Sustainability, Agri, Food and Environmental Research, (ISSN: 0719-3726), vol 12, special issue. 2024
http://dx.doi.org

Chapter 6

Earthquakes disaster in India, mitigation and their impacts

Desastres terremotos en India, mitigación y sus efectos

Sahdev, [1,*] Dr. Bharat Lal Sahu, [2] Dr. Shobhana Ramteke [3]

[1, 3] School of Studies in Environmental Science, Pt. Ravishankar Shukla University, Raipur, Chhattisgarh – 492010

[2] Department of Chemistry, Guru Ghasidas Vishwavidyalaya (A Central University), Bilaspur, CG, India

Email - *sahdevsahurkb@gmail.com

ABSTRACT

An earthquake is a natural disaster. This is due to the movement of tectonic plates. In India, the states like Assam, Uttarakhand, Maharashtra, Madhya Pradesh, Jammu and Kashmir, Ladakh, Gujarat, Tamil Nadu, Delhi, Sikkim, Odisha, etc. have suffered a maximum loss of life and property. In 2021, 2 people have died in Assam and 12 people have been injured. In 2015, there was an earthquake in Afghanistan, Pakistan, Nepal, and parts of India, in which the native people of India also lost their lives. There are mainly 4 types of earthquakes: tectonic, volcanic, collapse, and explosive earthquakes. Earthquakes are divided into 5 zones, zones I, II, III, IV, and V, with the most dangerous being zone V. In which the regions of Assam, Sikkim, Uttarakhand, Jammu, Kashmir, and Gujarat come. Earthquakes cause damage to humans, animals, forests, and agricultural land. This review discusses the history of earthquakes, damages, mitigation, management, etc.

Keywords: Earthquake, causes, risk in India, effects, mitigation, and (NIDM).

RESUMEN

El terremoto es un desastre natural. Esto se debe al movimiento de las placas tectónicas. En India, estados como Assam, Uttarakhand, Maharashtra, Madhya Pradesh, Jammu y Cachemira, Ladakh, Gujarat, Tamil Nadu, Delhi, Sikkim, Odisha, etc. han sufrido la máxima pérdida de vidas y propiedades. En 2021, 2 personas murieron en Assam y 12 personas resultaron heridas. En 2015, hubo un terremoto en Afganistán, Pakistán, Nepal y partes de la India, en el que también perdieron la vida los nativos de la India. Existen principalmente 4 tipos de terremotos: terremotos tectónicos, volcánicos, de colapso y explosivos. Los terremotos se dividen en 5 zonas, Zona I, II, III, IV y V, siendo la Zona V la más peligrosa. En el que vienen las regiones de Assam, Sikkim, Uttarakhand, Jammu, Kashmir

y Gujarat. Los terremotos causan daños a los seres humanos, los animales, los bosques y las tierras agrícolas. Esta revisión analiza la historia de los terremotos, los daños, la mitigación, la gestión, etc.

PALABRAS CLAVE: Terremotos, causas, riesgos, efectos, mitigación y (NIDM) en India.

INTRODUCTION

India has experienced a number of the world's largest earthquakes over the past century. More than 50% of the country's area is considered prone to destructive earthquakes [1]. An earthquake is the shaking of the Earth's surface resulting from the sudden release of energy into the earth's lithosphere which produces seismic waves. An earthquake is the energetic form of wave motion transmitted through the surface layer of the earth. This can be due to faulting, folding, plate movement, volcanic eruptions, and anthropogenic factors such as dams and reservoirs. Earthquakes are by far the most unpredictable and highly destructive of all-natural disasters. Small earthquakes caused by slight vibrational waves in the earth's crust occur every few minutes, while large earthquakes, usually caused by movements along faults, can be very disastrous, especially in densely populated areas [2]. Throughout the invasions of different ethnic and religious entities in the past two millennia, the Indian subcontinent has been known as Hindoostan, Hindustan, or India in recognition of its unique isolation imposed by surrounding mountains and oceans. The northern, eastern, and western mountains are the boundaries of the Indian plate. The shorelines are the echoes of ancient plate boundaries [3]. A feature of Indian earthquakes for which numerical deformation data have recently been exhumed is that these data, once analyzed, have required substantial revision of earlier informed, but speculative, interpretations of the causal mechanisms of historic earthquakes. Geodetic data have surfaced for 1819, 1881, 1897, 1905, and 2022 earthquakes that have largely negated the conclusions of many learned articles. This raises a cautionary flag: those conclusions concerning felt reports about earthquakes in history and prehistory have limited value in interpreting subsurface structure [3].

Figure: 1 The 2001 earthquake shook the entire country, there was no electricity, water and communication for weeks when the region was struck by the 7.7 magnitude quake Credit: Twitter image (@GujaratHistory)

Source: https://www.eastmojo.com/news/2021/01/26/20-years-of-gujarat-earthquake-numbers-that-highlight-the-devastation/

CAUSES OF EARTHQUAKE

The earth's crust consists of a solid core, mantle (i.e. molten magma), and various lithospheric plates. One of these terrestrial structures is shown below:

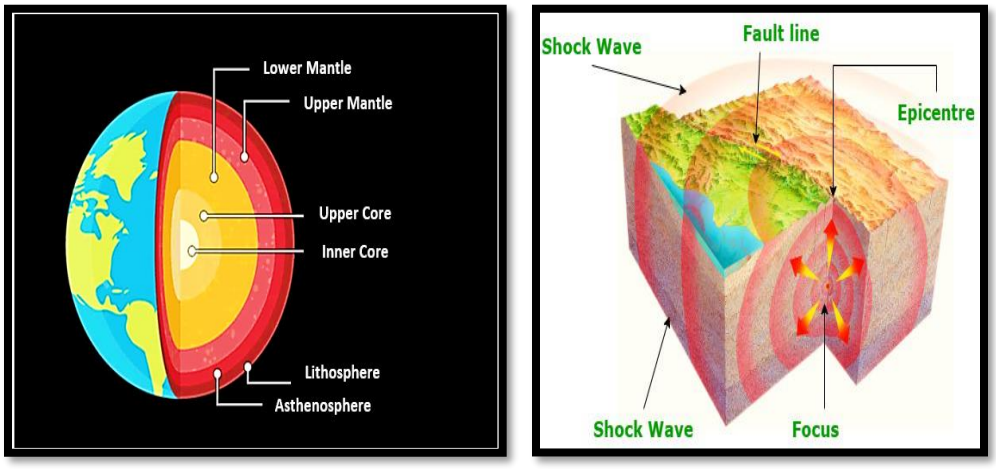

Figure: 2 Structure of Earth

Source: https://www.geeksforgeeks.org/what-causes-an-earthquake/

The outer shell of the Earth is made up of huge plates called tectonic plates that are in constant motion due to the convection currents caused by molten lava in the earth's crust. This constant movement causes the plates to slide against each other or move away from each other. These interactions and the displacement of tectonic plates under the Earth are observed by living organisms, including humans [5].

Earthquakes are caused by the sudden release of stress along the fractures of the earth's crust. The continuous movement of the tectonic plates causes the constant pressure to build up in the rock layers on both sides of the fault until the stress is large enough, which is released with jerky and sudden movement. These resulting waves of seismic energy originate from the ground and above the surface, causing the tremors we perceive as earthquakes [5].

TYPES OF EARTHQUAKES

1. Tectonic earthquakes: The most common form of earthquakes is caused by the movement of loose fragmented pieces of land on the earth’s crust knowns as tectonic plates [6].
2. Volcanic earthquake: These earthquakes are less common than the tectonic variety and occur before or after the eruption of a volcano. It is caused when the magma exiting the volcano is filled by rocks pushed to the surface [6].
3. Collapse earthquake: This earthquake occurs in underground mines. The main cause is the pressure generated in the rocks [6].
4. Explosion earthquakes: The occurrence of this type of earthquake is artificial. High-density explosion such as nuclear explosions is the primary cause [6].

THE EARTHQUAKE RISK IN INDIA

The Indian subcontinent has suffered some of the greatest earthquakes in the world with a magnitude exceeding 8.0. For instance, in a short span of about 50 years, four such earthquakes occurred: the Assam earthquake of 1897 (magnitude 8.7) [7], Kangra earthquake of 1905 (magnitude 8.6) [8], Bihar-Nepal earthquake of 1934 (magnitude 8.4) [9], and the Assam-Tibet earthquake of 1950 (magnitude 8.7) [10]. The significance of such earthquakes can be gauged from the fact that in his famous book on Engineering Seismology [11]. Professor C. F. Richter (known for the Richter scale) devotes an entire chapter entitled "Some Great Indian Earthquakes" to an introduction to the nature of earthquakes: the book does not have a similar chapter for large earthquakes in other parts of the world. Fortunately, only moderate magnitude earthquakes have occurred in India since 1950, which is no reason to believe that truly large earthquakes are a thing of the past. Of these four earthquakes, the two most interesting (1897 Assam and 1934 Bihar-Nepal) are discussed in detail here. There is also talk of another very interesting earthquake that happened about 180 years ago: the Kutch earthquake of 1819. To appreciate these earthquakes, keep in mind that in the Latur earthquake in 1993 (the most tragic earthquake of the last 50

years in India causing about 8000 deaths), severe damage was limited to a radius of 10 km and the maximum MSK intensity was only about VIII to IX in a much smaller area [12].

All the destructive earthquakes of recent years are of rather moderate magnitude compared to the large earthquakes discussed above. Nevertheless, these also had interesting properties, which will be briefly discussed here; some of these are discussed in more detail in the accompanying documents [12].

INDIA, PAKISTAN 2015

According to the United States Geological Survey (USGS), Pakistan is one of the most earthquake-prone areas in the world. [16] The earthquake was also felt in New Delhi, both in the territory of Azad Kashmir in Pakistan, in the Indian state of Jammu and Kashmir, and as far as Lucknow and in the prefectures of Kashgar, Aksu, Hotan, and Kizilsu in Xinjiang, China, while the damage was limited. Also reported in the Afghan capital Kabul. [13, to 15] The earthquake was also felt in the Nepalese capital Kathmandu [13].

NEPAL, INDIA 2015

The April 2015 Nepal earthquake (also known as the Gorkha earthquake) [18, 19], killed 8,964 people and injured 21,952 more. It occurred at 11:56 Nepal Standard Time on Saturday, 25 April 2015, with a magnitude of 7.8Mw [20] or 8.1Ms [21], and a maximum Mercalli Intensity of X (Extreme). Its epicenter was east of Gorkha District at Barpak, Gorkha, and its hypocenter was at a depth of approximately 8.2 km (5.1 mi).[20] It was the worst natural disaster to strike Nepal since the 1934 Nepal–Bihar earthquake.[22, 23, 24] The ground motion recorded in the capital of Nepal was of low frequency, which, along with its occurrence at an hour when many people in rural areas were working outdoors, decreased the loss of property and human lives [17, 25].

NEPAL, INDIA 2015

A major earthquake occurred in Nepal on 12 May 2015 at 12:50 pm local time (07:05 UTC) with a moment magnitude of 7.3, 18 kilometers (11 mi) southeast of Kodari. The epicenter was on the border between Dolakha and Sindhupalchowk, two districts of Nepal. This earthquake occurred on the same fault as the larger magnitude 7.8 earthquake on April 25, but further east than the original earthquake [26, 27]. As such, it is considered an aftershock of the April earthquake [27]. It struck at a depth of 18.5 km. Tremors were felt in northern India including Bihar, Uttar Pradesh, and West Bengal [28]. Tremors were felt up to a distance of about 2,400 km from the epicenter in Chennai [26, 29, and 30].

GANGTOK, SIKKIM 2011

The 2011 Sikkim earthquake (also known as the 2011 Himalayan earthquake) occurred with a magnitude of 6.9 on the Richter scale and was centered in the Kanchenjunga conservation area, near the state border

between Nepal and India Sikkim, 6:10 pm IST on Sunday, October 18th., September [31]. The earthquake was felt in northeastern India, Nepal, Bhutan, Bangladesh, and southern Tibet [32].

KASHMIR 2005

The 2005 Kashmir earthquake occurred on October 8 at 08:50:39 Pakistani standard time in Pakistan-administered Azad Kashmir. It was centered near the city of Muzaffarabad and also affected neighboring Balakot in Khyber Pakhtunkhwa and some Indian-administered areas of Jammu and Kashmir. It recorded a moment magnitude of 7.6 and had a maximum Mercalli intensity of XI (Extreme). The earthquake was also felt in Afghanistan, Tajikistan, India, and the Xinjiang region. The severity of the damage caused by the earthquake is attributed to the strong buoyancy. More than 86,000 people have died, a similar number have been injured and millions have been displaced. It is considered the deadliest earthquake in South Asia, surpassing the Quetta earthquake of 1935 [33, 34].

GUJARAT 2001

The 2001 Gujarat earthquake, also known as the Bhuj earthquake, occurred on January 26, India's 52nd Republic Day, at 8:46 am IST. The epicenter was approximately 9km southwest of Chobari village at Bhachau Taluka in the Kutch district of Gujarat, India [35, to 37].

CHAMOLI DISTRICT-UTTARAKHAND 1999

The 1999 Chamoli earthquake occurred on March 29 in the Chamoli district in the Indian state of Uttar Pradesh. About 103 people died in the earthquake [38].

JABALPUR EARTHQUAKE OF 1997

This earthquake is the first moderate earthquake (magnitude 6.0) to have occurred close to a major Indian city in recent times: Jabalpur has a population of about 1.2 million people [39, 40]. It provided an indication of the kind of seismic performance to expect from modern Indian structures. The maximum intensity was up to VIII (in a very small area); most parts of Jabalpur town experienced shaking intensity of VI and VII. Numerous R.C. frame buildings of three-four stories with brick infills performed well even though these may not have been designed for earthquake forces: this is because the brick infill walls acted as shear walls and took most of the seismic loads in such buildings [12]. On the other hand, several similar buildings but with an open-first story (i.e., few or no brick infills in the ground story) showed heavy distress to the ground-story columns such buildings could have collapsed due to the failure of ground story columns if the shaking had been stronger or lasted for a longer duration. Another interesting feature of the earthquake was heavy damage to a very large number of two and three-story brick-masonry residential buildings belonging to different government agencies: e.g., the ordnance factories, Department of Telecom, railways, etc. Such buildings did not have any earthquake-resistant features.

Damage to mummies (stair protrusion above the roof of the building) in such houses was a big problem. Most of the country's medium and large cities now have a huge inventory of R.C. frame buildings with an open first story (to accommodate vehicle parking), and two-three story brick masonry housing units; such buildings could cause major disasters in the future earthquakes affecting Indian cities [12].

KILLARI (LATUR) EARTHQUAKE OF 1993

On 30 September 1993, a magnitude 6.4 earthquake shook the area near the village of Killari in the Latur district, killing around 8,000 people [41, to 44]. The maximum intensity of agitation was about VIII-IX. Until this earthquake, the area was considered non-seismic and located in the lowest seismic zone (Zone I) by the Indian code (IS: 1893-1984). Most of the damage was limited to a relatively small area of 20km x 20km. The affected area had no modern cities, modern buildings, or large industries. In some villages, more than 30% of the population was killed. This earthquake will be remembered for the outstanding rescue, relief, and rehabilitation efforts undertaken for any earthquake in India's recent history. perhaps even exceptional by international standards [12].

UTTARKASHI EARTHQUAKE OF 1991

A magnitude 6.6 earthquake struck Uttarkashi, Tehri, and Chamoli districts in the state of Uttar Pradesh on October 20, 1991, at 2:52 a.m. [45, 46]. The death toll was estimated at around 768 people, with around 5,066 injured. The area has one of the lowest population densities in the state, hence the relatively low number of fatalities and injuries. The peak intensity of IX on the MM scale was assigned to an area of approximately 20 square kilometers. This earthquake provided excellent records of ground motion (acceleration as a function of time) in the region [47]. A maximum peak ground acceleration of about 0.31 g was recorded at Uttarkashi. Ground motion records have shown that motion in the Himalayan region has a significantly higher proportion of high-frequency content. During the earthquake, houses with R.C. Roof panels on weak cut stone masonry clearly [12]. He demonstrated the disastrous effects of often overlooked walls and columns on slabs and beams. Several 4-story buildings in Uttarkashi (not designed or detailed by engineers) featuring R.C. the stone frame and fillings withstood the earthquake quite well! This was due to the presence of a significant number of infill walls from the foundation to the top of the building which served as sliding walls. It could easily and incorrectly be concluded from such examples that all R.C. buildings, in general, are good for earthquakes. To be sober, the top two floors of the State Bank of India R.C. The collapse of the frame structure clearly illustrates the disaster that R.C. buildings can cause if not done correctly. An important bridge on the strategically important Uttarkashi-Harsil route collapsed; interrupting the traffic for several days [12, 48].

Table 1: List of earthquakes in India (2021 to 1819)

S. No.	Date	Location	Magnitude	Total deaths, injuries, and damage	Source
1.	2021- 04- 28	Assam	6.0 M_w	Deaths – 2 Injuries - 12 Damage - moderate damage	[51, to 53]
2.	2019-07-24	Maharashtra	4.1 M_w	Deaths – 1 Injuries - 1 Damage - minor	[54, 55]
3.	2018-09-12	Assam	5.3 M_w	Deaths – 1 Injuries - 25 Damage -	[56]
4.	2015-10-26	Afghanistan, India, Pakistan	7.7 M_w	Deaths – 399 Injuries - 2,536 Damage -	[13]
5.	2015-05-12	Nepal, India	7.3 M_w	Deaths – 218 Injuries - 3,500+ Damage -	[13]
6.	2015-04-25	Nepal, India	7.8 M_w	Deaths – 8,964 Injuries - 21,952 Damage - $10 billion	[13]
7.	2014-05-21	Odisha	6.0 M_w	Deaths – 2 Injuries - 250 Damage-buildings damaged/power outages	[57, 58]
8.	2013-05-01	Kashmir	5.7 M_w	Deaths – 3 Injuries - 90 Damage - $19.5 million	[53] NGDC
9.	2011-09-18	Gangtok, Sikkim	6.9 M_w	Deaths – >111 Injuries - Damage -	[32]
10.	2011-09-07	NCR	4.3 M_w	Deaths – Injuries - 1	[59]

				Damage - minor damage	
11.	2010-03-30	Diglipur, Andaman and Nicobar Islands	6.6 M_w	Deaths – Injuries - 10 Damage-buildings damaged	[60, 61]
12.	2009-03-26	Jharkhand	4.1 M_w	Deaths – Injuries - 5 Damage- buildings damaged	[62]
13.	2008-09-16	Satara district, Maharashtra	5.0 M_w	Deaths – 1 Injuries - 20 Damage- 1,500 buildings damaged.	[63]
14.	2008-02-06	West Bengal	4.3 M_w	Deaths – 1 Injuries - 50 Damage-buildings damaged.	[53] NGDC
15.	2007-11-06	Gujarat	5.1 M_w	Deaths – 1 Injuries - 5 Damage-buildings damaged.	[64]
16.	2005-10-08	Kashmir	7.6 M_w	Deaths – 86,000–87,351 Injuries - 69,000–75,266 Damage-2.8million displaced	[34]
17.	2001-09-25	Tamil Nadu	5.2 M_w	Deaths – 3 Injuries - Damage- minor damage	[65, 66]
18.	2001-01-26	Gujarat	7.7 M_w	Deaths–13,805–20,023 Injuries - ~166,800 Damage - $10 billion	[35]
19.	1999-03-29	Chamoli district-Uttarakhand	6.8 M_w	Deaths – ~103 Injuries- Damage-	[38]
20.	1997-05-22	Jabalpur, Madhya Pradesh	5.8 M_w	Deaths – 38–56 Injuries - 1,000–1,500 Damage - $37–143 million	[53]

21.	1993-09-30	Latur, Maharashtra	6.2 M_w	Deaths –9,748 Injuries - 30,000 Damage-	[53]
22.	1991-10-20	Uttarkashi, Uttarakhand	6.8 M_w	Deaths – 768–2,000 Injuries-1,383–1,800 Damage-	[53]
23.	1988-08-21	Udayapur, Nepal	6.9 M_w	Deaths – 709–1,450 Injuries- Damage-	[53]
24.	1967-12-11	Maharashtra	6.6 M_w	Deaths – 709–1,450 Injuries- 2,272 Damage- $400,000	[53]
25.	1934-01-15	Nepal	8.0 M_w	Deaths–6,000–10,700 Injuries- Damage	[53]
26.	1897-06-12	Shillong, India	8.0 M_w	Deaths –1,542 Injuries- Damage	[53]
27.	1819-06-16	Gujarat	7.7–8.2 M_w	Deaths – >1,543 Injuries- Damage	[53]

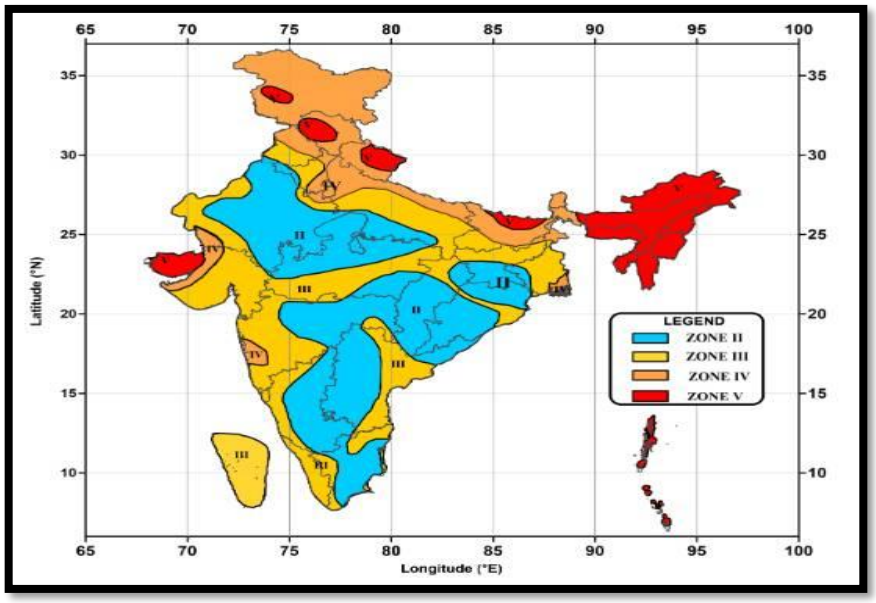

Figure: 2 Earthquake mapping in India

Source:https://pib.gov.in/PressReleasePage.aspx?PRID=1740656

EARTHQUAKE MAPPING IN INDIA

Bureau of Indian Standards [IS 1893 (Part I): 2002], divided the country into four seismic zones, Zone II, III, IV, and V. Zone V is the most active region and Zone II is the least seismically active.

Zone V: Entire northeast India, parts of part of Andaman & Nicobar Islands, North Bihar, Himachal Pradesh, Rann of Kutch in Gujarat, Uttaranchal, and Jammu & Kashmir [6].

Zone IV: Parts of Himachal Pradesh, and Jammu and Kashmir, Sikkim, parts of Gujarat, Rajasthan, Northern Parts of Uttar Pradesh, Bihar, Delhi, Sikkim, and small portions of Maharashtra near the west coast [6].

Zone III: Remaining parts of Gujarat, West Bengal, Uttar Pradesh, Madhya Pradesh, Jharkhand, Maharashtra, Orissa, Andhra Pradesh, Rajasthan, Kerala, Goa, parts of Punjab, Bihar, Jharkhand, Chhattisgarh, Lakshadweep Islands, Tamil Nadu, and Karnataka [6].

Zone II: Covers the remaining parts of the country [6].

IMPACTS OF EARTHQUAKE

Earthquakes are a natural hazard. If a large-scale shaking occurs, it can cause serious damage to people's lives and property. The immediate dangerous effects of an earthquake are: - Earthquakes, land differentials, landslides, and mudslides, fires, landslides, avalanches, landslides, flooding due to the failure of dams and dikes, structural collapse, and tsunami [50].

MEASUREMENT OF EARTHQUAKES

- Energy from an earthquake travels through the earth in the form of vibrations called seismic waves.
- Scientists can measure these seismic waves with so-called seismometers.
- A seismometer detects seismic waves beneath the instrument and records them as a series of zigzags.
- Scientists can determine the time, location, and intensity of an earthquake using information recorded by a seismometer.
- This recording also provides information on the rocks traversed by the seismic waves. • Seismic events are classified according to the magnitude or intensity of the shock.
- The magnitude scale is known as the Richter scale. Magnitude refers to the energy released during the earthquake. The size is expressed in absolute numbers, 0-10.
- The intensity scale is named after Mercalli, an Italian seismologist. The intensity scale takes into account the visible damage caused by the event. The range of the intensity scale is between 1-12 [50].

EARTHQUAKE HAZARD MITIGATION

Compared to other natural disasters, earthquakes are much more intense and unpredictable, resulting in massive damage. It also destroys most communication links and slows down a facility's movements, making it even more difficult for victims to decide on their next move or to get timely help. Therefore, although it is not possible to reverse earthquakes in India, it is important to focus more on managing the consequences than on preparing remedial measures [67].

- Establishment of several seismological centers or seismic monitoring centers to regularly monitor changes, especially in earthquake-prone areas in India
- To monitor the movement of tectonic plates, the use of GPS or Geographic Positioning System (GPS) is an ideal choice
- Educating people to minimize the impact of disasters will help a lot. It is best to create a vulnerability map to monitor changes and impact
- Modifications to buildings, especially in vulnerable areas, are an ideal decision. Discourage large industrial plants and the construction of tall buildings
- Finally, the last step is to make anti-seismic projects mandatory. The use of lighting equipment on construction sites will be an additional advantage [67].
- Earthquake preparedness, formerly disaster management and preparedness was an evolutionary path.
- In 1999, the Government of India established a High Power Committee and a National Post-Earthquake Committee in Gujarat to make recommendations on effective preparedness and mitigation mechanisms.

- The 10th Five Year Plan document contained a detailed chapter on disaster management.
- The 12th Financial Commission was tasked with revising the financial arrangements for disaster management and preparedness.
- The Disaster Management Act entered into force in December 2005 [6].

Before an earthquake:

- Follow and uphold safe local building codes for earthquake-resistant structures.
- Follow and defend poorly constructed structures to be upgraded.
- Make a plan and be prepared for an emergency.
- Identify medical centers and fire stations and organize rescue simulation exercises for the company in your region.
- Familiarize yourself with the electricity and water cut-off points in your home.
- Heavy items, glasses, and cutlery should be stored on lower shelves.
- Flower pots must not stand on the parapet [68].

During an earthquake:

- Remain calm and reassure others.
- During the event, the safest place is an open space, away from buildings.
- When inside, take cover under a desk, table, bed, or door, and counter
- Interior walls and stairs. Stay away from glass doors, glass, windows, or exterior doors. Do not rush out of the building, to avoid the stampede.
- Outdoors, move away from buildings and power lines.
- Once out in the open, stay there until the vibrations stop.
- If you are in a moving vehicle, stop and stay in the vehicle as soon as possible.
- Release all pets and pets to run outside.
- Do not use candles, matches, or other open flames. Extinguish all fires [68].

After an earthquake:

- Provide drinking water, food, and first aid equipment in inaccessible places.
- Don't spread or believe rumors.
- Turn on your transistor or TV for the latest news/bulletins and Aftershock warnings.
- Help others and develop self-confidence.
- Treat the injured and bring them help as far as possible and also inform them the hospital.
- Be prepared for aftershocks as they can strike.
- Close the lid of the gas stove in the kitchen, if it is on.
- If it's closed, don't open it. To do Do not use open flames.

- Do not operate switches or electrical devices if gas leaks are suspected.
- Check water pipes, electrical panels, and fittings.
- If damaged, disconnect the main power supply valves.
- Do not touch the PVE electrical cables.
- If necessary, open doors and cabinets carefully as objects may fall [68].

NATIONAL INSTITUTE FOR DISASTER MANAGEMENT (NIDM)

Under the provisions of Chapter VII of the DM Act, the Government of India has established the National Institute of Disaster Management (NIDM) under an Act of Parliament as the lead institute for disaster management capacity development. disasters in India and the region. The vision of NIDM is to create a disaster-resilient India by building capacity for disaster prevention and preparedness at all levels [69]. NIDM has been entrusted with key responsibilities in human resource development, capacity building, training, research, documentation, and policy advocacy in the field of disaster management. NIDM has established strategic partnerships with various departments and departments of central, state, and local governments, academic, research, and technical organizations in India and abroad, and other bilateral and multilateral international organizations. It provides technical support to state governments through the Disaster Management Centers (DMCs) of the State and Union Territory (ATI) Administrative Training Institutes. It currently supports up to 30 of these centers. Six of these are being developed as centers of excellence in specialized areas of risk management: floods, earthquakes, cyclones, droughts, landslides, and industrial disasters [69].

CONCLUSION

An earthquake is a natural disaster. This is due to the movement of tectonic plates. In India, the states like Assam, Uttarakhand, Maharashtra, Madhya Pradesh, Jammu and Kashmir, Ladakh, Gujarat, Tamil Nadu, Delhi, Sikkim, Odisha, etc. suffered as many human and material losses as possible. To deal with this disaster, now a new researcher in this field should come forward. The government needs them due to the use of new technology so that there can be less loss of life and property than before this disaster. The government should churn out a new researcher. The NGOs should make people aware of the measures to save them from this disaster.

REFERENCES

1. Jain, S. K. (1998). Indian earthquakes: an overview. *Indian Concrete Journal*, *72*, 555-562.

2. Lotus Arise (2021). https://lotusarise.com/earthquake-causes/

3. Bilham, R. (2004). Historical studies of earthquakes in India. *Ann. Geophys*, *47*(2), 839-

858.

4. https://www.eastmojo.com/news/2021/01/26/20-years-of-gujarat-earthquake-numbers-that-highlight-the-devastation/

5. https://www.geeksforgeeks.org/what-causes-an-earthquake/

6. https://www.iasexpress.net/earthquakes-management-india/

7. Oldham, R. D. (1899). *Report of the great earthquake of 12th June, 1897*. Office of the Geological survey.

8. Middlemiss, C. S. (1910). *The Kangra earthquake of 4th April, 1905* (Vol. 38). Geological survey of India.

9. GSI 1993, Bihar - Nepal Earthquake: August 20, 1988, Special Publication No. 31, Geological Survey of India, Calcutta

10. The Central Board of Geophysics, 1953, A Compilation of Papers on the Assam Earthquake of August 15, 1950, Government of India, Calcutta.

11. Richter, C. F. (1958). ELEMENTARY SEISMOLOGY.

12. Jain, S. K. (1998). Indian earthquakes: an overview. *Indian Concrete Journal*, *72*, 555-562.

13. https://en.wikipedia.org/wiki/October_2015_Hindu_Kush_earthquake

14. "The Latest: UN Mobilizing to Aid Quake Victims". The Associated Press. ABC News. 26 October 2015. Retrieved 26 October 2015.

15. "阿富汗发生７． ８级强震新疆南部多地震感强烈". xinhuanet.com. Archived from the original on 28 October 2015. Retrieved 26 October 2015.

16. "Pakistan in the most active quake zone, says US Geological Survey". www.dawn.com. 27 October 2015. Retrieved 28 October 2015.

17. https://en.wikipedia.org/wiki/April_2015_Nepal_earthquake

18. "Aftershocks of Gorkha Earthquake". National Seismological Centre, Nepal.

19. Chidanand Rajghatta (26 April 2015). "Is this the 'Big Himalayan Quake' we feared?". The Times of India. Retrieved 26 April 2015.

20. "M7.8 – 36 km E of Khudi, Nepal". United States Geological Survey.

21. 2015 年 4 月 25 日尼泊尔 8.1 级地震情况通报 (in Chinese (China)). China Earthquake Networks Center. 25 April 2015. Archived from the original on 4 May 2015. Retrieved 28 April 2015.

22. Sugden, Joanna (26 April 2015). "What 1934 Told Nepal to Expect About the Next Big Quake". The Wall Street Journal.

23. "Timeline: Nepal 2015 to 1934, the worst quake disasters in the last 80 years". 27 April 2015. Retrieved 28 April 2015.

24. "Nepal earthquake: Eerie reminder of 1934 tragedy". 25 April 2015.

25. Parajuli, Rishi Ram; Kiyono, Junji (1 January 2015). "Ground Motion Characteristics of the 2015 Gorkha Earthquake, Survey of Damage to Stone Masonry Structures and Structural Field Tests". Frontiers in Built Environment. 1: 23. doi:10.3389/fbuil.2015.00023.

26. https://en.wikipedia.org/wiki/May_2015_Nepal_earthquake

27. "M7.3 - 18km SE of Kodari, Nepal". USGS Earthquake Hazards Program.

28. "7.3 Magnitude Earthquake hits North India including Bihar". news.biharprabha.com. 12 May 2015. Retrieved 12 May 2015.

29. "Mild tremors in Chennai too". The Hindu. 12 May 2015.

30. "Ttremors felt in Chennai". Times of India. 12 May 2015.

31. "Magnitude 6.9 – SIKKIM, INDIA". United States Geological Survey. 18 September 2011. Archived from the original on 21 September 2011. Retrieved 18 September 2011.

32. https://en.wikipedia.org/wiki/2011_Sikkim_earthquake

33. "The great Quetta tragedy". DAWN Newspaper. 25 October 2005. Archived from the original on 27 October 2005. Retrieved 24 January 2022.

34. https://en.wikipedia.org/wiki/2005_Kashmir_earthquake

35. https://en.wikipedia.org/wiki/2001_Gujarat_earthquake

36. Gupta, Harsh K., et al. "Bhuj earthquake of 26 January 2001." Journal-Geological Society of India 57.3 (2001): 275–278.

37. "15 years of Gujarat earthquake: A trauma etched in Gujarat's memory". The Times of India. Retrieved 19 May 2017.

38. https://en.wikipedia.org/wiki/1999_Chamoli_earthquake

39. Jain, S. K., Murty, C. V. R., Arlekar, J. N., Sinha, R., Goyal, A., & Jain, C. K. (1997). Some observations on engineering aspects of the Jabalpur earthquake of 22 May 1997. *EERI special earthquake report, EERI newsletter*, *32*(2), 1-18. [Also, reprinted in the Bulletin of the Indian Concrete Institute, No. 64, July-Sept. 1998]

40. Rai, D. C., Narayan, J. P., Pankaj, P., & Kumar, A. (1997). Jabalpur earthquake of May 22, 1997: reconnaissance report.

41. Narula, P. L., Shome, S. K., & Murty, B. S. R. (1996). *Killari Earthquake, 30 September 1993*. Geological Survey of India.

42. Jain, S. K., Murty, C. V. R., Chandak, N., Seeber, L., & Jain, N. K. (1994). The September 29, 1993, M6. 4 Killari, Maharashtra Earthquake in Central India. *EERI Special Earthquake Report, EERI Newsletter*, *28*(1), 8.

43. Seeber,L., Jain,S.K., Murty,C.V.R., and Chandak,N., 1993, "Surface Rupture and

Damage Patterns in the Ms=6.4, September 29, 1993 Killari (Latur) Earthquake in Central India," NCEER Bulletin, Vol.7, No.4, October, page 12.

44. Seeber, L., Ekström, G., Jain, S. K., Murty, C. V. R., Chandak, N., & Armbruster, J. G. (1996). The 1993 Killari earthquake in central India: A new fault in Mesozoic basalt flows?. *Journal of Geophysical Research: Solid Earth*, *101*(B4), 8543-8560.
45. GSI 1992, Uttarkashi Earthquake: October 20, 1991, Special Publication No. 30, Geological Survey of India, Calcutta.
46. Jain, S. K. (1992). On better engineering preparedness: lessons from the 1988 Bihar earthquake. *Earthquake spectra*, *8*(3), 391-402.
47. Jain, S. K., & Das, S. (1993). Analysis of strong motion records from Uttarkashi earthquake for assessment of code provisions for different seismic zones. *Earthquake spectra*, *9*, 739-739.
48. Murty, C. V. R., & Jain, S. K. (1997). Seismic performance of bridges in India during past earthquakes. *Bridge Struct Eng*, *27*(4), 45-79.
49. https://pib.gov.in/PressReleasePage.aspx?PRID=1740656
50. https://www.drishtiias.com/to-the-points/paper1/earthquake-4
51. "M 6.0 - 9 km NNW of Dhekiajuli, India". earthquake.usgs.gov. Retrieved 2021-04-28.
52. "Assam Earthquake: 6.4 magnitude quake, 7 aftershocks jolt Northeast, tremors felt in Bengal". India Today. Retrieved 2021-04-28.
53. https://en.wikipedia.org/wiki/List_of_earthquakes_in_India
54. "1 killed as 4 earthquakes hit Maharashtra's Palghar in 12 minutes". Hindustan Times. 2019-07-25. Retrieved 2019-07-25
55. "M 4.1 - 25 km WSW of Shirgaon, India". United States Geological Survey. Retrieved 2022-01-27.
56. "M 5.3 - 5km NE of Sapatgrām, India". earthquake.usgs.gov. Retrieved 2018-09-12.
57. "Starkes Erdbeben vor der Küste von Indien – Spürbar in weiten Teilen von Indien (Kalkutta, Bangalore, Chennai und Delhi) und Bangladesch – Mindestens 2 Tote und 250 Verletzte" (in German).
58. "M 6.0 - 276 km SE of Kon?rka, India". United States Geological Survey. Retrieved 2022-04-04.
59. "M 4.3 - 6 km NE of Pitampura, India". U.S. Geological Survey. Retrieved 2022-03-21.
60. ":: ASC :: 30 March 2010, M6.6 West Island (Andaman Islands) India Earthquake". asc-india.org. Retrieved 2022-03-21.
61. "M 6.6 - 217 km N of Bamboo Flat, India". U.S. Geological Survey. 2010-03-30. Retrieved 2022-03-21.
62. "M 4.1 - 19 km SSE of Ch??b?sa, India". asc-india.org. Retrieved 2022-03-21.

63. "M 5.0 - 7 km NNE of Patan, India". earthquake.usgs.gov.

64. USGS. "M 5.1 - Gujarat, India". United States Geological Survey.

65. ASC. ":: ASC :: 25 September 2001, M5.5 Puducherry (Pondicherry) Earthquake". Retrieved 2022-03-21.

66. USGS. "M 5.2 - 39 km SE of Marakkanam, India". United States Geological Survey.

67. https://unacademy.com/content/upsc/study-material/ncert-notes/earthquakes-in-india/

68. Ministry of Earth Sciences, overment of India, https://seismo.gov.in/dos-and-donts

69. National Disaster Management Plan May 2016, https://www.mha.gov.in/sites/default/files/National%20Disaster%20Management%20Plan%20May%202016.pdf

Received: 11th November 2022; Accepted: 20th April 2023; First distribution: 25th April 2023