in the Eastern Himalaya. It is known for its pristine environment and rich biodiversity. There is wide rural-urban population composition where 74.85% lives in rural area while 25.15% in urban area. The East district is the most urbanized district among four districts where urban population constitutes 43.19% which is above state figure of 25.15% (Census of India, 2011).

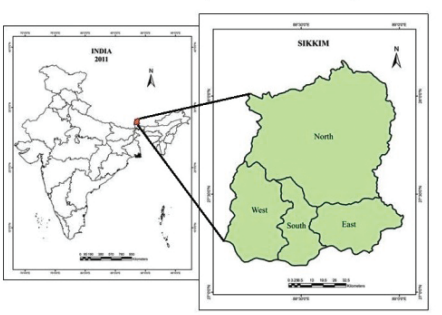

Figure 1: Location Map of Sikkim

Sikkim is located in the Alpine-Himalayan mountain system- a major earthquake belt and falls under zone IV which is high damage risk zone or destructive in nature (Bureau of Indian Standard). The Bureau of Indian Standard (BIS) has categorized the country into four seismic zones viz. Zone II, Zone III, Zone IV and Zone V. The seismic Zone V represents seismically the most prone region with higher incidence of activities of earthquakes which includes majority of northeastern states, parts of Jammu and Kashmir, Himachal Pradesh, Uttaranchal, Rann of Kutch in Gujarat, part of North Bihar and Andaman & Nicobar Islands. Zone II is the least prone region with lower incidents of activities of earthquakes. Sikkim is categorized in Zone IV along with Jammu & Kashmir and Himachal Pradesh, Union Territory of Delhi, northern parts of Uttar Pradesh, Bihar and West Bengal. Sikkim's location at the centre of Eastern Himalaya makes it sensitive to tremors even the epicenter is in other surrounding regions like North-East region or Nepal or Tibetan-China region. The occurrence of earthquake in Sikkim can trigger multiple effects like landslide, GLOF or earthquake induced flood in its river system which can devastate the region. Further, this region receives considerable amount of rainfall which make the region even more vulnerable.

Table 2: Earthquake History in Sikkim

Date	Magnitude	Region	Date	Magnitude	Region
18-09-11	6.8	Sikkim-Nepal Border Region	02-01-13	3	Gangtok, Sikkim
18-09-11	5	India (Sikkim)-Nepal Border Region	03-10-13	5	Sikkim
18-09-11	4.5	India (Sikkim)-Nepal Border Region	04-07-14	3.9	Nepal-Sikkim (India) Border Region
18-09-11	4.2	India (Sikkim)-Nepal Border Region	17-09-14	3.9	Nepal - India (Sikkim) Border Region
22-09-11	3.9	Sikkim	23-04-15	4	West Sikkim
17-10-11	3.5	Sikkim	25-04-15	7.9	Nepal
29-10-11	3.5	Sikkim, India	26-04-15	6.9	Nepal

09-12-11	3.7	India (Sikkim)-Nepal Border Region	27-04-15	5.1	Nepal-India (West Bengal) Border Region
13-12-11	2.9	Gangtok, Sikkim	15-08-15	4	Sikkim
14-12-11	4.5	India (Sikkim)-Nepal Border Region	10-10-15	4.5	Sikkim
18-12-11	3.7	India (Sikkim)-Nepal Border Region	12-03-16	3.8	Jalpaiguri-Sikkim
18-01-12	3.4	Sikkim, India	28-08-16	4.2	India (Sikkim)-China Border Region
14-02-12	3.6	Sikkim-Nepal Border Region	18-09-16	3.2	Darjeeling-Sikkim
27-03-12	4.9	Sikkim-Nepal Border Region	01-12-16	3.5	Bhutan-India(Sikkim) Border Region
30-05-12	4	Sikkim-Nepal Border Region	17-01-17	3.6	North Sikkim
11-06-12	3.8	Sikkim-Nepal Border Region	23-02-17	3.5	Sikkim
18-09-12	4.1	Sikkim	26-03-17	4.6	East Sikkim
11-10-12	3.3	India (Sikkim) – Tibet border region	16-05-17	4	Sikkim
22-10-12	3.9	Nepal-India (Sikkim) Border Region	08-07-17	3	East Sikkim
30-11-12	4.1	West Sikkim			

Source : (a) Sikkim State Disaster Management Authority, Government of Sikkim.
(b) India Meteorological Department, Ministry of Earth Sciences, Government of India.
(c) National Disaster Management Authority, Government of India.

Over the years, earthquakes has been frequent and constant threat in Sikkim. The earthquake of 18 September 2011 in Sikkim of 6.8 magnitude is the most devastating in its history where 97 people died (75 in Sikkim) and caused huge socio-economic loss (National Disaster Management Plan 2016). The psychological trauma is beyond calculation. In 2011 alone, Sikkim had experienced the maximum number of tremors (11 times) including the high intensity of 6.8 magnitude of 18 September and experienced

nine tremors in 2012. After the earthquake of 18 September 2011, Sikkim has felt more than 38 tremors of varying intensity. Although the maximum number of earthquake intensity was below 5 RS, the possibility of high intensity earthquake is always there due to geological history of the Himalaya.

Table 3: Houses Damaged in Sikkim (in Numbers)
(Due to Sikkim Earthquake of September 18, 2011)

Districts	Fully Damaged	Severe Damaged	Partially Damaged	Minor Damaged
North	6000	-	-	-
South	820	-	446	1582
East	6000	-	9000	-
West	1679	5327	8342	-
Total	**14499**	**5327**	**17788**	**1582**

(Source: Khawas and Rai (2017)

The table 3 shows the house damage done by Sikkim earthquake of September 18, 2011 in four districts. Here, the house damaged is categorized into 'fully damaged', 'severe damaged', 'partially damaged' and 'minor damaged'. Among these four categories, the 'fully damaged' houses have been recorded from all districts where North and East districts observed high number of 6000 houses each. However, in total, the 'partially damaged' houses have recorded the most – 17788 houses followed by 'fully damage'- 14499 houses. The number of 'minor damaged' houses have recorded the lowest among these categories. This data shows the kind of intensity and destructive nature of earthquake.

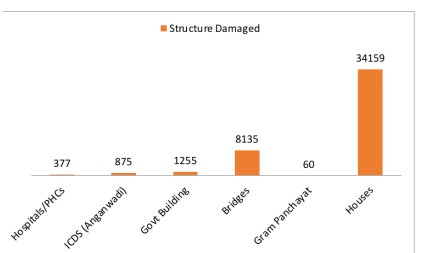

Figure 2: Structural Damages within Sikkim (in Numbers)
(Due to Sikkim earthquake of September 18, 2011)

(Source: Khawas and Rai (2017)

Figure 2 again depicts the structural damage done by the Sikkim earthquake of September 18, 2011. The figure shows that the maximum damages were observed in 'houses' (34159) followed by 'bridges' (8135) and 'Govt. building' (1255). The figure reveals the structural issue of houses/buildings.

3.1 Earthquakes Vulnerabilities in Sikkim

i. **Urbanization:** Urbanization alters the demographic and socio-economic structure. It generally leads to population and settlement growth. The population growth is one of the primary factors of exposure to various hazards. This is also in the case of earthquake. The increasing population growth increases the exposure to earthquake vulnerability. The situation is even critical in Himalayan region due to its geological setting and unplanned growth. Further, the unplanned urbanization makes Himalayan region a 'concrete' hub of settlement which enhances the degree of earthquake vulnerability. Similarly, Sikkim- a small Himalayan state is no exception to earthquake vulnerability. Over the years in Sikkim, the vulnerability of various disasters has increased due to increasing concentration of population and environmental degradation (Acharya, Bandyopadhyay and Praharaj 2012).

   For instance, the Sikkim earthquake of 18 September 2011 is most devastating experience in history of the state. The maximum effects were reported from urban centers/compact settlements where the commonly reported incidents were infrastructural damages like collapse/cracks of government and private building. Referring to Sikkim earthquake of 18 September 2011, Khawas and Rai (2017) have also mentioned that "unchecked and unplanned urbanization was the chief reason for the damage of building structures in Sikkim. They mentioned that shaking of the ground was not what killed most of the people but the falling buildings in Sikkim was the reason of vast causalities and death".

   Over the years in Sikkim, the urban centers have observed considerable in population growth over finite geographical area due to factors like employment opportunities, education, business, tourism. The industrialization especially of Pharmaceutical companies in surrounding urban centers have further contributed in the spurt urban growth.

Table 4: Decadal Change in Population of Sub-Division by Residence, 2001-2011

Districts, Sub-division	Percentage Decadal Variation 2001-2011			Percentage Urban Population	
	Total	Rural	Urban	2001	2011
Sikkim	**12.89**	**-4.99**	**156.52**	**11.07**	**25.15**
North District	**6.53**	**-1.80**	**272.12**	**3.04**	**10.62**
Chungthnag	-4.42	-4.42	0.00	0.00	0.00
Mangan	10.30	-0.86	272.12	4.09	13.79
West District	**10.69**	**8.03**	**187.72**	**1.48**	**3.85**
Gyalshing	11.26	6.40	384.66	1.29	5.60
Soreng	10.07	9.83	24	1.69	1.91
South District	**11.65**	**-1.51**	**437.23**	**3.00**	**14.44**
Namchi	13.22	-6.84	437.23	4.52	21.44
Ravong	8.56	8.56	0.00	0.00	0.00
East District	**15.73**	**-16.18**	**131.75**	**21.57**	**43.19**
Gangtok	16.41	-24.19	120.62	28.04	53.13
Pakyong	12.97	12.97	0.00	0.00	0.00
Rongli	14.11	-10.09	0.00	0.00	12.21

(Source: Census of India, 2011)

During 2001-2011, the rural and urban decadal growth of -4.99% and 156.52% respectively has observed in Sikkim. Sikkim has total urban populations of 153,578 persons. Gangtok tops the list of high urban population with population of 100,286 which recorded growth rate of 241.6% in 2001-2011. In 2001, Gangtok had 28.04% of urban population which has increased to 53.13% in 2011. In 2001-2011, Gangtok observed the striking percentage decadal variation of urban and rural population of 120.62% and (-24.19%) respectively. Overall, there has been substantial increase in urban population in 2001-2011 (Census of India, 2011). All the districts have observed the substantial growth in urban population in 2001-2011. Such rapid and unplanned urban growth has raised issues like land use pattern, building structure/spacing, drainage system, environmental degradation, traffic etc. These urban centers are hubs of huge concrete buildings with varied heights - maximum five slabs or above. Such unregulated urban growth along with increasing concentration of urban population adds fuel to already fragile topography. In addition, the location of convergent boundary of Indian and

Eurasian tectonic plates where Main Dun Thrust (MDT) & Main Boundary thrust (MBT) lie nearby Gangtok, which makes the area further vulnerable to earthquake (City Disaster Management Plan, Government of Sikkim 2015). The damage and casualties would be large in these urban centers if the high magnitude earthquake strikes the region.

Therefore, physical aspects like fragile topography, high rainfall coupled with socio-economic and demographic factors like high urban population, unplanned urban growth has enhanced the exposure and the vulnerability aspects of earthquake in Sikkim. Unfortunately, it has not been realized yet by large section of population in general and concerned stakeholders in particular; which is a matter of great concern.

ii. Industrial Units and Development projects

In India, the industrialization process/development projects had started to spread rapidly after the advent of India's liberalization policy in 1991. From then onwards, the industrialization process/development projects even started to be established in far flung regions of the country with the primary objective of 'development' of those regions. In this process, the Northeastern States also saw establishment of various industrial units/development projects. Likewise, Sikkim also welcomed such industrial units/development projects and lately Hydroelectric Plants and Pharmaceutical Companies especially.

Now, Sikkim with geographical area of 7096 sq.kms and population of 610,577(smallest State in terms of area and population) is home to 14 major Pharmaceutical Companies. Mostly, these companies started to venture in Sikkim from the year 2000 onwards mainly due to the New Economic Policy of the North Eastern Region and Indian Government's North-East Industrial and Investment Promotion Policy (NEIIPP 2007) that promised to offer tax incentives/exemption to the Northeast States for more than 10 years (Sikkim Development Report 2008). Therefore, despite its late entry the sheer number of pharmaceutical companies are astounding in Sikkim. Surprisingly, all these pharmaceutical companies are concentrated in around or near river side of Teesta, Rangpo and Ranikhola (Subba 2015).

These companies offer both opportunities and challenges. Local employment generation (mostly unskilled labor) is the direct benefit of these companies.

However, location of such huge multi-storey companies around or near river side is a major concern considering fragile Himalayan topography as this region falls under seismically active Zone IV. Therefore, their location around or near river beds poses risk in earthquakes. Further, the location of more than 30 Hydroelectric power dams upstream makes the situation critical. This will affect not only the surrounding areas but also the people living in downstream areas of Sikkim and West Bengal. There is possibility of high number of casualties because these Pharmaceuticals Companies operate day and night. Hence, the establishment of industrial units/development projects like Pharmaceutical Companies and Hydropower dams in river system has enhanced the risk factor associated with earthquakes in Sikkim.

There is no denying the fact that these developmental projects are important for the economic growth. However, there are certain aspects which need to be taken consideration before establishment of any big industrial/development projects. Like the concept of 'one size does not fit all'; the concerned government should consider the critical aspects like 'carrying capacity', geology, topography and environment of the region before implementation of any big industrial unit/development project.

3.2 Policy Suggestions

Timely preparedness is the viable option to deal with earthquakes as not much can be done to stop them. The preparedness in terms of minimizing risk/vulnerability aspects is crucial to avert the disaster-losses. It requires both infrastructural and human resource planning. The infrastructural planning needs to include broadly industrial, urban and developmental planning. In human resource planning, the State Disaster Response Force (SDRF), policy/decision makers, medical personnel need to actively engage in preparedness, management and post-disaster recovery process. In this aspect, the Government of Sikkim (GoS) recently has come up with volumes of disaster management plans under Sikkim State Disaster Management Authority (SSDMA). However, in terms of infrastructural planning Sikkim need to do lots of work. The GoS needs to prepare its short and long term planning to mitigate disasters. The feasibility of sites to industrial units/development projects needs to be studied; and sites should be allocated far away from river side and urban centers. There should be strict building code and regulation for private, government and industrial constructions. The structural and non-structural aspects of building are crucial to minimize earthquake casualties. Therefore, a regular

awareness programme from the government about the non-structural management of household objects in building especially of hazardous materials like LPG, electricity is highly recommended.

Some Sikkim specific earthquake resilience suggestions are: First, focus should be to limit urban migration and unscientific urban growth which can be done through channelizing administrative services and development establishments outside urban centers. Second, it is essential to equip human resources including medics, SDRF with scientific training about disaster preparedness and management; they have to be in 'ready-to-go' position as part of quick response team. Third, reform in building structure needs immediate attention to curb the unscientific and sky-rocketing constructions. In a phased manner, efforts should be made to make earthquake resilient buildings and settlements. With government's intervention it is possible to limit the building height to a standard level as the building resilience is the key to minimize the effect of earthquake. The scientific feasibility of construction of buildings and infrastructure units should be carried out incorporating micro-level environmental, geological setting or 'carrying capacity' of the area. The mapping or zoning of geologically weak areas and land use planning is advisable. Fourth, consultations with technical/experts, urban planners/researchers and police personnel are highly recommendable in making and implementing industrial unit/development projects. Fifth, there should be public awareness about the preventive disaster measures and adaptation of disaster friendly housing. Sixth, comprehensive insurance of property and life is highly recommended which would be a smart move in dealing post disaster tragedy.

4. Conclusion

In a nut shell, it is impossible to stop natural hazards like earthquake but its adversities can minimize with timely preventive measures. The timely prevention approach will be more efficacious than post-disaster curative approach. Therefore, Sikkim needs to come up with its own area specific and disaster specific management plans and policies.

References

1. Asthana Vinay (2014): Disaster Risk Management: Shifting Paradigm, Economic and Political Weekly, vol XlIX no 39, pp. 17-20.
2. Government of Sikkim (2015): State Disaster Management Plan, Gangtok: Sikkim State Disaster Management Authority.
3. Government of Sikkim (2012): Multi-Hazard Risk Vulnerability Assessment, Gangtok, East Sikkim, Gangtok: State Disaster Management Authority.
4. Government of Sikkim (2015): City Disaster Management Plan: Evacuation and Response, Gangtok: Sikkim State Disaster Management Authority.
5. Government of India (2017): Annual Report (2016-2017), New Delhi: Ministry of Earth Sciences.
6. Government of Sikkim (2014): Sikkim Human Development Report, New Delhi: Routledge.
7. Government of India (2016) : National Disaster Management Plan, New Delhi: National Disaster Management Authority.
8. Government of India (2009): National Policy on Disaster Management, New Delhi: National Disaster Management Authority.
9. Mohapatra, A.K., Mohanty, W.K. (2010): An Overview of Seismic Zonation Studies in India GEOtrendz pp 175-178. Nambiar Malini (2015): A Decade of Disaster Risk Management in India, Vol L, No. 5, pp. 36-40.
10. Nambiar Malini (2015): A Decade of Disaster Risk Management in India, Vol L, No. 5, pp. 36-40.
11. Özerdem A, Barakat S. (2000): After the Marmara Earthquake: Lessons for Avoiding Short Cuts to Disasters, Third World Quarterly, Vol. 21, No. 3, pp. 425-439.
12. Ray C.N. (2005): A Note on the Disaster Management Bill, 2005, Economic and Political Weekly, Vol. 40, No. 47, pp. 4877-4881.
13. Sarkar Subhradipta and Sarma Archana (2006): Disaster Management Act, 2005: A Disaster in Waiting?, Economic and Political Weekly, Vol. 41, No. 35, pp. 3760-3763.
14. United Nations, "The Sendai Framework for Disaster Risk Reduction 2015-2030".
15. Khawas and Rai (2017): Seismic resistance of vernacular constructions in the Himalayas: experience from the 2011 Sikkim Himalayan earthquake, Hill Geographer.
16. Huber Amelie and Joshi Deepa (2015): Hydropower, Anti-Politics, and the Opening of New Political Spaces in the Eastern Himalayas, World Development.
17. Subba Depesh (2018): Socio Economic and Environmental Implications of Pharmaceutical Companies in Sikkim, Journal of Politics and Governance.