CITY RESILIENCE

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MULTI-HAZARD

DISASTER RISK & RESILIENCE

JAIPUR CITY

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MULTI-HAZARD DISASTER RISK AND RESILIENCE

JAIPUR CITY

nidm
Resilient India - Disaster Free India
National Institute of Disaster Management
(Ministry of Home Affairs, Government of India)

Multi-Hazard Disaster Risk and Resilience for Jaipur City

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FOREWORD

RAJENDRA RATNOO

EXECUTIVE DIRECTOR

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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 Jaipur city" is a part of the 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 Jaipur city in Rajasthan. 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 Jaipur. Hence, this study will prove to be remarkable in providing a more localized approach to the Jaipur 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)

PREFACE

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Resilient India - Disaster Free India

सत्यमेव जयते

Prof. Anil Kumar Gupta

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It's a matter of immense pleasure for me to present this study for "Multi-hazard Disaster Risk & Resilience for Jaipur 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 study presents a scorecard to measure the level of disaster risks and resilience for the Jaipur city and has also been conducted as a pilot for three more cities of India viz. Guwahati, Srinagar and Vishakhapatnam 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 report highlights the hazards and risks specific to the Jaipur city and its level of resilience in the form of preparedness and capacity building.

(Anil K Gupta)

ACKNOWLEDGEMENT

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 support received from Shri Shankar Lal Saini, Mr. Brajesh Kumar, Prof. Reepunjaya Singh, Prof. Ravi Goyal, Dr. Laxmi Kant Sharma, and many more for developing a consensus on the methodology and outcomes of the study during the assessment of risk and resilience for Jaipur city, is highly appreciable.

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 a 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 Islary 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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BPL	Below Poverty Line
BMTPC	Building Materials and Technology Promotion Council
CAW	Crime Against Women
CDRI	Composite Disaster Risk Index
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
GJMC	Greater Jaipur Municipal Corporation
IMD	India Meteorological Department
IMR	Infant Mortality Rate
JHMC	Jaipur Heritage Municipal Corporation
JMC	Jaipur Municipal Corporation
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

Image credit: canva

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 UN Sustainable Development Goals (SDGs) contribute to reducing disaster risk 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 created vital milestones on the journey towards 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 administrations in urban areas continue to lag in disaster risk reduction and have inadequate disaster management, causing the people's substandard quality of life.

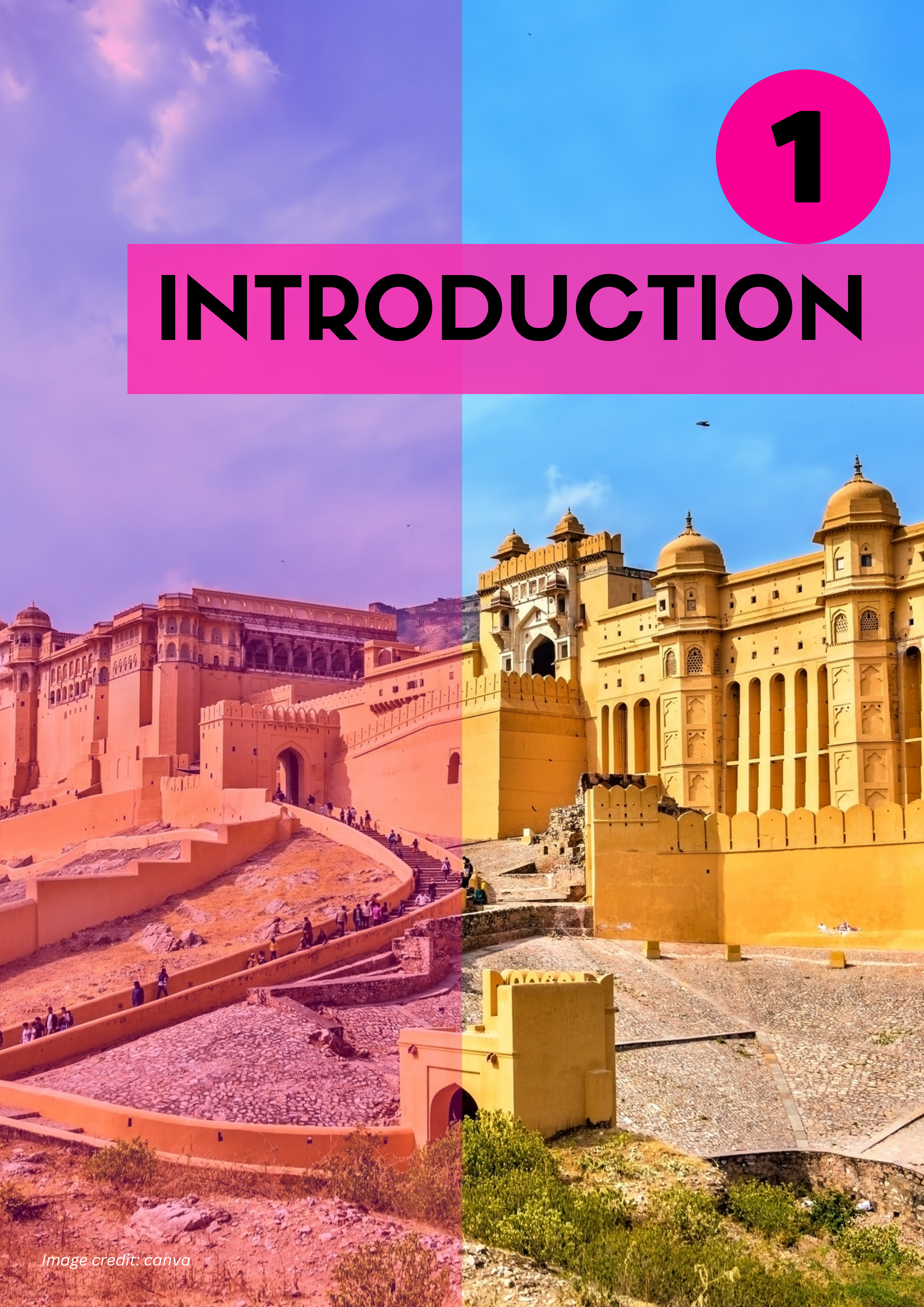
Therefore, the Government of India launched the 'Smart Cities Mission' in 2015 and selected 100 cities to accelerate financial growth and improve the living conditions of citizens through comprehensive work on the social, economic, and institutional pillars of the city. Jaipur city is one of the Smart 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.

Increase in population and urban expansion intensifies vulnerability to disaster events for the population of disabled, children, below the poverty line, etc., during the disasters. Jaipur holds a special place in people's hearts as a multifaceted city with a flair for expansion and a traditional touch. Jaipur city ranked 10th in population among India's megacities in 2011 (3.07 million in 2011) with a yearly population growth rate of approximately 5% compared to 2001. The projected population of the city is about 6.5 million in 2025. In 2019, The Government of Rajasthan announced the division of Jaipur Municipal Corporation (JMC) into two municipal corporations such as Greater Jaipur Municipal Corporation (GJMC) and Jaipur Heritage Municipal Corporation (JHMC). According to the Master Development Plan (MDP) 2025, the urbanised region of the city needs to be enlarged up to 954 Km^2.

The projected urbanization shows an increase of 73.56% for the period of 2020–2040. The MDP-2025 envisions Jaipur as a worldwide metropolis and world-class city where all people are engaged in productive work with a high quality of life in a sustainable environment. This necessitates planning and action to meet the challenge of population growth and in-migration to Jaipur, 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 Jaipur city with new and complex modern patterns of development. Jaipur city is classified as seismic disturbance Zone-II, making it less vulnerable to earthquakes. However, the city is susceptible to natural and man-made disasters such as floods, drought, heat waves, cold waves, fire accidents, etc. For example, Jaipur has experienced huge impacts due to the fire incidents such as the Indian Oil Corporation (IOC) fire incident in 2009, where 6 people died and around 150 were injured. Therefore, there is an immediate requirement for assessing the city's disaster risk and resilience and accordingly, implementing the disaster management plan.

In this study, hazard, vulnerability, and exposure indices for Jaipur city are computed using several indicators (as per the MHA-UNDP Report, 2019). The study showed that Jaipur city is more prone to disasters such as Heatwave, Fire accidents, and Industrial hazards followed by Drought, Lightning, Cold waves, and Urban floods. Similarly, Jaipur city is more vulnerable to disasters in terms of Social infrastructure, Children, Industries, and Disabled People followed by Physical Infrastructure, Poverty, Aged People, and Unsafe buildings. The study also revealed that the population of Jaipur has a high hazard-specific exposure index for natural disasters like Heat waves, Industrial Hazards, and Drought that may lead to an economic loss for 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



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In a rapidly urbanizing world, it is estimated that by 2050, two-thirds 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 exposure will enhance the future climate change risks and associated impacts on the cities (IPCC, 2022). Rapid urbanization intensifies human-induced warning, 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).

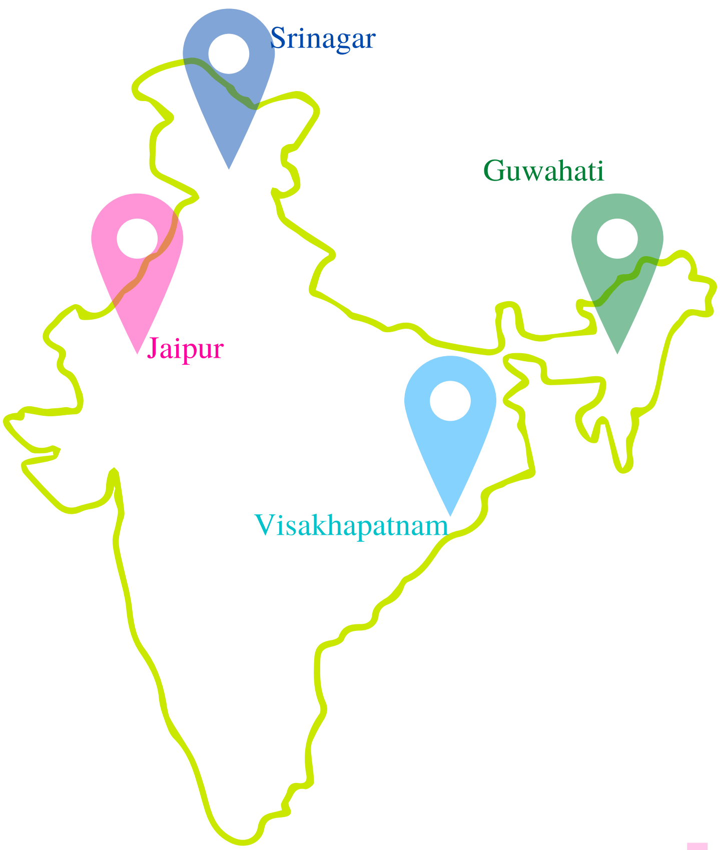


Figure 1

Selected cities for the study: Guwahati, Jaipur, Srinagar, and Visakhapatnam

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 the 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 crucial. 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) (consists of Goal 11 of making the cities and human settlements inclusive, safe, resilient, and sustainable) (Stanton-Geddes & Vun, 2019).

The cumulative consequences of the different programs 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 national, state, and district levels.

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 risk and resilience is required with an assessment and technical capacity development by Urban Local Bodies (ULBs) (G. 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, but there is a lack of scientific studies and availability of tools 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).

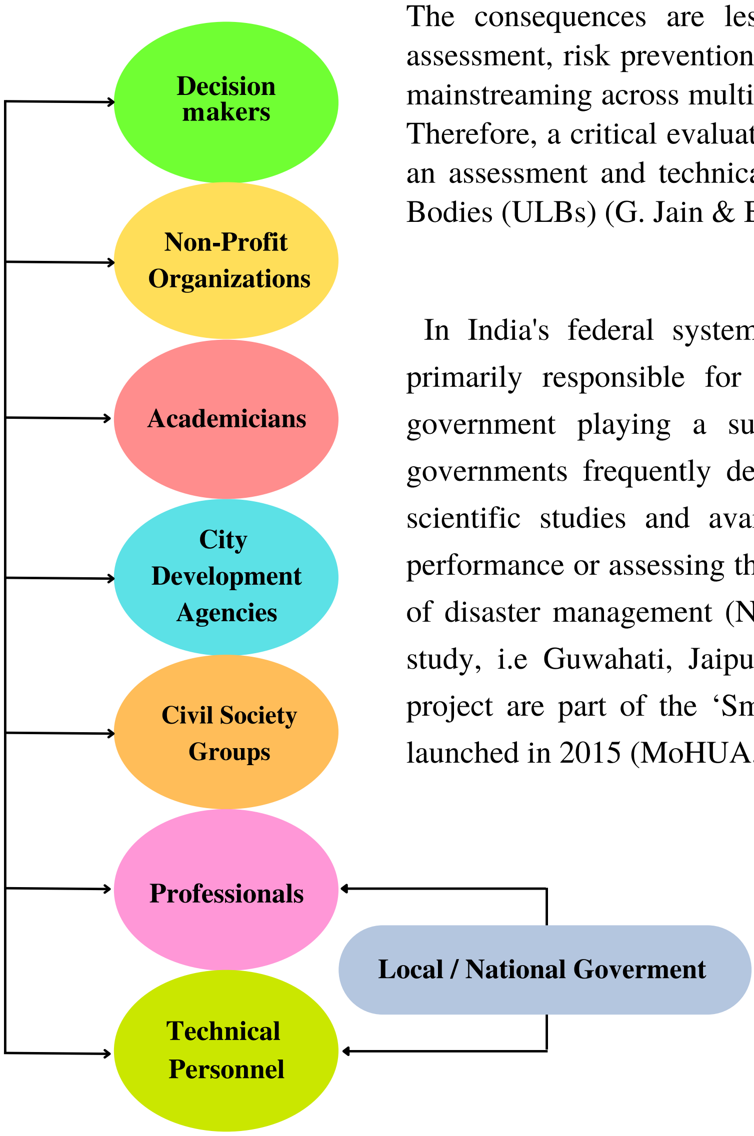


Figure 2

Technical Report's primary audience

The project aims to understand the perceptions & contexts for city risk & resilience and provides helpful guidance to city administrations & policymakers on actions required to form resilience to disasters. The four 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 has yet to build a solid and robust database of hazards, vulnerabilities, risks, and resilience, the 'model' theoretical framework on indicators is greatly hampered by a lack of data at the city level to monitor indicators' progress.

Thus, to make Jaipur 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 first study of its kind at the city level, on multi-hazard disaster risk & resilience to develop a risk and resilience scorecard. This study can be extended to other cities in India to evaluate the 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 to academics and interested people for further research.

2

JAIPUR CITY PROFILE

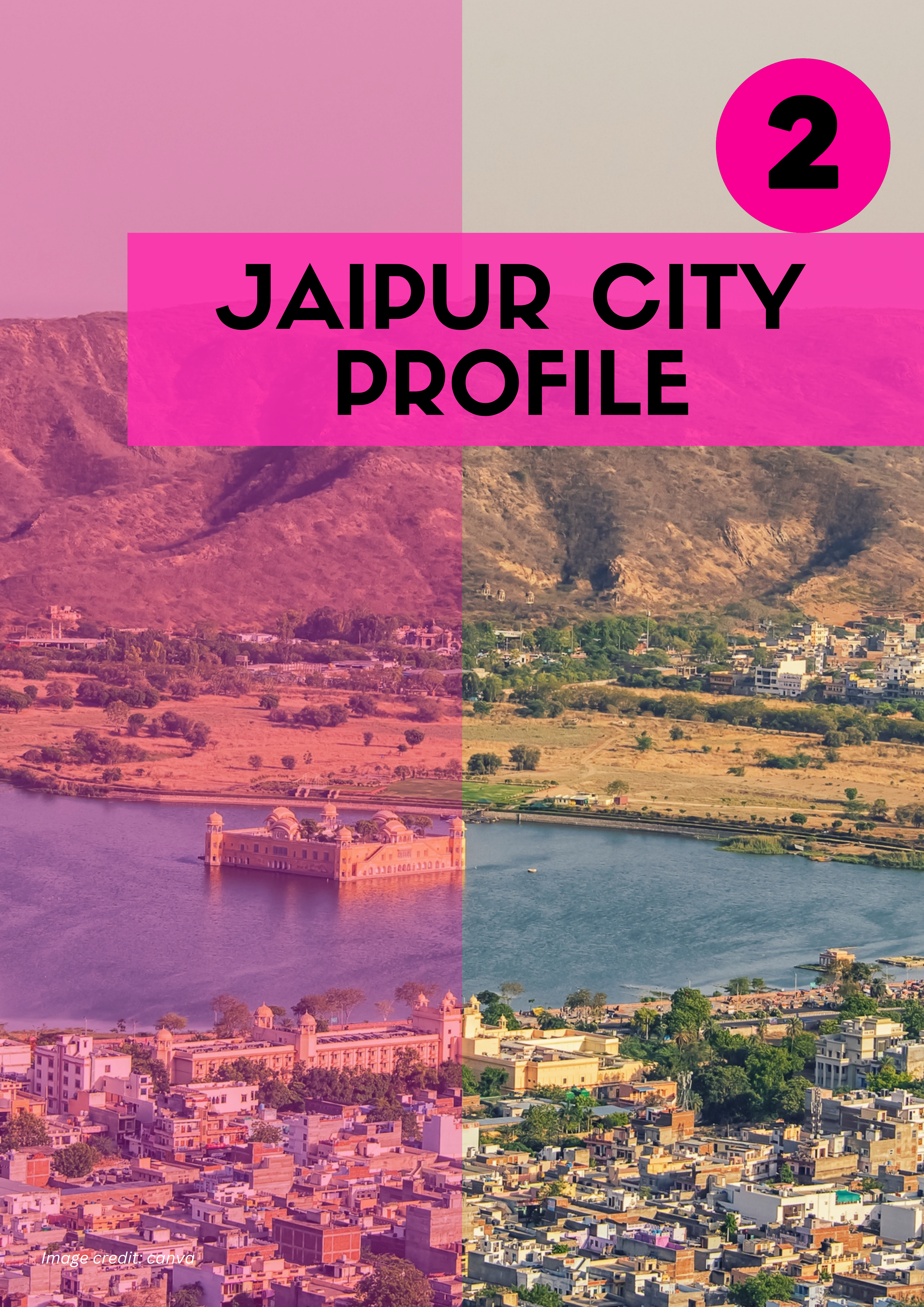


Image credit: canva

Jaipur, the capital of Rajasthan, is one of India's first planned cities, situated in the semi-desert land of the state (Tyagi et al., 2011). In 1876, the buildings and walls were painted in pink colour during the Prince of Vales's visit; thus, the city is known as 'Pink City' (Jaipur Municipal Corporation, 2022; NIUA, 2015). The city population was 3.07 million in 2011, with a 2.71% annual growth rate (Bansal, 2017). The municipal corporation has an area of 382.80 km^2 , which is almost half of Singapore. The city has a population density of 8020 persons per km^2 , whereas India has a population density of 382.80 persons per km^2 , which means the population density of Jaipur city is more than 21 times the population density of India (MoHUA, 2022). Its latitude and longitude are 26° 01' 36" North and 75° 04' 32" East, respectively (Fig. 1).

The city is in the foothills of the Aravalli range and bounded by hillocks on the north and east sides and plains on the west and south sides. The elevation above mean sea level is 390 metres (JCMC, 1951). The humidity, cloudiness and rainfall activities increase during the monsoon season, which runs from June to September and irregularly through the rest of the year because of the western disturbances (Tyagi et al., 2011). Jaipur ranked 10th in population among India's megacities in 2011, with a yearly growth rate of approximately 5% compared to 2001(Vyas & Goyal, 2020). The projected population of the city in 2025 is about 6.5 million (JDA, 2011).

Jaipur city has been selected and ranked 3rd in the list of 'Round 1 Smart Cities' of the 100 Smart Cities in the Ministry of Urban Development's (MoUD) 'Smart Cities Mission', which was launched in June 2015 (MoHUA, 2022; MyGov, 2022). Jaipur city stands at 13th rank in Economic Activity, 23rd in the Quality of Life, 24th in Citizen Perception and 40th in Sustainability in the year 2021 (The Times of India, 2021b). The Government of Rajasthan announced the division of JMC into two municipal corporations, Greater Jaipur Municipal Corporation (GJMC) and Jaipur Heritage Municipal Corporation (JHMC), on October 18, 2019 (The Times of India, 2019). The JHMC was placed at 32nd rank and GJMC was placed at 36th rank among Urban Local Bodies (ULBs) with a population of above 4 million in the annual cleanliness survey conducted by the central government, as per Swachh Survekshan 2021 (The Times of India, 2021c) while, Jaipur city holds 370th rank in the Swachchh Bharat ranking conducted in 2014-15 by the MoUD (MoHUA, 2022).

The walled city of Jaipur serves as the city's Central Business District, with about 60% of the city's business operations. It is well-known for its traditional handicrafts, gems and jewellery, textiles, wooden furniture, and leather purses, among other things (JDA, 2011).

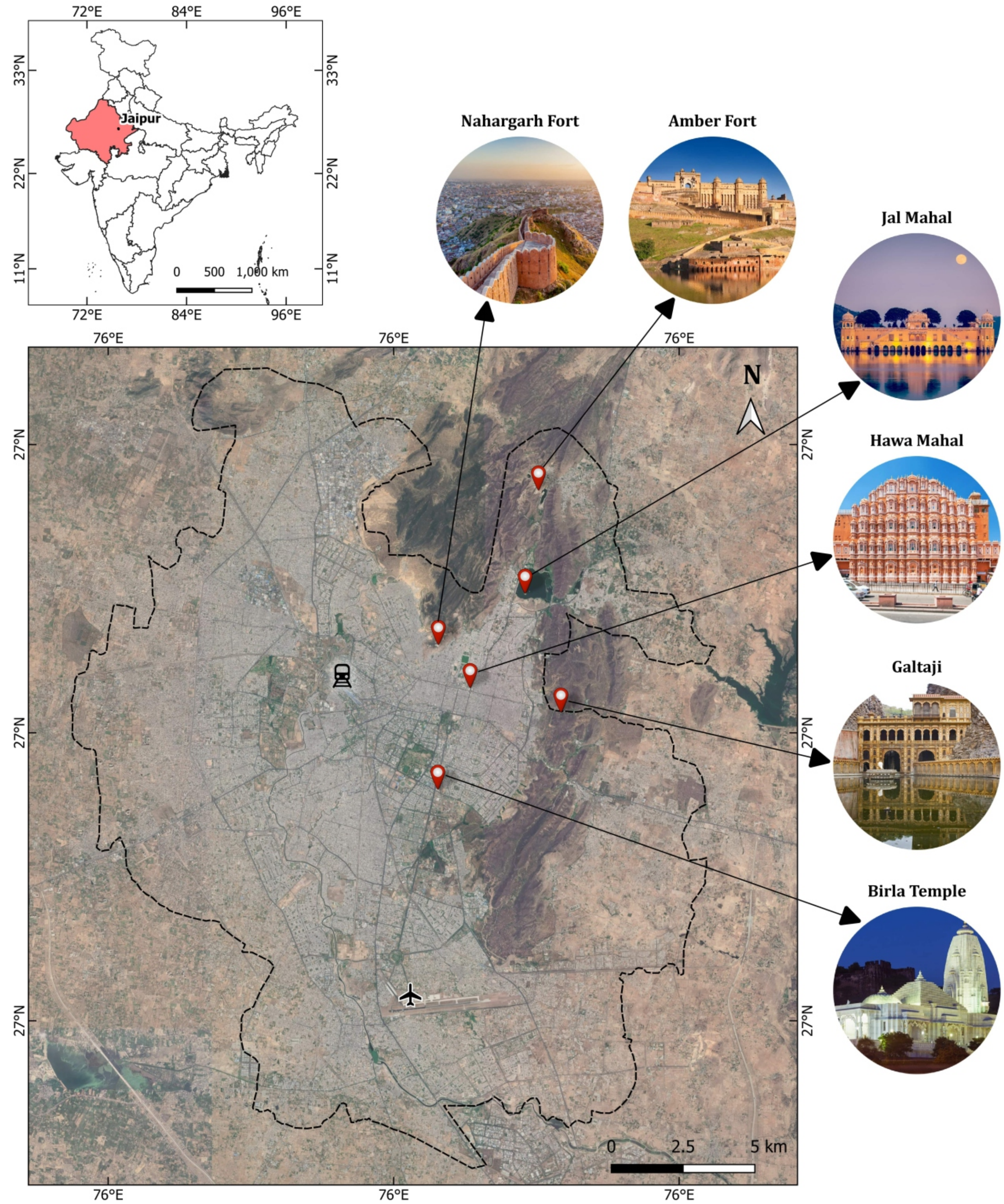


Figure 3

Location map of Jaipur city

Population

3.07 million

Population Density

8020 person per sq.km

Annual Growth Rate

2.71%

Indian Megacities Population

Rank 10

Smart Cities Mission (Round 1)

Rank 3rd

Image credit: canva

3

RISK PROFILE OF THE CITY

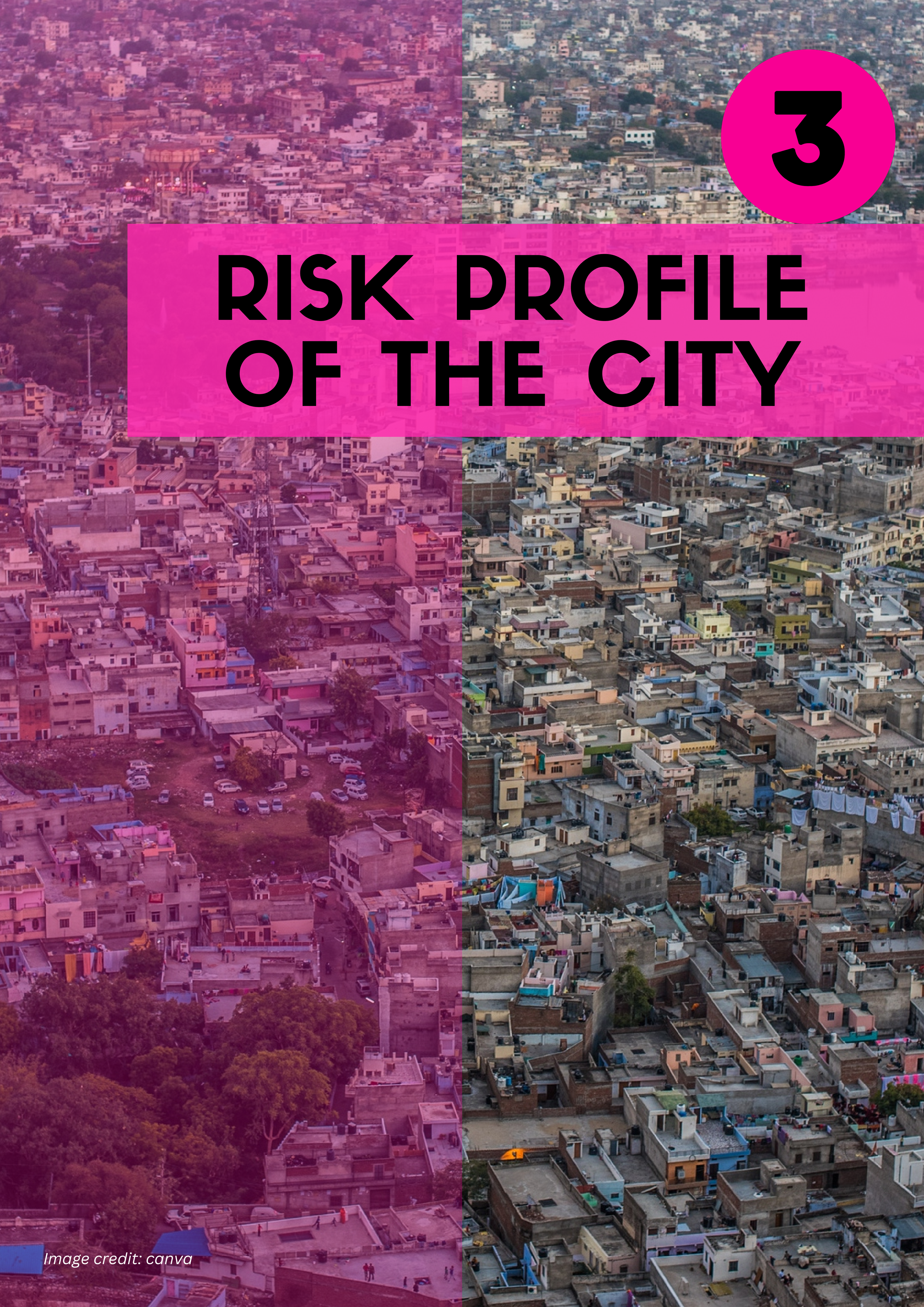


Image credit: canva

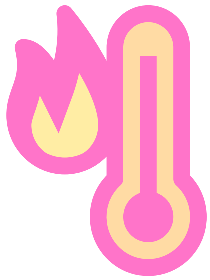
The risk profile and disasters triggered in the past in Jaipur city are as follows:

- As per the Building Materials and Technology Promotion Council (BMTPC) Atlas, Jaipur city falls under earthquake Zone-II up to magnitude 4.9. For instance, an earthquake measuring 3.8 magnitude struck on Jan 29, 2016 (Hindustan Times, 2022), a magnitude of 4.3 struck on Jul 08, 2018 (The Times of India, 2018) and a magnitude of 3.0 struck on Dec 17, 2020, hit Jaipur city (NCS, 2020).

- Jaipur city is now experiencing increasing water scarcity and reduced drinking water sources due to the droughts that occurred with recurrence in 5 years (JCMC, 1951; Mundetia & Sharma, 2014). All 13 blocks of the city are in dark zones due to the lowering of the water table (Vyas & Goyal, 2020; Sharma & Goyal, 2020; Goyal & Surampalli, 2018). The water table has decreased, exceeding 25 meters below in the last decade (CGWB, 2013). The research shows that 13 drought years have hit Jaipur between 2000 and 2016. Also, recently Jaipur city has witnessed drought events in 2017 and 2019.

The average rainfall of the city is 600 mm, almost 90% of which receives in the monsoon period (i.e., June to September); the remaining comes from the winter cyclones (DDMP Jaipur, 2014; IMD, 2011). Jaipur city was flooded in 1981 and is susceptible to floods, as seen from 1984 to 1989 and 1999 to 2002 (CGWB, 2013). The city experienced some notable flash floods in 2012 and 2020 (Flood List, 2020; Goyal et al., 2022; The Times of India, 2021a).

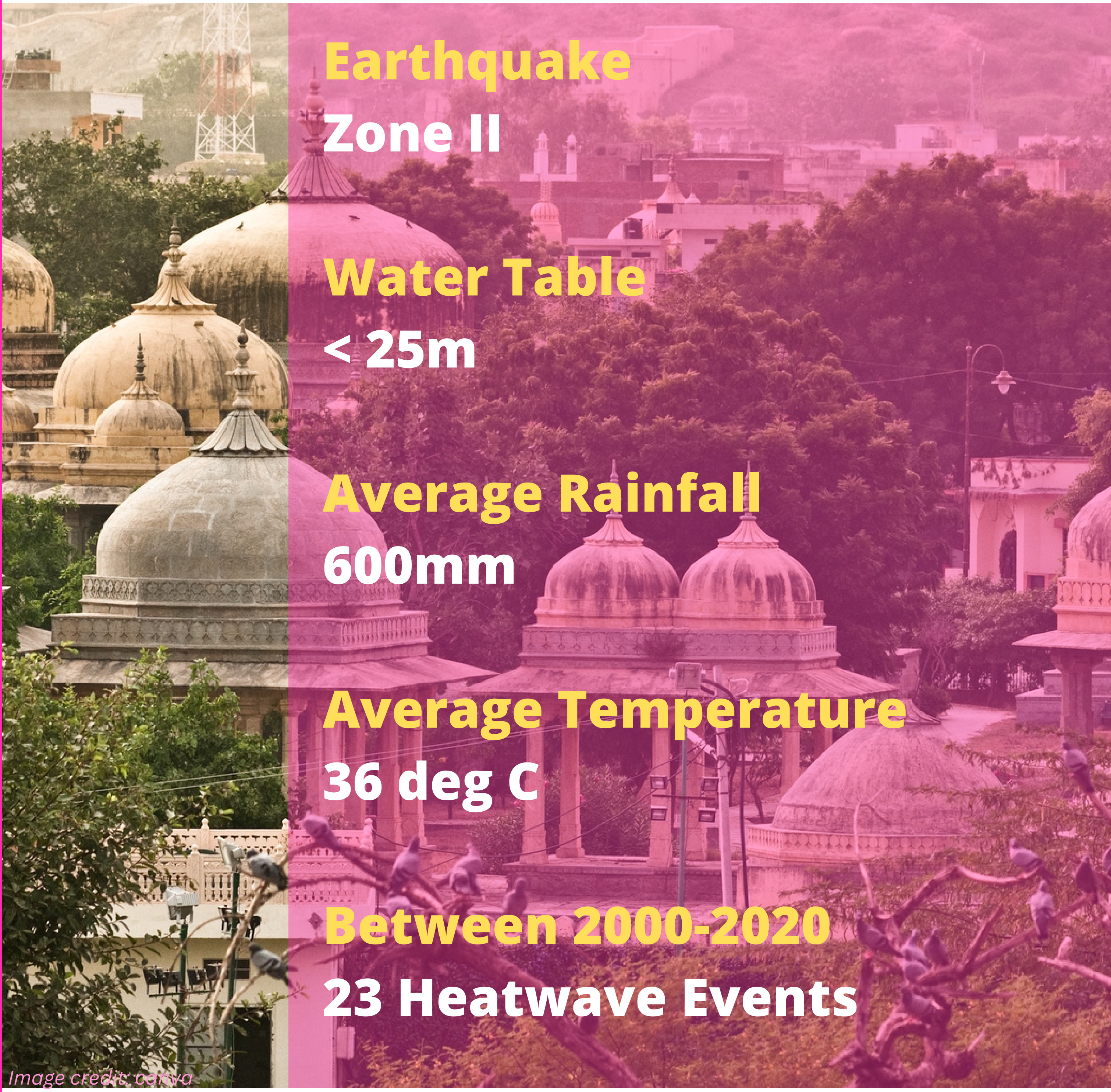
- Jaipur city is characterized by high temperatures and low rainfall. The mean temperature of the city is 36°C, changing from 18°C in winter to 40°C in summer, and in May month, maximum temperatures range from 40 to 47°C. A heatwave occurs during the season when the daytime temperature increases to 4-6°C above normal (Tyagi et al., 2011). Based on the research, 23 heatwave events (5 days+) occurred between 2000 to 2020.



Jaipur city has experienced huge impacts due to fire accidents in the past. For instance, the Indian Oil Corporation (IOC) fire incident in 2009 killed 12 people and injured several people (M.K. Jain, 2018). The research showed 72 cases, 6 injuries, and 52 deaths from fire incidents between 2000 and 2020.

The lightning events also led to mortalities in Jaipur city. For example, the Amer Fort lightning tragedy killed 16 people and many were injured in 2021 (BBC News, 2021).

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



4

STUDY OF MULTI-HAZARD DISASTERS

Image credit: canva

In this study, a multi-hazard disaster risk matrix is 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 are collected and generated for several parameters chosen to compute exposures, vulnerabilities, and hazard indices. Based on the importance of the parameters, specific weights are given to the parameters according to the Risk and Resilience matrix developed by the MHA-UNDP 2019 report (Refer 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 exposures (Refer Figure 3). The parameters and their relative weights were identified and taken from MHA-UNDP Report, 2019 (UNDP, 2019).

The Disaster Resilience Score (DRS) is computed by summing up the scores achieved by Jaipur 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 are rescaled to 100 to compute resilience, enable comparison, and thereby DRI. Based on guidelines and contents provided under the DM Act 2005 and DMP 2009 of the country, a set of questions are used for the performance assessment of Jaipur city. As per the MHA-UNDP Report (2019), responses (received from the city's administration) assessment of the Questionnaire, are computed in quantitative terms. The risk and resilience scorecard methodology is explained and presented sequentially in Figure 2.

i) What constitutes risks of disasters

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

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

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.

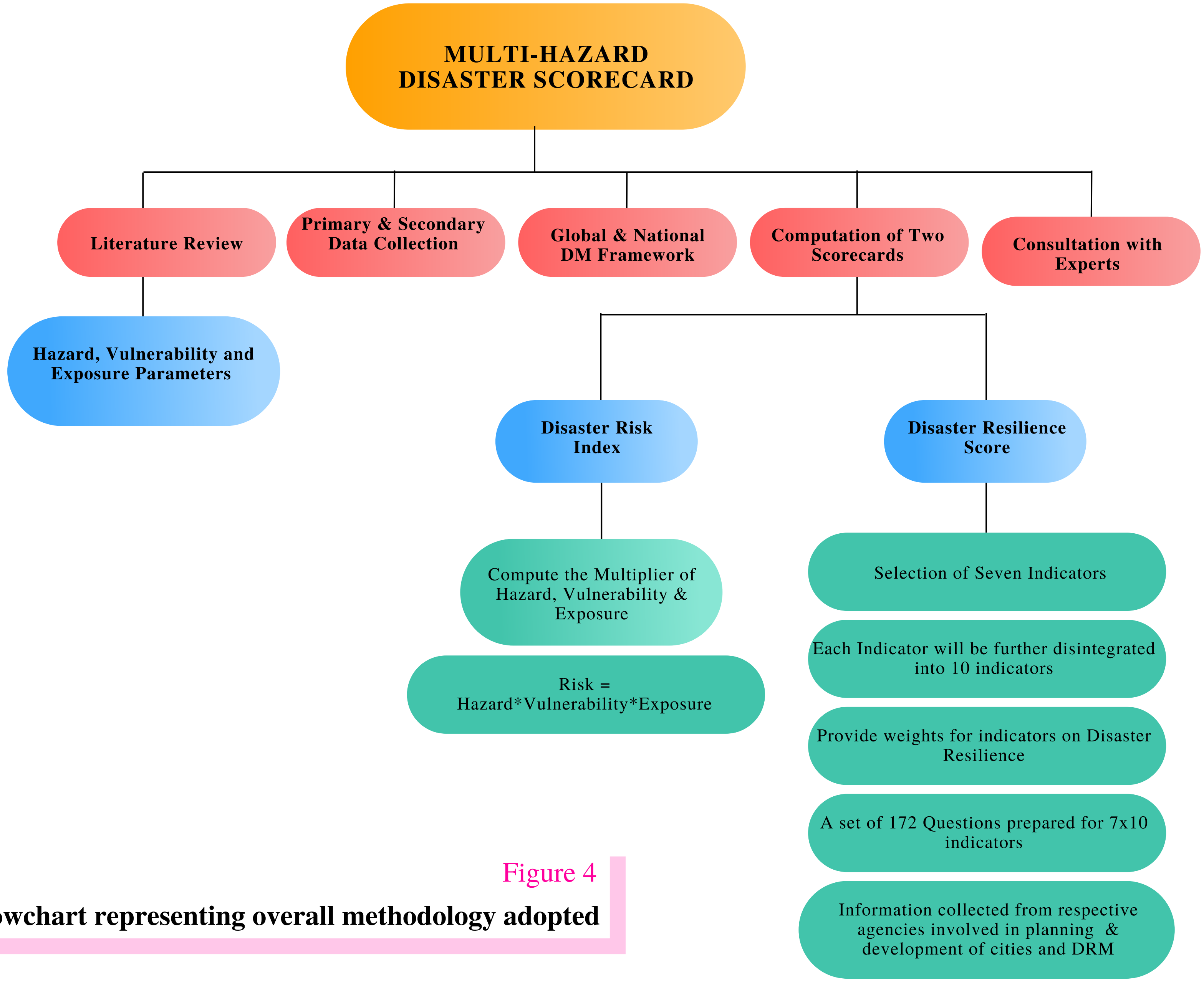


Figure 4

Flowchart representing overall methodology adopted

ii) Selection of indicators for hazard, vulnerability, and exposure

The indicators of hazards, vulnerabilities, and exposures have been chosen on their importance and the data accessibility uniformly across the city (Refer Figure 3). Although specific datasets for some indicators, like livestock, forest fire, agriculture, etc., are available at the district level, they were chosen and the best use of datasets was made based on the existing datasets.

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

iv) For exposures, (a) population and (b) GDP are selected. The 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 heat waves. Similarly, the susceptible forest and mangrove cover are significantly related to forest fire, but not related to industrial hazards. Thus, based on their significance, hazard-specific vulnerabilities were 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, the risks of disasters from an earthquake are much higher than from forest fires or landslides. 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 than exposed human conditions of poverty or gender bias. The datasets of past disasters have been used to develop relative weights (Refer Table 3).

viii) Comparative weights on hazards, vulnerabilities, and exposures

The risk level for the city of Jaipur, which has a high population density of 8,020 person per km^2 and GDP, is overestimated when hazards, vulnerabilities, and exposures are given equal weights. It was agreed that the relative weights 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
Cyclone	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)
Tsunami	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%
Fire	Normalized fire index of Jaipur city based on average annual. a) Number of accidents of fire b) Number of deaths c) Number of injuries	Equal weights
Forest Fire	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
Coastal Erosion	a) Length of coastline b) Coastal length (km) under erosion c) Coastal area (sq km) under erosion	Equal weights
Industrial Hazard	a) MAH industries b) MPI industries c) CEPI index	a) 50% b) 25% (c) 25%
Lightning	Normalized annual average lightning mortality in city	Mortality index scaled 0 to 10

MAH: Maximum Accident Hazard
MPIs: Maximum Polluting Industries
CEPI: Comprehensive Environmental Pollution Index

Table 2

List of 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 Jaipur 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

Indicator	Weight%
Earthquake	15
Landslide	7
Avalanche	3
Drought	15
Urban Flood	15
Heat Wave	6
Cold Wave	6
Cyclone	15
Tsunami	3
Fire	3
Forest Fire*	3
Coastal Erosion	3
Industrial Hazard	3
Lightning	3

VULNERABILITIES

Indicator	Weight%
Buildings*	15
Agriculture*	10
Poverty*	10
Women*	8
Children*	8
Disability	6
Aged	6
Livestock*	6
Industries	6
Physical Infrastructure	5
Social Infrastructure*	5
Deforestation	5
Depletion of Mangrove	5
Water Stress*	5

EXPOSURES

Indicator	Weight%
Population	50
Economy	50

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

Note:

1. As per the MHA-UNDP 2019 report, the total hazard indicators in the list are 14. However, Jaipur 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 are considered for Jaipur city except the Depletion of Mangrove (13 vulnerable indicators are considered out of 14) as there is no mangrove in the city.

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

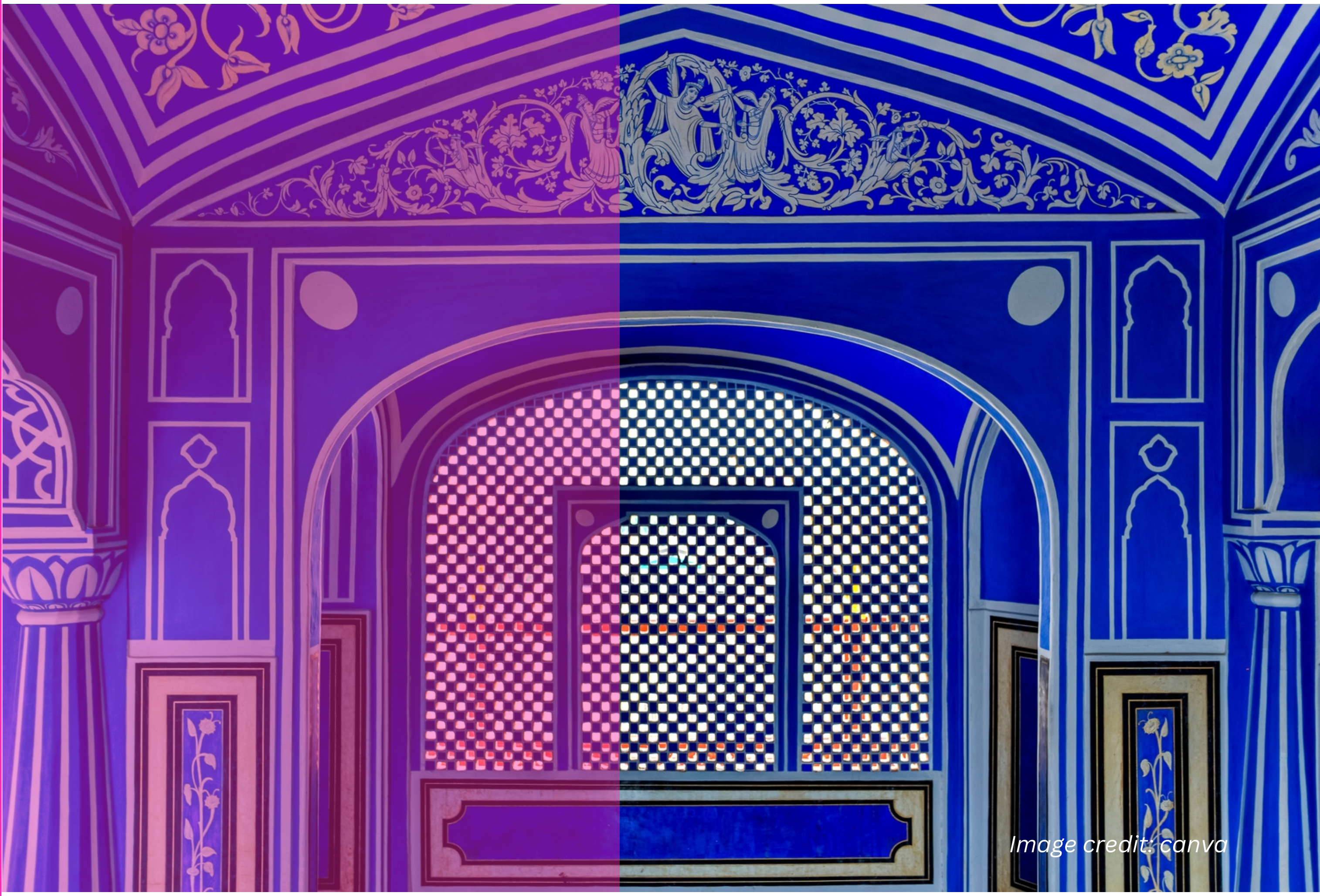


Image credit: canva

5

HAZARD INDEX COMPUTATION DATASETS

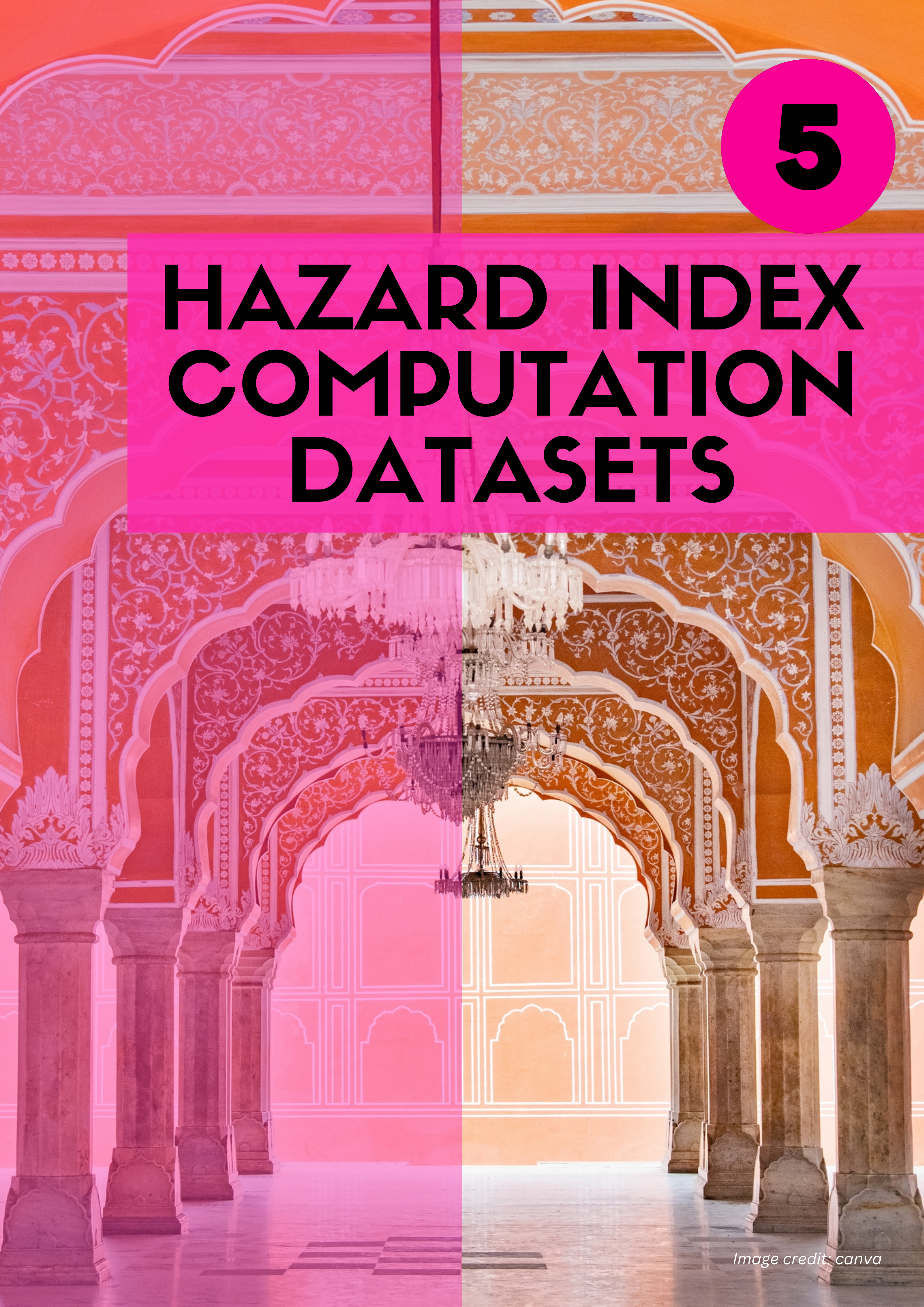


Image credit: canva

1. Earthquake

The earthquake data of the city is derived from 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^2)	Area (km^2) 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	%	
382.80	382.80	100	0.00	0.00	0.00	0.00	0.00	0.00	2.00

Since the whole of Jaipur city lies in Zone II (for which the weight is 2), the area falling in the earthquake hazard zone is considered the city's area, i.e., 382.80 km^2 . It means the whole city is susceptible to earthquake events in a low-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^2)	Area (km^2) 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	%	
382.80	382.80	100	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Since the whole of Jaipur city lies in Zone I (for which the weight is 0), the area falling in the landslide hazard zone is considered the city's area, i.e., 382.80 km^2 . It means 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). Equal weights of 20% have been given on each parameter (Table 6). The data sources for these parameters are provided in the annexure section at the end of the report (Annexure 1).

Table 6 **Drought Index**

Drought Prone Area (km^2)	No. of Drought Years	Moisture Index	Frequency		Normalized				Drought Index (Out of 10)
			SSI	SPI	Drought Years	Moisture Index	SSI	SPI	
0	13	-0.08	17	35	10.00	7.45	6.54	7.95	**6.39**

It is observed that there were 13 drought years between 2000 to 2016. Therefore, Jaipur is experiencing increased water scarcity and reduced drinking water sources due to the droughts that occurred with recurrence over 5 years.

Image credit: canva

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 weights have been given to all the parameters (Table 7). The data sources for these parameters are provided in the annexure section at the end of the report (Annexure 1).

Table 7 **Flood Hazard Index**

City Area (km^2)	Flood Affected Area (km^2)					Flood Hazard Index (Out of 10)
	Average Annual Flooding	Maximum Annual Flooding	Year of Maximum Flooding	Average Flooded Area (%)	Maximum Flooded Area (%)	
382.80	-	-	2012	33	27.20	4.91

Among 382.80 km^2 total area of the city, the observed area of maximum flooding, was 27.20% in 2012 during 2000 to 2020 and the average flooded area was about 33%.

5. Heat Wave

Heat waves have been captured through 4 parameters: (a) the number of days with a heat index 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 weights 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	
5	4	23	0.54	10.00

Four average heatwave events (5 days+) with temperatures above 40°C or above occurred between 2000 to 2018 in the city, every year. The number of days with HI above 54 was five days and the longest average heat wave was 23 days long.

6. Cold Wave

Cold Wave Hazard Index has been worked out, following the Indian 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 3 different temperature brackets in the city, has been worked out with equal weight to calculate the cold 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)
5	**5.56**

There were 5 numbers of 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 between 2000 to 2018 over the city. Cities in the hilly areas may have a high cold wave risk index, compared to the plain cities like Jaipur.

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 equal weights of 33.33% on these 3 parameters.

Table 10 **Fire Hazard Index**

Accidents of Fire			Fire Hazard Index (Out of 10)
Cases	Deaths	Injured	
72	52	6	**10.00**

The city had 72 cases, 52 deaths, and 6 injuries that occurred due to fire accidents between 2001 to 2015. The data sources for these parameters are given in the annexure section at the end of the report (Annexure 1).

Indian Oil Corporation (IOC) depot fire, Sitapura Industrial Area, Jaipur. (Source: The Hindu, 29 October 2009)

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 the Jaipur district (lack of city-level data) in terms of 3 types of a forest fires: high, moderate, and no risk. This has been supplemented with data on types of forests in the cities- very dense (50%), dense (30%) and open forests (20%), as brought out in the annual India State of Forest Report 2019. The assigned weights are multiplied by the risk zone multiplier to get the value of the hazard index for the desired city region.

Table 11 **Forest Fire Index**

Total Area-City (km^2)	**Total Area-District (km2)**	**Forest Area (km^2)**						**Forest Fire Index (Out of 10)**
		Very Dense	**Dense**	**Open**	**Total**	**% of Total**	**Risk Zonation**	
382.80	13,418.77	9.50	120.68	484.63	613.75	4.57%	0.00	**0.00**

The total forest area in the Jaipur district is about 613.75 km^2. It is found that there is no risk zone for forest fires in the city.

9. Industrial Hazard

The datasets are obtained from several sources like the Central Pollution Control Board (CPCB), the City Municipal Corporation, etc. (Table 12). The weights assigned for Maximum Hazard Industries (MHI), Maximum Polluting Industries (MPI) and Comprehensive Environmental Pollution Index (CEPI) are 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	
15	99	66.82	**8.34**

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 66.82 in Jaipur city. The city shows a high score on the industrial hazard index, about 8.34, which means there is a high risk that contributes to the trigger of the hazards, which may lead to disasters.

10. Lightning

Lightning accounts for significant mortalities during disasters in several cities in India. Although, 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	
7	0.47	**5.83**

In Jaipur city, the lightning events, that led to mortalities, were only 7 in the past 15 years (2000-2015). It is challenging to say the risk of lightning occurrence as it is a natural phenomenon, but the hazard index shows that the city is experiencing a moderate rate of lightning. For example, the Amer Fort lightning tragedy killed around 16 people and many were injured in 2021 (BBC News, 2021).

Summary of Hazard Indicators

- As per the MHA-UNDP 2019 report, 10 hazard indicators, relevant to Jaipur city, based on the geographical and topographical features of the city, have been considered.
- The methodology and weights, adopted to compute the hazard indices, are as per the MHA-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 Jaipur city.
- Jaipur city is more prone to Heatwaves, Fire Accidents, and Industrial Hazards compared to other hazard indicators.

6

VULNERABILITY INDEX COMPUTATION DATASETS

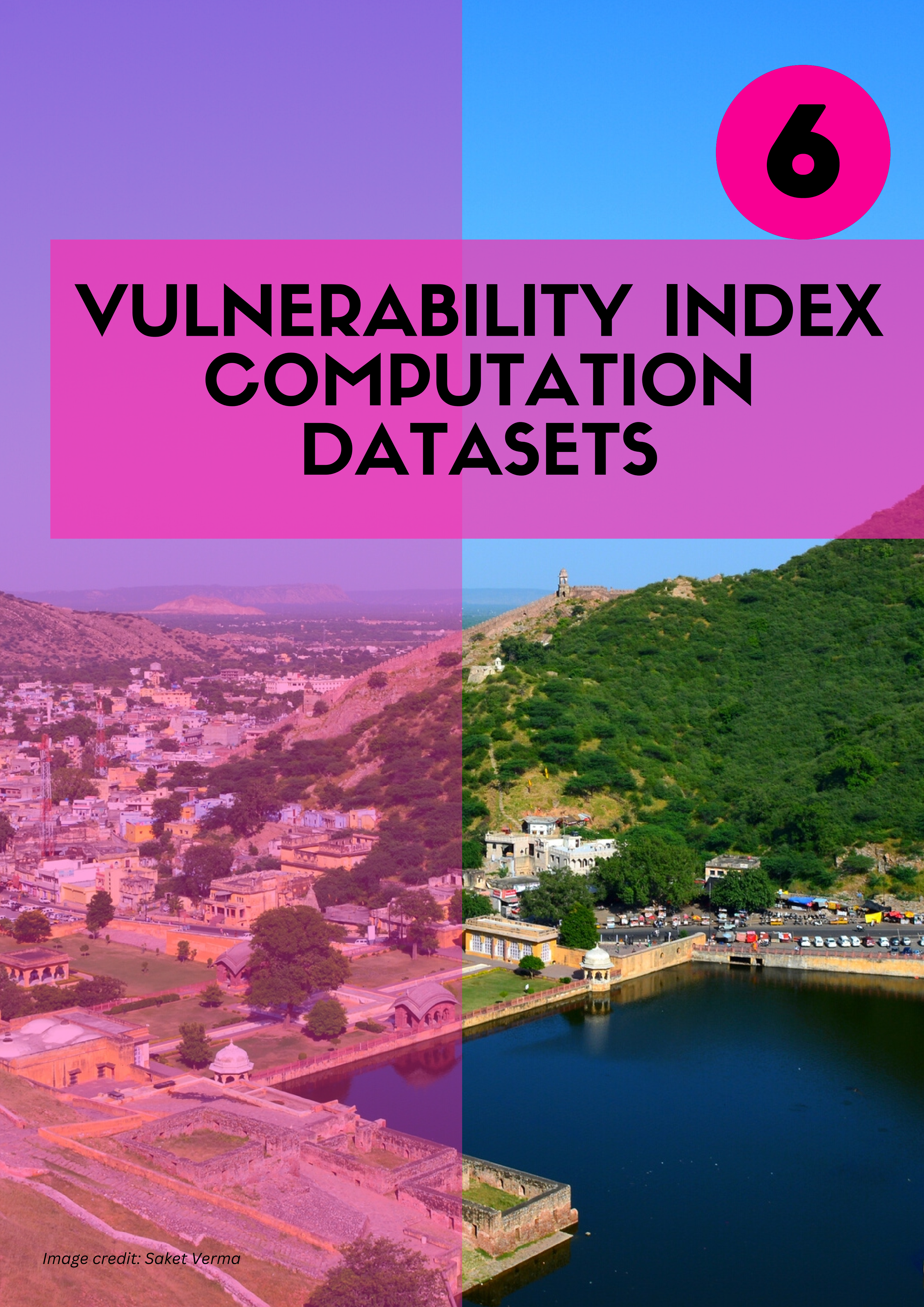


Image credit: Saket Verma

1. Buildings

a. Walls

The source of datasets of building walls is the '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 building weights 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	GI, Metal Asbestos	Burnt Bricks	Concrete	Any other material	**Vulnerability Index of Walls (Out of 10)**
10,844	1,521	76,117	1,921	58,912	4,15,899	1,626	5,58,241	13,865	6,958	**6.42**

The vulnerability index of walls is about 6.42, computed based on the different building materials. It is observed that the building walls constructed with burnt bricks are more in number compared to other building materials. Jaipur city is vulnerable to hazards like earthquake and urban flood, which damages the building walls. Therefore, the 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 walls 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 weights 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)**
61,532	2,393	2,082	3,977	10,422	5,14,298	94,277	4,52,498	4,425	**6.26**

The vulnerability index of roofs is about 6.26, computed based on the different building materials. It is observed that the building roofs constructed with stone slates are more in number compared to other building materials. Jaipur city is highly vulnerable to hazards like lightning and earthquakes, which impact the building roofs. Therefore, the 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 cropped and irrigated areas (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 website. However, these 2 parameters are included due to their associated impact on the urban population in the city. Considering the relative importance of crops and irrigation, 80% of the weight 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	
11,14,300	10,008.10	0.90%	3,810.51	0.34%	**0.05**

The vulnerability index of the crop is 0.05, which is computed based on the area of agriculture in the Jaipur district. The cropped area is about 0.90% of the total area under agriculture compared to the irrigated area. The crop vulnerability index shows that Jaipur's agricultural area is less susceptible to disasters.

3. Poverty

For the poverty data, Census 2011 data on the homeless population has been adopted in this study at the district level (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 for working out the poverty vulnerability index.

Table 17 **Poverty Vulnerability Index Computation**

BPL Population (in Lakhs)			Homeless Population (in Lakhs)			Poverty Vulnerability Index (Out of 10)
Rural	Urban	Total	Rural	Urban	Total	
82.65	18.2	100.85	1.08	0.73	1.81	7.78

The poverty vulnerability index for the Jaipur region is 7.78, which means that people, who live below the poverty line and are homeless in Jaipur, are more susceptible to disasters because they are more exposed to hazards and have lower coping mechanisms against disasters.

4. Women

The gender Vulnerability Index is worked out based on six parameters: sex ratio (women per 1,000 men), illiteracy (%), WHH (Women Headed Household %), 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 weight 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)
31,57,671	909	58%	6.56%	319	1,492	79.68%	5.42

The greater the vulnerability, the more severe the impact of hazards. The 6.56% WHH is an indicator of strength in the city. The MMR per 1,00,000 childbirths is about 319 and the average number of CAW is 1,492 cases. The dependent women 79.68% indicate non-working women in the region. The gender vulnerability index of Jaipur is 5.42, which indicates women have a moderate vulnerability to disasters.

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 of 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's age groups of 0 to 6 and 7 to 18, have been given differential weights 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	
27,37,163	33.97%	9,29,926	66.03%	18,07,237	52	6.37%	1,74,264	6.37%	1,74,264	10

The index of child vulnerability has been computed based on 3 parameters for Jaipur region: age group of children of different ages, children not attending school, and children working. The IMR is 52, which is a childcare factor. The index of child vulnerability is 10, which indicates that children are quite susceptible to disasters. For example, children die due to the building collapse, as they will usually be inside the building and are 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 an equal weight.

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	%	
30,70,000	84,308	1.27	26,525	31.46	17,730	21.03	6,577	7.80	11,399	13.52	5,916	7.02	11,320	13.43	9.10

We know that disasters can increase the number of disabled persons and worsen the situations of those, who are already impaired. The disability vulnerable index of Jaipur city is 9.1, computed based on the population with different aspects of disability. The share of the population with a disability is about 1.27% of the city's total population. Among various disabilities, visual disability is the highest, at approximately 31.46%, which means the visually disabled population in Jaipur is 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 the dependency ratio (ratio of population in the 60+ age group over the working population in the 19-59 age group). City-wise data on all 3 parameters have been compiled from Census 2011 (Table 21). Each parameter is given an equal weight 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	%		
30,70,000	3,42,135	5.16	33,678	0.51	20.05%	6.96

In disasters, aged people suffer disproportionately. The elderly vulnerability index of Jaipur city is 6.96, computed using different age groups and dependency ratios. It is found that the age group of 60-79 is more susceptible to disasters as it has a vulnerability index of 5.16% compared to the 80+ age group. The dependency ratio is about 20.05% in Jaipur city, which means the ratio of the population in the 60+ age group over 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 2 parameters, (a) the number of bovine animals and (b) other animals, with 75:25 weights ratio between the 2 parameters.

Table 22 **Livestock Vulnerability Index**

Livestock (Numbers)			Industrial Hazard Index (Out of 10)
Bovine Animals	Other Animals	Total Animals	
17,08,327	10,95,670	28,03,997	5.55

The vulnerability index of livestock is 5.55, which is computed based on the number of different animals in Jaipur. The number of bovine animals is more than other livestock animals. The index of livestock vulnerability shows that the number of livestock in Jaipur 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 (SEZs). Data on MSMEs have been collected from the database of the Development Commissioner (MSMEs), while data on Industrial Clusters and SEZs in cities have been collected from several sources (Table 23). The industrial vulnerability index has been worked out, based on differential weights of 40% on MSMEs, 40% on Industrial Clusters, and 20% on SEZ.

Table 23 **Industries Vulnerability Index**

Industry (Numbers)			Industrial Vulnerability Index (Out of 10)
MSME Industries (Numbers)	Industrial Clusters (Numbers)	Special Economic Zones (SEZ) (Numbers)	
21,066	7	1	10.00

The industrial vulnerability index of Jaipur is 10, which shows that industries are the highest vulnerable indicator in the city. It is observed that there are 21,066 MSMEs industries, 7 industrial clusters, and 1 SEZ in the city. Therefore, there is a need to formulate guidelines, norms, and regulations to ensure safety for hazardous industries and to reduce the probability of disaster events.

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 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 weights have 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	
7,800	55	0	0	1	0	5.28

The index of the physical infrastructure of Jaipur is 5.28, 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 Jaipur. 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 infrastructures in 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 weights 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	
1,526	1,764	209	10	50	7	15	47	66	70	**10.00**

Social infrastructure includes structures and other related physical facilities that provide community services in the Jaipur district (lack of data at the city level). The index of the social infrastructure of Jaipur is 10, computed using the number of educational and health institutions. These social infrastructure facilities are certainly damaged during Jaipur's severe earthquake and urban floods. The factors like structural design, materials quality, maintenance standards, design age, etc., make 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 weight has been given to both parameters while calculating the index.

Table 26 **Forest Cover Depletion Index**

Total Area of District (km^2)	Changes in Forest Cover (km^2)			Forest Cover Depletion Index (Out of 10)
	Dense	Open	Total	
13,418.77	-48.04	3.65	-44.39	3.05

The depletion index of forest cover is 3.05, which is computed using the total area and change in forest cover of the Jaipur 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 Jaipur district.

13. Water Stress

The extent of water stress in the district (lack of data at the city level) is 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 weight is 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% is given to over-exploited, 30% to critical, and 20% to sub-critical components.

Table 27 **Water Stress Index**

Surface Water (km^2)			Terrestrial	Subsurface Water (Number)				Water Stress Index (Out of 10)
Total Area	Non-irrigated Area	%	Moisture Index (MI)	Over Exploited	Critical	Subcritical	Safe	
11,14,300	11,10,489	0.99	-0.08	14	1	0	0	6.10

The water stress index is 6.10, computed using Jaipur's terrestrial, surface, and subsurface water. The stress on terrestrial and surface water sources has been captured in Moisture Index (MI) and non-irrigated areas have been 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 Jaipur city, based on the geographical and topographical features, have been considered, except the depletion of mangroves.
- The methodology and weights adopted to compute the vulnerability indices are as per the MHA -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 Jaipur city.
- Jaipur city is more vulnerable to disasters in terms of Social infrastructure, Children, Industries and Disabled people in comparison 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 Jaipur city based on the scale: The classes of the different hazard indicators based on the index values are presented in Table 29.

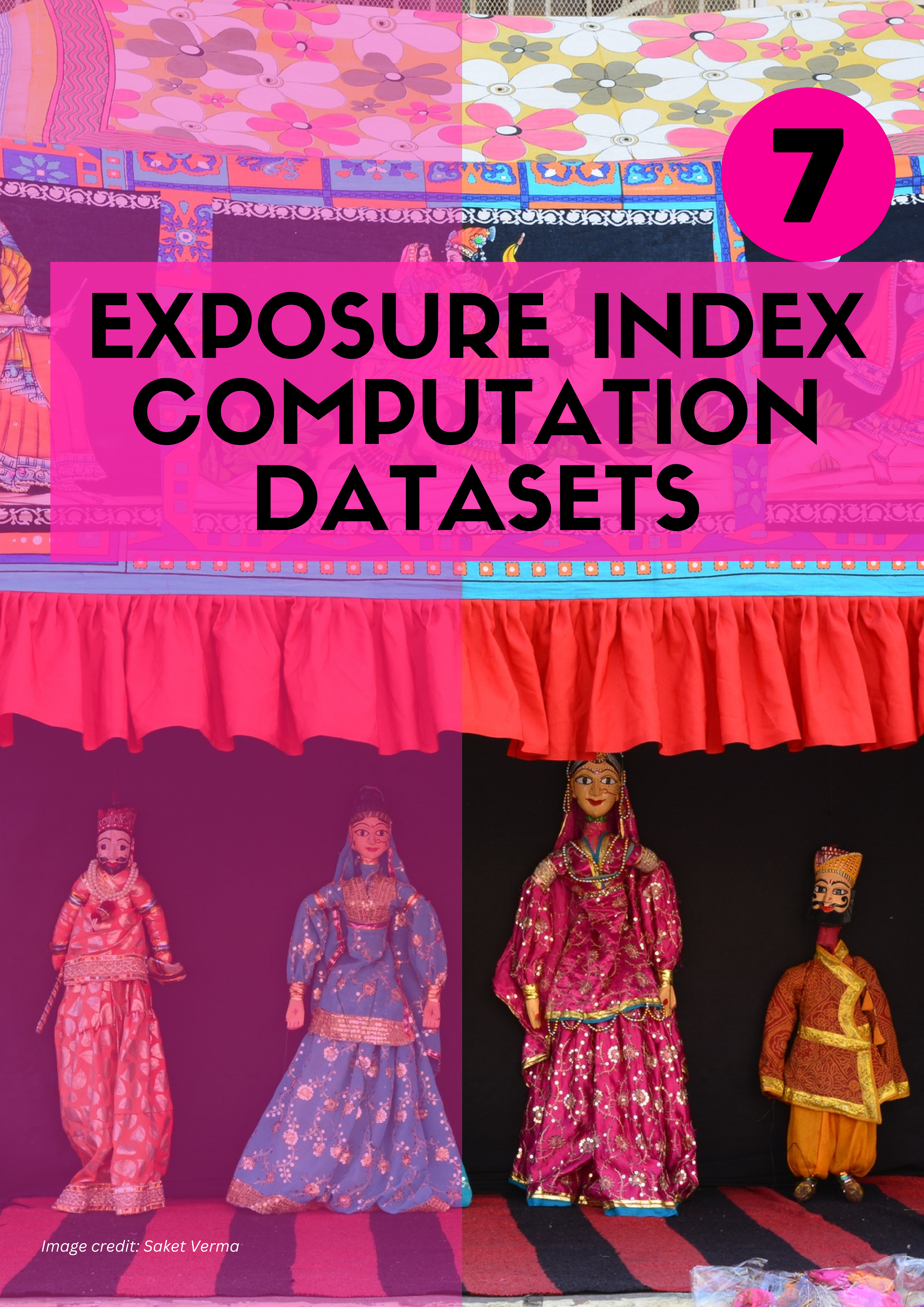
Table 29 **Classification of hazards based on the index**

HAZARDS		
Indicator	**Index**	**Class**
Earthquake	2.00	Low
Landslide	0.00	Unlikely
Drought	6.39	Modeatre
Urban Flood	4.91	Moderate
Heat Wave	10.00	Very High
Cold Wave	5.56	Moderate
Fire	10.00	Very High
Forest Fire*	0.00	Unlikely
Industrial Hazard	8.34	High
Lightning	5.83	Moderate

Classification of computed vulnerability indicators for Jaipur city 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)	6.34	Moderate
Agriculture	0.05	Unlikely
Poverty	7.78	High
Women	5.42	Moderate
Children	10.00	Very High
Disability	9.10	High
Aged	6.96	Moderate
Livestock	5.55	Moderate
Industries	10.00	Very High
Physical Infrastructure	5.28	Moderate
Social Infrastructure	10.00	Very High
Deforestation	3.05	Low
Water Stress*	6.10	Moderate



7

EXPOSURE INDEX COMPUTATION DATASETS

Image credit: Saket Verma

Data on exposures have been collected on 2 parameters in each city: exposure of population and exposure of economy as reflected in district GDP. While data on population exposure is compiled from Census 2011, exposure of city GDP is derived from the newspaper article (The Times of India dated Mar 24, 2019). 2 parameters are considered for calculating the Exposure Index. These are (a) population density (=Population/Area in km2) and (b) per capita GDP (=GDP (in Cr. Rs.)/ Population) of a city (Table 32). Both parameters have been normalized by dividing by the maximum value and multiplying by 10 to put them on a scale of 0 to 10. Then a simple average of these parameters was taken since equal weights were given on both.

Table 31 **Average Exposure Index**

Area (km^2)	Population		City GDP		Average Exposure Index (Out of 10)
	Total	Density	Total (Rs. Cr.)	Per Capita (Rs.)	
382.80	3,070,000	8,020	275,47.4	89,731	10.00

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

8

RESILIENCE SCORECARD

Image credit: canva

The 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). The Resilience scorecard is computed discretely for Jaipur city based on the 7 parameters on the scale of 100: Risk Assessment, Risk Prevention and 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)**

	Aggregate Indicators	Weights	Values for Jaipur City
1	Risk Assessment	10%	**54**
2	Risk Prevention and Mitigation	20%	**28**
3	Risk Governance	20%	**29**
4	Disaster Preparedness	20%	**52**
5	Disaster Response	10%	**34**
6	Disaster Relief and Rehabilitation	15%	**36**
7	Disaster Reconstruction	5%	**46**
	Disaster Resilience Index	**38.30 on a scale of 100** (Through weighted aggregate of seven parameters)	

Based on the following values and their associated weightage as per the MHA-UNDP Report, 2019, the DRS value of 38.30 was computed for Jaipur city on a scale of 100. Thus, Jaipur city is the least resilient, based on the resilient score in comparison to other cities, comparatively higher in the number of hazard occurrences and disaster risk index. Thus, city administration should make more efforts to make the city highly resilient to natural and man-made disasters.

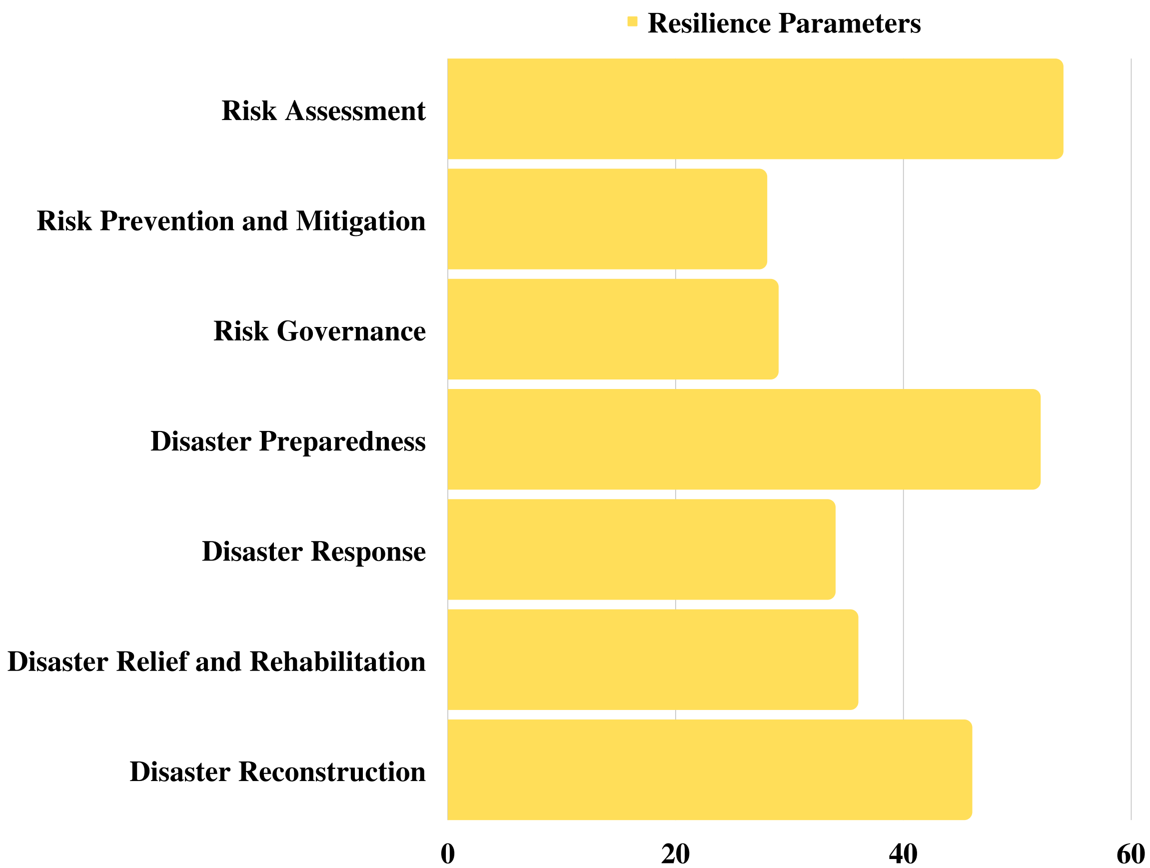


Figure 6
Disaster Resilience Scorecard for Jaipur City

SDRF performing a search operation for people affected by lightning at Amber Fort of Jaipur (Source: Independent, 12 July 2021)

9

CONCLUSION

Image credit: canva

The study showed that Jaipur city is more prone to Heatwave, Fire accidents, and Industrial Hazards followed by Droughts, Lightning, Cold waves, and Urban floods. Similarly, Jaipur city is more vulnerable to disasters in terms of Social infrastructure, Children, Industries, and Disabled People followed by Poverty, Aged People, and Unsafe buildings. The study also revealed that the population of Jaipur has a high exposure index to natural disasters such as Heatwave, Drought, and Floods, which may lead to an economic loss for the city. In terms of exposure, Jaipur's per capita GDP and population density, are the highest as compared to the other 3 cities.

The resilience score of the city is 38.30 on a scale of 100 and it indicates that the city is least resilient to the hazards, that occurred in the region. Jaipur performs best in terms of Risk Assessment and Disaster Reconstruction. Jaipur is in the last position out of all 4 cities in terms of 5 out of 7 indicators of the disaster resilience score i.e. Risk Prevention and Mitigation, Risk Governance, Disaster Preparedness, Disaster Response, and Disaster Relief and Rehabilitation. It is noteworthy that Jaipur city is not susceptible to Avalanches, Cyclones, Tsunamis, and Coastal Erosion events, due to its geographical and topographical features.

Jaipur city has the highest risk occurrence for Drought, Heat Waves, and Fire among all the cities. While high population density with 8,020 persons per sq. km increases its risk associated with hazards and makes the city highly vulnerable for children, the disabled, below the poverty line, the homeless, the aged, livestock, and women population. The Social infrastructure and Industries are highly vulnerable to hazards in the city. Jaipur city is the least resilient, comparatively, due to low scores and the least effort has been made in Risk Prevention and Mitigation, Risk Governance, Disaster Response, Relief, and Rehabilitation. Therefore, city administration should enhance efforts to decrease risks associated with a vulnerable population, infrastructure and provide improvement in policy-making for disaster management plans such that making city risk resilient to multi-hazard disasters. Thus, it requires more combined and effective efforts from the municipal, government administration, and regional population.

10

COMPARATIVE DISASTER RISK & RESILIENCE ASSESSMENT

Image credit: canva

The present study provides Multi-hazard Disaster Risk and Resilience at the city level with a comparative analysis of Guwahati, Jaipur, Srinagar, and Visakhapatnam cities. The risk index profiling of these cities is 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 the vulnerability and exposure parameters, except Building Walls, Building Roofs, and Social infrastructure, have been computed comparatively for the cities. Thus, based on this assessment, Jaipur is at higher risk for Heatwave, Fire, and Industrial Hazards, while highly vulnerable to Social infrastructure, Poverty, Children, Elderly, and Water stress index 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 weights to work out the DRI on a scale of 10, as shown in Figure 4.

The 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 the city level. The disaster resilience score for all the cities has been shown in Figure 5 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 during the past decade and a half and it may be expected that the impacts of these initiatives will be felt in the years ahead.

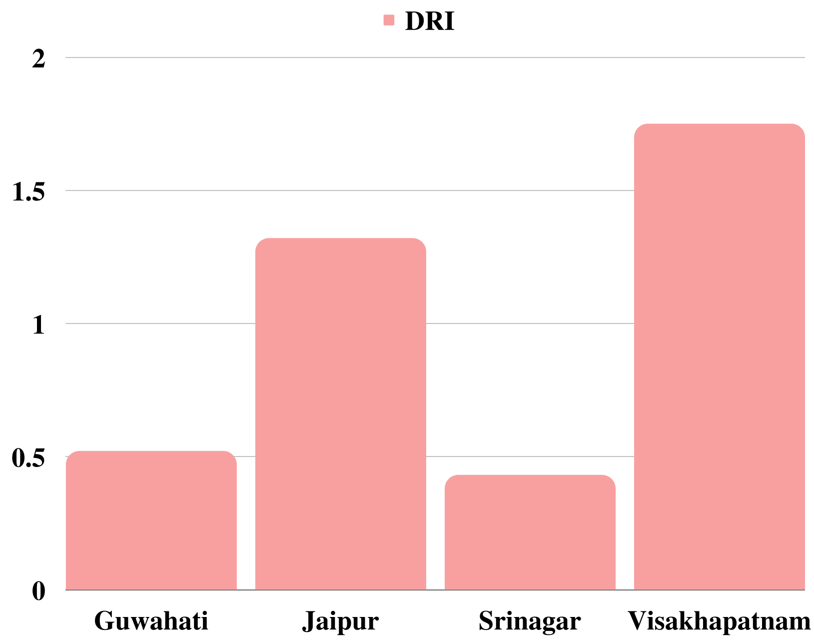


Figure 7
Disaster Risk Index

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

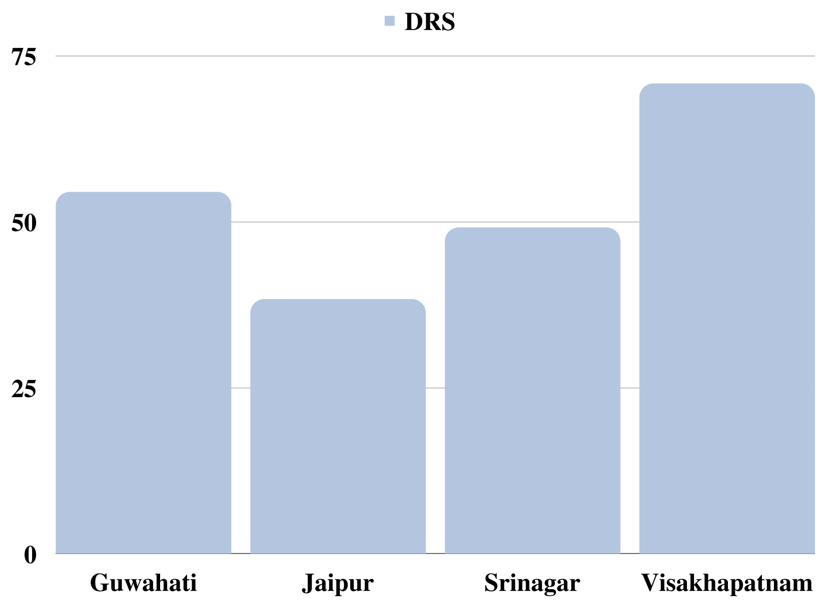


Figure 8
Disaster Resilience Score

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

11

LIMITATIONS AND FUTURE SCOPE

Image credit: canva

The limitations are as follows:

- The city level datasets for certain hazard, vulnerability and exposure indicators are unavailable. Thus, district level datasets are considered for 1 hazard indicator (Forest Fire) and 6 vulnerability indicators (Buildings, Agriculture, Livestock, Social infrastructure, Deforestation, Women, Children, Poverty, and Water stress) in the present studies.

- Specific hazard datasets like Landslide, Avalanche and Coastal erosion were obtained from the national susceptible zone maps for respective hazards 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 are not 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 resiliency against potential risks at a micro-scale.

- This study uses 2 scorecards (Disaster Risk and Disaster Resilience Scorecard) as per the MHA-UNDP 2019 are used for 4 Indian cities. However, in the future, this study can be expanded to include all Indian cities. Disaster risk 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	Source
1	Area (Sq. Km)	382.80	https://iihs.co.in/
2	Earthquake Zone (Area)	II (382.80)	https://data.gov.in/resources/list-and-zone-factors-important-cities-towns-high-risk-earthquake-zone-and-moderate-risk; https://bmtpc.org/DataFiles/CMS/file/VAI2019/MAP/eqmap/EQ_JPG/EQ_INDIA.jpg
3	Landslide Zone (Area)	I (382.80)	https://bmtpc.org/topics.aspx?mid=56&Mid1=186
4	Heat Wave	Average Heat Index: 0.54; No. of HWs: 4; Length of Longest HW: 23; No. of Days with Heat Index > 54: 5Value	https://zenodo.org/record/3987736#.YfJvnP5BzIV
5	Cold Wave	Plain Areas (temperature < 4 0C)	Computed using Minimum temperature (Minimum temperature is derived from Indian Meteorological Department)
6	Forest Fire (District)	13418.77, 9.5, 120.68, 484.62, 613.75 (Total area, very dense forest area, Dense Forest area, Open Forest area, Total Forest area in sq.km)	https://www.fsi.nic.in/forest-report-2019
7	Lightning (Average)	0.47	https://ncrb.gov.in/en/accidental-deaths-suicides-in-india?field_adsi_year_value%5Bvalue%5D%5Byear%5D=2000&field_accidental_deaths_suicides_value=1&items_per_page=10
8	Industrial Hazards	15, 99, 66.82 (MAH industries, MPI industries, CEPI index)	http://www.hrdp-idrm.in/e5783/e26901/ (MAH Units) https://cpcb.nic.in/displaypdf.php?id=Q1BBL05ld0l0ZW1fMTUyX0ZpbmFsLUJvb2tfMi5wZGY= (Refer page 26-28 for CEPI Score 2009)
9	Fire	72; 6; 52 (No. of cases; Injured; Died)	https://ncrb.gov.in/en/accidental-deaths-suicides-in-india?field_adsi_year_value%5Bvalue%5D%5Byear%5D=2000&field_accidental_deaths_suicides_value=1&items_per_page=10
10	Drought	0,13, -0.08,17,35 (Drought-prone area, number of drought years, moisture index, frequencies of SSI, and SPI)	https://www.indiastatdistricts.com/

Table 34: Vulnerability datasets and their sources

S.No.	Vulnerability	Data Parameter	Values	Sources
1	Agriculture	Total area hectares, Cropped area, Irrigated area	11,143, 10008.10, 3810.51	https://www.indiastatdistricts.com/
2	Livestock	Total Animals, Bovine Animals, Other Animals	2803997, 1708327, 1095670	https://dahd.nic.in/documents/statistics/livestock-census (Refer Volume III for Jaipur)
3	Deforestation	Change in Dense Forest cover, Change in Open Forest cover (2001-2019) (in %)	-48.04, 3.65	https://www.fsi.nic.in/forest-report-2019
4	Women	Sex Ratio, Illiteracy, WHH, MMR, CAW, Dependent	909, 58%, 6.56%, 319,1492,79.68%	https://statistics.rajasthan.gov.in/content/dam/planning-portal/Directorate%20of%20Economics%20and%20Statistics/Publication/Other%20publication/women%20and%20men%20in%20rajasthan%202018.pdf (Link for sex ratio of Jaipur District, refer page no-5 and WHH- Jaipur district- refer page no: 10), https://www.im4change.org/docs/679Rajasthan_Bulletin-2011-12.pdf (Refer Page no: 34 for MMR) https://censusindia.gov.in/census.website/data/data-visualizations/PopulationSearch_PCA_Indicators (for Illiteracy) https://ncrb.gov.in/sites/default/files/CII%202020%20Volume%201.pdf (CAW)
5	Children	Children population (0-6 years), (7-18 years), IMR, Non-school going children, Working children	929926, 1807237, 50, 174264, 174264	https://censusindia.gov.in/census.website/data/population-finder (Common source for 0-6 and 7-18), https://statistics.rajasthan.gov.in/content/dam/planning-portal/Directorate%20of%20Economics%20and%20Statistics/Publication/Other%20publication/women%20and%20men%20in%20rajasthan%202018.pdf (Refer Page no: 31 for IMR) https://censusindia.gov.in/nada/index.php/catalog/16959 (number of children attending school)
6	Aged	Age group 60+, Age group 80+, Dependency Ratio	342135, 33678, 20.05%	https://censusindia.gov.in/nada/index.php/catalog/2322/study-description
7	Disabled	Visual, Hearing, Speech, Physical, Mental Disabled and Any other Disability	26525, 17730, 6577, 11399, 5916, 11320	https://censusindia.gov.in/nada/index.php/catalog/42520

S.No.	Vulnerability	Data Parameter	Values	Sources
8	Industries	Micro, Small and Medium Enterprises (MSME), Industrial clusters, Special Economic Zones (SEZ)	21066, 7,1	https://rajasthan.gov.in/business/sez/pages/default.aspx (Refer for SEZ Zones in Jaipur); https://industries.rajasthan.gov.in/content/industries/doi/rscdp/clusters-list.html (Refer for cluster zones in Jaipur, however, available for all cities over Rajasthan) http://dcmsme.gov.in/old/dips/state_wise_dips/State%20Industrial%20Profile%202014-15_rajistan.pdf (Refer page no: 53 for MSME for Jaipur urban area)
9	Depletion of mangroves	Change of mangrove cover during 2001-2020, Dense mangrove, Open mangrove	0	https://fsi.nic.in/isfr19/vol1/chapter3.pdf
10	Poverty	Rural, Urban BPL Population, Rural and Urban Homeless population (Lakhs)	82.65, 18.2, 108308, 73236	https://censusindia.gov.in/nada/index.php/catalog/7246
11	Water stress	Surface Water (%), Moisture Index, Sub-Surface Water (Over-Exploited, Critical, Sub-critical, Safe)	0.99%, -0.08, (14,1,0,0)	http://cgwb.gov.in/gwresource.html

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)
Jaipur	7800	55	1	0	0	0
Source: https://www.indiastatdistricts.com/, https://jaipur.rajasthan.gov.in/content/raj/jaipur/en/about-jaipur/location---area.html#						

13. Social Infrastructure										
City	Primary School	Secondary School	College	University	Engineering	Medical	Polytechnique	Dispensaries/ Health Centers	FW Centers	Hospital/Medical Schools
Jaipur	1526	1764	209	10	50	7	15	47	66	70
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
Jaipur	0.4	0.2	0.2	0.4	1.1	27.9	10.2	59.1	0.5

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
Jaipur	0.2	0.1	2.2	0.1	70.7	3	20.8	0.2	1.7	0.9

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

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
Jaipur	30,70,000	382.20	8,020	2,75,47,41,70,000	89,731	https://timesofindia.indiatimes.com/city/jaipur/barmer-vaults-to-no-1-in-per-capita-income/articleshow/68543841.cms Population density = Population / Area in sq.km

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 X2= 2, X3= 4, X4= 6, X5= 10 is the intensity of the ith hazard zone, wi's are the percentage area of the city in the ith hazard zone, i = 2, 3, 4, and 5 in equation (i).

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

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 X1= 0, X2= 4, X3= 8, X4= 10 is the intensity of the ith hazard zone, wi's are the percentage of the area of the city in the ith hazard zone in equation (i).

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

3. Drought

The drought Hazard Index has been calculated as the average of the normalized scores of the parameters. For X1 (drought-prone area) and X2 (drought years), moisture index, X3 frequency of SSI and X4 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.

$$X_i^* = 10 \times (X_i) / (\max (X_i)) \ldots\ldots\ldots\ldots\ldots\ldots \textit{(i)}$$

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

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.

$$X_i^* = (X_i)/10 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (i)$$

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

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

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

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.

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

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

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

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°C 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.

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

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

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.

$$X_i^* = 10\times(X_i)/\,(\max\,(X_i)) \;\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.\; (i)$$

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

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.

$$X_i^* = 10\times(X_i)/\,(\max\,(X_i)) \;\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.\; (i)$$

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

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%.

$$X_i^* = 10\times(X_i)/\,(\max\,(X_i)) \;\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.\; (i)$$

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

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.

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

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

11. Tsunami

For Tsunami Hazard Index, 3 parameters have been normalized by dividing by the maximum value and multiplying by 10 to put on a scale of 0 to 10 according to formula (i). Then, a weighted average of all these parameters had been taken where the weights had been pre-specified.

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

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

12. Coastal Erosion

For Coastal Erosion Hazard Index, 3 parameters have been normalized by dividing by the maximum value and multiplying by 10 to put on scale of 0 to 10. Then, a simple average of all these parameters had been taken since equal weights had been pre specified.

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

13. Cyclone

For calculating the Cyclone Hazard Index parameters (a), (b), (c), (d), (e), as shown in the table have been normalized by dividing by the maximum value and multiplying by 10 to get on the scale of 0 to 10 according to formula (I). For (f) an ad hoc score has been developed, which follows the following properties: (i) Score (yes) > Score (no) (ii) The mean of all scores = (0+10)/2 = 5. Out of several possible choices, the middle point has been chosen, which gives the values: Score (yes) = 5.85, Score (no) = 2.49. The score has been assigned corresponding to the responses Yes and No. Then, a weighted average of all these parameters had been taken, where the weights had been pre-specified.

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

$$X_6^* = \{5.85 \ if \ X_6 = yes \ 2.49 \ if \ X_6 = no$$

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

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)

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

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.

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

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

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.

$$X_i^* = 10\times(X_i - \min(X_i))/ (\max(X_i)-\min(X_i)) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots. \textit{(i)}$$

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

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.

$$X_1^* = 10\times(X_i - \min(X_i))/ (\max(X_i)-\min(X_i)) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots. \textit{(i)}$$

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

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

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

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.

$$X_1^* = 10\times(X_i - \min(X_i))/ (\max(X_i)-\min(X_i)) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots. \textit{(i)}$$

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

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

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

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.

$$X_1^* = 10\times(X_i - \min(X_i))/ (\max(X_i)-\min(X_i)) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \textit{(i)}$$

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

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

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

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)

$$I_a = 0.75\times(X_b)/X_t + 0.2\times X_o/X_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \textit{(i)}$$

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%.

$$X_i^* = 10\times(X_i)/ (\max(X_i)) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \textit{(i)}$$

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

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.

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

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

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

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.

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

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

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

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.

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

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

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.

$$X_1^* = 10\times(\max(X_1) - X_1)/ (\max(X_1)\text{-}\min(X_1))\ldots\ldots\ldots\ldots\ldots\ldots\ldots \; (i)$$

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

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

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

Exposure Index Computation

Two parameters have been considered for calculating the Exposure Index.

These are
(a) population density (=Population/Area in km^2) 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.

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

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

ANNEXURE 3

Disaster Resilience Questionnaire Responses

1. Risk Assessment (Weights 10%)

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

2. Risk Prevention & Mitigation (Weights 20%)

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

3. Risk Governance (Weights 20%)

	Indicators/Questions	Aggregate Points	Points Assigned
3.1	Institutional mechanisms for risk governance	6	0
3.2	Disaster Management Policy and Plans	10	5
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	3.5
3.6	Multi-Stakeholder Platform	2	2
3.7	Community Involvement and Participation	5	1
3.8	Enforcement and Compliance	4	1
3.9	Monitoring and Evaluation	2	0
3.10	Transparency and Accountability	2	1
	Others	5	0

4. Disaster Preparedness (Weights 20%)

	Indicators/Questions	Aggregate Points	Points Assigned
4.1	End-to-End Early Warning Systems	5	2
4.2	Emergency Operation Centers	5	3
4.3	Disaster Communication System	5	2
4.4	Emergency Medical Preparedness	5	4
4.5	Scenario Building, Simulation and Mock Drills	5	1
4.6	Contingency Plans, SOPs, Manuals	5	3
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	1
	Others	5	2

5. Disaster Response (Weights 10%)

	Indicators/Questions	Aggregate Points	Points Assigned
5.1	State Agencies for Disaster Response	10	8
5.2	Incident Response System	4	0
5.3	Coordination with GOI, NDRF Armed, Forces	2	0
5.4	Evacuation, Search and Rescue	7	2
5.5	Emergency Medical Response	5	1
5.6	Emergency Support Functions	5	1
5.7	Protection of vulnerable women and children	5	1
5.8	Disposal of dead bodies	3	1
5.9	Disposal of Animal Carcasses	2	1
5.10	Disposal of Debris	2	1
	Others	5	1

6. Disaster Relief & Rehabilitation (Weights 15%)

	Indicators/Questions	Aggregate Points	Points Assigned
6.1	Minimum Standard of Relief	2	1
6.2	Ex-gratia Relief	1	1
6.3	Relief Logistics and Supply Chain Management	7	2.5
6.4	Food and Essential Supplies	7	1
6.5	Drinking Water, Dewatering and Sanitation	7	2.5
6.6	Health and Mental Health Care	7	2
6.7	Management of Relief Camps	5	1
6.8	Veterinary Care	3	1
6.9	Relief Employment	3	2
6.10	Temporary and Intermediary Shelters	3	1
	Others	5	3

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

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