

## *Governing Factors and Conditions Cognate with Hazards in Disaster Management: An Indian Perspective*

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On account of distinctive geo-climatic and socio-economic Conditions, India is vulnerable to a large number of natural and anthropogenic disasters, this positions India in one of the ten most disaster-prone countries of the world. India is highly vulnerable to floods, droughts, cyclones, earthquakes, landslides and forest fires. The major reasons of compounding of Disaster risks in India are increasing vulnerabilities related to changing demographics, rapid, uncontrolled, unplanned urbanization, lack of investment in proper infrastructure, development with high-risk zones, Urban-rural poverty, Degradation of environment and mismanagement of natural resources, climate change, geological hazards, epidemics and pandemics. Education, public awareness, attentiveness, and proper training, preparedness for enhancing the capacity are the foundation of approaches intended at reducing vulnerabilities to natural hazards to a community and population.

### INTRODUCTION

**H**azards, resultant of either natural earth processes or anthropogenic activities, have the potential to affects life, property, and the ecosystem. When these hazards are mild they may not impact us. But if they are of a higher magnitude then they can cause catastrophic events resulting in enormous losses of lives and properties (Bryant, 2005). Such events, termed as disasters, can be devastating. Several regions in the world have experienced various kinds of hazards. It takes many years for resettlement and to come back to normalcy for an area or region that has been affected by a hazard. Rapid unplanned urbanization to fulfill the demand of increasing population and climate change are intensifying the socio-economic impacts of hazards (Keller, E.A. 2010).

Hazard is defined as “A dangerous phenomenon, substance, human activity or condition that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage” (UNISDR Terminology). Hazards can be characterized by their magnitude or intensity, speed of onset, duration, and area of extent. The word ‘hazard’ has originated from the word ‘hasard’ in old French and ‘az-zahr’ in Arabic meaning ‘chance’ or ‘luck’. On the other hand, Disasters is defined as, “A catastrophe, mishap, calamity or grave occurrence in any area, arising from natural or manmade 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 is of such a nature or magnitude as to be beyond the coping capacity of the community of the affected area”(Disaster Management Act, 2005, Government of India; nidm.gov.in/PDF).

A hazard is a phenomenon that poses a threat to people, structure, or economic assets and which may cause a disaster. They could be either manmade or naturally occurring in our

environment (Brebbia et al., 2011). However, in such conditions, the extent of damage mainly depends on the impact, intensity, and characteristics of the phenomenon; and the extent of affect to the people, environment, and infrastructures (Burton and Kates, 1964; Burton et al. 1993). Those elements of the physical environment, harmful to man, and caused by forces extraneous to him (Burton et al. 1978). The difference between Hazard and Disaster is, while a hazard is a potentially damaging condition, physical event, phenomenon, or human activity; a disaster is an actual event that disrupts the functioning of a community.

The different natural hazards have different characteristics regarding their influence and impact. In nature, one hazard can also trigger the advent of another hazard or be simultaneously associated with one another. For example, an earthquake can cause secondary hazards such as landslide (Bobrowsky, 2013). The 2004 Indian Ocean Earthquake and the 2010 Haiti Earthquake are the worst earthquakes of the 21st century. They caused billions of dollars in damage. Many were injured or became homeless. Understanding the science about the natural hazards will help formulate strategies for their preparedness, mitigation, and management.

The objective of the present paper is, defining and differentiating between the terms, hazards, and disasters, classification of various types of hazards including their effects and explanation of various governing factors and conditions of hazards in India's perspective.

## CLASSIFICATION OF HAZARDS

There are numerous classifications for the hazards.

**I:** According to EM-DAT<sub>6</sub>, the International Disaster Database, Centre for Research and Epidemiology for Disasters (CRED), the general classification of hazards is as follows:

1. Natural
2. Man-made/Technological

### 1. Natural Hazards

Natural process or phenomenon that may cause loss of life, injury or health-related complications, damage of property and services of economic or social values, or environmental damage. The phenomenon of increased incidences of geophysical and hydro-meteorological hazard events, which arises from the interaction of natural hazards with overexploited or degraded land and environmental resources. Example: flooding, drought, landslides and land subsidence, etc. (Bryant, E. 2005; nidm.gov.in/PDF).

**a) Geophysical Hazards:** A hazard that occurs from solid earth processes in plate tectonics. This term is also referred to as geological hazard. These events are usually due to natural processes; however, humans have a larger influence on the impact of the events. Example: Earthquakes, Tsunamis, Mass Movement (dry), Volcanic eruptions (Gill, and Malamud,2014; Shen et al. 2018).

**b) Meteorological Hazards:** The hazards that are caused by extreme weather and atmospheric conditions. These are related to wind and temperature that may last from minutes to days. Example: extreme temperatures like heatwaves and cold waves, Cyclones, hurricanes, fog, storm, freezing rain (Shannon, 2020).

**c) Hydrological Hazards:** These hazards are driven by hydrological (water) processes. These events are caused by the occurrence, movement, and distribution of surface and subsurface freshwater and saltwater. Examples: Floods, Landslide, Tsunamis, Wave action. (Gill, and Malamud,2014)

**d) Climatological Hazards:** The hazards that are caused by atmospheric processes ranging from climatic variability. Example: Drought, Wildfire, Glacial lake outburst (Keller, E.A. 2010).

**e) Biological Hazards:** These are the hazards caused by biological vectors of organic origin including toxins and bioactive substances that may cause loss of life, illness, loss of livelihoods and services, damage of property, or environmental damage (nidm.gov.in/PDF). In recent years vector-borne diseases such as the Zika virus, Dengue, Chikungunya, and Nipah virus have affected millions of people globally (Brauch et al., 2011). Climate variability and weather affect the increase in the incidence of such diseases (Baskar and Baskar, 2009). COVID19 also known as the coronavirus has infected a million people in China and many succumbed to the disease. The root cause of this virus is yet to be established through medical experts and scientists believe that it may be transmitted from bats and meat products. The disease causes a serious type of pneumonia, and there is no treatment or vaccine for the virus. The disease has also spread to parts of Italy, Spain, France, USA, and in the Asia-Pacific including India as well. Example: Epidemic, Insect Infestation, animal accident, locust.

**f) Extra-terrestrial:** An event that is caused by activities occurring in outer space and effecting earth such as asteroids, meteoroids, and comets. Example: Impact, Space weather.

## 2. Man-Made Hazards or Technological Hazards

These are the hazards created due by industrial or technological circumstances, these include infrastructure failures, unsafe measures, accidents, unsafe anthropogenic activities, that may result into loss of life, illness, injury, loss of livelihoods and services, damage of property social and economic disruption, or environmental damage (nidm.gov.in/PDF). The list of such hazards is extensive, various occur sporadically while others take place frequently. These events occur in close proximity to human settlements. These can be categorised as:

**a) Industrial accidents:** Examples: Collapse, fire, chemical spill, explosion, gas leak, oil spill, radiation, poisoning, others.

**b) Transport accidents:** Examples: Road, Water Air, and Rail.

**c) Miscellaneous accidents;** Example: Fire, Explosion, Collapse, others (Tselios and Tompkins 2020).

Apart from these, there are complex emergencies, conflicts, famines, displaced populations. These also include environmental degradation, and pollution, and a range of other challenges such as poverty, climate change, the threat of a pandemic, etc. These aggravating factors lead to increased frequency, complexity, and severity of disasters.

**II.** Another classification of hazards is based on the sudden or slow onset. The hazards are categorised into the following by WHO (Emergency health training program for Africa):

**A) Natural (physical):** Weather related (Earth movement and meteorological)

1. Internal (tectonics & telluric)
2. External (topographical)

**B) Natural (biological)**

1. Epidemics
2. Infestations

### **C) Manmade/Technological**

1. Structural failures. Example - Wars, civil strife, etc.
2. Industrial disasters. Example – Fires, Nuclear accidents, Chemical accidents, etc.

### **III. Miscellaneous types of hazards**

**1. Environmental hazards:** These hazards are caused due to human interventions. Examples are the formation of acid rain, contamination of the atmosphere or surface waters, and soil with harmful substances (Keller, E.A. 2010).

**2. Chronic Hazards:** The hazards which are caused as consequence from a continuous state of affairs which accumulate over time and not from a single isolated event. Examples: pollution, large-scale toxic contamination, famine, and resource degradation (Keller, E.A. 2010).

**3. Secondary Hazards:** These are hazards that follow as a result of the main hazardous event. For example, a primary hazard is an earthquake. Secondary hazards caused due to the primary hazard may include the collapse of buildings, failure of dams, fire, landslides, tsunami, pollution of water bodies, soil liquefaction, and hazardous substances to spill over, interruption in water and electric supplies, and so on.

### **GOVERNING FACTORS AND CONDITIONS COGNATED WITH HAZARDS**

**1. Hazardous Event:** The physical constraint of the hazard event that causes the destruction and devastation is known as a Hazardous event. Events become a disaster when they cause loss of life and livelihood and affect society, economy, and the environment adversely. A natural phenomenon like a volcanic eruption, flood, cyclone, earthquake, etc is physical events. A natural phenomenon that occurs in a populated area that results in affecting life and property is a hazardous event (Keller, E.A. 2010).

**2. Capacity:** It can be defined as "resources, means, and strengths which exist in households and communities and which enable them to cope with, withstand, prepare for, prevent, mitigate or quickly recover from a disaster" (nidm.gov.in/PDF). Hazards are always rampant, but a hazard becomes a disaster only when the vulnerability is high, and the capacity to cope with the vulnerability is low. In other words, the incidence or probability of a hazard and the vulnerability of the population increases the risk of being severely affected.

**3. Risk:** As described by NIDM, INDIA, Risk is the expected loss from a given hazardous event for a given element of vulnerability over a specified time period. It is a function of:

- The probability of a hazard of a particular magnitude occurring;
- The elements susceptible to potential loss or damage (at risk);
- The nature of vulnerability to those elements;
- A specified future time period.

A community is said to be at 'risk' when it is exposed to hazards and in all probability is going to be severely affected by its adverse impact. The 'disaster management' is basically 'disaster risk management' which extensively includes all measures which will reduce

disaster-related losses of life, property, or assets by either reducing the hazard or vulnerability of the elements at risk.

Conventionally risk is expressed by the notation **Risk = Hazards x Vulnerability/ Capacity**. Some disciplines also include the concept of exposure to refer particularly to the physical aspects of vulnerability. Beyond expressing a possibility of physical harm, it is crucial to be aware that risks are inherent within the social systems or can be created (nidm.gov.in/PDF; Gill, and Malamud,2014).

**4. Rate of Onset of Hazards:** Natural hazards can also be classified into rapid onset hazards and slow-onset hazards. The speed of onset of a hazard is an important variable since it determines the available warning time (Fang et al., 2017).

Rapid onset hazards	Slow onset hazards
These hazards form with little warning and strike rapidly.	These hazards take years to manifest itself.
Examples: Earthquakes, landslides, and flash floods generally give no warnings.	Examples: drought and disease epidemics.

Tsunamis can only indicate warning periods ranging from minutes to a few hours. On the other side, hurricanes and floods can be predicted and warning signals for the probability of occurrence are known ranging from several hours to a few days in advance. Furthermore, volcanoes can erupt suddenly but usually give indications of eruption weeks or months in advance. Contrarily, desertification, drought, and subsidence act slowly over a period varying from months or years. Hazards such as erosion or sedimentation have varying lead times. The damage may occur suddenly as the result of a storm or may develop over many years.

**5. Spatial Dispersion:** This refers to the pattern of distribution and coverage of a hazard over the geographic area in which the hazard can occur. It refers to where hazards are located. For example, earthquakes tend to occur along the plate boundaries. Tropical storms tend to be centered on the coastal areas in the tropics. The hazards can be dealt with well if their spatial distributions are mapped.

**6. Temporal Spacing:** Refers to the effect of seasonality and sequencing of events in the case of hazards. Some events are quite random (volcanoes) while others have seasons (river floods tropical cyclones, hurricanes). Each disaster has a different space and time signature (**Table-1**).

**Table-1: Disaster Time and Space Characteristics**

Type	Impact time	Spatial Extent
Earthquake	Seconds to minutes	102 – 104 sq.km
Landslide	Seconds	0.1 – ½ sq.km
Forest fires	Minutes to days	101 – 103 sq.km
Floods	Minutes to hours	105 – 107sq.km
Cyclones	Few hours	103 – 104 sq.km
Drought	Months to years	106 sq.km
Desertification	Tens of years	107 – 108 sq.km

## 7. Hazard Dimensions

The impact of a disastrous event is in part a function of its frequency and magnitude. It is also influenced by various factors like vegetation, population climate, geology, and land use, etc. Magnitude is an important characteristic for analysing any hazard. Only the events exceeding some defined level of magnitude are considered hazardous.

There is usually an inverse relationship between the magnitude of an event and its frequency. For example, the larger the flood, the less frequently the flood occurs.

**8. Return Period:** This refers to the repeat interval or recurrence period of the natural hazard. Most of the hazards have return periods on a human timescale. The inverse of probability expressed in percentages gives the estimated period between events of a similar size or intensity. The frequency is measured in terms of a hazard's recurrence interval. This is calculated statistically to measure the return period of a hazard of a given magnitude and intensity. It has been noted that in the cases of extreme events, their frequencies are low whereas magnitudes are very high in terms of destructive capacity. This can be understood as an event of a hundred-year flood that would cause severe damage compared to a five-year flood.

People can be affected, either directly or indirectly, by a hazardous event.

- (a) Direct effects: These effects include those who have suffered severe health issues, illness, injury, or other effects. It also includes population who were displaced, evacuated, relocated, or has suffered direct damage to their economic, livelihoods, physical, cultural, social, and environmental assets (Gocić, et al., 2020).
- (b) Indirect effects: These are indirect in nature and include those who suffered consequences over time. This can be due to disruption or changes in the economy, critical infrastructure, basic services, social, health, and psychological consequences.

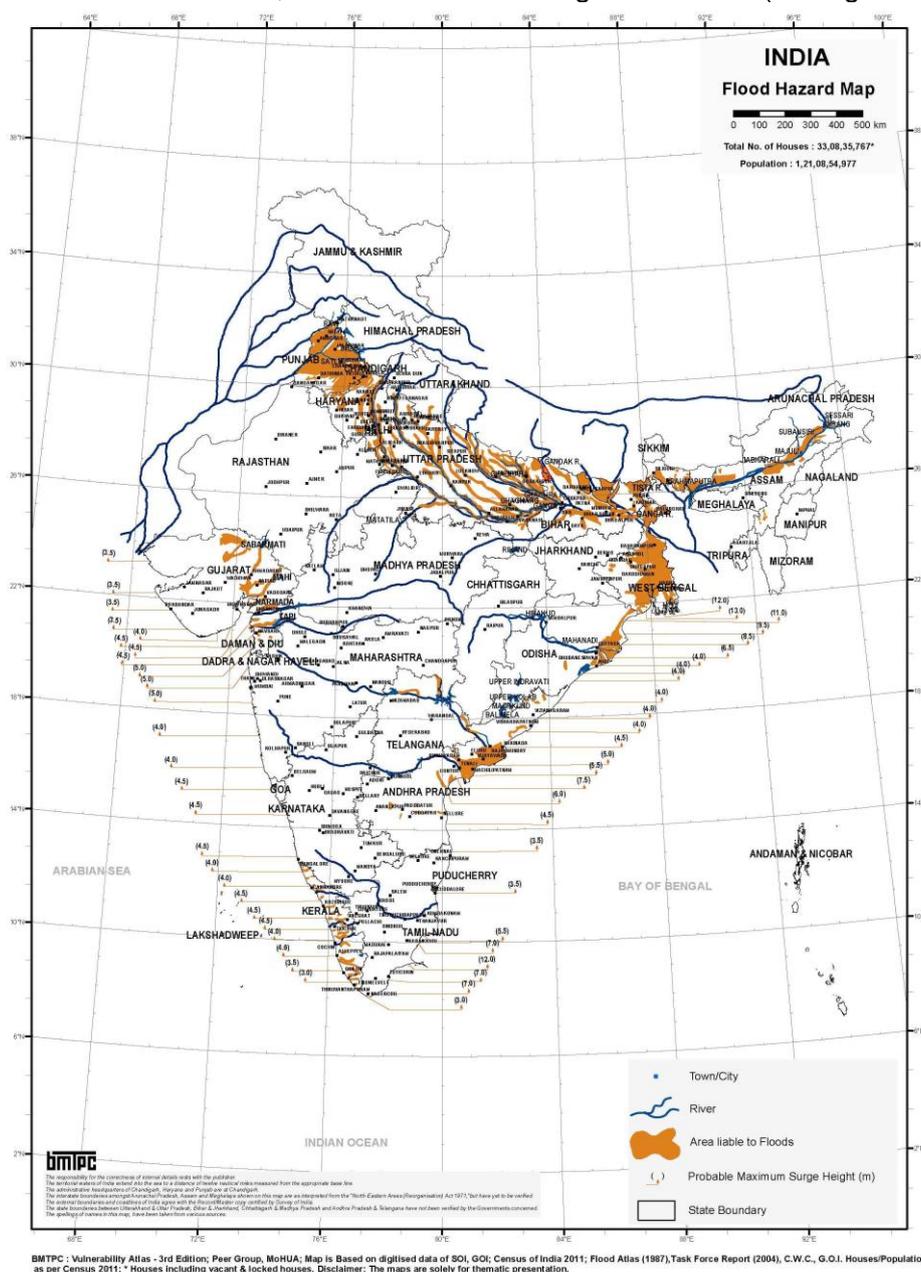
## MAJOR HAZARDS OF INDIA

The Indian subcontinent is highly vulnerable and susceptible to various natural and anthropogenic disasters. Thirty-one disasters have been identified by HPC (2001) in the country. These disasters have been further categorised into five sub-groups.

- India is ranked among one of the ten most disaster-prone countries in the world. Vast topographic features, adverse geo-climatic conditions, environmental degradation, explosive rate of population growth, urbanisation, uneven industrialisation, etc. are some of the key factors which increase the vulnerability factor of the country to an enormous extent.
- The unique geo-tectonic features of the Himalayan region and its adjacent alluvial plains make the region enormously susceptible to floods, landslides, earthquakes, etc.
- The western part of the country, including states like Rajasthan, Gujarat, and some parts of Maharashtra commonly face drought situations in large regions.
- Various human-induced activities like demographic pressure, deforestation, illegal mining, constructions, etc. are also responsible for the increase in the frequency of disasters.
- The extreme weather conditions, glacial snowmelt, etc. are some of the factors which make the country prone to various kinds of disasters like cyclones, floods, cloud bursts, etc. (Disaster Management in India, 2011; nidm.gov.in/PDF).

## 1. Flood hazard

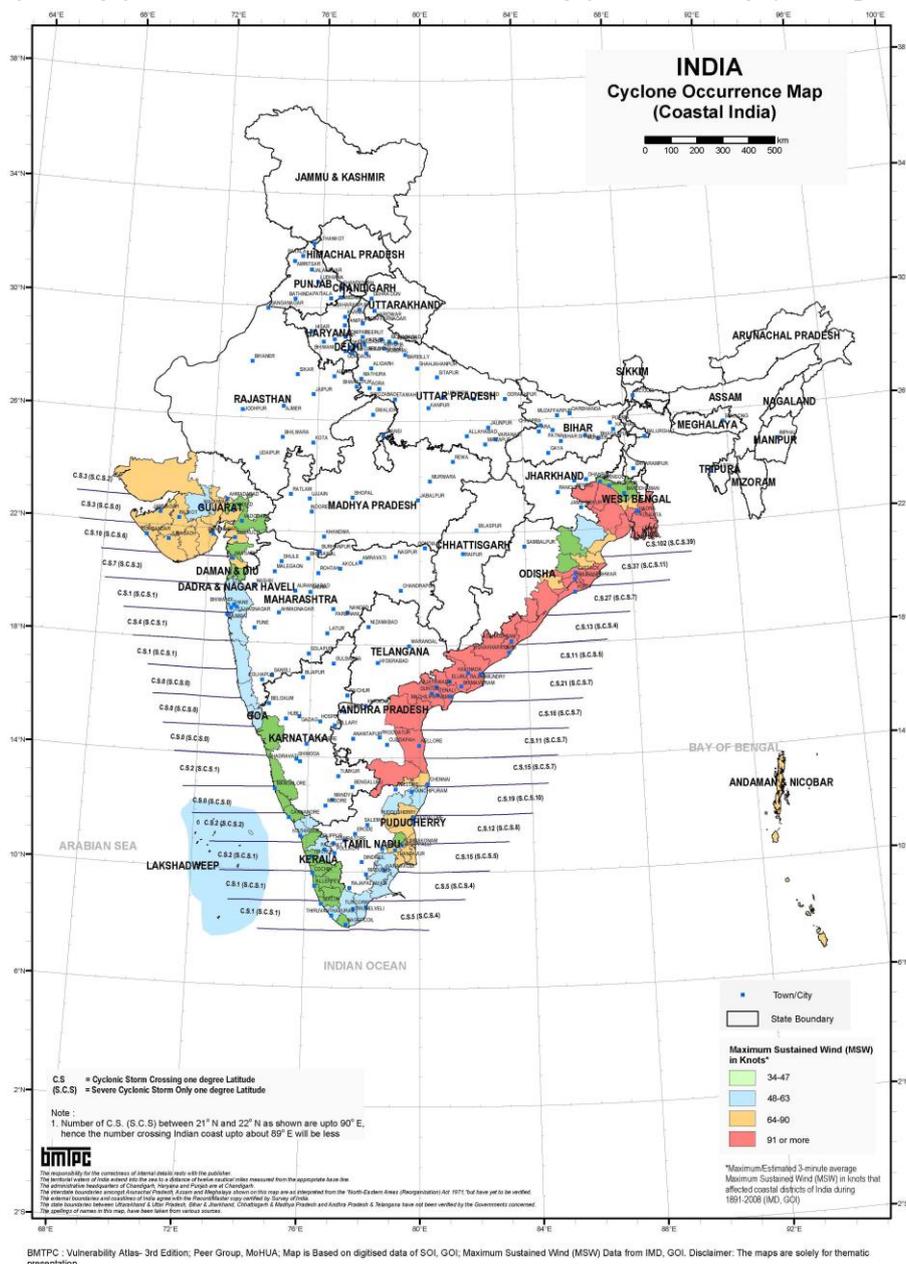
- In India, around 40 million hectares out of a geographical area of 3290 lakh hectares are prone to floods and related devastation (**Fig 1**).
- On average every year, around 75 lakh hectares of land are being affected and 1600 lives are lost due to flood.
- India can be divided into four regions for the study of flood hazards and its consequences, these are 1. Gangetic- Brahmaputra, 2. Central India 3. North- west and 4. Deccan region.
- In the region of Andaman and Nicobar Islands and Lakshadweep comprises particular characteristics, which result in flooding and erosion (nidm.gov.in/PDF).



**Fig 1. Flood hazard map of India (Source: BMPIC, India 2019)**

## 2. Cyclone Hazard

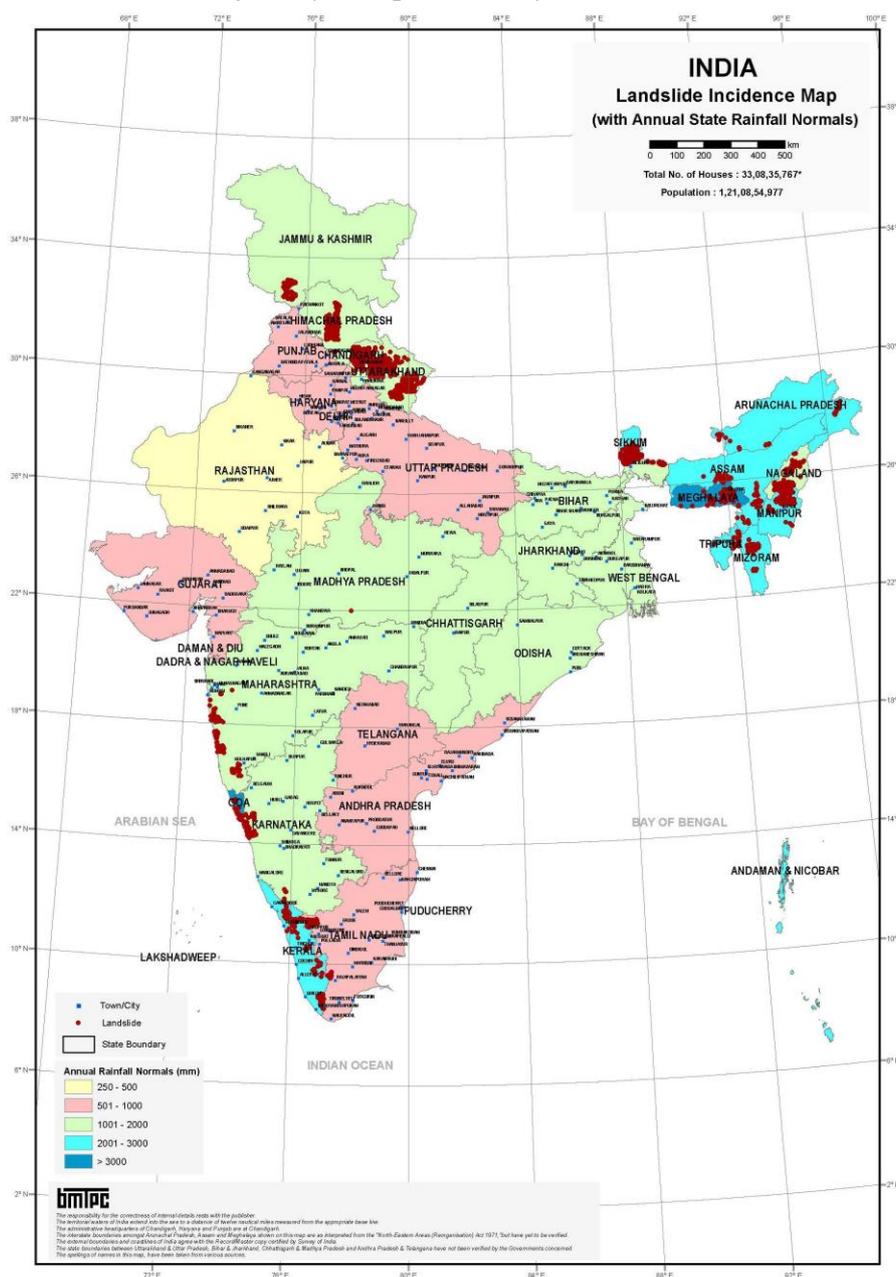
- India comprises of 7,516 km long coastline out of which 5,700 km is prone to cyclones (**Fig 2**).
- In India, around 8% of the country's area and one-third of its population live in 13 coastal states and UTs, encompassing 84 coastal districts are vulnerable to cyclones.
- Tamil Nadu, Andhra Pradesh, Orissa, West Bengal, and Puducherry on the east coast and Gujarat on the west coast are more prone to cyclones.
- Cyclones usually occur in the months of May –June, and October – November with their primary peaks in November and secondary peaks in May (nidm.gov.in/PDF).



**Fig 2. Cyclone hazard map of India (Source: BMTPC, India 2019)**

### 3. Landslide Hazard

- In India, around 12.6% of the land area - an area that exceeds 0.42 million km is prone to landslides (**Fig 3**).
- Around 21 states and parts of the Union Territory of Jammu and Kashmir, Ladakh, Puducherry, and Andaman & Nicobar Islands are most affected by the landslide.
- In the Himalayan and Arakan-Yoma belt of the North-Eastern parts of India Due to its geodynamical active domains landslide occurs whereas in the relatively stable domains of the Meghalaya Plateau, Western Ghats and Nilgiri Hills different types are landslides are frequent (nidm.gov.in/PDF).



BMTPC: Vulnerability Atlas - 3rd Edition: Peer Group, MoHUA, GOI. Map is Based on digitised data of SOI; Landslide Incidence data GSI; Annual Rainfall data IMD; Houses/Population as per Census 2011; \*Houses including vacant & locked houses. Disclaimer: The maps are solely for thematic presentation.

**Fig 3. Landslide hazard map of India (Source: BMTPC, India 2019)**

#### 4. Earthquake Hazard

- According to NIDM Geographic Areas in Seismic Zones (Table 2).
- The entire Himalayan region is considered vulnerable to high-intensity earthquakes of magnitude  $\geq 8$  on the Richter scale (Fig 4).

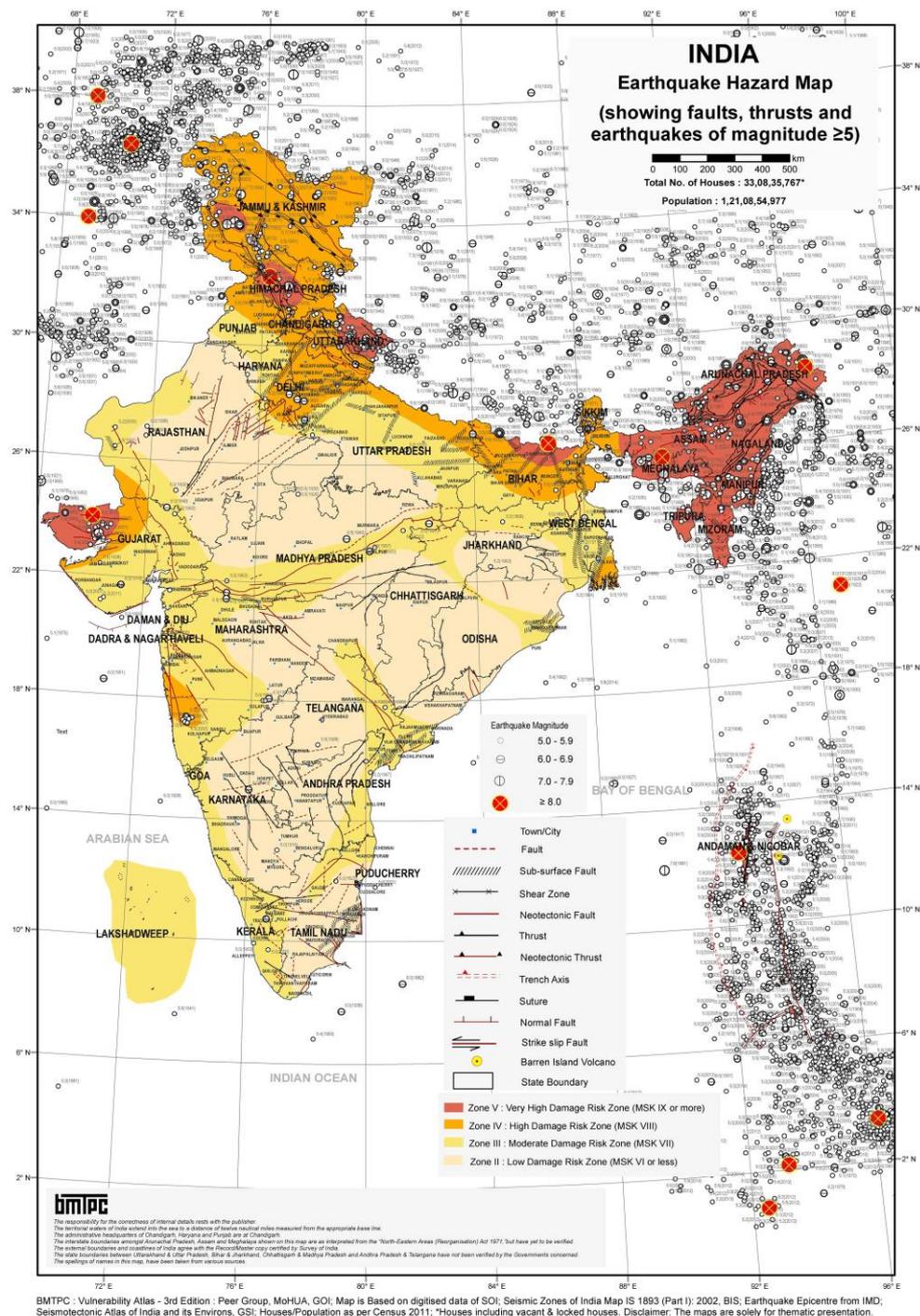


Fig 4. Earthquake hazard map of India (Source: BMTPC, India 2019)

## **DISASTER RISK REDUCTION (DRR)**

Disaster Risk Reduction is the systematic approach to identifying, assessing, and reducing the risks of a disaster. The conceptual framework of this approach is based on the broad context of sustainable development which includes prevention or limiting (mitigation and preparedness) the adverse impacts of hazards, minimising vulnerabilities, and disaster risks throughout society.

According to the IPCC Fourth Assessment Report, the disaster risk reduction framework includes the following fields of action:

- Risk awareness and assessment including hazard analysis and vulnerability/capacity analysis;
- Knowledge development includes education, training, research and information, generation, improvement, and sharing;
- Public commitment and institutional frameworks include organisational, policy, legislation, and community action;
- Application of other measures includes application of science and technology, environmental management, land-use, and urban planning, protection of critical facilities, partnership and networking, and financial instruments;
- Early warning systems including development of advanced forecasting systems, dissemination of warnings, preparedness measures, and reaction capacities building.

In the disaster risk reduction, mitigation refers to structural and non-structural measures undertaken to limit or minimise the adverse impact of natural hazards, environmental degradation, and technological hazard ([nidm.gov.in/PDF](http://nidm.gov.in/PDF)).

## **DISCUSSION AND CONCLUSION**

As India is highly prone to disasters, it is essential to be acquainted with natural hazards, their types, effects, impacts, vulnerability, human intervention, and an overview of assessing hazards. The adverse effects of ever-escalating population growth, urbanization, and density have led to higher potential exposure to natural hazards (Bobrowsky, 2013). Natural hazards vary in dimensions. Assessing hazards and risks is the first important step. The response to different hazards requires adopting different strategies. Further, policies play a fundamental role in influencing the impact of natural disasters (Bryant, E. 2005).

Education, public responsiveness, awareness, alertness, attentiveness, and proper training, preparedness for enhancing the capacity are the foundation of approaches intended at reducing vulnerabilities to natural hazards to a community and population. The Hyogo Framework for Action 2005-2015: Building the Resilience of Nations and Communities to Disasters, adopted at the World Conference on Disaster Reduction, highlights knowledge and education as one of the five main priorities of action. Attention should be accorded and support is given to efforts targeting school children and youth and people at large with the aim of making people more aware of the threat of hazards and the necessity and possibility to become better prepared before disasters strike ([nidm.gov.in/PDF](http://nidm.gov.in/PDF)).

An event is called a disaster when it impacts the community, overwhelms the community's response capacity, and requires multi-agency response. Disasters occur when adverse environmental events interact with a population that is sensitive to the event. Hazards are caused mainly due to natural and man-made factors. Natural hazards include earthquakes, landslides, tsunamis, floods, droughts, cyclones, tsunamis, etc. Manmade hazards include accidents, epidemics, gas leaks, etc. The geographical extent of hazards varies from place

to place and person to person. With this, the vulnerability of hazards also varies and is largely governed by factors such as age, gender, education, technology, etc. However, researchers, scientists, academicians all across the world are dedicatedly working on reducing the vulnerabilities of hazards and also on minimising the impacts of these harmful events. The human factor plays an important role in highlighting this issue as community members can work together in reducing vulnerability (Keller, E.A. 2010).

Disaster management comprises planned activities that precede, continue during, and are done post the disaster event to reduce the impacts and effects of a hazard thereby preventing adverse impacts. Therefore, with a robust and proactive strategy, we cannot only work towards reducing hazards but, also work on minimising the risk of future hazard events.

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<https://www.undp.org>

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