



CITY RESILIENCE



सत्यमेव जयते



भारत 2023 INDIA

# MULTI-HAZARD DISASTER RISK & RESILIENCE GUWAHATI CITY



॥ ज्ञानम् सर्वजनहिताय ॥

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Resilient India - Disaster Free India





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# MULTI-HAZARD DISASTER RISK AND RESILIENCE FOR GUWAHATI CITY



Resilient India - Disaster Free India

National Institute of Disaster Management  
(Ministry of Home Affairs, Government of India)

## Multi-hazard Risk and Resilience for Guwahati City

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### **Disclaimer:**

This publication is based on the research study carried out under the project entitled "Multi Hazard Disaster Risk & Resilience: Practical Learning and Step-by-Step Guide to Improve Disaster Resilience at City Levels" from 2021 to 2022. This study includes various sets of Information from research work undertaken in joint collaboration with National Institute for Disaster Management, New Delhi and Indian Institute of Technology (IIT), Indore. Authors acknowledge all the contributions from original sources i.e., published, unpublished literature, reports, documents, and web resources. This report in full or in parts can be freely referred, cited, translated and reproduced for any academic and noncommercial purpose with appropriate citation of authors and publishers.

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Disasters are highly unpredictable and instantaneous in nature and thus demand an immediate action. India has adopted a strategic approach towards disaster management which is focused on preparedness and mitigation so the rising numbers of disasters can be brought down significantly.

A significant reduction in losses and damages due to disasters in the country has been achieved with the enactment of the Disaster Management Act, 2005 and the implementation of the National Disaster Management Policy, 2009 and National Disaster Management Plan, 2016.

A study on "Disaster Risk and Resilience in States and Union Territories – An Analytical Study" was conducted in 2019 which analyzed and measured the disaster risk and resilience level of the States/UTs of India. This report on "Multi-hazard Risk and Resilience for Guwahati city" is a part of a broader study titled "Multi-hazard Disaster Risk & Resilience: Practical Learning and Step-by-Step Guide to Improve Disaster Resilience at City Levels". This report is a propagation of the aforementioned study to the next step i.e. at the level of cities and particularly for Guwahati city in Assam. This study has been conducted by the Indian Institute of Technology, Indore, Madhya Pradesh under the aegis of National Institute of Disaster Management, Ministry of Home Affairs, Government of India in order to improve the overall resilience level of the cities/urban local bodies towards disaster risks.

The impacts and effects of disaster are more immediate and intense at the level of the cities/urban local bodies. This study is dedicated to evaluate the risk and resilience indices for the hazards specific to the city of Guwahati. Hence this study will prove to be remarkable in providing a more localized approach to the Guwahati city for understanding internal disaster risks and improving their preparedness and resilience thereby making them a self-sufficient paragon to deal with disasters.



(Rajendra Ratnoo)



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# PREFACE

It's a matter of immense pleasure for me to present this study for "Multi-hazard Disaster Risk & Resilience for Guwahati City" developed in collaboration with Indian Institute of Technology, Indore as a part of the broader study on "Multi-hazard Disaster Risk & Resilience: Practical Learning and Step-by-Step Guide to Improve Disaster Resilience at City Levels". This report presents a scorecard to measure the level of disaster risks and resilience for the Guwahati city and has also been conducted as a pilot for three more cities of India viz. Srinagar, Vishakhapatnam and Jaipur representing a diverse range of geophysical characteristics. I strongly believe that this study is going to assist various line department officials in taking well-informed and precise decisions in case of the emergence of a disaster.

Climate-related extremes have more pronounced effects in cities because of the more complex urban infrastructure systems, rapid increase in urban populations and intensive economic activities. Cities are currently facing an over-burden due to the increased migration and thus are becoming sensitive and vulnerable to disasters and even unanticipated incidents like the sudden heat wave intensification in the United Kingdom in 2022. Thus, the cities specifically should be more and more focused on increasing their understanding of localized risks and developing resilience. A bottom-up approach may prove to be exceptional wherein the resilience at city levels can altogether build resilience at state and national levels.

This study is very detailed and is in the form of seven reports viz. a technical report which encompasses the development of risk and resilience scorecard for all four cities, four city-specific technical reports, a step-by-step disaster management guide to improve disaster resilience of Indian cities and a mayor's handbook. This particular report highlights the hazards and risks specific to the Guwahati city and its level of resilience in the form of preparedness and capacity building.

  
(Anil K Gupta)



This study on “Multi-hazard Disaster Risk & Resilience: Practical Learning and Step by-Step Guide to Improve Disaster Resilience at City Levels” has been carried out with a collaborative effort from the National Institute of Disaster Management (NIDM), New Delhi and the Indian Institute of Technology (IIT), Indore research teams.

Special thanks to the government authorities from the four cities i.e., Guwahati, Jaipur, Srinagar, and Visakhapatnam for providing valuable suggestions, feedback, and timely response for the required datasets in preparing disaster scorecards for risk and resilience of the selected cities. The project team is grateful to Maj. Gen. Manoj Kumar Bindal and Shri Taj Hassan (former Executive Directors) and also to Shri Rajendra Ratnoo, IAS, present Executive Director NIDM for their constant support and engagement in performing this study and ensuring the effective functioning of the project. A number of consultation workshops were hosted which saw participation and suggestions from regional experts, scientific community, government organizations, and National Disaster Response Force (NDRF).

The contribution of principal investigator Professor Manish Kumar Goyal and his research team comprising Dr. Vikas Poonia (Former Research Scholar, IIT Indore), Mr. Vijay Jain, Mr. Shivukumar Rakkasagi, Mr. Shivam Singh and Mr. Kuldeep Singh Rautela (Research Scholars, IIT Indore) are acknowledged for joining hands with us in completion of this study for providing a technical assessment of natural and man-made hazards in the cities through collected data and in compilation of the report. The study was supported with continuous support of the team from NIDM comprising of Dr. Kopal Verma (also acknowledged for the special efforts in designing the report), Dr. Uzma Parveen, Ms. Fatima Binte Amin, and Mr. Michael Islay for their overall coordination with all the cities authorities and collection of the datasets. The project team extends thanks to the library and the entire publication cell of NIDM for their support and publication of this report.

  
(Anil K Gupta)



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# LIST OF ABBREVIATIONS

BPL	Below Poverty Line
BMTPC	Building Materials and Technology Promotion Council
CAW	Crime Against Women
CEPI	Comprehensive Environmental Pollution Index
CGWB	Central Ground Water Board
DM	Disaster Management
DRI	Disaster Risk Index
DRR	Disaster Risk Reduction
DRS	Disaster Resilience Score
FSI	Forest Survey of India
GMDA	Guwahati Metropolitan Development Authority
IMD	India Meteorological Department
IMR	Infant Mortality Rate
MAH	Maximum Accident Hazard
MDP	Master Development Plan
MHA	Ministry of Home Affairs
MHI	Maximum Hazard Industries
MoHUA	Ministry of Housing and Urban Affairs
MoUD	Ministry of Urban Development
MMR	Maternal Mortality Rate
MPIs	Maximum Polluting Industries
MSMEs	Micro, Small and Medium Enterprises
NCRB	National Crime Records Bureau
NDRF	National Disaster Response Force
NOAA	National Oceanic and Atmospheric Administration
OGD	Open Government Data

# LIST OF ABBREVIATIONS

ORGI	Office of the Registrar General & Census Commissioner, India
OSM	OpenStreetMap
SDGs	Sustainable Development Goals
SEZs	Special Economic Zones
SFDRR	Sendai Framework for Disaster Risk Reduction
SPI	Standardized Precipitation Index
SSI	Standardized Soil Moisture Index
ULBs	Urban Local Bodies
UNDP	United Nations Development Programme
WHH	Women Headed Household



# **EXECUTIVE SUMMARY**



India has taken a significant step towards developing an effective Disaster Management (DM) system, such as the endorsement of the DM Act 2005, the formulation of the National Policy on DM 2009, the publication of guidelines and the implementation of plans at the District, State, and National levels. Disaster Risk Reduction (DRR) refers to a policy goal or objective and the strategic & operational measures used to reduce exposure, hazard, or vulnerability and improve resilience. The Sendai Framework for DRR (2015-2030) was the first key agreement of the post-2015 development agenda and provided distinct actions to defend from disaster risks. Also, the United Nations Sustainable Development Goals (SDGs), contribute in reducing disaster risks and building resilience, by endorsing education for sustainable development, such as SDG 4 (ensure inclusive and equitable quality education and promote lifelong learning opportunities for all), SDG 9 (Support domestic technology development, research, and innovation in developing countries) and SDG 11 (Sustainable cities and communities). The establishment of the National Disaster Response Force (NDRF) in 2006, achieved a vital milestone in the journey toward the country's DRR. Urban areas, act as facilitators of economic growth, as they contribute significantly to the country's income, employment creation, and productivity (GDP). The city administration in urban areas continues to lag in disaster risk reduction and has inadequate disaster management capacities, causing people's substandard quality of life.

Therefore, the Government of India launched the 'Smart Cities Mission' in 2015 and selected 100 cities, to accelerate financial growth and improve the living conditions of citizens, through comprehensive work on social, economic, and institutional pillars of the city. Guwahati city is one of the Smart Cities, which aims to leverage the city's heritage & tourism and improve the citizens' quality of life, with modern technology-based practices and inclusive solutions.

An increase in population and urban expansion intensifies vulnerability to disaster events for the population of women, children, below the poverty line, etc., during the disasters. Guwahati is one of the major cities in Northeast India, with a rich cultural heritage and traditions. Guwahati city was ranked 48th in population among India's cities in 2011, with a yearly population growth rate of approximately 1.8% as compared to 2001. The Guwahati Metropolitan Development Authority (GMDA) is the supreme responsible body for coordinating all disasters in different phases of disaster management. The city is situated along the Brahmaputra River and bounded by the foothills of the Shillong plateau on the southern side. The Master Develop Plan (MDP) 2025 envisions Guwahati city, with the following objectives: i) Preservation of natural sensitive environment ii) smart intraurban transportation, iii) well-defined distribution of physical and social infrastructure, iv) efficient economic zones, v) Increase the tourism image vi) Affordable housing and vii) various land-development processes.

This necessitates planning and action to meet the challenges of population growth and in-migration to Guwahati, providing adequate housing, addressing the problems of small businesses, upgrading old and dilapidated areas of the city, providing adequate infrastructure services, conserving the natural environment, heritage and blending Guwahati city with new and complex modern patterns of development. Guwahati city is classified as seismic disturbance Zone-V, making it highly vulnerable to earthquakes. For instance, industrial property, worth in millions, burnt out due to leakage of the cylinder in Basistha, due to the late reaching of a fire brigade. Water scarcity conditions persist in the region, as only 0.3 million households of the population have access to tap water. Private water suppliers and tube wells are major sources of water to fulfil the daily water demand of the city.

In this study, hazard, vulnerability, and exposure indices, for Guwahati city have been computed using several indicators (as per the MHA-UNDP 2019 report). The study showed that, Guwahati city is more prone to Earthquake, Urban Flood, Heat wave and Industrial Hazard, followed by Fire accident, Drought, and Forest Fire. Similarly, Guwahati city is more vulnerable to disasters in terms of Deforestation, Women, Livestock, Poverty and Unsafe Buildings. The study also revealed that the population of Guwahati has a high hazard specific exposure to natural disasters such as Earthquake, Urban Flood and Heat wave, which may lead to an economic loss of the city. This research can be expanded to other cities in India. The risk and resilience indices will aid in evaluating disaster risks at the city level and can play an essential role in disaster resilience.



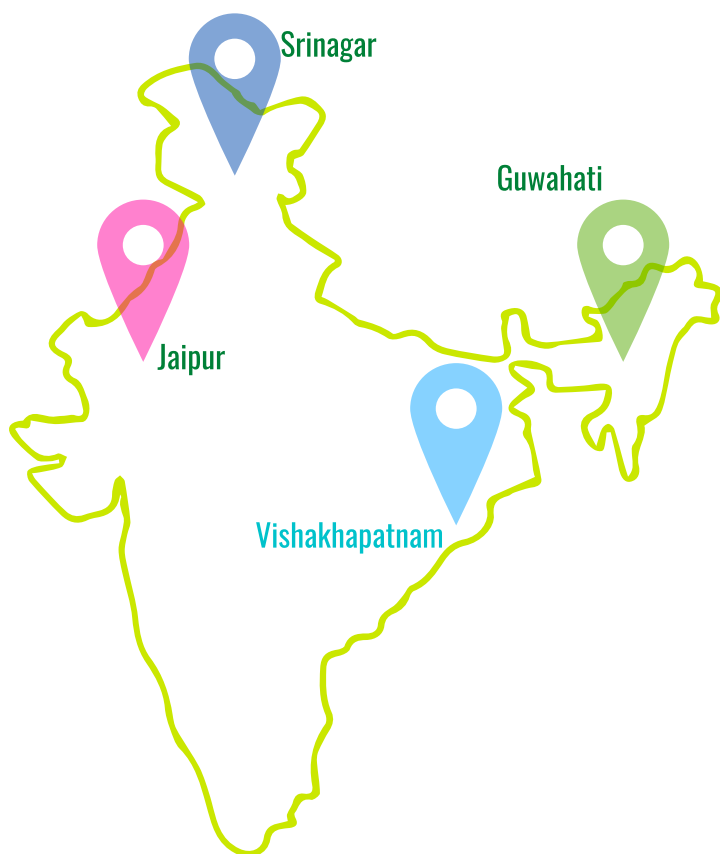
1

# INTRODUCTION





In a rapidly urbanizing world, it is estimated that, by 2050, two-third of the world's population will reside in cities and every year for the next 30 years, about 70 million people will relocate to cities (CDP, 2022). The interactions between rapid urbanization, changes in land use, vulnerability and population exposed, will enhance the future climate change risks and associated impact on the cities (IPCC, 2022). The rapid urbanization intensifies the human induced warming, climate change and extreme events, like severe heat waves, heavy precipitation etc. For example, flooding will become more likely in coastal cities, due to the rise in the sea level and more frequent occurrence of extreme rainfall events (IPCC, 2021).

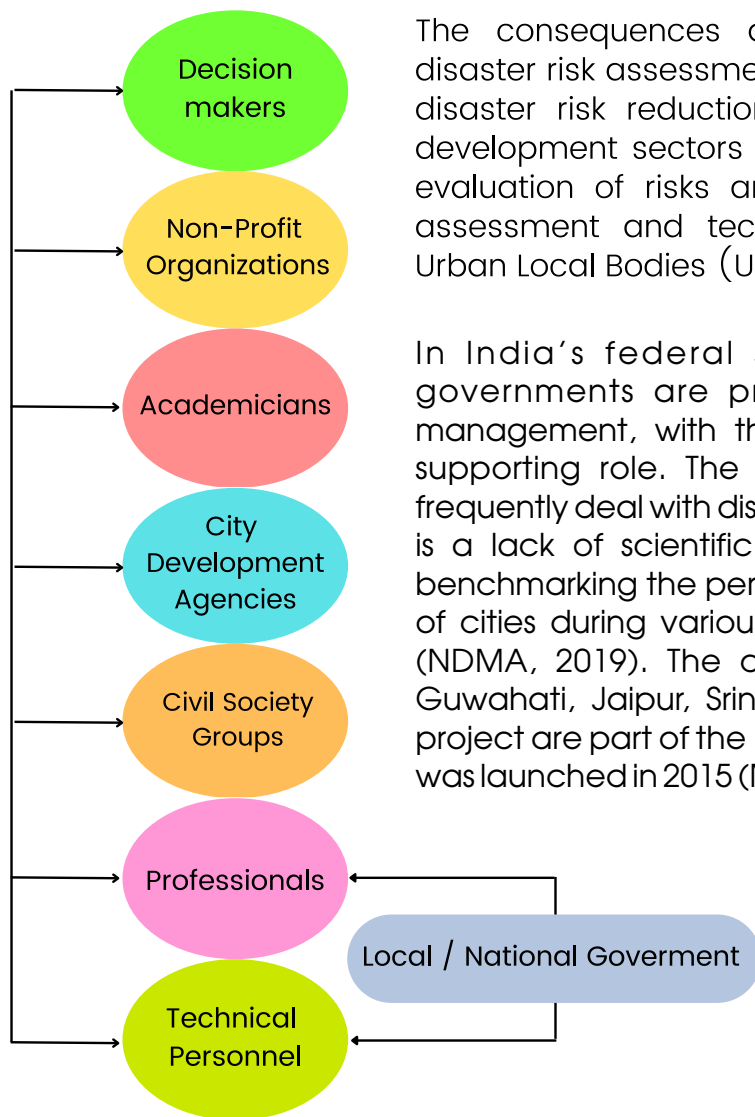


**Figure 1**  
Selected cities for the study: Guwahati, Jaipur, Srinagar, and Vishakhapatnam

An increase in population and urban expansion intensifies vulnerability to disaster events and a lack of basic amenities; the population below the poverty line is highly vulnerable during disasters (ESCAP, 2021). Climate change is becoming more closely associated with urban issues, since it is anticipated to increase the hazards of underdeveloped infrastructure and resource-deficient urban areas (Gupta et al., 2019). The pillars of making any city robust to a changing environment are disaster risk reduction and climate change adaptation (WMO Report, 2022). The use of indigenous knowledge, alongside scientific understanding in disaster risk reduction (DRR), is becoming increasingly popular to lessen community susceptibility to environmental risks (UNICEF, 2022).

The public-private involvement, strong governance and institutional framework, including disaster resilience, adaptability, Environment and sustainability are having a crucial role in disaster management. The necessary step-change in urban risk management may be realized by combining action through these technological and developmental frameworks, i.e., the Sendai Framework for Disaster Risk Reduction (SFDRR) and Sustainable Development Goals (SDGs) (consist of Goal 11 of making the cities and human settlements inclusive, safe, resilient and sustainable) (Stanton-Geddes & Vun, 2019).

The cumulative consequences of different programmes, may be seen in sophisticated early warning systems, coordinated responses to disasters and approaching disasters, dramatic reductions in disaster fatalities and a general improvement in disaster awareness at all levels, such as national, state and district levels.



**Figure 2**

**Technical Report's primary audience**

The consequences are less noticeable in city-level disaster risk assessment, risk prevention & mitigation and disaster risk reduction mainstreaming across multiple development sectors (NDMA, 2019). Therefore, a critical evaluation of risks and resilience, is required with an assessment and technical capacity development by Urban Local Bodies (ULBs) (Jain & Bashir Bazaz, 2016).

In India's federal system of governance, state governments are primarily responsible for disaster management, with the central government playing a supporting role. The regional and local governments frequently deal with disasters as shown in Figure 2, but there is a lack of scientific studies and tools availability, for benchmarking the performance or assessing the progress of cities during various phases of disaster management (NDMA, 2019). The cities selected for the study, i.e., Guwahati, Jaipur, Srinagar, and Visakhapatnam, in this project are part of the 'Smart Cities Mission' of India, which was launched in 2015 (MoHUA, 2022).

The project aims to understand the perceptions & contexts for city risk resilience and provides helpful guidance to city administrators & policy makers on actions required to form resilience to disasters. The 4 Indian cities of the study exhibit a broad range of geographical variances, in terms of climate, terrain, vegetation, hydrology and habitation pattern, creating a patchwork of practically every natural hazard.

As India is yet to build a solid and robust database of hazards, vulnerabilities, risks, and resilience, the 'model' theoretical framework on indicators, is greatly hampered by lack of data at the city level to monitor indicators' progress.



Thus, to make Guwahati city resilient, the regional population should react to disasters with the logic of urgency and strategically reduce human, land/property and ecological loss, by evolving a complete, practical, multi-disaster and technology-focused approach, for Disaster Management (DM). Therefore, this is the 1st study of its kind at the city level, on multi-hazard disaster risks & resilience, to develop a risk and resilience scorecard. This study can be extended to other cities in India to evaluate disaster risks and to plan for disaster resilience. This Technical Report's primary audience consists of decision-makers, professionals, and technical personnel from local to national governments, city development agencies, non-profit organizations and civil society groups. The report is also essential for academics and interested people for further research.





An aerial photograph of Guwahati, India, showing a dense urban area with numerous multi-story buildings and a large green forested area in the foreground. A green semi-transparent banner is overlaid across the middle of the image, containing the text 'GUWAHATI CITY PROFILE'. In the top right corner, there is a green circle containing the number '2'.

**2**

# **GUWAHATI CITY PROFILE**

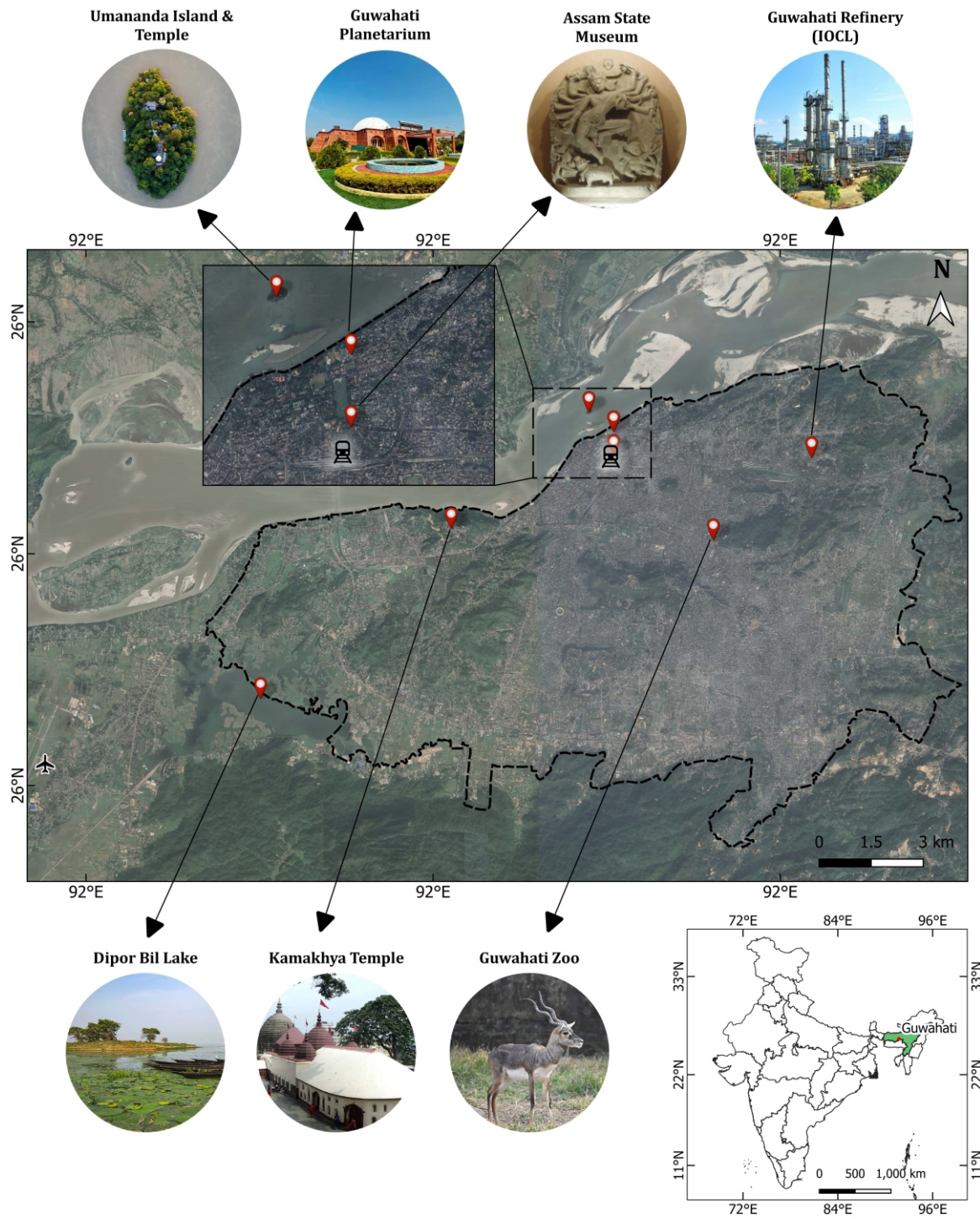


Guwahati, the capital of Assam, is one of India's important cities, due to its significant population, transportation connectivity and its strategic location in Northeast India (Borah & Borah, 2021). Since 1990s, migration from rural to urban regions, has progressed in Assam. This leads to rapid unplanned development and expansion of Guwahati city. This caused a twofold increase in urban built-up area in three decadal periods from 1990-2020. This urban expansion was carried out primarily from the city centre to the south, south-east and across National Highway 37, for better connectivity with the whole Northeast Indian states.

The city consists of the Deepor Beel wetland, which is the only Ramsar wetland in the Assam state (Desai et al., 2014; Misra & Hussain, 2022; Nath et al., 2021). The municipal corporation has an area of 174.47 km<sup>2</sup>, which is almost half of Maldives country. The city has a population density of 5487.20 persons per km<sup>2</sup>, whereas India has a population density of 382 persons per km<sup>2</sup>, which means, the population density of Guwahati city is 14 times more than the population density of India (MoHUA, 2022). Its latitude and longitude are 26° 10' 20'' North and 91° 103 44' 45'' East, respectively, as shown in Figure 1. The important places across the Guwahati city are shown in Figure 3.

The city municipal corporation has a Master Development Plan (MDP) 2025 for accommodating its growing population. The city had a population of 9,57,352 people in 2011, which is expected to increase by 2.8 million by 2025. The city has elevation ranges from 49.5 m to 55.5 m, above mean sea level. Humidity inherently remains about 80 to 90% in the city's climate, except during the dry winter season. Guwahati city has been selected and ranked 20<sup>th</sup> in the list of 'Round 1 Smart Cities', of the 100 Smart Cities in the Ministry of Urban Development's (MoUD) 'Smart City Mission', which was launched in June 2015.

Guwahati city stands at 46<sup>th</sup> in Ease of living, 51<sup>st</sup> in Municipal Performance and 45% urban sustainability in the year 2021 (Borah & Borah, 2021; Smart Cities Mission, 2018, 2020). The Guwahati Metropolitan Development Authority is the supreme responsible body to coordinate all disasters in different phases of disaster management (Guwahati Metropolitan Development Authority, 2022). Guwahati city holds 312<sup>th</sup> rank in the Swachchh Bharat ranking, conducted in 2021 by the Ministry of Housing and Urban Affairs (MoHUA) (Times of India, 2021). It is well-known for its traditional handicrafts, religious temples, forests, and other things.



**Figure 3**  
Location map of Guwahati city



## Population

0.95 million 

## Population Density

5487 person per sq.km 

## Annual Growth Rate

1.80% 

## Indian Cities Population

Rank 48 

## Smart Cities Mission (Round 1)

Rank 20 



An aerial photograph of a village. The houses are mostly white with blue accents and have brown tiled roofs. They are built on a hillside. In the background, there are green hills and a power line tower. A large green circle with the number 3 is in the top right corner.

**3**

# **RISK PROFILE OF THE CITY**

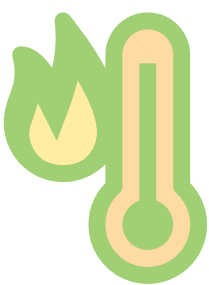


The risk profiles and disasters triggered in the past in Guwahati city are as follows:



As per the Building Materials and Technology Promotion Council (BMTPC) Atlas, Guwahati city falls under earthquake Zone-V, up to magnitude 7.9. For instance, earthquake measuring 3.7 magnitude struck on Jul 05, 2022, magnitude of 5.2 struck on Jul 07, 2021, and magnitude of 6.4 struck on April 29, 2021, the Guwahati city (The Economic Times, 2022).

The annual average rainfall of the city is 1613 mm, almost 90% of which is received in the monsoon period (i.e., June to September). Guwahati city was flooded every year with significant casualties occurring annually. The city has observed urban floods and flash floods frequently, due to ineffective drainage and climate change, prominently with notable floods in 2004, 2014, 2017 and 2022 (Goyal et al., 2022; Guwahati Development Department, 2022; Tanoue et al., 2021; The Hindu, 2022; Sharma & Goyal, 2020; Goyal & Surampalli, 2018).



Guwahati city is characterized with a likeable temperature, which ranges from 19°C to 28°C in a year. Still, water scarcity conditions persist in the region, as only 0.3 million households of the population have access to tap water. Based on the research, there were 8 heatwave annual average events (5 days+) and 5 drought years observed between 2000 to 2020 (Das & Umamahesh, 2021; IIT Guwahati, 2019; Times of India, 2022).

Guwahati city has more narrow passages, making it vulnerable to fire accidents, as the fire brigade is not able to reach a place on time. For instance, industrial property, worth in millions, got burnt due to the leakage of a cylinder in Basistha, due to the late reaching of a fire brigade. The research showed 5 cases, 5 injuries and 5 deaths due to fire incidents, between 2000 and 2020 (Guwahati Metropolitan Development Authority, 2022; The Sentinel, 2022).



The city is prone to industrial due to significant numbers of hazardous (10) and polluting (10) industries, with a moderate industrial hazard index of 3.33. Hazards like, Avalanche, Tsunami, Coastal erosion, and Cyclone are not associated with the city due to its location and climatic conditions, while events like Lightning, Landslides and Cold waves are unlikely or have low occurrence in the region.

Therefore, it is essential to invest in enhancing urban resilience and undertaking risk-reducing measures, for sustainable urban development of Guwahati city.

## **Earthquake**

**Zone V**

## **Average Rainfall**

**1613 mm**

## **Average Temperature**

**23.5 deg C**

## **Between 2000-2020**

**8 Heatwave Events**

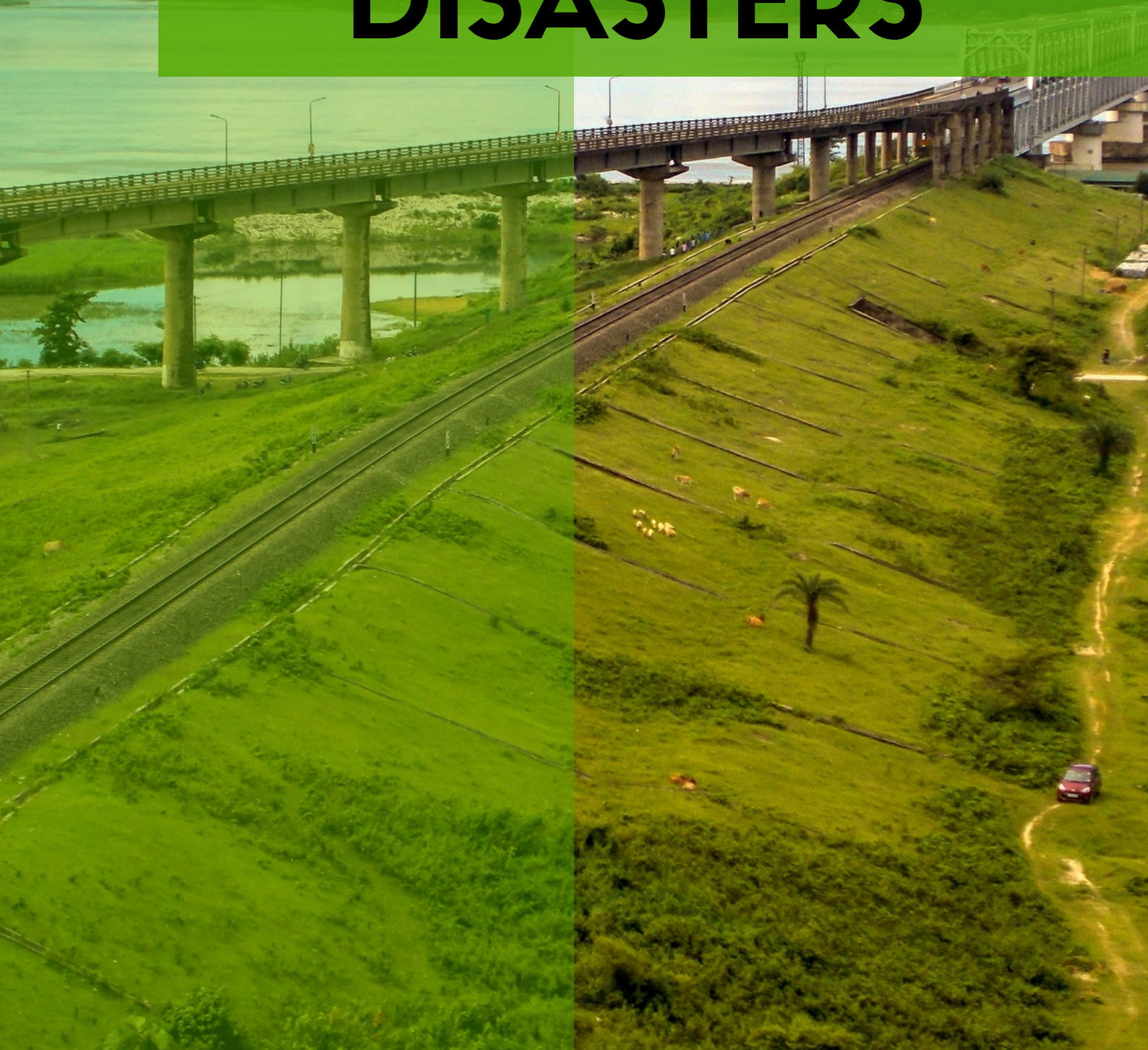
## **Between 2000-2020**

**5 Droughts & Fire Incidents**



4

# STUDY OF MULTI-HAZARD DISASTERS





In this study, a multi-hazard disaster risk matrix has been developed by collecting primary and secondary data at the urban level, as per the Ministry of Home Affairs (MHA) and the United Nations Development Programme (UNDP) report, “Disaster Risks and Resilience in India: An Analytical Study 2019” (UNDP, 2019). The datasets have been collected and generated for several parameters chosen to compute exposures, vulnerabilities, and hazard indices. Based on the importance of the parameters, specific weights have been given to the parameters, according to the Risk and Resilience matrix, developed by the MHA-UNDP 2019 report (Page no.: 35) (UNDP, 2019). The methodology of the Disaster Risk Index (DRI) considered 14 indicators of hazards (12 for natural hazards and 2 for man-made hazards), 14 indicators of vulnerabilities, and 2 indicators of exposure (Refer to Table 1). The parameters and their relative weightage were identified and taken from MHA-UNDP Report, 2019 (UNDP, 2019).

The Disaster Resilience Score (DRS) has been computed by summing up the scores achieved for Guwahati city, on each of 7 indicators (based on the quantitative norms), such as, i) assessment of risk, ii) prevention and mitigation of risk, iii) governance of risk, iv) preparedness, v) response, vi) relief and rehabilitation and vii) reconstruction of a disaster. Such scores have been rescaled to 100, to compute resilience, enable comparison, and thereby DRS. Based on guidelines and contents provided under the DM Act 2005 and DM Policy 2009 of the country, a set of questions have been used for the performance assessment of Guwahati city. As per the MHA-UNDP Report (2019), responses (received from the city’s administration) assessment of the Questionnaire has been computed in quantitative terms. The risk and resilience scorecard methodology has been explained and presented sequentially in Figure 4.

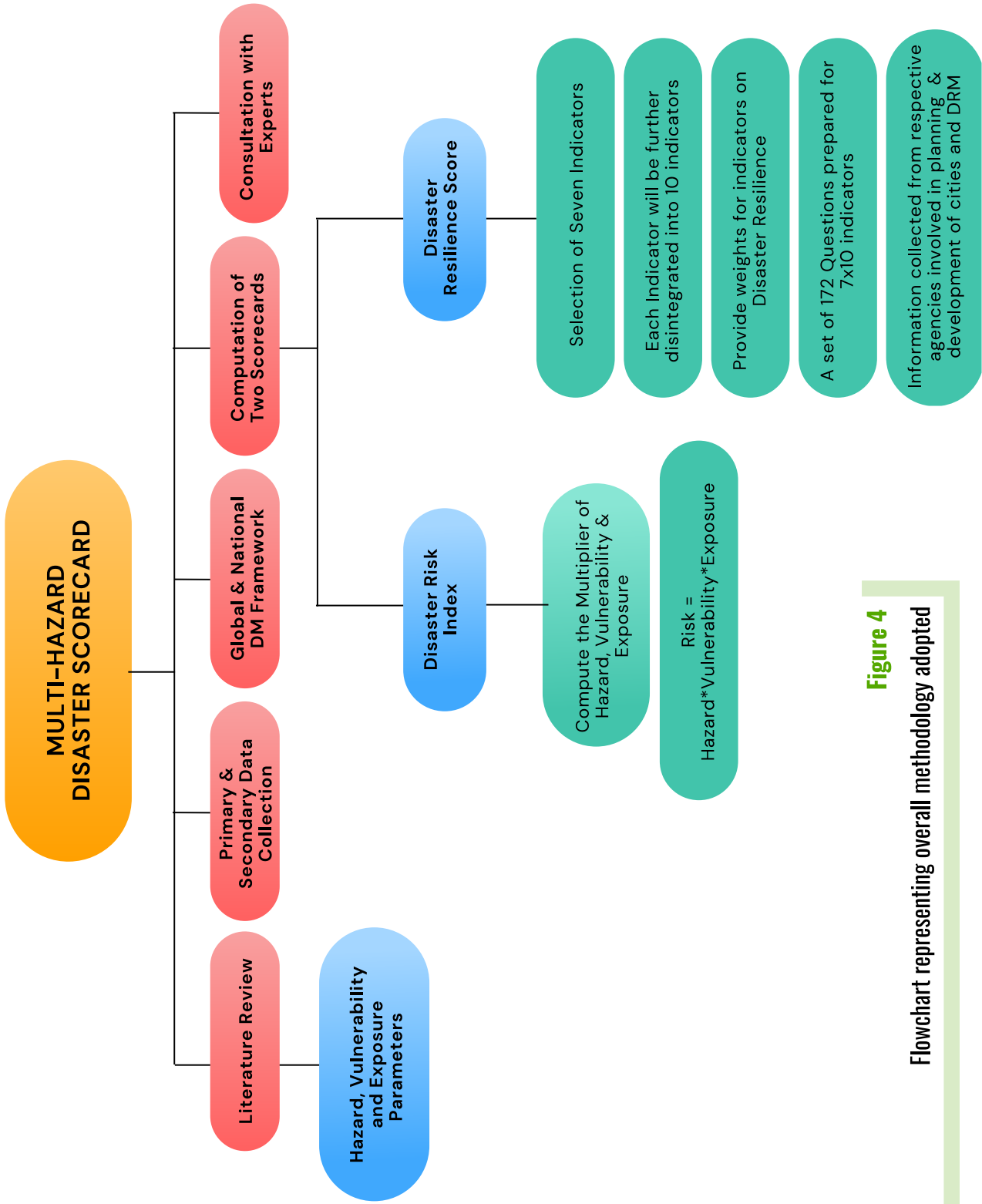
### i) What constitutes risks of disasters

Risks are measured using equation (i) (IPCC, 2014)

$$R = \{(h \times v) \times e\} \div c \text{ ----- (i)}$$

Where,

- R** = disaster risk;
- h** = hazard (the possibility of an occurrence of an event which causes loss);
- v** = vulnerability, factors increasing the vulnerability of an area or public to the impacts of hazard;
- e** = exposure of vulnerable people and assets to hazards
- c** = capacity or resources that could decrease the risk level or the impacts of disasters.



**Figure 4**

Flowchart representing overall methodology adopted

ii) Selection of indicators for hazard, vulnerability and exposure

The indicators of hazards, vulnerabilities, and exposure would be chosen on their importance and the data accessibility uniformly across the city (Refer Figure 5). Although specific datasets for some indicators like livestock, forest fire, agriculture etc., are available at the district level and were chosen and the best use of datasets was ensured based on their availability.



Figure 5

Indicators selected for hazards, vulnerabilities, and exposures

### iii) Parameters on indicators and their weights

Each of these 14 hazards, 14 vulnerabilities, and 2 exposure indices have various parameters. These parameters (Refer Table 1) have been chosen for the computation of indices on hazards, vulnerabilities, and exposure, based on available datasets of the city. The weightages have been assigned to the parameters (Refer Table 2), following the MHA-UNDP Report, 2019 (Page numbers 33 and 34; Disaster Risks and Resilience in India- A systematic study by the MHA-UNDP 2019).

iv) For exposures, (a) population and (b) GDP have been selected. 50% of equal weights are given to both parameters.

### v) Hazard-specific vulnerabilities

Each indicator of vulnerability is not related to each hazard. For instance, the susceptible buildings and infrastructure are exceptionally related to earthquakes and landslides but are not associated with a heatwave. Similarly, the susceptible forest and mangrove cover, are significantly related to forest cover, but not related to industrial hazards. Thus, based on their significance, hazard-specific vulnerabilities have been factored in to measure risks, in an individual instance.

### vi) Comparative weights on indicators of hazards, vulnerabilities, and exposures

Each hazard and vulnerability indicator will not generate an identical extent of risks. For instance, an earthquake could create a severely high risk of disasters as compared to either forest fire or landslide. Similarly, each vulnerability cannot develop a similar quantity of damages and losses. For instance, the vulnerability of buildings and infrastructure can cause severe deaths, damages, and economic losses more than exposed human conditions of poverty or gender bias. The datasets of past disasters have been used to develop relative weights (Table 3).

### viii) Comparative weights on hazards, vulnerabilities, and exposures

The risk level for the city of Guwahati, which has a high population density of 5487.20 person per km<sup>2</sup> and GDP, has been overestimated when hazards, vulnerabilities and exposures are given equal weightage. It was agreed that the relative weightage of H (hazard), V (vulnerability) and E (exposure) should be stated in the ratio of 4:2:1 because, hazards are the main factors, that increase the risk of disasters (MHA-UNDP Report, 2019).



**Table 1****List of hazards, parameters, and their relative weights**

(as per MHA-UNDP Report, 2019, Page No: 33)

Hazards	Parameters on Hazard	Weights on parameters
Earthquake	Seismic hazard zonation: Zone-V, IV, III, and II	Zone-V: 10, Zone-IV: 6, Zone-III: 4, Zone-II: 2
Landslide	Landslide hazard zonation: Zone- IV, III, II, and I	Zone-IV: 10, Zone-III: 8, Zone-II: 4, Zone-I: 0
Avalanche	Avalanche hazard zonation: Zone- V, IV, III, II, and I	Zone-V: 10, Zone-IV: 8, Zone- III: 6, Zone-II: 4, Zone-I: 0
Drought	a) Drought-prone area, b) Number of drought years, c) Moisture index, d) Frequency of SSI (Standardized Soil Moisture Index), e) Frequency of SPI (Standardized Precipitation Index).	Equal weights
Urban Flood	a) Average annual flooding, b) Maximum annual flooding, c) Year of maximum flooding, d) Average flooded area (%), e) Maximum flooded area (%)	Equal weights
Heat Wave	a) Average Heat Index based on National Oceanic and Atmospheric Administration (NOAA) methodology b) Number of days with a heat index above 54 c) Number of a heat wave (temperature above 40°C for 5+ days) d) Longest duration of a heat wave	Equal weights
Cold Wave	When the temperature goes below 4°C in plain areas and below - 4°C in hilly areas	Equal weights

Hazards	Parameters on Hazard	Weights on parameters
<b>Cyclone</b>	a) Number of cyclones b) Number of severe cyclones c) Probable maximum wind speed d) Probable maximum precipitation e) Probable maximum rainfall f) Maximum Storm Surge	Equal weights of 15% for (a) and (c) to (f) and 25% weights for (b)
<b>Tsunami</b>	a) Length of coastline b) Population living within 0.5 km of coasts c) Average height of tsunami wave	a) 25% b) 25% c) 50%
<b>Fire</b>	Normalized fire index of Guwahati city based on average annual. a) Number of accidents of fire b) Number of deaths c) Number of injuries	Equal weights
<b>Forest Fire</b>	Forest fire zonation in very dense, dense and open forests a) High risk zone-very dense b) Moderate risk zone- dense c) No risk zone- open forests	Values of 10, 5 and 0 for 3 risk zones with weights of 50%, 30% and 20% on 3 types of forests
<b>Coastal Erosion</b>	a) Length of coastline b) Coastal length (km) under erosion c) Coastal area (sq km) under erosion	Equal weights
<b>Industrial Hazard</b>	a) MAH industries b) MPI industries c) CEPI index	a) 50% b) 25% c) 25%
<b>Lightening</b>	Normalized annual average Lightning mortality in Jaipur city	Mortality index scaled 0 to 10

MAH: Maximum Accident Hazard

MPIs: Maximum Polluting Industries

CEPI: Comprehensive Environmental Pollution Index



**Table 2****Parameters and weights on vulnerabilities**

(as per MHA-UNDP Report, 2019, Page No: 34)

Vulnerabilities	Parameters on Vulnerabilities	Weights on parameters
Unsafe Buildings	Number of buildings constructed predominantly with materials used for construction of roofs and walls and classified as Very High (VH), High (H), Moderate (M), Low (L) and Very Low (VL) risk in earthquake, landslide, flood, and cyclone	VH:10, H:8, M: 6, L:4, VL: 2
Social infrastructure	Number of educational and health institutions in the city	a) 40% weights on primary educational institutions b) 10% weights on higher educational institutions c) 25% weights on primary health institutions d) 25% weights on hospitals
Physical infrastructure	a) Length of roadways b) Length of railways c) Number of airports and seaports	Equal weights on each parameter and further equal weights on sub-parameters within each parameter
Livestock Population	Number of livestock in the city a) Bovine animals b) Other animals	a) 80% b) 20%
Vulnerable Women	a) Sex ratio b) Illiteracy (%) c) MMR d) WHH (%) e) CAW f) Dependent (%)	Equal weights
Vulnerable Children	a) Age group 0-6 and 7-18 b) Non-school going children c) Working children d) IMR	Equal weights
Aged People	a) Age group 60+ b) Age group 80+ c) Dependency Ratio	Equal weights

Hazards	Parameters on Hazard	Weights on parameters
Disabled People	Types of disability a) Visual b) Hearing c) Speech d) Physical e) Mental f) Any other	Equal weights
Net Cropped Area	a) Cropped area b) Irrigated area	a) 80% b) 20%
Industries	a) Number of MSME in Guwahati city b) Number of industrial clusters c) Number of SEZ	a) 40% b) 40% c) 20%
Rural/Urban Poor	a) BPL population (rural and urban) b) Homeless population	Equal weights on both, with further equal weights on rural and urban BPL and Homeless
Deforestation	Change of forest cover (positive, negative, overall) during 2001-2015 a) Dense forests b) Open forests	Equal weights
Depletion of Mangroves	Change of mangrove cover (positive, negative, overall) during 2000-2021 a) Dense mangrove b) Open mangrove	Equal weights
Water Stress	a) Terrestrial water as captured in moisture index b) Surface water as captured in area under irrigation c) Sub-surface area as reflected in Central Ground Water Board (CWGB) data	Equal weights

MMR: Maternal Mortality Rate per 1,00,000 child births  
CAW: Crime Against Women (cases registered per 1,00,000 women)  
IMR: Infant Mortality Rate  
MSMEs: Micro, Small and Medium Enterprises  
SEZs: Special Economic Zones.  
BPL: Below Poverty Line



**Table 3**

**Comparative weights on hazards, vulnerabilities, and exposures**  
(as per MHA-UNDP scorecard report, 2019, Page No: 36)

HAZARDS		VULNERABILITIES		EXPOSURES	
Indicator	Weight%	Indicator	Weight%	Indicator	Weight%
Earthquake	15	Buildings*	15	Population	50
Landslide	7	Agriculture*	10	Economy	50
Avalanche	3	Poverty*	10		
Drought	15	Women*	8		
Urban Flood	15	Children*	8		
Heat Wave	6	Disability	6		
Cold Wave	6	Aged	6		
Cyclone	15	Livestock*	6		
Tsunami	3	Industries	6		
Fire	3	Physical Infrastructure	5		
Forest Fire*	3	Social Infrastructure*	5		
Coastal Erosion	3	Deforestation*	5		
Industrial Hazard	3	Depletion of Mangrove	5		
Lightning	3	Water Stress*	5		

\*In the absence of city-level data, the district-level data have been considered for these indicators in the entire study.

1. As per the MHA-UNDP 2019 report, the total hazard indicators in the list are 14. However, Guwahati city is not prone to Avalanche, Cyclone, Tsunami, and Coastal Erosion hazards, due to the geographical and topographical features of the city.

2. Likewise, all the vulnerable indicators in the list of the MHA-UNDP 2019 report have been considered for Guwahati city, except Depletion of Mangrove (13 vulnerable indicators are considered out of 14), as there is no mangrove in the city.

3. The present study has been carried out, comparatively over Guwahati, Jaipur, Srinagar, and Visakhapatnam cities. The risk index profiling of these cities has been computed comparatively for different hazards, vulnerabilities, and exposure parameters. Therefore, various indices in this report for Guwahati city should not be seen in isolation as compared to the other three cities and should not be viewed in isolation.



**5**

# **HAZARD INDEX COMPUTATION DATASETS**



# 1. Earthquake

The earthquake data of the city is derived from the Open Government Data (OGD) Platform India (data.gov.in), as per the National Building Code 2005 (Ministry of Home Affairs). The values on a scale of 0 to 10, have been adopted for various seismic zones. Accordingly, the hazard index of the city has been worked out: Zone-V (Very High Risk): 10, Zone-IV (High Risk): 6, Zone-III (Moderate Risk): 4, and Zone-II (Low Risk): 2, through Earthquake Hazard Zoning Atlas of India of 2016 (Table 4).

**Table 4 Earthquake hazard index**

City Area (km <sup>2</sup> )	Area (km <sup>2</sup> ) in Earthquake Hazard Zones								Earthquake Hazard Index (Out of 10)
	ZONE II (Low Risk)		ZONE III (Moderate Risk)		ZONE IV (High Risk)		ZONE V (Very High Risk)		
	Area	%	Area	%	Area	%	Area	%	
174.47	0.00	0.00	0.00	0.00	0.00	0.00	174.47	100	10.00

Since the whole of Guwahati city lies in Zone V (for which the weight is 10), the area falling in the earthquake hazard zone has been considered the entire city's area, i.e., 174.47 km<sup>2</sup>. It means that the whole city is susceptible to earthquake events in a Very high-risk zone.

# 2. Landslide

As per the Landslide Hazard Zonation Atlas of India (2003), the entire landmass of India has been classified into 4 landslide hazard zones: Zone-IV (Very High), Zone-III (High), Zone-II (Moderate to Low) and Zone-I (Unlikely). Based on this area analysis, the landslide hazard index has been worked out, based on the following values ascribed to each zone, on a scale of 0 to 10: Zone-IV: 10, Zone-III: 8, Zone-II: 4, Zone-I: 0 (Table 5).

**Table 5 Landslide hazard index**

City Area (km <sup>2</sup> )	Area (km <sup>2</sup> ) in Landslide Hazard Zones								Landslide Hazard Index (Out of 10)
	ZONE I (Unlikely)		ZONE II (Moderate Risk)		ZONE III (High Risk)		ZONE IV (Very High Risk)		
	Area	%	Area	%	Area	%	Area	%	
174.47	174.47	100	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Since the whole city of Guwahati lies in Zone I (for which the weight is 0), the area falling in the landslide hazard zone has been considered the entire city's area, i.e., 174.47 km<sup>2</sup>. This means that the city is unlikely to be susceptible to landslide events.

### 3. Drought

No agency has carried out drought hazard zonation of the city. In the absence of such zonation, parameters of drought, have been captured through 5 parameters: (a) drought-prone area, (b) number of drought years, (c) moisture index, (d) frequencies of SSI (Standardized Soil Moisture Index) and (e) SPI (Standardized Precipitation Index). An equal weightage of 20%, has been given on each parameter (Table 6). The data sources for these parameters have been provided in the annexure section, at the end of the report (Annexure 1).

**Table 6 Drought Index**

Drought Prone Area (km <sup>2</sup> )	No. of Drought Years	Moisture Index	Frequency		Normalized				Drought Index (Out of 10)
			SSI	SPI	Drought Years	Moisture Index	SSI	SPI	
0	5	0.472	7	44	3.85	0.00	2.69	10.00	<b>3.31</b>

It is observed that there were 5 drought years during 2000 to 2016. Therefore, Guwahati has been experiencing increased water scarcity and reduced drinking water sources, due to the meteorological and soil moisture droughts prominently.



# 4. Urban Flood

The urban flood index has been calculated using the BMTPC (2006) map and literature. Urban floods have been captured through 5 parameters: (a) average annual flooding, (b) maximum annual flooding, (c) year of maximum flooding, (d) average flooded area (%), and (e) maximum flooded area (%). Equal weightages have been given to all the parameters (Table 7). The data sources for these parameters have been provided in the annexure section, at the end of the report (Annexure 1).

**Table 7 Flood Hazard Index**

City Area (km <sup>2</sup> )	Flood Affected Area (km <sup>2</sup> )					Flood Hazard Index (Out of 10)
	Average Annual Flooding	Maximum Annual Flooding	Year of Maximum Flooding	Average Flooded Area (%)	Maximum Flooded Area (%)	
174.47	64.00	113.00	2014	29.61	52.34	<b>6.48</b>

Out of the 174.47 km<sup>2</sup> total area of the city, the observed area of maximum flooding was 52.34% in 2014, during 2000 to 2020 and the average flooded area was about 29.61%.

# 5. Heat Wave

Heat waves have been captured through 4 parameters: (a) the number of days with a heat index (HI) above 54, (b) the average number of the heat wave (temperature above 40°C for 5+ days), (c) the average longest duration of the heat wave and (d) average Heat Index, based on National Oceanic and Atmospheric Administration (NOAA) methodology (Table 8). Equal weightages have been given to each parameter.

**Table 8 Heat Wave Index**

Heat Waves				Heat Wave Index (Out of 10)
No of days with a Heat Index (HI) above 54 (Annual Average)	Average number of Heat Waves (5 days +)	Average longest Heat Wave (No of Days)	Average Index of Heat Waves	
1	2	8	0.69	<b>5.12</b>

Two numbers of average heatwave events (5 days+) with temperatures atleast 40°C or above occurred between 2000 to 2018 over the city every year. The number of days with HI above 54 was 1 day, and the average longest heat wave was 2 days.

## 6. Cold Wave

Cold Wave Hazard Index has been worked out following the India Meteorological Department (IMD) Weather Forecast, which defines a day as cold when the temperature goes below 4°C in plain areas and below - 4°C in hilly areas. The percentage of days with cold wave conditions in three different temperature brackets in the city has been worked out with equal weight to calculate the heat wave hazard index on a scale of 0 to 10 in other indices (Table 9).

**Table 9 Cold Wave Index**

Plain Areas (temperature <4°C)	Cold Wave Index (Out of 10)
0	0.00

There were no cold wave events observed, as the temperature less than 4°C (the sudden decrease of temperature, less than the usual minimum level and the prolongation of the event for a few days) occurred during 2000 to 2018 over the city. Cities in hilly areas may have a high cold wave risk index as compared to the plain cities like Guwahati.

## 7. Fire

The Directorate General of National Disaster Response Force (NDRF) and Civil Defence commissioned a study on fire hazard and risk analysis in the country, for revamping fire services in the States. The study did not cover fire risks in the districts or did not compile data on city fires. In the absence of any city-level database on fire, the National Crime Records Bureau (NCRB) State-level database, has been relied upon, to assess (a) the number of cases of fire accidents registered, (b) the number of deaths, and (c) number of injuries during 2001-2015 (Table 10). Data has been normalized at the city level, based on population. The fire hazard index has been worked out, based on an equal weightage of 33.33% on these 3 parameters.

**Table 10 Fire Hazard Index**

Accidents of Fire			Fire Hazard Index (Out of 10)
Cases	Deaths	Injured	
5	5	5	3.33



The city had 5 cases, 5 deaths and 5 injuries, that occurred due to fire accidents during 2001 to 2015. The data sources for these parameters have been given in the annexure section, at the end of the report (Annexure 1).



Impact of Earthquake (2021) in Guwahati. (Source: The Indian Express, 28 April 2021)

## 8. Forest Fire

The study on 'Vulnerability of India's Forests to Fire', published in 2019 by the Forest Survey of India (FSI), is the basis for data on forest fires (Table 11). The study has classified Guwahati district (lack of city-level data), in terms of 3 types of forest fire: high, moderate and no risks. This has been supplemented with data, on types of forests in the district - very dense (50%), dense (30%), and open forests (20%) as has been brought out in the Annual India State of Forest Report 2019. The assigned weightages have been multiplied with the risk zone multiplier, to get the value of the hazard index.

**Table 11 Forest Fire Index**

Total Area-City (km <sup>2</sup> )	Total Area-District (km <sup>2</sup> )	Forest Area (km <sup>2</sup> )						Forest Fire Index (Out of 10)
		Very Dense	Dense	Open	Total	% of Total	Risk Zonation	
174.47	4,281.66	63.75	653.44	714.40	1,424.50	33.27%	2.60	<b>2.60</b>

The total forest area in the Guwahati district is about 1424.50 km<sup>2</sup>. It is found that, there are low risk zones for forest fire in the district.

## 9. Industrial Hazard

The datasets have been obtained from several sources, like the Central Pollution Control Board, the City Municipal Corporation, etc. (Table 12). The weightage assigned for Maximum Hazard Industries (MHI), Maximum Polluting Industries (MPI), and Comprehensive Environmental Pollution Index (CEPI) is 50%, 25%, and 25%, respectively.

**Table 12 Industrial Hazard Index**

Parameters of Industrial Hazards			Industrial Hazard Index (Out of 10)
Maximum Hazard Industries (MHI)	Maximum Polluting Industries (MPI)	Average CEPI of major Industrial Clusters	
10	10	46.26	<b>4.68</b>



The CEPI calculates the pollution level of air, water, and soil, due to the industrial clusters in the city. The average CEPI of major clusters is about 46.26 in Guwahati city. The city shows a moderate score on the industrial hazard index of about 4.68, which means, there is a high risk, that contributes to trigger the hazards, which may eventually lead to disasters.

## 10. Lightning

Lightning accounts for significant mortalities, during disasters in several cities in India. There is a lack of scientific studies, assessing the lightning impact on the country's population. The datasets of lightning mortalities were obtained through the National Crime Records Bureau (NCRB) database, at a city level. The lightning mortality index has been worked out on a scale of 0 to 10 (Table 13).

**Table 13 Lightning Hazard Index**

Accidents of Fire		Lightning Hazard Index (Out of 10)
Total Lightning Mortalities	Lightning Mortalities Average Annual	
0	0	0

In Guwahati city, lightning events have not led to mortalities in the past 15 years (2000–2015). It is challenging to predict the risks of lightning occurrence, as it is a natural phenomenon, but the hazard index shows that the city is experiencing an unlikely rate of lightning hazard.

### Summary of Hazard Indicators:

- As per the MHA-UNDP 2019 report, 10 hazard indicators, relevant to Guwahati city, based on the geographical and topographical features of the city, have been considered.
- The methodology and weightage used to compute the hazard indices, are as per the MHA and the UNDP report “Disaster Risks and Resilience in India: An Analytical Study 2019”.
- The hazard indices have been computed for different hazard parameters at the city level, except for Forest Fire (for which the data was available at the district level), for Guwahati city.
- Guwahati city is more prone to Earthquake, Urban Flood, Heat Wave, Industrial Hazard, and Drought, as compared to other hazard indicators.



6

# VULNERABILITY INDEX COMPUTATION DATASETS





# 1. Buildings

## a. Walls

The source of datasets of building walls is 'Office of the Registrar General & Census Commissioner, India (ORGI)', used in this study (Table 14). Hazard zones are Zone V: Very High Damage Risk Zone, Zone IV: High Damage Risk Zone, Zone III: Moderate Damage Risk Zone, Zone II: Low Damage Risk Zone, and Zone I: No Risk Zone. Vulnerable buildings weightages are VH= Very High (damage potential 100%); H= High (50%); M=Medium (25%); L=Low (10%); VL= Very Low (5%).

**Table 14 Vulnerability index of walls**

Grass, Thatch, Bamboo	Plastic Polythene	Mud Unburnt bricks	Wood	Stone not packed with mortar	Stone packed with mortar	Gl, Metal Asbestos	Burnt Bricks	Concrete	Any other material	Vulnerability Index of Walls (Out of 10)
83,730	1,776	6,021	2,922	4,092	11,730	1,395	1,38,391	39,481	850	4.29

The vulnerability index of walls is about 4.29, computed based on the different building materials. It is observed that the building walls constructed with burnt bricks are more in number as compared to other building materials. Guwahati is vulnerable to hazards, like earthquake and urban flood, which damages the building walls. Therefore, resistant designs and specifications should be incorporated into the materials, used for the construction of walls to tackle these disasters.

## a. Roofs

The source of datasets of building roofs is 'Office of the Registrar General & Census Commissioner, India (ORGI)', used in this study (Table 15). Hazard zones are Zone V: Very High Damage Risk Zone, Zone IV: High Damage Risk Zone, Zone III: Moderate Damage Risk Zone, Zone II: Low Damage Risk Zone, and Zone I: No Risk Zone. Vulnerable buildings weightages are VH= Very High (damage potential 100%); H= High (50%); M=Medium (25%); L=Low (10%); VL= Very Low (5%).

**Table 15 Vulnerability index of roofs**

Grass, Thatch, Bamboo	Plastic Polythene	Hand-made tiles	Machine-made tiles	Burnt Bricks	Stone Slates	GI, Metal Asbestos	Concrete	Any other material	Vulnerability Index of Roofs (Out of 10)
8,272	693	1,114	388	824	7,185	2,03,105	68,531	276	1.82

The vulnerability index of roofs is about 1.82, computed based on the different building materials. It has been observed that the building roofs constructed with GI, Metal Asbestos are more in number, compared to other building materials. Guwahati city is highly vulnerable to hazards, like earthquake, which impact the building roofs. Therefore, resistant designs and material specifications should be considered for constructing roofs to resist disasters.

## 2. Agriculture

The Crop Vulnerability Index has been worked out based on 2 parameters: cropped area and irrigated area (Table 16). District-wise data on the area under crops and irrigation has been collected from the Directorate of Economics and Statistics, Ministry of Agriculture, Cooperation and Farmers Welfare, GoI, through the [Indiastatdistricts.com](http://Indiastatdistricts.com) website. However, these 2 parameters have been included because of their associated impact on the urban population in the city. Considering the relative importance of crop and irrigation, 80% of weightage has been given to areas under crops and 20% to irrigated areas.

**Table 16 Crop Vulnerability Index**

Total area of district (hectare)	Area Under Agriculture (hectare)				Flood Hazard Index (Out of 10)
	Cropped Area		Irrigated Area		
	Area	%Area	Area	%Area	
1,52,800	8,000	5.24%	4,000	2.62%	0.26

The vulnerability index of the crop is 0.26, which is computed based on the area under agriculture in the Guwahati district. The cropped area is about 5.24% of the total area under agriculture as compared to the irrigated area. The crop vulnerability index shows that Guwahati's agricultural area is less susceptible to disasters.



## 3. Poverty

For poverty data, Census 2011 data on the homeless population has been adopted in this study (Table 17). The parameters BPL (Below Poverty Line) and Homeless Population have 2 sub-parameters for rural and urban areas. An equal weight of 25% has been given to each of these 4 sub-parameters towards working out the poverty vulnerability index.

**Table 17 Poverty Vulnerability Index**

BPL Population (in Lakhs)			Homeless Population (in Lakhs)			Poverty Vulnerability Index (Out of 10)
Rural	Urban	Total	Rural	Urban	Total	
90.85	9.01	99.86	1.03	0.25	1.29	<b>5.33</b>

The homeless population is the least in Guwahati, among all the cities. The poverty vulnerability index for Guwahati district is 5.33, which means, the people who live below poverty line and homeless in Guwahati district, are more susceptible to disasters, because they are more exposed to hazards and have lower coping capacities against disasters.

## 4. Women

Gender Vulnerability Index has been worked out based on 6 parameters: sex ratio (women per 1,000 men), illiteracy (%), WHH (Women Headed Household in %), MMR (Maternal Mortality Rate per 1,00,000 childbirths), CAW (Crime Against Women cases registered per 1,00,000 women) and dependent (%). District-wise data on all 6 parameters were compiled from Census 2011 (Table 18). Equal weightage has been given to each of these 6 parameters.

**Table 18 Gender Vulnerability Index**

Total Female Population	Sex Ratio	Illiteracy (%)	WHH (%)	MMR	CAW	Dependent (%)	Gender Vulnerability Index (Out of 10)
6,06,353	958	56%	14.18%	366	500	83.92%	<b>6.08</b>

The greater the vulnerability, the more severe the impact of hazards. The 14.18% WHH is an indicator of strength in the city. The MMR per 1,00,000 childbirths in the district, is about 366 and the average number of CAW is 500 cases. The dependent parameter of 83.92 %, shows non-working women in the district. The gender vulnerability index of Guwahati district is 6.08, which is the maximum, among all the districts of cities. It indicates women have a relatively high moderate vulnerability to disasters, in comparison to all the districts of cities.

## 5. Children

The child vulnerability index has been worked out based on 4 parameters: age group, children not going to school, children working, and IMR (Infant Mortality Rate). District-wise data for all parameters have been compiled from Census 2011 (Table 19). Each parameter has been given an equal weightage of 25%. In contrast, 2 sub-parameters in children age groups of 0 to 6 and 7 to 18, have been given differential weightage in a 60:40 ratio, as younger children are more vulnerable during disasters.

**Table 19 Child Vulnerability Index**

Age Group of Children (Years)						Not Going to School		Working Children		Child Vulnerability Index (Out of 10)
0-18 (Numbers)	0-6 (%)	0-6 (Numbers)	7-18 (%)	7-18 (Numbers)	IMR	(%)	Numbers	(%)	Numbers	
3,83,900	32.66%	1,25,386	67.34%	25,85,14	46	7.49%	28,745	7.49%	28,745	1.16

The index of child vulnerability has been computed based on 3 parameters for Guwahati district: age group of children of different ages, children not attending school, and children working. The IMR in the city is 46, which is a childcare factor. The index of child vulnerability is 1.16, which indicates that children are less susceptible to disasters. For example, the children die due to the building collapse, as they will usually be inside the building and would be unaware of, what to do to survive earthquakes.

## 6. Disability

The disability vulnerability index has been worked out based on 6 parameters: visual, hearing, speech, physical, mental, and other disabilities. The data on all these parameters have been compiled from Census 2011 (Table 20). Each parameter has been given equal weightage.



**Table 20 Disability Vulnerability Index**

Total Population	Disabled		Visual		Hearing		Speech		Physical		Mental		Any other		Disability Vulnerability Index (Out of 10)
	Population	%	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%	
9,57,352	16,869	1.35	2,123	12.59%	3,664	21.72	1,235	7.32	1,606	9.52	1,309	7.76%	5,904	35.00%	0.16

We know that disasters can increase the number of disabled persons and worsen the situations for those, who are already impaired. The disability vulnerable index of Guwahati city is 0.16, computed based on the with different aspects of disability. The share of the population, with a disability is about 1.35% of the city's total population. Among various disabilities, other disabilities are the highest at approximately 35%, which means there is a large number of “other” disabled populations in Guwahati, which are more susceptible to disasters.

## 7. Aged

The elderly vulnerability index has been worked out based on 3 parameters: the population in the 60+ age group, the population in the 80+ age group, and dependency ratio (ratio of population in the 60+ age group with the working population in the 19-59 age group). City - wise data on all 3 parameters has been compiled from Census 2011 (Table 21). Each parameter has been given an equal weightage of 33.3%.

**Table 21 Elderly Vulnerability Index**

Total Population	60-90 Age Group		80+ Age Group		Dependency Ratio	Elderly Vulnerability Index (Out of 10)
	Number	%	Number	%		
9,57,352	67,752	5.40%	6,489	0.52%	19.41%	0.00

During disasters, aged people suffer disproportionately. The aged vulnerability index of Guwahati city is 0.00, computed using different age groups and dependency ratios. It is found that the age group of 60–79 is unlikely susceptible to disasters, as it has 5.40% of the total population. The dependency ratio is about 19.41% in Guwahati city, which indicates, the ratio of the population in the 60+ age group with the working population in the 19–59 age group.

## 8. Livestock

Livestock data has been compiled from Livestock Census 2012 (Table 22). The livestock vulnerability index has been worked out, based on two parameters, (a) the number of bovine animals and (b) other animals, with a 75:25 weightage ratio between the 2 parameters.

**Table 22 Livestock Vulnerability Index**

Livestock (Numbers)			Industrial Hazard Index (Out of 10)
Bovine Animals	Other Animals	Total Animals	
1,17,229	88,314	2,05,543	<b>5.35</b>

The vulnerability index of livestock is 5.35, which has been computed based on the number of different animals in Guwahati. The number of bovine animals is more in total livestock compared to other animals. The index of livestock vulnerability shows that the number of livestock in Guwahati is moderately susceptible to disasters.

## 9. Industries

City-wise data on industries has been collected from multiple sources on 3 parameters: the number of Micro, Small and Medium Enterprises (MSMEs), industrial clusters, and Special Economic Zones (SEZ). Data on MSMEs, have been collected from the database of the Development Commissioner (MSME), while data on Industrial Clusters and SEZ in cities have been collected from several sources (Table 23). The industrial vulnerability index has been worked out based on a differential weightage of 40% on MSME, 40% on Industrial Clusters, and 20% on SEZ.



**Table 23 Industries Vulnerability Index**

Industries			Industrial Vulnerability Index (Out of 10)
MSME Industries (Numbers)	Industrial Clusters (Numbers)	Special Economic Zones (SEZ) (Numbers)	
1500	0	0	0.28

The industrial vulnerability index of Guwahati is 0.28, which shows that the industries have a low vulnerable indicator in the city. It is observed that there are 1500 MSMEs industries and no industrial clusters and SEZs in the city. There is a need to formulate guidelines, norms, and regulations, to ensure safety in hazardous industries and to reduce the probability of disaster events in the future.

## 10. Physical Infrastructure

Data on 6 types of physical infrastructure – roadways, railways, airports, and seaports, have been collected from multiple sources. Each city's total length of roadways and railways has been compiled using Open Street Map (OSM) data in the QGIS software. The Airport Authority of India has collected data on the city's airports. In contrast, data on seaports has been compiled from Basic Port Statistics (Table 24). Equal weightage has been given to each of the parameters, with sub-parameters within the parameters in calculating the Physical Vulnerability Index.

**Table 24 Physical Infrastructure Vulnerability Index**

Road Length (km)	Railway Length (km)	Sea Port (Numbers)		Airport (Numbers)		Physical Infrastructure Vulnerability Index (Out of 10)
		Major	Minor	Int. + Dom.	Domestic	
1,380	34	0	0	1	0	2.64

The index of the physical infrastructure of Guwahati is 2.64, computed using the elements of physical infrastructure, such as roads and bridges, railway lines, seaports, and airports. Road length is more than railway length, indicating that, roadways are more vulnerable and typically damaged, during disasters such as floods in Guwahati. The factors, such as quality of construction, standards of maintenance, age of the structure etc., make the physical infrastructures vulnerable to hazards.

# 11. Social Infrastructure

Social infrastructure data has been limited to health and educational institutions, as these are considered critical lifeline infrastructure, during any significant disaster. Data on the number of health and educational institutions have been compiled from the database of Census 2011, at the district level (Table 25). The social vulnerability index has been worked out with equal weightage on these 2 parameters.

**Table 25 Social Infrastructure Vulnerability Index**

Number of Educational Institutions							Number of Health Institutions			Social Infrastructure Vulnerability Index (Out of 10)
School Education		Higher Education				Polytechnic (Number)	Primary Healthcare			
Primary	Secondary	College	University	Engineering	Medical		Dispensaries	FW Centres	Hospitals/ Med. Schools	
258	139	130	1	2	1	3	8	11	48	2.67

Social infrastructure includes structures and other related physical facilities, that provide community services in the Guwahati district (lack of data at the city level). The index of the social infrastructure of Guwahati is 2.67, computed using the number of educational and health institutions. These social infrastructure facilities get usually damaged during Guwahati's severe earthquake and urban floods. The factors like structural design, materials quality, maintenance standards, design age etc., make the social infrastructures vulnerable to hazards.

# 12. Deforestation

Changes in the district's forest cover (lack of data at the city level) have been captured on 2 parameters: dense forests and open forests from 2000 to 2015 (Table 26). Equal weightage has been given to both parameters while calculating the index.



**Table 26 Forest Cover Depletion Index**

Total Area of District (km <sup>2</sup> )	Changes in Forest Cover (km <sup>2</sup> )			Forest Cover Depletion Index (Out of 10)
	Dense	Open	Total	
4,281.66	-18.69	30.67	11.98	<b>7.52</b>

The depletion index of forest cover is 7.52, which has been computed using the total area and change in forest cover of the Guwahati district. The negative value shows the decrease in forest cover change and the positive value shows the increase in forest cover change. The depletion is an indication for quantifying the environmental vulnerability of forests, in the Guwahati district.

## 13. Water Stress

The extent of water stress in the district (lack of data at the city level), has been captured through 3 parameters: surface, terrestrial and sub-surface water, from the website of the Central Ground Water Board (CGWB), Ministry of Jal Shakti (Table 27). Equal weightage has been given to each parameter, for calculating the water stress index. Sub-surface water has 4 sub-parameters: over-exploited, critical, sub-critical, and safe. This is distributed as follows: 50% has been given to over-exploited, 30% to critical and 20% to sub-critical components.

**Table 27 Water Stress Index**

Surface Water (km <sup>2</sup> )			Terrestrial	Subsurface Water (Number)				Water Stress Index (Out of 10)
Total Area	Non-irrigated Area	%	Moisture Index (MI)	Over Exploited	Critical	Subcritical	Safe	
1,52,800	1,48,800	0.97	0.47	0	0	0	7	<b>0.33</b>

The water stress index is 0.33, computed using Guwahati's terrestrial, surface and subsurface water. The stress on terrestrial and surface water sources has been captured in the Moisture Index (MI) and areas of non-irrigated areas, as used in estimating the indices of drought hazard and agricultural vulnerability.

### Summary of Vulnerability Indicators:

- As per the MHA-UNDP 2019 report, 13 vulnerability indicators, relevant to Guwahati city, based on the geographical and topographical features of the city have been considered, except for the depletion of mangroves.
- The methodology and weightage used, to compute the vulnerability indices, are as per the MHA and the UNDP report “Disaster Risks and Resilience in India: An Analytical Study 2019”.
- The vulnerability indices have been computed for different vulnerability parameters at the city level, except for Buildings, Agriculture, Livestock, Social infrastructure, Deforestation, Women, Children, Poverty, and Water stress (for which the data was available at the district level) for Guwahati city.
- Guwahati city is more vulnerable to disasters. in terms of Deforestation, Women, Livestock, Poverty and Unsafe Buildings, as compared to other vulnerability indicators.

The scale of classification based on index values: The classification is based on a scale of 0 to 10 as per Table 28.

**Table 28 Scale of Classification based on index values**

Class	Range
Very High	Equal to 10
High	7 – 10
Moderate	3 – 7
Low	0 – 3
Unlikely	Equal to 0



Classification of computed hazard indicators for Guwahati City, based on the scale: The classes of the different hazard indicators, based on the index values, are presented in Table 29.

**Table 29 Classification of hazards based on the index**

HAZARDS		
Indicator	Index	Class
Earthquake	10.00	Very High
Landslide	0.00	Unlikely
Drought	3.31	Moderate
Urban Flood	6.48	Moderate
Heat Wave	5.12	Moderate
Cold Wave	0.00	Unlikely
Fire	3.33	Moderate
Forest Fire	2.60	Low
Industrial Hazard	4.68	Moderate
Lightning	0.00	Unlikely

Classification of computed vulnerability indicators for Guwahati, based on the scale: The classes of the different vulnerable indicators, based on the index values are presented in Table 30.

**Table 30 Classification of vulnerabilities based on the index**

VULNERABILITIES		
Indicator	Weight%	Class
Buildings (Walls & Roof)	3.05	Moderate
Agriculture	0.26	Low
Poverty	5.33	Moderate
Women	6.08	High
Children	1.16	Low
Disability	0.16	Low
Aged	0.00	Unlikely
Livestock	5.35	Moderate
Industries	0.28	Low
Physical Infrastructure	2.64	Low
Social Infrastructure	2.67	Low
Deforestation	7.52	High
Water Stress*	0.33	Low



7

# EXPOSURE INDEX COMPUTATION DATASETS





Data on exposures have been collected on 2 parameters in each city: exposure to population and exposure to economy, as reflected in district GDP. While data on exposure to the population has been compiled from Census 2011, exposure of city GDP has been derived from a newspaper article (The Times of India, dated Mar 24, 2019). 2 parameters have been considered for calculating the Exposure Index. These are: (a) population density (= Population /Area in km<sup>2</sup>) and (b) per capita GDP (=GDP (in Cr. Rs.) / Population) of a city (Table 31). Both parameters have been normalized by dividing with the maximum value and multiplying with 10, to put them on a scale of 0 to 10. Then, a simple average of these parameters was taken since equal weightage was given on both.

**Table 31 Average Exposure Index**

Area (km <sup>2</sup> )	Population		City GDP		Average Exposure Index (Out of 10)
	Total	Density	Total (Rs. Cr.)	Per Capita (Rs.)	
174.47	9,57,352	5,487.20	1,54,52,540	47,900	<b>6.09</b>

The average exposure index is 6.09 for Guwahati city, which has been computed by estimating the district's population density and per capita income and then assigning equal weightage to both indicators, on a scale of 10. The index shows that, the population of Guwahati is moderately exposed to disasters.



8

# RESILIENCE SCORECARD



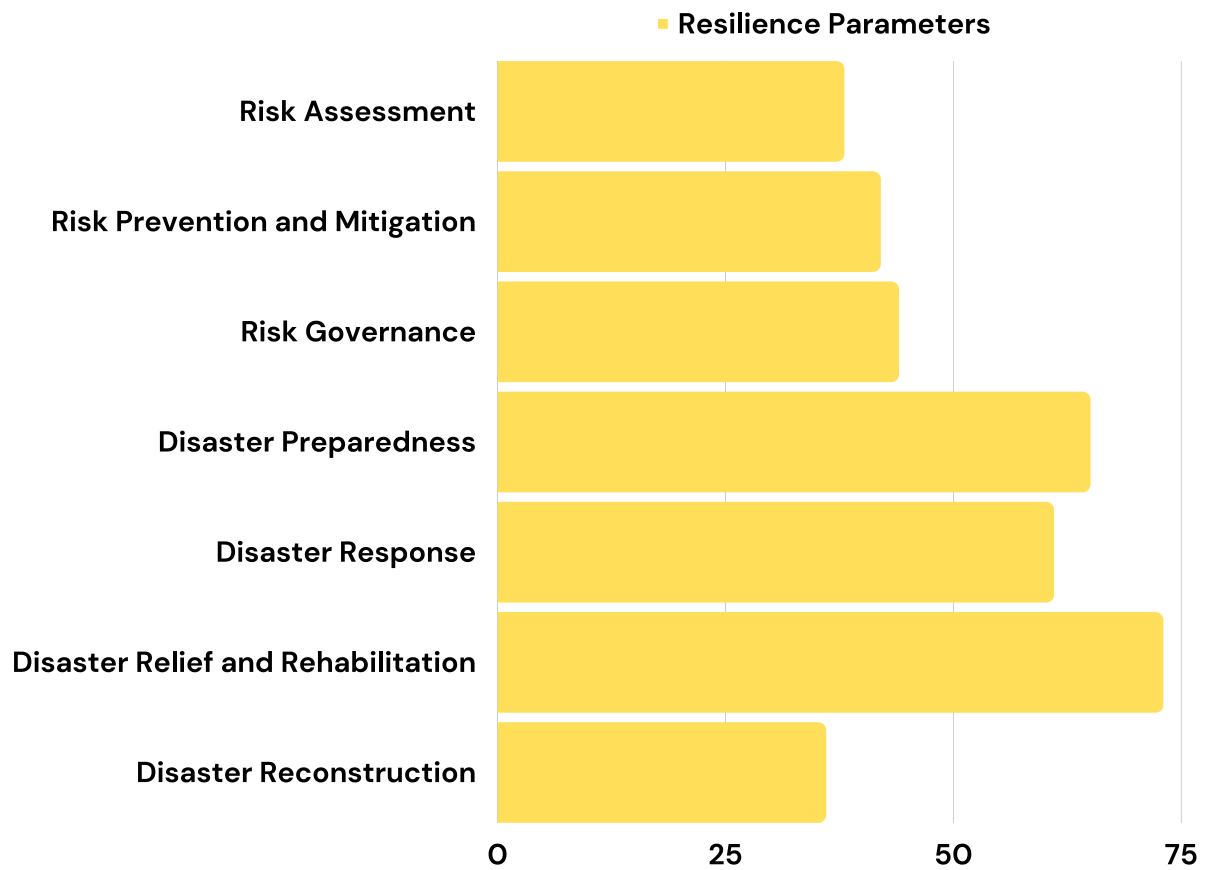


Disaster Resilience Score (DRS) is based on the information collected from the cities on 7x10 indicators, through a questionnaire comprising of 172 questions (as per Figure 2). Resilience scorecard has been computed discretely for Guwahati city, based on the 7 parameters on a scale of 100: Risk Assessment, Risk Prevention, Mitigation, Risk Governance, Disaster Preparedness, Disaster Response, Disaster Relief & Rehabilitation, and Disaster Reconstruction, as shown in Table 32 and Figure 4.

**Table 32 Weights of Indicators on Disaster Resilience**  
(MHA UNDP Report, 2019)

S.No.	Aggregate Indicators	Weights	Values for Guwahati City
1	Risk Assessment	10%	38
2	Risk Prevention and Mitigation	20%	42
3	Risk Governance	20%	44
4	Disaster Preparedness	20%	65
5	Disaster Response	10%	61
6	Disaster Relief and Rehabilitation	15%	73
7	Disaster Reconstruction	5%	36
<b>Disaster Resilience Score</b>		<b>54.45 on a scale of 100</b> (Through weighted aggregate of seven parameters)	

Based on the following values and their associated weightage, as per MHA-UNDP Report 2019, the disaster resilience score is 54.45 for Guwahati city, on a scale of 100. Therefore, although the risk associated with Guwahati city is comparatively ranked 3rd in the number of hazards occurring among all the cities, the city is moderately resilient based on their resilience score. Thus, city administration should enhance efforts for making the city highly resilient to natural and man-made disasters.



**Figure 6**  
**Disaster Resilience Scorecard for Guwahati City**



SDRF rescuing people affected by flood in Guwahati (Source: News18, 14 June 2017)

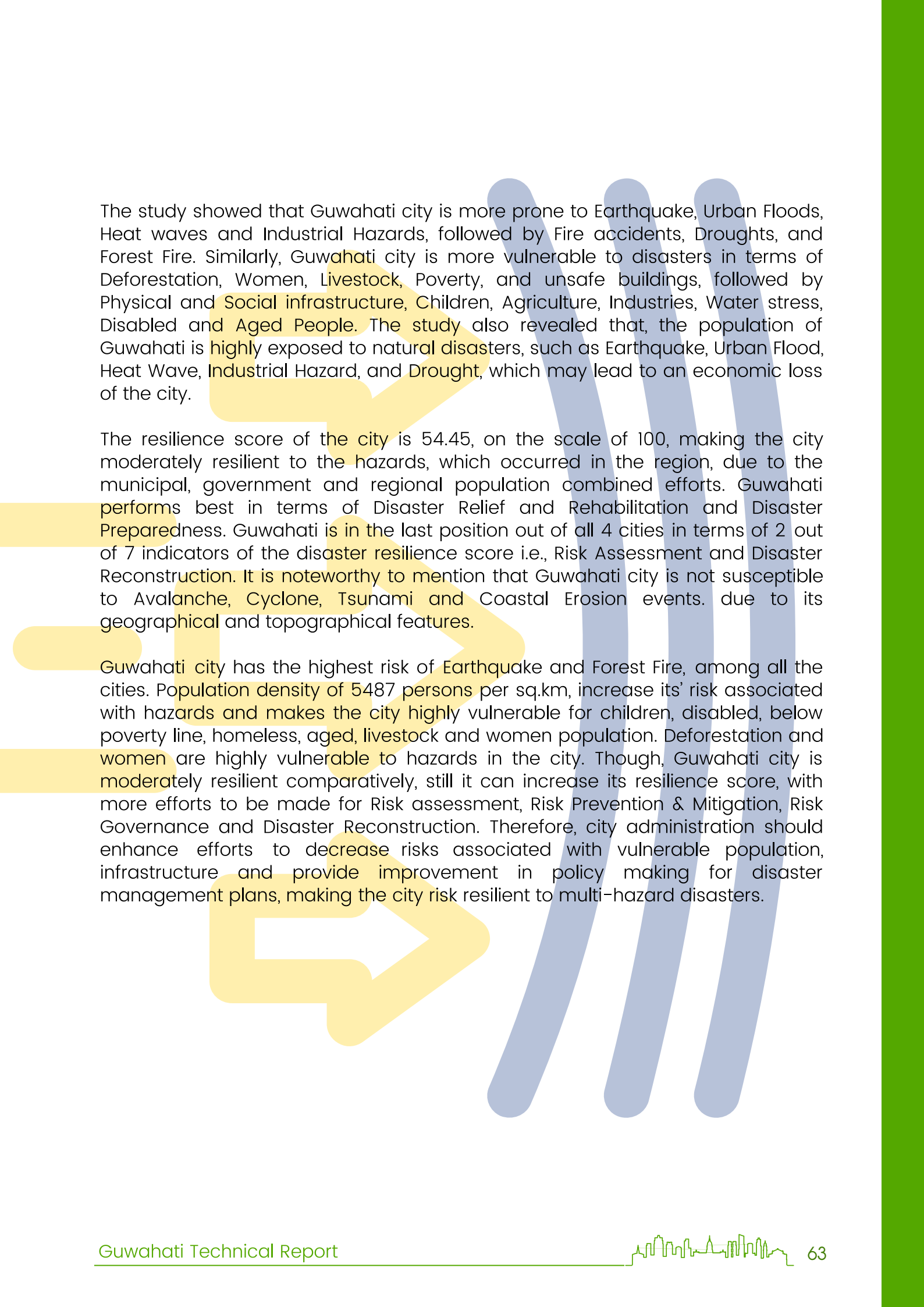


9

# CONCLUSION







The study showed that Guwahati city is more prone to Earthquake, Urban Floods, Heat waves and Industrial Hazards, followed by Fire accidents, Droughts, and Forest Fire. Similarly, Guwahati city is more vulnerable to disasters in terms of Deforestation, Women, Livestock, Poverty, and unsafe buildings, followed by Physical and Social infrastructure, Children, Agriculture, Industries, Water stress, Disabled and Aged People. The study also revealed that, the population of Guwahati is highly exposed to natural disasters, such as Earthquake, Urban Flood, Heat Wave, Industrial Hazard, and Drought, which may lead to an economic loss of the city.

The resilience score of the city is 54.45, on the scale of 100, making the city moderately resilient to the hazards, which occurred in the region, due to the municipal, government and regional population combined efforts. Guwahati performs best in terms of Disaster Relief and Rehabilitation and Disaster Preparedness. Guwahati is in the last position out of all 4 cities in terms of 2 out of 7 indicators of the disaster resilience score i.e., Risk Assessment and Disaster Reconstruction. It is noteworthy to mention that Guwahati city is not susceptible to Avalanche, Cyclone, Tsunami and Coastal Erosion events. due to its geographical and topographical features.

Guwahati city has the highest risk of Earthquake and Forest Fire, among all the cities. Population density of 5487 persons per sq.km, increase its' risk associated with hazards and makes the city highly vulnerable for children, disabled, below poverty line, homeless, aged, livestock and women population. Deforestation and women are highly vulnerable to hazards in the city. Though, Guwahati city is moderately resilient comparatively, still it can increase its resilience score, with more efforts to be made for Risk assessment, Risk Prevention & Mitigation, Risk Governance and Disaster Reconstruction. Therefore, city administration should enhance efforts to decrease risks associated with vulnerable population, infrastructure and provide improvement in policy making for disaster management plans, making the city risk resilient to multi-hazard disasters.



**10**

# **COMPARATIVE DISASTER RISK & RESILIENCE ASSESSMENT**

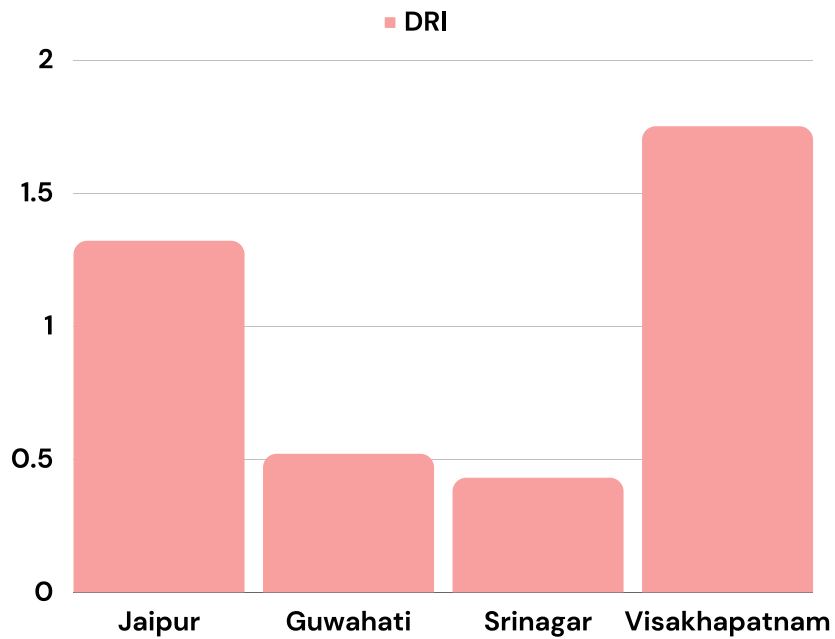




The present study provides Multi-Hazard Disaster Risks and Resilience, at the city level with a comparative analysis of Guwahati, Jaipur, Srinagar and Visakhapatnam cities. The risk index profiling of these cities have been computed comparatively for different hazards, vulnerabilities, and exposure parameters. In the statistical assessment for calculating the Disaster Risk Index (DRI), all the hazard indicators were computed comparatively for all the cities.

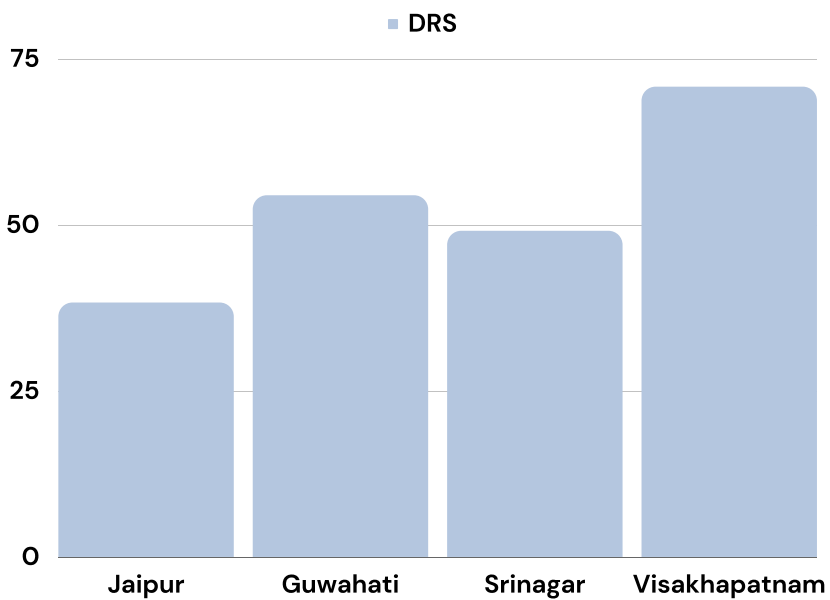
All vulnerability and exposure parameters (except Buildings, Agriculture, Livestock, Social infrastructure, Deforestation, Women, Children, Poverty, and Water stress) have been computed comparatively for the cities. Thus, based on this assessment, Guwahati is at higher risk for Earthquake, Urban Flood, Heat Wave, Industrial Hazard and Drought, while highly vulnerable to Deforestation, Women, Livestock, Poverty and Unsafe Buildings, based on the comparison with other cities. For all 4 cities, hazard-specific risk indices for each of the 14 hazards have been aggregated with suitable weightage to work out the Composite Risk Index as shown in Figure 5.

Disaster Resilience Score (DRS) is computed exclusively for each city based on the assessment of the responses received by the city administration for the questionnaire, regarding disaster management at city levels. Disaster Resilience Score for all the cities has been shown in Figure 6 and responses for questionnaires have been mentioned in Annexure 3. This study shows that the level of resilience to disasters in cities is low and requires extensive improvement. Most of the existing level of resilience has been developed in the past decade and a half, and it may be expected that the impacts of these initiatives will be felt in the years to come.



**Figure 7**  
**Disaster Risk Index**

Based on DRI, the order of cities at risk is  
**Visakhapatnam > Jaipur > Guwahati > Srinagar**



**Figure 8**  
**Disaster Resilience Score**

Based on DRS, the order of cities at resilience is  
**Visakhapatnam > Guwahati > Srinagar > Jaipur**



# LIMITATIONS AND FUTURE SCOPE





The limitations are as follows:

- The city level datasets for certain hazards, vulnerability, and exposure indicators, are unavailable. Thus, district level datasets have been considered for 1 hazard indicator (Forest Fire) and 9 vulnerability indicators (Buildings, Agriculture, Livestock, Social infrastructure, Deforestation, Water stress, Poverty, Women, and children) in the present study.
- Specific hazard datasets, like Landslide, Avalanche, and Coastal erosion, were obtained from the national susceptible zone maps, for respective hazard data in the absence of data at the city levels.
- The risk analysis of the vulnerability of buildings, is limited to significant materials used for building walls and roofs. In contrast, other parameters, such as foundation designs, structural designs and quality & maintenance of structures has not been considered as it is challenging to get datasets at a city scale.

The future scope can include:

- The study can be further extended at the town, municipality, and village level to improve the mitigation measures and resilience against potential risks at a micro-scale.
- This study uses 2 scorecards (Disaster Risk and Disaster Resilience Scorecard), as per the MHA-UNDP 2019, for four Indian cities. However, in the future, this study can be expanded to include all Indian cities. Disaster risks and resilience scorecards at the city level will undoubtedly play an essential role in enhancing disaster resilience.
- The study can be further extended on impact assessment and representation of the impacts of disasters, by developing dashboards, interactive maps, etc., to improve community awareness and preparedness for emergencies.

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# ANNEXURE 1

Sources of Hazard,  
Vulnerability and  
Exposure Datasets



**Table 33: Hazard datasets and their sources**

S.No.	Parameter	Value	Sources
1	Area (Sq. Km)	174.47	<a href="https://iihs.co.in/">https://iihs.co.in/</a>
2	Earthquake Zone (Area)	V (174.47)	<a href="https://data.gov.in/resources/list-and-zone-factors-important-cities-towns-high-risk-earthquake-zone-and-moderate-risk">https://data.gov.in/resources/list-and-zone-factors-important-cities-towns-high-risk-earthquake-zone-and-moderate-risk;</a> <a href="https://bmtpc.org/DataFiles/CMS/file/VAI2019/MAP/eqmap/EQ_JPG/EQ_INDIA.jpg">https://bmtpc.org/DataFiles/CMS/file/VAI2019/MAP/eqmap/EQ_JPG/EQ_INDIA.jpg</a>
3	Landslide Zone (Area)	I (174.47)	<a href="https://bmtpc.org/topics.aspx?mid=56&amp;MidI=186">https://bmtpc.org/topics.aspx?mid=56&amp;MidI=186</a>
4	Heat Wave	Average Heat Index: 0.69; No. of HWs: 8; Length of Longest HW: 2; No. of Days with Heat Index > 54: 1	<a href="https://zenodo.org/record/3987736#.YfJvnP5BzIV">https://zenodo.org/record/3987736#.YfJvnP5BzIV</a>
5	Cold Wave	0	Computed using Minimum temperature (Minimum temperature is derived from Indian Meteorological Department)
6	Forest Fire (District)	4281.66, 63.75, 653.44, 714.40, 1424.50 (Total area, very dense forest area, Dense Forest area, Open forest area, Total forest area in sq. km)	<a href="https://www.fsi.nic.in/forest-report-2019">https://www.fsi.nic.in/forest-report-2019</a>
7	Lightning (Average)	0	<a href="https://ncrb.gov.in/en/accidental-deaths-suicides-in-india?field_adsi_year_value%5Bvalue%5D%5Byear%5D=2000&amp;field_accidental_deaths_suicides_value=1&amp;items_per_page=10">https://ncrb.gov.in/en/accidental-deaths-suicides-in-india?field_adsi_year_value%5Bvalue%5D%5Byear%5D=2000&amp;field_accidental_deaths_suicides_value=1&amp;items_per_page=10</a>
8	Industrial Hazards	10, 10, 46, 26 (MAH industries, MPI industries, CEPI index)	<a href="https://cpcb.nic.in/displaypdf.php?id=Q1BBLO5ld0IOZWfMTUyXOZpbmFslUJvb2tfMi5wZGY=(Refer page 26-28 for CEPI Score 2009)">https://cpcb.nic.in/displaypdf.php?id=Q1BBLO5ld0IOZWfMTUyXOZpbmFslUJvb2tfMi5wZGY=(Refer page 26-28 for CEPI Score 2009)</a>
9	Fire	5; 5; 5 (No. of cases; Injured; Died)	<a href="https://ncrb.gov.in/en/accidental-deaths-suicides-in-india?field_adsi_year_value%5Bvalue%5D%5Byear%5D=2000&amp;field_accidental_deaths_suicides_value=1&amp;items_per_page=10">https://ncrb.gov.in/en/accidental-deaths-suicides-in-india?field_adsi_year_value%5Bvalue%5D%5Byear%5D=2000&amp;field_accidental_deaths_suicides_value=1&amp;items_per_page=10</a>
10	Drought	0,5,0,472,7,44 (Drought-prone area, number of drought years, moisture index, frequencies of SSI, and SPI)	<a href="https://www.indiastatdistricts.com/">https://www.indiastatdistricts.com/</a>

**Table 34: Vulnerability datasets and their sources**

S.No.	Vulnerability	Data Parameter	Values	Sources
1	Agriculture	Total area hectares, Cropped area, Irrigated area	152800, 8000, 4000	<a href="https://www.indiastatdistricts.com/">https://www.indiastatdistricts.com/</a>
2	Livestock	Total Animals, Bovine Animals, Other Animals	205543, 117229, 88314	<a href="https://dahd.nic.in/documents/statistics/livestock-census">https://dahd.nic.in/documents/statistics/livestock-census</a> (Refer Volume III)
3	Deforestation	Change in Dense Forest cover, Change in Open Forest cover (2001-2019) (in %)	-18.69, 30.67	<a href="https://www.fsi.nic.in/forest-report-2019">https://www.fsi.nic.in/forest-report-2019</a>
4	Women	Sex Ratio, Illiteracy, WHH, MMR, CAW, Dependent	958, 56%, 14.18%, 366, 500, 83.92%	<a href="https://kamrup.assam.gov.in/sites/default/files/public_utility/Census-2011-District%20Census%20Handbook-Part%20XII-A.pdf">https://kamrup.assam.gov.in/sites/default/files/public_utility/Census-2011-District%20Census%20Handbook-Part%20XII-A.pdf</a> (Refer Page no: 29 for Sex Ratio); <a href="https://www.im4change.org/docs/632assam-ahs-bulletin23x36.pdf">https://www.im4change.org/docs/632assam-ahs-bulletin23x36.pdf</a> (MMR) <a href="https://censusindia.gov.in/nada/index.php/catalog/2297">https://censusindia.gov.in/nada/index.php/catalog/2297</a> (Illiteracy) <a href="https://censusindia.gov.in/nada/index.php/catalog/2919">https://censusindia.gov.in/nada/index.php/catalog/2919</a> (For WHH- Kamrup Metro); <a href="https://police.assam.gov.in/information-services/crime-data">https://police.assam.gov.in/information-services/crime-data</a> (CAW)
5	Children	Children population (0-6 years), (7-18 years), IMR, Non-school going children, Working children	125386, 258514, 46, 28745, 28745	<a href="https://censusindia.gov.in/census.website/data/population-finder">https://censusindia.gov.in/census.website/data/population-finder</a> (Common source for 0-6 and 7-18), <a href="https://www.im4change.org/docs/632assam-ahs-bulletin23x36.pdf">https://www.im4change.org/docs/632assam-ahs-bulletin23x36.pdf</a> (IMR) <a href="https://censusindia.gov.in/nada/index.php/catalog/16969">https://censusindia.gov.in/nada/index.php/catalog/16969</a> (number of children attending school)
6	Aged	Age group 60+, Age group 80+, Dependency Ratio	67752, 6489, 19.41%	<a href="https://censusindia.gov.in/nada/index.php/catalog/2297">https://censusindia.gov.in/nada/index.php/catalog/2297</a>
7	Disabled	Visual, Hearing, Speech, Physical, Mental Disabled and Any other Disability	2123, 3664, 1235, 1606, 1309, 5904	<a href="https://censusindia.gov.in/nada/index.php/catalog/42520">https://censusindia.gov.in/nada/index.php/catalog/42520</a>



S.No.	Vulnerability	Data Parameter	Values	Sources
8	Industries	Micro, Small and Medium Enterprises (MSME), Industrial clusters, Special Economic Zones (SEZ)	1500, 0, 0	<a href="http://dcmsme.gov.in/old/cips/state_wise_dips/Assam%20State%20Profile,%202014-15.pdf">http://dcmsme.gov.in/old/cips/state_wise_dips/Assam%20State%20Profile,%202014-15.pdf</a> (For MSME) <a href="http://sezindia.nic.in/upload/uploadfiles/files/n.pdf">http://sezindia.nic.in/upload/uploadfiles/files/n.pdf</a> (For SEZs)
9	Depletion of mangroves	Change of mangrove cover during 2001-2020, Dense mangrove, Open mangrove	0	<a href="https://fsi.nic.in/isfr19/vol1/chapter3.pdf">https://fsi.nic.in/isfr19/vol1/chapter3.pdf</a>
10	Poverty	Rural, Urban BPL Population, Rural and Urban Homeless population (Lakhs)	90.85, 9.01, 10392, 2527	<a href="https://censusindia.gov.in/nada/index.php/catalog/7256">https://censusindia.gov.in/nada/index.php/catalog/7256</a>
11	Water stress	Surface Water (%), Moisture Index, Sub-Surface Water (Over-Exploited, Critical, Sub-critical, Safe)	0.97%, 0.472, (0,0,0,7)	<a href="http://cgwb.gov.in/gwresource.html">http://cgwb.gov.in/gwresource.html</a>

## 12. Physical Infrastructure

City	Length of roadways	Length of railways	No. of airports (Int+Domestic)	No. of airports (Domestic)	No. of seaports (Major)	No. of seaports (Major)
Guwahati	1380	34	1	0	0	0

Source: [https://des.assam.gov.in/sites/default/files/swf\\_utility\\_folder/departments/ecostat\\_medhassu\\_in\\_oid\\_3/this\\_comm/statistical\\_hand\\_book\\_assam\\_2018.pdf](https://des.assam.gov.in/sites/default/files/swf_utility_folder/departments/ecostat_medhassu_in_oid_3/this_comm/statistical_hand_book_assam_2018.pdf) (Refer Page no. 206)

## 13. Social Infrastructure

City	Primary School	Secondary School	College	University	Engineering	Medical	Polytechnique	Dispensaries/ Health Centers	FW Centers	Hospital/Med -ical Schools
Guwahati	258	139	130	1	2	1	3	8	11	48

Source: <https://censusindia.gov.in/census.website/data/handbooks>

**14 a. Material of Roof (% of buildings as per prominent materials used for roofs)**

City	Grass/ Thatch/ Bamboo / Wood/Mud etc.	Plastic/ Polythene	Handmade Tiles	Machine made Tiles	Burnt Brick	Stone/ Slate	G.I./Metal/ Asbestos sheets	Concrete	Any other material
Guwahati	1	0.2	0.4	0.2	0.4	2.9	64.7	30.2	0.1

Source: <https://censusindia.gov.in/nada/index.php/catalog/9408>

**14 b. Material of Wall (% of buildings as per prominent materials used for walls)**

City	Grass/ Thatch/ Bamboo etc.	Plastic/ Polythene	Mud/ Unburnt brick	Wood	Burnt Brick	Stone not packed with mortar	Stone packed with mortar	G.I./Metal/ Asbestos sheets	Concrete	Any other material
Guwahati	23.2	0.6	1.2	1.2	50.3	4.9	4.9	0.8	15.7	0.3

<https://censusindia.gov.in/nada/index.php/catalog/9620>

**Table 35: Exposure datasets and their sources**

**12. Physical Infrastructure**

City	Population	Area in sq.km	Population Density	GDP in Cr.Rs.	Per Capita GDP	Remarks
Guwahati	9,57,352	174.47	5,487.20	1,54,52,540	47,900	<a href="http://164.100.161.224/upload/uploaddfiles/files/Assam_Guwahati.pdf">http://164.100.161.224/upload/uploaddfiles/files/Assam_Guwahati.pdf</a>

# **ANNEXURE 2**

## **Statistical Note on Methodology**



# HAZARD INDEX COMPUTATION

## 1. Earthquake

Earthquake Hazard Index has been calculated as the weighted average of the prescribed values of the seismic hazard zones, where the weights are the percentage of the area, falling within a particular zone. Here  $X_2 = 2$ ,  $X_3 = 4$ ,  $X_4 = 6$ ,  $X_5 = 10$  is the intensity of the  $i$ th hazard zone,  $w_i$ 's are the percentage area of the city in the  $i$ th hazard zone,  $i = 2, 3, 4,$  and  $5$  in equation (i).

$$I = \frac{\sum_{i=2}^5 w_i \times X_i}{\sum w_i} \dots \dots \dots (i)$$

## 2. Landslide

Landslide Hazard Index has been calculated as the weighted average of the prescribed values of the landslide hazard zones, where the weightages are the percentage of the area falling within a particular zone. Here  $X_1 = 0$ ,  $X_2 = 4$ ,  $X_3 = 8$ ,  $X_4 = 10$  is the intensity of the  $i$ th hazard zone,  $w_i$ 's are the percentage of the area of the city in the  $i$ th hazard zone in equation (i).

$$I = \frac{\sum_{i=1}^4 w_i \times X_i}{\sum w_i} \dots \dots \dots (i)$$

## 3. Drought

The drought Hazard Index has been calculated as the average of the normalized scores of the parameters. For  $X_1$  (drought-prone area) and  $X_2$  (drought years), moisture index,  $X_3$  frequency of SSI and  $X_4$  frequency of SPI, have been normalized by dividing by the maximum value and multiplying by 10 to put on a scale of 0 to 10 using equation (i) (MHA-UNDP Report, 2019). Then, an average of all these parameters was taken, since equal weightage had been pre-specified.

$$X_i^* = 10 \times (X_i) / (\max (X_i)) \dots \dots \dots (i)$$

$$I = \text{mean} (X_i^*)$$

## 4. Urban Flood

The urban flood index has been calculated, as the weighted average of the 3 prescribed indicators, which are the values of the percentage of flood-prone area, according to the mapping by BMTPC (2006) (BMTPC, 2011), using equation (i) and standardized by equation (ii), where  $w$  denotes the percentage of flood area in the risk zone and  $Y$  denotes the pre-specified score of the zones, as well as total number of flood-prone cities in the district, with a population greater than 1 Million and 10 Million, standardized by equation (iii), where the equal weightage had been pre-specified to every parameter.

$$X_1^* = (X_1)/10 \dots\dots\dots (i)$$

$$X_2^* = \frac{\sum_{i=1}^5 w_i \times Y_i}{\sum w_i} \dots\dots\dots (ii)$$

$$X_3^* = 10 \times (X_3) / (\max(X_3)) \dots\dots\dots (iii)$$

$$I = \frac{\sum_{i=1}^3 w_i \times X_i^*}{\sum w_i}$$

## 5. Heat Wave

The first 3 parameters (annual average of the number of hot days, number of heat waves and length of longest heat wave), have been normalized by dividing by the maximum value and multiplying by 10, to put on a scale of 0 to 10 to equation (i). The average heat index, during the heat waves, has been normalized, according to equation (ii). Then, a simple average of all these parameters had been taken, to get the index, since equal weightage had been pre-specified.

$$X_1^* = 10 \times (X_1) / (\max(X_1)) \dots\dots\dots (i)$$

$$X_4^* = 10 \times (X_4 - 54) / (\max(X_4) - 54) \dots\dots\dots (ii)$$

$$I = \text{mean}(X_i^*)$$

## 6. Cold Wave

As per the India Meteorological Department (IMD, Pune) criteria, a cold wave is defined based on the actual minimum temperature of a station. Cold Wave is considered, when the minimum temperature of a station is, 4 degree Celcius or less for plains and -4 0C or less for hilly regions. The cold wave index for days with cold wave events has been computed with equal weightage on a scale of 0 to 10, using equation (i). A simple average had been taken to get the index since equal weightage had been pre-specified.

$$X_1^* = 10 \times (X_1) / (\max(X_1)) \dots\dots\dots (i)$$

$$I = \text{mean}(X_i^*)$$

# 7. Fire

The parameters, such as cases, deaths and injuries due to fire accidents, have been normalized by dividing with the maximum value and multiplying by 10, to put it on a scale of 0 to 10, using equation (i). Then, a simple average of all these parameters was taken, since equal weightage had been pre-specified. Since the data has been compiled at the city level, an assumption has been made that, the incidence is equally likely across all areas; hence, the areas with more population would be at a higher risk.

$$X_i^* = 10 \times (X_i) / (\max(X_i)) \dots\dots\dots (i)$$

$$I = \text{mean}(X_i^*)$$

# 8. Forest Fire

We obtained a multiplier, which has been defined as the weighted average of proportions of "very dense", "dense" and "open" forest cover, in the district (area of forest category in the district divided by total forest cover in the district), where the weightage had been pre-specified. The multiplier is strictly between 0 and 1 using equation (i). Then, this multiplier is multiplied with the pre-assigned score associated with the risk category of the district, to get the hazard index.

$$X_i^* = 10 \times (X_i) / (\max(X_i)) \dots\dots\dots (i)$$

$$I = \text{mean}(X_i^*)$$

# 9. Industrial Hazard

The first 2 parameters (i.e., Maximum Hazard Industries and Maximum Polluting Industries) have been normalized by dividing with the maximum value and multiplying with 10, to put on a scale of 0 to 10 using equation (i). The CEPI (Comprehensive Environmental Pollution Index) has been rescaled on a scale of 10, which is 10 for CEPI>80, 8 for CEPI>70, 60 for CEPI>60, and 4 for CEPI>50, 2 for CEPI<50. Then, a weighted average of all these parameters was taken, where the weights had been pre-specified as 50%:25%:25%.

$$X_i^* = 10 \times (X_i) / (\max(X_i)) \dots\dots\dots (i)$$

$$I = \frac{\sum_{i=1}^3 w_i \times X_i^*}{\sum w_i}$$



# 10. Lightning

The average annual deaths have been normalized by dividing with the maximum value and multiplying with 10, to put it on a scale of 0 to 10 using equation (i). Since the data has been compiled at the district level, an assumption has been made that, the incidence is equally likely across the city; hence the city with more population would be at a higher risk.

$$X_i^* = 10 \times (X_i) / (\max (X_i)) \dots \dots \dots (i)$$

$$I = \text{mean} (X_i^*)$$

# 11. Avalanche

Avalanche Hazard Index has been calculated as the weighted average of the prescribed values of the seismic hazard zones, where the weightage are the percentage of area falling within a particular zone. Here  $X_1= 0$ ,  $X_2= 4$ ,  $X_3= 6$ ,  $X_4= 8$ ,  $X_5=10$  is the intensity of the  $i$ th hazard zone and  $w_i$ 's are percentage of area of city in the  $i$ th hazard zone as shown in equation (i).

$$I = \frac{\sum_{i=1}^5 w_i \times X_i}{\sum w_i} \dots \dots \dots (i)$$

# VULNERABILITY INDEX COMPUTATION

## 1. Buildings

### a. Walls

In order to capture the effect, each particular hazard has, on each specific type of wall, the following coding has been used: X: {VH = 10, H = 8, M = 6, L = 4, VL = 2} and each hazard index has been categorized according to 5 risk zones. A weighted average of these, have been taken, where the weightages are the proportion of a particular wall type in all houses of the district.

### b. Roofs

In order to capture the effect, each particular hazard has, on each specific type of roof, the following coding has been used: X: {VH = 10, H = 8, M = 6, L = 4, VL = 2} and each hazard index has been categorized, according to 5 risk zones. A weighted average of these have been taken, where the weightages are the proportion of a particular roof type in all houses of the district.

## 2. Agriculture

For agriculture, the net non-irrigated cropped area (total cropped area–irrigated area) and irrigated area, have been normalized by dividing with the district’s total area and multiplying with 10, to put on a scale of 0 to 10, using equation (i). Then, a weighted average of all these parameters was taken, where the weightage had been pre-specified as 80% on the former and 20% on latter. ( : Cropped area, : Irrigated area, : Total area)

$$I_a = 0.8 \times (X_c - X_i)/X_t + 0.2 \times X_i/X_t \dots \dots \dots (i)$$

## 3. Poverty

All parameters (rural and urban BPL and Homeless population) have been normalized by dividing with the maximum value and multiplying with 10, on a scale of 0 to 10 using equation (i). Then, a simple average of all these parameters was taken, since equal weightage had been pre-specified.

$$X_i^* = 10 \times (X_i) / (\max (X_i)) \dots \dots \dots (i)$$

$$I = \text{mean} (X_i^*)$$

# 4. Women

All parameters have been normalized by dividing with the maximum value and multiplying with 10, to put them on a scale of 0 to 10, according to equation (I). Then, a simple average of all these parameters was taken, since equal weightage had been pre-specified.

$$X_i^* = 10 \times (X_i - \min(X_i)) / (\max(X_i) - \min(X_i)) \dots \dots \dots (i)$$

$$I = \text{mean}(X_i^*)$$

# 5. Children

All parameters have been normalized by dividing with the maximum value and multiplying with 10, to put them on a scale of 0 to 10, according to equation (I). Then, an average of groups of these parameters was taken, since equal weightage had been pre-specified. Within each group, a weighted average of each of the parameters in the group has been taken, where the weightage had been pre specified. This has been done twice, once with absolute numbers and once with percentages. Then, a geometric mean of both these indices was taken to obtain the final index.

$$X_1^* = 10 \times (X_i - \min(X_i)) / (\max(X_i) - \min(X_i)) \dots \dots \dots (i)$$

$$I_1 = \text{mean}(X_i^*)$$

$$I_2 = \text{mean}(X_i^*)$$

$$I = \text{geo mean}(I_1, I_2)$$

# 6. Disability

All parameters have been normalized by dividing with the maximum value and multiplying with 10, to put them on a scale of 0 to 10, according to equation (I). Then, a simple average of all these parameters was taken, since equal weightage had been pre-specified. This has been done twice, once with absolute numbers and once with percentages. Then, a geometric mean of both these indices was taken to represent the final index.

$$X_1^* = 10 \times (X_i - \min(X_i)) / (\max(X_i) - \min(X_i)) \dots \dots \dots (i)$$

$$I_1 = \text{mean}(X_i^*)$$

$$I_2 = \text{mean}(X_i^*)$$

$$I = \text{geomean}(I_1, I_2)$$

# 7. Aged

All parameters have been normalized by dividing with the maximum value and multiplying with 10, to put them on a scale of 0 to 10, according to equation (i). Then, a simple average of all these parameters was taken, since equal weightage had been pre-specified. This has been done twice, once using absolute numbers and once using percentages. Then, a geometric mean of both these indexes was taken to represent the final index.

$$\begin{aligned}
 X_i^* &= 10 \times (X_i - \min(X_i)) / (\max(X_i) - \min(X_i)) \dots\dots\dots (i) \\
 I_1 &= \text{mean}(X_i^*) \\
 I_2 &= \text{mean}(X_i^*) \\
 I &= \text{geo mean}(I_1, I_2)
 \end{aligned}$$

# 8. Livestock

For livestock, the number of bovine animals and other animals, has been normalized by dividing with the total number of the district and multiplying with 10, to put it on a scale of 0 to 10, using equation (i). Then, a weighted average of all these parameters was taken, where the weightage had been pre-specified as 75% on the former and 25% on the latter.

( $X_b$  : No. of bovine animals,  $X_o$  : No. of other animals,  $X_t$  : Total No. of animals)

$$I_a = 0.75 \times (X_b) / X_t + 0.25 \times X_o / X_t \dots\dots\dots (i)$$

# 9. Industries

The total number of industries, industrial clusters, and SEZs, has been normalized by dividing with the maximum value and multiplying with 10, to put on a scale of 0 to 10, equation (i). Then, a weighted average of all these parameters was taken, where the weightage had been pre-specified as 40%:40%:20%.

$$\begin{aligned}
 X_i^* &= 10 \times (X_i) / (\max(X_i)) \dots\dots\dots (i) \\
 I &= \frac{\sum_{i=1}^3 w_i \times X_i^*}{\sum w_i}
 \end{aligned}$$

# 10. Physical Infrastructure

All parameters have been normalized by dividing with the maximum value and multiplying with 10, to put on a scale of 0 to 10, using equation (i). Then, a simple average of groups of these parameters (Road & Rail Connectivity, Sea and Air Connectivity) was taken, since equal weightage had been pre-specified using equation (ii). Within each group, a simple average of each of the parameters in the group has been taken.

$$X_i^* = 10 \times (X_i) / (\max(X_i)) \dots \dots \dots (i)$$

$$Y_j = \text{mean}(X_i : X_i \in j^{\text{th}} \text{ group}) \dots \dots \dots (ii)$$

$$I = \text{mean}(Y_j)$$

# 11. Social Infrastructure

All parameters have been normalized by dividing with the maximum value and multiplying with 10, to put on a scale of 0 to 10, using equation (i). Then, a simple average of groups of sub-groups of these parameters (Educational Institutions and Health Institutions), was taken, since equal weightage had been pre-specified using equation (ii). Within each group, a simple average of each of the sub-group of parameters has been taken. Within each sub-group, a simple average of each of the parameters, in the sub-group has been taken.

$$Y_j = \text{mean}(X_i : X_i \in j^{\text{th}} \text{ subgroup}) \dots \dots \dots (i)$$

$$Z_j = \text{mean}(Y_i : Y_i \in j^{\text{th}} \text{ group}) \dots \dots \dots (ii)$$

$$I = \text{mean}(Z_j)$$

# 12. Deforestation

All parameters of change (dense & open) have been normalized by dividing with the maximum value and multiplying with 10, to put it on a scale of 0 to 10, according to equation (i). Then, a simple average of all these parameters was taken, since equal weightage had been pre-specified.

$$X_i^* = 10 \times (X_i - \min(X_i)) / (\max(X_i) - \min(X_i)) \dots \dots \dots (i)$$

$$I = \text{mean}(X_i^*)$$



# 13. Water Stress

All parameters of change have been on a scale of 0 to 10 according to equations (i), (ii), and (iii). Then, a simple average of all these parameters was taken, since equal weightage had been pre-specified.

$$X_1^* = 10 \times (\max(X_1) - X_1) / (\max(X_1) - \min(X_1)) \dots \dots \dots (i)$$

$$X_2^* = (100 - X_2) / (100) \dots \dots \dots (ii)$$

$$X_3^* = \left( \frac{\sum_i^3 w_i \times X_i}{\sum w_i} \right) \dots \dots \dots (iii)$$

$$I = \text{mean}(X_i^*)$$

## EXPOSURE INDEX COMPUTATION

Two parameters have been considered for calculating the Exposure Index.

These are

- (a) population density (=Population / Area in km<sup>2</sup>) and
- (b) per capita GDP (=GDP (in Cr. Rs.) / Population) of a city.

Both parameters have been normalized by dividing with the maximum value and multiplying by 10, to put them on a scale of 0 to 10, according to equation (i).

Then, a simple average of these parameters was taken, since equal weightage has been given on both the parameters.

$$X_i^* = 10 \times (X_i) / (\max(X_i)) \dots \dots \dots (i)$$

$$I = \text{mean}(X_i)$$



# **ANNEXURE 3**

**Disaster Resilience  
Questionnaire Responses**



1. Risk Assessment (Weights 10%)	Indicators/Questions	Aggregate Points	Points Assigned	
	1.1	Hazard Vulnerability Risk Assessment	10	5.5
	1.2	Digital Risk Mapping in Public Domain	5	0
	1.3	Real Time Data on Risks and Disasters	5	4
	1.4	Micro Zonation of Earthquake Risks	3	1
	1.5	Flood Risk Assessment	3	2
	1.6	Drought Risk Assessment	5	0
	1.7	Dissemination of Risk Information to People	3	2.5
	1.8	Assessing Traditional and Local Knowledge	3	0
	1.9	Assessing Patterns of Emerging Risks	3	2
	1.10	Developing Database on Disasters	5	2
	Others	5	0	

2. Risk Prevention & Mitigation (Weights 20%)	Indicators/Questions	Aggregate Points	Points Assigned	
	2.1	Disaster Risk Mitigation Projects	8	4
	2.2	Mainstreaming DRR in Development	3	1
	2.3	State and Disaster Risk Mitigation Fund	3	0
	2.4	Safety standards for constructions and land use	7	5
	2.5	Safety audit/ retrofitting of lifeline infrastructure/ buildings	8	5
	2.6	Construction of cyclone/ flood shelters	3	0
	2.7	Eco System Approach for Disaster Risk reduction	3	1
	2.8	Social Safety Net for Poor and Vulnerable	5	1.5
	2.9	Mitigation of risks of heritage	2	1
	2.10	Integration of climate change adaptation with DRR	3	2
	Others	5	0.5	

3. Risk Governance (Weights 20%)	Indicators/Questions	Aggregate Points	Points Assigned	
	3.1	Institutional mechanisms for risk governance	6	1.5
	3.2	Disaster Management Policy and Plans	10	3
	3.3	Disaster Management Manuals and Procedures	2	2
	3.4	Decentralization and Devolution of Functions	2	1
	3.5	Training and Capacity Development	10	8.5
	3.6	Multi-Stakeholder Platform	2	1
	3.7	Community Involvement and Participation	5	2
	3.8	Enforcement and Compliance	4	1
	3.9	Monitoring and Evaluation	2	0
	3.10	Transparency and Accountability	2	2
	Others	5	0	

4. Disaster Preparedness (Weights 20%)	Indicators/Questions	Aggregate Points	Points Assigned	
	4.1	End-to-End Early Warning Systems	5	4
	4.2	Emergency Operation Centers	5	5
	4.3	Disaster Communication System	5	4
	4.4	Emergency Medical Preparedness	5	3.5
	4.5	Scenario Building, Simulation and Mock Drills	5	3.5
	4.6	Contingency Plans, SOPs, Manuals	5	2
	4.7	Community Based Disaster Preparedness	5	3
	4.8	Awareness Generation	5	3
	4.9	Resource Inventory	3	2
	4.10	Media Partnership	2	2
	Others	5	0.5	



5. Disaster Response (Weights 10%)		Indicators/Questions	Aggregate Points	Points Assigned
	5.1	State Agencies for Disaster Response	10	5
	5.2	Incident Response System	4	3
	5.3	Coordination with GOI, NDRF Armed, Forces	2	1
	5.4	Evacuation, Search and Rescue	7	7
	5.5	Emergency Medical Response	5	5
	5.6	Emergency Support Functions	5	5
	5.7	Protection of vulnerable women and children	5	2
	5.8	Disposal of dead bodies	3	1
	5.9	Disposal of Animal Carcasses	2	0
	5.10	Disposal of Debris	2	1.5
	Others	5	0	

6. Disaster Relief & Rehabilitation (Weights 15%)		Indicators/Questions	Aggregate Points	Points Assigned
	6.1	Minimum Standard of Relief	2	2
	6.2	Ex-gratia Relief	1	1
	6.3	Relief Logistics and Supply Chain Management	7	6.5
	6.4	Food and Essential Supplies	7	6.5
	6.5	Drinking Water, Dewatering and Sanitation	7	7
	6.6	Health and Mental Health Care	7	4
	6.7	Management of Relief Camps	5	5
	6.8	Veterinary Care	3	1.5
	6.9	Relief Employment	3	0.5
	6.10	Temporary and Intermediary Shelters	3	2
		Others	5	0.5

7. Disaster Reconstruction (Weights 5%)	Indicators/Questions	Aggregate Points	Points Assigned	
	7.1	Damage and Loss Assessment	5	2.5
	7.2	Post Disaster Needs Assessment	5	3
	7.3	Financing Reconstruction	5	0
	7.4	Institutional Mechanisms for Reconstruction	5	0
	7.5	Building Back Better	5	1.5
	7.6	Reconstruction of Houses	5	1
	7.7	Reconstruction of Infrastructure	5	0
	7.8	Livelihood Reconstruction	5	5
	7.9	Regeneration of Ecology and Environment	3	1.5
	7.10	Learning from Reconstruction and Recovery	2	0.5
	Others	5	3	





# CITY RESILIENCE

## About the Institute

National Institute of Disaster Management (NIDM) was constituted under an Act of Parliament with a vision to play the role of a premier institute for capacity development in India and the region. The efforts in this direction that began with the formation of the National Centre for Disaster Management (NCDM) in 1995 gained impetus with its redesignation as the National Institute of Disaster Management (NIDM) for training and capacity development. Under the Disaster Management Act 2005, NIDM has been assigned nodal responsibilities for human resource development, capacity building, training, research, documentation and policy advocacy in the field of disaster management.

NIDM is proud to have a multi-disciplinary core team of professionals working in various aspects of disaster management. In its endeavour to facilitate training and capacity development, the Institute has state-of-the-art facilities like class rooms, seminar hall and video-conferencing facilities etc. The Institute has a well-stocked library exclusively on the theme of disaster management and mitigation. The Institute provides training in face-to-face, on-line and self-learning mode as well as satellite based training. In-house and off-campus face-to-face training to the officials of the state governments is provided free of charge including modest boarding and lodging facilities.

NIDM provides Capacity Building support to various National and State level agencies in the field of Disaster Management & Disaster Risk Reduction. The Institute's vision is to create a Disaster Resilient India by building the capacity at all levels for disaster prevention and preparedness.



**National Institute of Disaster Management**  
(Ministry of Home Affairs, Government of India)

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