Disaster Resilience and Smart Cities

Integrated Research and Action for Development

Sustainable and Disaster Resilient Urban Development

Assessment of 10 Cities in India

Smart City
MISSION TRANSFORM-NATION

Ministry of Housing and Urban Affairs
Government of India

November 2019
IRADe-PR-65(2019)

Sustainable and Disaster Resilient Urban Development

Assessment of 10 Cities in India

Rohit Magotra, Jyoti K Parikh, Moumita Shaw, Asha Kaushik

Integrated Research and Action for Development (IRADe)

Disclaimer

 The presentation of material in this publication and in maps which appear herein does not imply the expression of any opinion on the part of IRADe concerning the legal status of any country, state or city or the delineation of their frontiers or boundaries.

Please use the following reference:

Magotra R, Parikh J, Shaw M and Kaushik A. Sustainable and Disaster Resilient Urban
Development: Assessment of 10 cities in India. IRADe, 2019

IRADe-PR-65(2019)

Cover Page Image Courtesy of Freepress Kashmir, 25 June 2019

Preface

We are happy to present a summary of 10 city reports on the theme "Sustainable and Disaster Resilient Urban Development" supported by the Ministry of Housing & Urban Affairs (MoHUA). Natural Disasters include a wide range of climate-related risks like Earthquakes, floods, droughts, cyclones, Tsunamis, landslides among others.

Increasing urban population concentrated in small geographic areas have the potential of a massive spread of risks, be it collapsed buildings, destroyed or damaged infrastructure - bridges, flyovers or water reservoirs or even epidemics due to failed waste management systems. Many such events viz. floods in the cities of; Patna, Chennai, Bengaluru, Hudhud cyclone in Vishakhapatnam and deluge witnessed by Srinagar in 2014 has alerted us all, that a city disaster management plan (CDMP) must be there in all cities.

The cycle of rescue, restoration, and restructuring for urban risk reduction (URR) is well known. We focus on the Urban Risk Resilience (URR) for a long term planning of disaster-resilient city. URR should be made an integral part of developmental plans.

Integrated Research & Action for Development (IRADe) has come a long way in engaging itself in climate-resilient cities. We started from a simple comparative exercise of 14 cities done in 2007, a 30-page report accompanied by an analysis of Surat & Haridwar. This was followed by 20 cities analysis using HIGS methodology that is described also in this report sponsored by Asian Countries Climate Change Research Network (ACCCRN). The HIGS methodology was published by the International Institute for Environment and Development (IIED), London, UK. We also carried out a very detailed study using CARTOSAT and GIS data using a hydrological model for Surat, mapping inundation areas for every part of the Surat city. The current 10 city series also goes further in 3 ways:

- **a)** Detailed timelines for hazards and hazard mapping show that most cities face multi-hazard risks.
- **b)** Detailed spatial analysis using GIS maps of vulnerable locations using CARTOSAT data.
- **c)** Service level benchmarks and other land posts that measure sustainable development

The erstwhile JnNURM narrative gave way to smart city narrative. No smart city can afford so much loss that wipes away decades of progress. Climate change will result in increased frequency and magnitudes of extreme events and there is a need for systemic response that looks at engineering, design and technical solutions to ensure disaster resilient cities. The smart cities need to develop disaster resilience at a fast pace as huge economic losses occur even if cities do not function for a week.

The guidelines and recommendation of this report were referred by MoHUA for integrating disaster/climate resilience in smart city plans for 10 Indian cities. We hope that the city administrations will find a series of 10 city reports helpful towards realizing smart city plans. The national governments can use these studies to design National Disaster Resilience Framework

Prof Jyoti K Parikh

Executive Director

IRADe

Acknowledgement

We thank everyone who contributed to the richness and the multidisciplinary perspective of this report "Sustainable and Disaster Resilient Urban Development- Case Study of 10 cities''. We are grateful to the Ministry of Urban Development for choosing IRADe to do this study. We are particularly thankful to Mr. Shankar Aggarwal, the former Secretary, Ministry of Housing and Urban Affairs for his constant involvement and support to IRADe during the course of this study. We are also thankful to Mr. Sanjay Sharma, Under Secretary, Ministry of Housing and Urban Affairs and Dr. P.H. Rao, the former Team Leader, SSU to review the city reports during the course of this study

The study could not have been taken place without the support of the respective Municipal Corporations, the City Urban Development Departments, Disaster Management Authorities and the concerned officials of the 10 cities who formally supported the project and facilitated data collection, stakeholder consultations. We are also thankful to the Municipal Commissioners of all the 10 cities who were consulted for the study for their valuable inputs and insights.

IRADe extends its gratitude to all the speakers, panelists and participants of the Four Regional Workshops; North, South, East and West India regional workshops for their time, input and expert advice to make this study practical and implementable for the 10 cities.

We would like to extend our sincere thanks to Dr. Kirit Parikh, Chairman, IRADe, for having given his valuable comments and suggestions throughout the course of this study. Last but not the least we would like to thank the researchers- Dr. Manoj Kumar, Ms Mani Dhingra, Ms Sonali Vyas, Ms Riya Rahiman and Mr. Mohit Gupta who contributed to this project study. We also acknowledge contributions of summer interns from Centre of Environmental Planning and Technology, Ahmedabad.

Prof Jyoti Parikh

Mr. Rohit Magotra

Contents

Executive Summary 1
1. Introduction 2
2. Scope and Methodology 3
2.1 Scope of the Study 3
2.2 Methodology 4
3. Analysis 6
3.1 Hazard Vulnerability 6
3.1.1 Floods 7
3.1.2 Earthquake 8
3.1.3 Landslides 9
3.1.4 Cyclones & Wind Storm 10
3.1.5 Heat Wave 11
3.2 Urban Population Growth 16
3.3 Slum Population 18
3.4 Urban Infrastructure 20
3.4.1 Water Supply 21
3.4.2 Sewerage and Sanitation 22
3.4.3 Storm Water Drainage 23
3.4.4 Solid Waste Management 24
3.5 Disaster Preparedness and Mitigation Strategies 26
3.6 Land use and Hazard Vulnerability Assessments using GIS tool 27
4. Conclusion/ Recommendation 33
4.1 Disaster Risk Reduction (DRR) 33
4.2 Database Management 35
4.3 Natural Resource Management through Macro and Regional Planning 35
4.4 Governance and Institutional Framework 36
4.5 Technical Capacity at Urban Local Body Level (ULBs) 37
4.6 Robust Infrastructure 38
4.7 Improving Socio-economic Conditions 38
4.8 Investments and Intervention through Public Private Partnership 39

Executive Summary

Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation, Special Report of the Intergovernmental Panel On Climate Change, (SREX)-2012 establishes the link between Climate Change and extreme weather events like storms, cyclones, floods, heatwaves and predicts considerable increase in the frequency of such events leading to disasters. In the last 30 years, India, with unplanned urbanization and growing vulnerabilities, has been hit by 431 disasters affecting nearly 150 crore people besides massive damages in the property (DMI, 2011), the highest among disaster-prone displacement with nearly 23 lakh uprooted (UNIDSR, 2017). Through Disaster Management Act, 2005, Government of India has recognized the importance of resilience of cities in any extreme event, and awarded a study to IRADe on '*Sustainable and Disaster Resilient Urban Development, India'* to assess the state of resilience in 10 cities – Ahmedabad, Bhopal, Bhubaneshwar, Dehradun, Guwahati, Hyderabad, Pune, Shillong, Srinagar and Vishakhapatnam – across 10 states in India. The study followed a holistic methodology by incorporating factors that give local/regional diversification as well as the flexibility to be customized for use in other regions/cities.

A study of vulnerability for the 10 cities was carried out in the aspects of natural hazards, existing critical infrastructure, recovery and response system of city governance, and the socio-economic status of the population.

The study indicated increased population density and urbanization, increases vulnerability to disaster, and in absence of basic facilities, slum population is the most vulnerable group at the times of disaster. Most of the cities are don't meet MoHUA benchmarks for Urban Infrastructure and hence are highly exposed to multiple climate hazards. To mitigate the same certain action are required to be taken by the cities. Disaster Risk Reduction (DRR) using of indigenous knowledge alongside scientific knowledge is increasingly advocated to reduce community vulnerability to environmental hazards. Database management will provide inundation information about the onset, duration and passing of a hazard event. Natural Resource Management plan and regional plan can make the city well informed about hazards. Robust Infrastructure, building stronger transportation system, water supply, sanitation and power infrastructure with optimum physical resilience and Improving Socio-economic conditions of urban poor is necessary. Strong Governance and Institutional Framework, covering disaster resilience, adaptation, environment and sustainability, is highly required as the cities, upgraded on all fronts, training need assessments and Technical Capacity building by Urban Local Bodies and public private participation can be play a key role.

The study has also considered certain aspects of the *Sendai Declarati*on, UNISDR, 2015, such as minimizing socio-economic losses, like critical infrastructure and basic services, and improving access to multi-hazard early warning systems and disaster risk information.

Sustainable and Disaster Resilient Urban Development: Assessment of 10 cities in India

1. Introduction

With the increasing unplanned urbanization, their impacts are increasing, which is primarily associated with poorly planned and unmanaged urban development, degraded ecosystems, and poverty. Unplanned urbanization has been a challenge, increasing the vulnerability of cities to natural as well as man-made hazards. As per the 2011 census, 31% of India's population lives in urban areas (GoI). According to the United Nations Population Fund's State of the World Population Report, 2007, by 2030, 40.76% of India's population will live in its urban area. According to a study by the United Nations, almost 890 million people across the globe (60% of the global population) live in cities that are at risk of at least one major natural hazard —floods, droughts, cyclones, or earthquakes (UN 2012). In 2011, 80% of global disaster-related economic losses occurred in the Asia and Pacific region. Though only 40% of all disasters triggered by natural hazard events in the world occur in Asia, 88% of affected people reside in this region (ADB, 2013).

Disaster is defined as an event or a series of events that give rise to casualties and damage or loss of properties, infrastructure, environment, essential services or means of livelihood on such a scale which is beyond the normal capacity of the affected community to cope with. Disaster is also sometimes described as a "catastrophic situation in which the normal pattern of life or eco-system has been disrupted and extraordinary emergency interventions are required to save and preserve lives and or the environment" (DMI, 2011).

The Disaster Management Act 2005 uses the following definition for disaster: "Disaster" means a catastrophe, mishap, calamity or grave occurrence in any area, arising from natural or manmade causes, or by accident or negligence which results in substantial loss of life or human suffering or damage to, and destruction of, property, or damage to, or degradation of, environment, and is of such a nature or magnitude as to be beyond the coping capacity of the community of the affected area. "community or society to cope using its own resources."

The **UNISDR (2009) defines disaster** as: "A serious disruption of the functioning of a community or a society involving widespread human, material, economic or environmental losses and impacts, which exceeds the ability of the affected community or society to cope using its own resources."

Source: National Disaster Management Plan, NDMA, GoI, 2016

The "smart cities" effort, in 100 cities across India, aims to create urban spaces where green, high-tech initiatives bring more efficient management of resources, including water and energy, and better services to the citizens. To make cities disaster-resilient right at the inception stage, the efficiency in urban planning can have a major impact on communities' preparedness and capacities to recover. Smart growth strategies like creating flexible land-use policies, targeting public investment, and engaging the entire community in decision-making can help communities recover from a disaster, rebuild according to a shared community vision, and be better prepared for a disaster.

The Government of India recognizes the importance of resilience of cities across India in the event of any disaster. Cities can become disaster resilient through multi-sectoral and multi-stakeholder approaches along with policy level intervention. It is always required that the preparedness (resilience) of the cities should be such that minimum time is taken in response, recovery and risk reduction measures. The Disaster Management Cycle [7] is an ongoing process by which governments, businesses, and civil society plan for and reduce the impact of disasters, react during and immediately following a disaster, and take steps to recover after the disaster. These phases do not always, or even generally, occur in isolation or in this precise order. Often phases of the cycle overlap and the length of each phase greatly depends on the severity of the disaster.

Figure 1: Disaster Management Cycle

2. Scope and Methodology

2.1 Scope of the Study

In order to give a concrete roadmap for disaster resilience in the 10 cities under the project, IRADe conducted a study on '*Sustainable and Disaster Resilient Urban Development, India'*, for the Ministry of Urban Development (MoUD), under the Comprehensive Capacity Building Programme, and assessed the state of resilience of selected 10 cities across India with diverse physiography/topographic characteristics. The cities were selected (from among JnNURM cities) to cover regional variation, covering a wide range of parameters ─ city profile, natural hazard profile, infrastructure and land use, and city management and governance.

The cities selected for the study:

– Ahmedabad, Gujarat
– Bhopal, Madhya Pradesh
– Bhubaneshwar, Orissa
– Dehradun, Uttarakhand
– Guwahati, Assam
– Hyderabad, Telangana
– Pune, Maharashtra
– Shillong, Meghalaya
– Srinagar, Jammu & Kashmir
– Vishakhapatnam, Andhra Pradesh

Location map of the cities is provided in fig.2

Figure 2: Location of Cities

2.2 Methodology

Factors like infrastructure, governance, hazards and socio-economic status and such other indicators influence the relation between disaster risk and resilience. Since the definition of disaster resilience is highly contextual and governed by local/regional factors, the methodology adopted gives due consideration to local/regional parameters. Therefore, in this study IRADe has incorporated factors that capture local/regional diversification. This gives the flexibility to customise these and similar factors in study of other regions/cities.

Disaster resilience was assessed on the following aspects:

- **Hazard vulnerability**: list of hazards on past hazards and their frequency and magnitude of impact (on socio-economic fabric, infrastructure and human life)
- **Evaluation of existing critical infrastructure**: based on above mentioned disaster proneness
- **Governance:** the response and recovery system and evaluation of city management and governance in the context of disaster proneness. This study also examines financial resources of the urban local bodies (ULBs) for disaster management and disaster response system.
- **Socio-economic status:** slum population, population below poverty line, availability of basic services to urban poor.

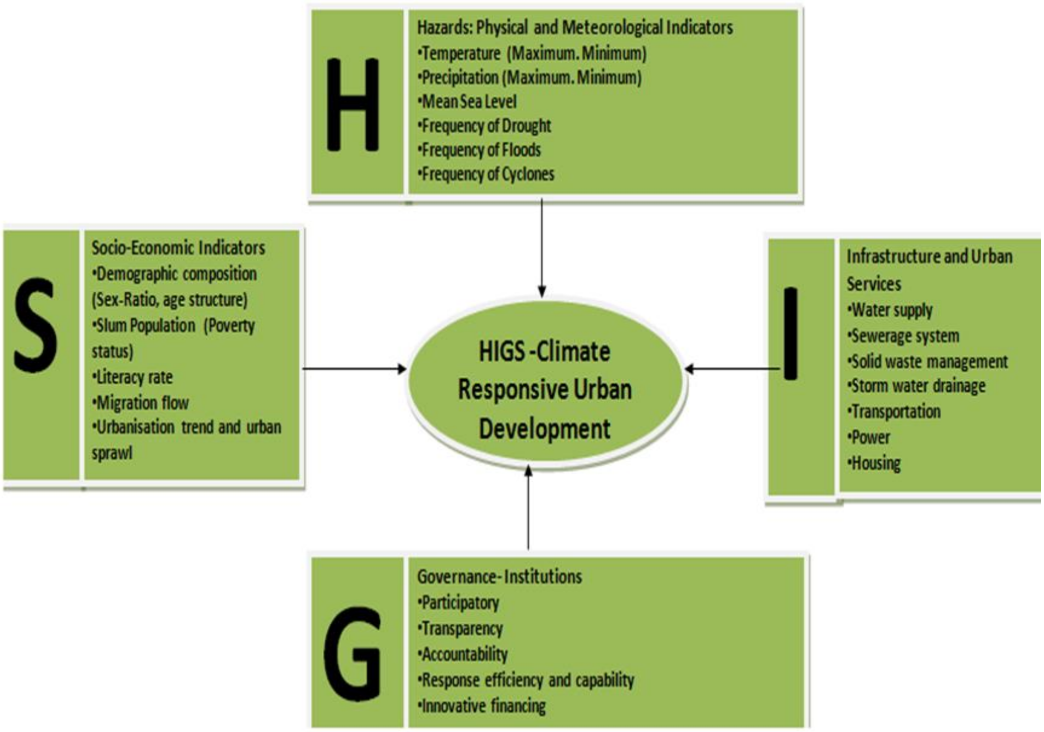


Figure 3: HIGS Framework

To understand and analyse climate-resilient measures in India's urban centres, IRADe developed a framework of Hazards-Infrastructure-Governance-Socio-Economic characteristics (HIGS), determined on the basis of each city's characteristics like location, economic and geographical parameters, to determine the 10 cities exposure to hazards. The framework is dynamic as it includes city-specific features based on this IRADe developed a matrix to represent resilience.

Data collected for 10 cities' governance and their performance, preparedness, financial indicators and Service Level Benchmarks (SLB) of their respective Urban Local Bodies (ULB). was compiled and analysed to develop the cities' vulnerability assessment matrix. Spatial analysis through GIS was conducted to identify each city's critical urban hotspots highly susceptible to disastrous impacts of hazards. Spatial analysis integrated the hazard assessment layer, which was derived from the hazard profile of the city, with vulnerable urban components exposed to these hazards. At a city level, disaster resilience to hazards like cyclones, urban flooding, heatwaves and others was assessed through each city's socio-economic vulnerability measured in terms of total population and slum population cover, current status of physical infrastructure and comparison with the National SLBs and the cities' existing institutional framework and disaster mitigation preparedness. The project recommendations for each city were based on their respective findings of HIGS vulnerabilities.

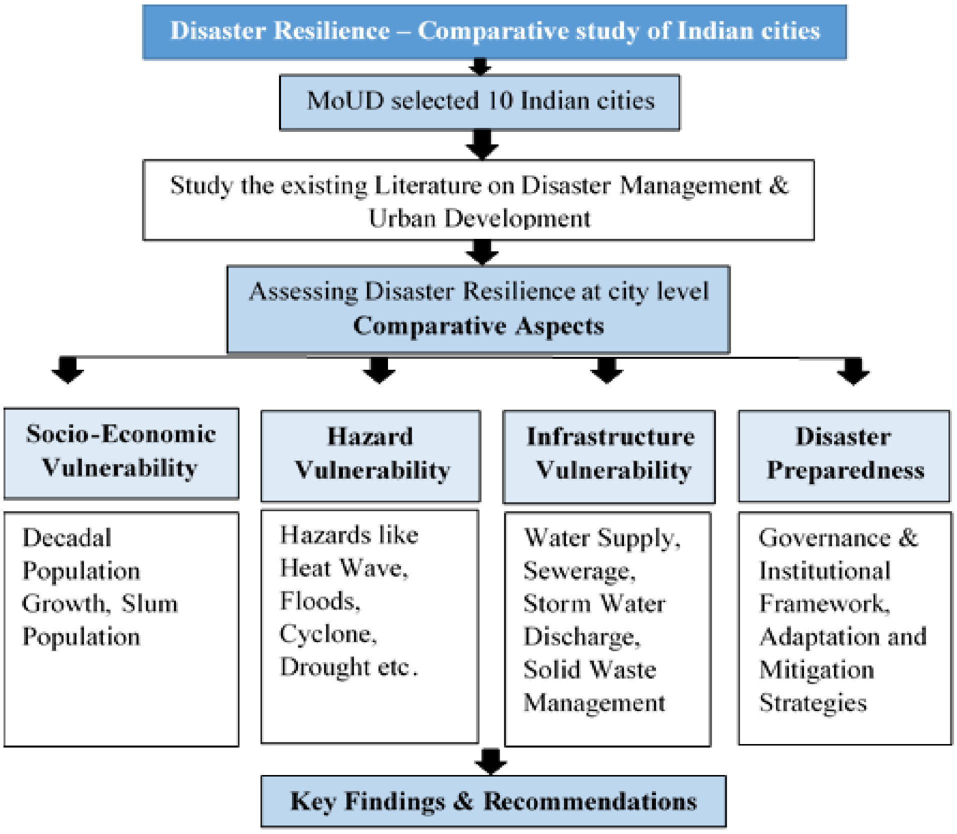


Figure 4: Study Methodology

3. Analysis

3.1 Hazard Vulnerability

India's geo-climatic conditions, as well as its high degree of socio-economic vulnerability make it one of the most disaster-prone countries in the world [8]. Indian cities are exposed to multiple natural hazards such as tropical cyclones, urban floods, drought/ water scarcity, landslides, heat and cold waves. During the last 30 years, the country has been hit by 431 major disasters resulting in enormous loss to life and property. According to the Prevention Web statistics, 143,039 people were killed and about 150 crores were affected by various disasters in the country during these three decades [9]. The Major disaster that hit various parts of India in the last 40 years are listed in Table 1 below:

Table 1:Major Disasters in India

Major Disasters in India (last 40 years) **[10]**				
Sl No.	Events	Year	States and Area	Fatalities
1.	Drought	1972	Large part of the country	200 million people affected
2.	Cyclone	1977	Andhra Pradesh	10,000 deaths, hundreds of thousands homeless & 40,000 cattle deaths
3.	Drought	1987	15 States	300 million people affected
4.	Cyclone	1990	Andhra Pradesh	967 people died, 435,000 acres of land affected
5.	Latur Earthquakes	1993	Latur, Marathwada region of Maharashtra	7,928 people died 30,000 injured
6.	Cyclone	1996	Andhra Pradesh	1,000 people died, 5,80,000 houses destroyed, Rs. 20.26 billion estimated damage
7.	Orissa Super Cyclone	1999	Orissa	Over 10,000 deaths
8.	Earthquake	2001	Gujarat	13,805 deaths 6.3 million people affected
9.	Tsunami	2004	Coastline of Tamil Nadu, Kerala, Andhra Pradesh, Pondicherry and Andaman & Nicobar Islands of India	10,749 deaths, 5,640 people reported missing, 2.79 million people affected; 11,827 hectares of crops damaged; 300,000 fisher folk lost their livelihood
10.	Floods	2005	Maharashtra	1094 deaths, 167 injured and 54 reported missing
11.	Earthquake	2005	Mostly Pakistan, Partially Kashmir	1400 deaths in Kashmir (86,000 deaths in total)
12.	Flood	2008	North Bihar	527 deaths, 19,323 livestock perished, 2,23,000 houses damaged, 3.3 million persons affected
13.	Cyclone Nisha	2008	Tamil Nadu	2004 deaths
14.	Drought	2009	252 Districts in 10 States	-
15.	Floods	2009	Andhra Pradesh and Karnataka	300 people died
16.	Cloudburst	2010	Leh, Ladakh in J&K	257 people died
17.	Earthquake	2011	North Eastern India with epicenter near Nepal Border and Sikkim	97 people died (75 in Sikkim)

Major Disasters in India (last 40 years) **[10]**				
Sl No.	Events	Year	States and Area	Fatalities
18.	Landslides / cloudburst	2012	Uttarakhand in Himalaya	Hundreds died and huge economic loss
20.	Flood	2012	Assam, Madhya Pradesh, Rajasthan	Hundreds died and damage to property and agriculture.
21.	Floods/ Landslides	2013 [11]	Uttarakhand and Himachal Pradesh	4,094 people died
22.	Floods / Cyclones Phailin	2013	Odisha and Andhra Pradesh	Hundreds died and huge economic loss
23.	Cyclone Hud Hud	2014	Andhra Pradesh & Odisha	Hundreds died and damage to property and agriculture.
24.	Flood	2014	Jammu & Kashmir	Hundreds died and huge economic loss

Source: NIDM (NIDM, http://nidm.gov.in/PDF/safety/ppt/pres1.pdf)

India is one of the 10 most disaster-prone countries in the world. The country is prone to disasters due to a number of factors; both natural and human-induced. Out of 35 states and union territories in the country, 27 are disaster-prone. The percentage of India's landmass prone to various hazards is shown in Fig 5.

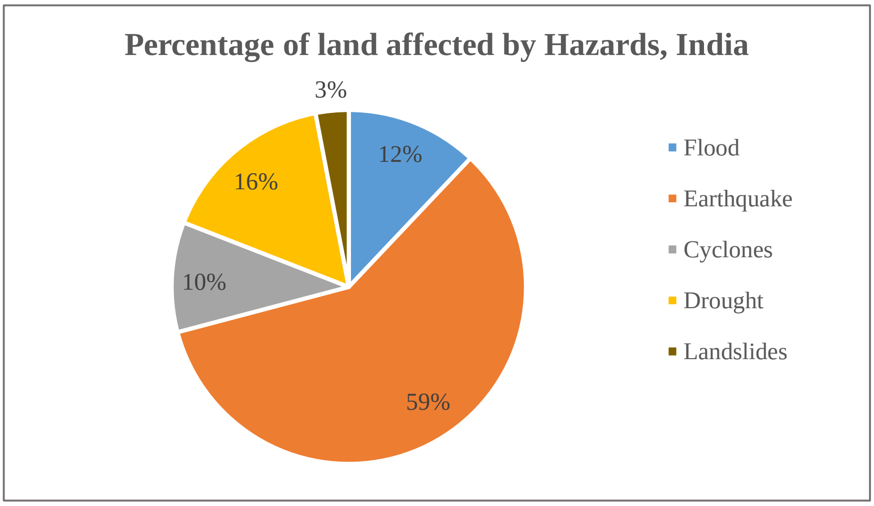


Figure 5: Percentage of Land affected by Hazards, India
Source: NIDM, 2016

3.1.1 Floods

According to the National Institute of Disaster Management, reports over 40 million hectares (12%) of the land in India is prone to flood and river erosion (DMI, 2011). Urban floods are a result of inadequate or poor maintenance of storm water drains, improper planning, encroachment on drains and water bodies, occupation of low-lying areas, modification of catchments, and climate change. Urban floods are now a common occurrence in Indian cities as can be seen in table 2.

Table 2: Flooding Events in India

Cities	Flooding Years
Hyderabad	2000, 2001,2002, 2006 & 2008
Ahmedabad	2001
Delhi	2002 & 2003
Chennai	2004 & 2015
Mumbai	2005, 2007 & 2015
Bangalore	2005, 2009 & 2013
Surat	2006& 2013
Kolkata	2007 & 2013
Jamshedpur	2008
Delhi	2009, 2010, 2013, 2016
Guwahati and Delhi	2010 & 2011
Srinagar	1992, 2014 and 2015

Source: IIT Guwahati; 2012 [13]

Urban flooding is caused due to inadequate or inappropriate drainage. High-intensity rainfall can cause flooding when the city sewage system and draining canals do not have the necessary capacity. In such an event flooding can also happen or be exacerbated by sewage backflow.

Flooding in urban areas is caused by intense and/or prolonged rainfall, which overwhelms the capacity of the drainage system and it accounted by the number of water loggings recorded.

Ahmedabad, Bhubaneshwar, Guwahati, Srinagar and Vishakhapatnam are highly prone to floods. These cities and fall under the severe flood risk zones (Fig.6) as their level of vulnerability to floods is high owing to their geographical location along coasts and nearness to catchment areas. However, cities like Dehradun, Hyderabad, Pune, and Shillong are in moderate-risk zones. An increase in urban flooding results in an increase in vector and water-borne diseases, high traffic congestions, chocking of drains, damage to public and private property.

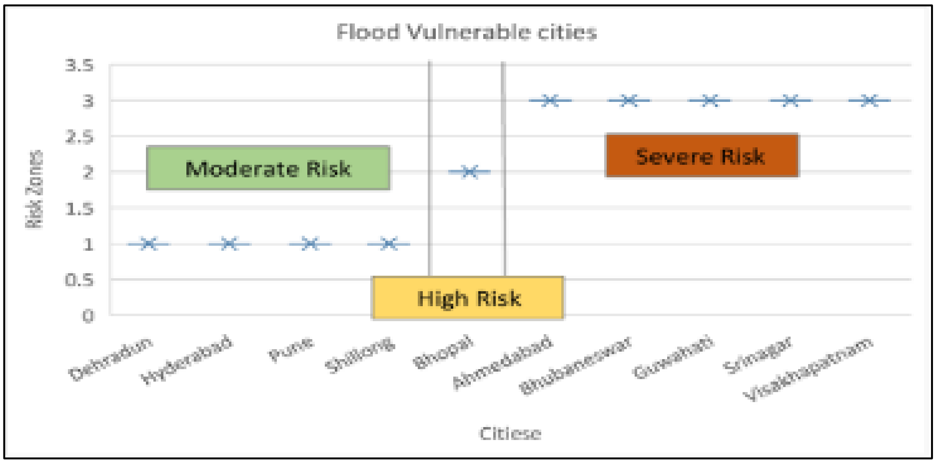


Figure 6: Flood Vulnerability in Cities

3.1.2 Earthquake

As stated earlier, 58.6% of India's landmass is prone to earthquakes of moderate to very high intensity. The seismic zonation map shows that India has high risks and vulnerabilities from earthquakes. India has witnessed more than 650 earthquakes of magnitude greater than 5 on the Richter Magnitude Scale, during the last hundred years. Factors like rapid development, unplanned urbanization, and concentration of economic development are found to increase earthquake risk through greater hazards, exposure, and vulnerability. Some of the major earthquake events have been listed.

Table 3: Earthquake Events, India

Place / Cities	Year	Fatalities
Indian Ocean	December,2004	>283,106
Kashmir	October, 2005	130,000
Bihar & Nepal	January, 1934	>30,000
Gujarat	January, 2001	20,000
Kangra	April, 1905	>20,000
Latur	September, 1993	>9,748
Assam	August, 1950	1,526
Assam	June, 1897	1,500
Uttarkashi	October, 1991	>1,000
Koynanagar	December, 1967	180

Earthquake is a sudden movement of the Earth's lithosphere (its crust and upper mantle). Earthquakes are caused by the release of built-up stress within rocks along geologic faults or by the movement of magma in volcanic areas. They are usually followed by aftershocks.

Dehradun, Guwahati, Shillong, and Srinagar lie in high-risk zone (Zone IV & V) in terms of earthquakes. Ahmedabad, Pune, and Bhubaneswar lie in a moderate risk zone (Zone III). Ahmedabad, despite being in a moderate risk zone, experienced a huge loss of lives and property in the 2001 Bhuj earthquake. This stresses the need for adopting development regulations for earthquake resistant structures in all the cities.

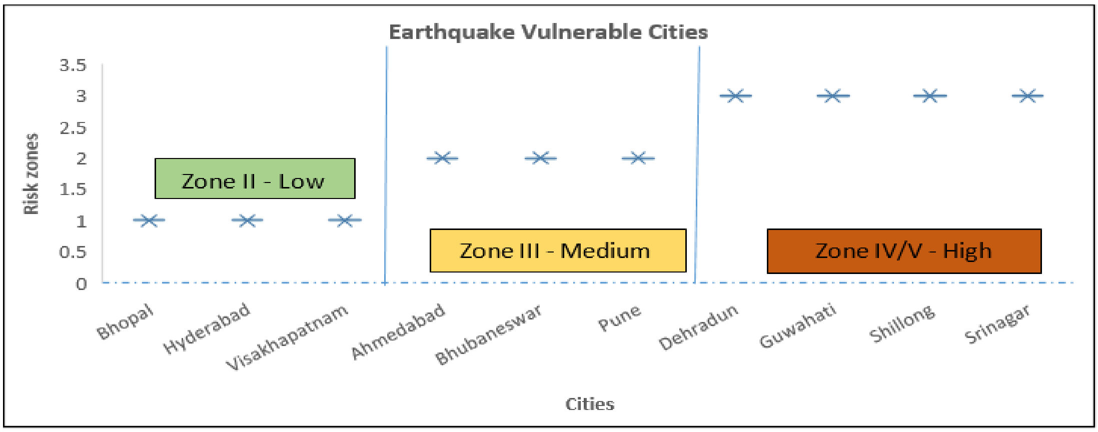


Figure 7: Earthquake Vulnerable Cities

3.1.3 Landslides

Landslides are a mass movement of rock, soil, or debris material forming a slope (natural or engineered) towards the lower and external part of the slope, along a defined sliding surface.

Mass movement occurs under the effect of gravity and mass transport material is transported by an agent (e.g. water flowing in a river, wind)

Landslides are simply defined as the mass movement of rock, debris or earth down a slope. The term has come to include a broad range of motions whereby falling, sliding and flowing under the influence of gravity dislodges earth material. In the hilly terrains of India, including the Himalayas, landslides have been a major and widely spread natural disaster to strike life and property and occupy a position of major concern. Some of the major landslide events are listed below, table 4.

Table 4: Landslide event, India

States/ cities	Years	Fatalities
Rajouri, Jammu & Kashmir	January, 2005	Ten people were killed and some others went missing after a house collapsed.
Lachen river valley, Sikkim	September, 2012	21 deaths. Damage to the buildings and roads.
Pelling, Sikkim	June, 2011	16 people were killed besides damage to property.
Kullu, Himachal Pradesh	February, 2014	Washed away roads and terraced fields.
Mandi, Himachal Pradesh	August, 2011	Blocked national highways.
Dehradun, Uttarakhand	August, 2014	7 deaths, concrete houses collapsed.
Nainital, Uttarakhand	July, 2013	6 deaths
Uttarakhand	June, 2013	5,700 deaths, Kaidarnath, Gaurikund, and the market town of Rambada were completely washed out.
Maharashtra	July, 2014	Nearly 44 houses were buried and around 134 people died.

Source: NDMA

Nearly 20 states of India fall under different landslide hazard categories. Cities like Dehradun and Srinagar are highly vulnerable to landslides and fall under the severe risk zones (Fig.8). Population growth has resulted in the development of residential areas on moderate to steep slopes. The construction activities on the hill slopes have increased the runoff of soil resulting in landslides.

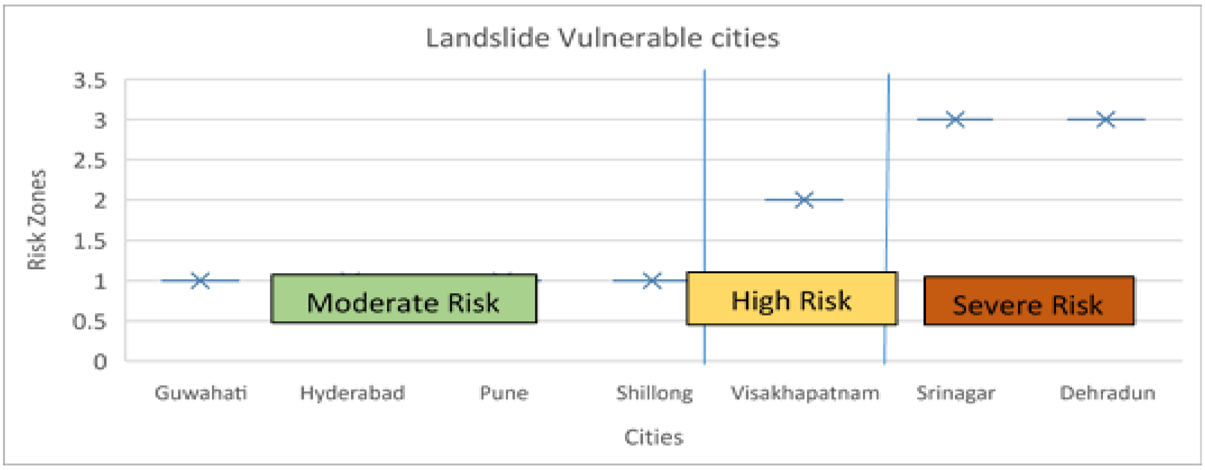


Figure 8: Landslide Vulnerable cities

3.1.4 Cyclones & Wind Storm

With a coastline of 7516 kms, the Indian sub-continent is among the worst affected regions by cyclones. India is exposed to nearly 10% of the world's tropical cyclones [16]. Data for the period 1980-2000 shows that on an average, 370 million people are exposed to cyclones in India every year.

The number of major tropical cyclones to strike the coastal states in India during 1891-2002 are as follows: Kerala (3), West Bengal (69), Karnataka (2), Odisha (98), Maharashtra (13), Andhra Pradesh

(79), Goa (2), Tamil Nadu (54), Gujarat (28) and Pondicherry (8). Some of the most recent cyclone incidences are listed in Table 5

Table 5: Cyclonic Events, India

States/ cities	Years	Fatalities
Cyclone Nilam, Tamil Nadu	October, 2012	20 deaths and the evacuation of 13,000 people
Cyclone Thane, Tamil Nadu	December, 2011	41 deaths, damage to standing crops
Cyclone Laila, Andhra Pradesh	May, 2010	32 deaths, evacuation of thousands of people, agricultural crops over 12,000 hectares destroyed.
Cyclone Aila, West Bengal	May, 2009	100 deaths

Cyclones are caused by atmospheric disturbances around a low-pressure area distinguished by swift and often destructive air circulation. Cyclones are usually accompanied by violent storms and bad weather.

Bhubaneshwar, Hyderabad, and Vishakhapatnam are highly vulnerable to cyclonic activities with wind velocity ranging between 45 – 55 m/ sec, whereas Guwahati, Shillong and Srinagar encounter windstorms. Recurring cyclones and windstorms account for a large number of deaths, loss of livelihoods, loss of public and private property and severe damage to infrastructure, thus seriously reversing the developmental gains at regular intervals.

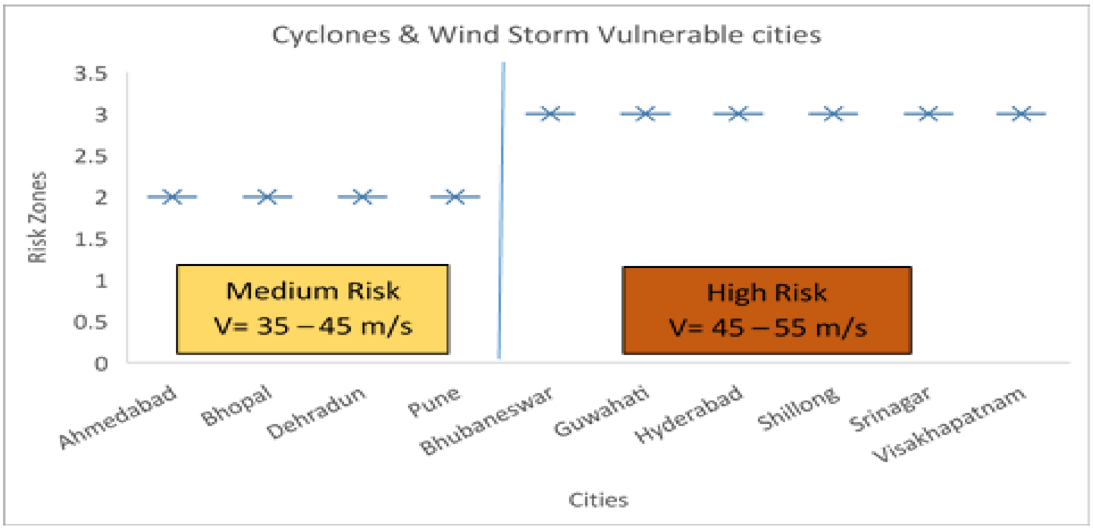


Figure 9: Cyclones & Wind storm Vulnerable cities

3.1.5 Heat Wave

Climate change vulnerabilities (CVV) have given rise to heat waves where there is a 5 to 7 ^{0}C increase in average summer temperature. While India is accustomed to high temperatures, a large number of fatalities from recent heatwaves highlight the importance of this public health risk. Heatstroke is the second most common contributing cause of accidental death from natural causes. The country recorded a 61% increase in heat-related mortality between 2004 and 2013 (NRCB, 2014).

A significant warming trend in the annual mean temperature during different seasons in India is recorded in Figure 10. It has also been reported that there is a substantial acceleration of warming in last three decades.

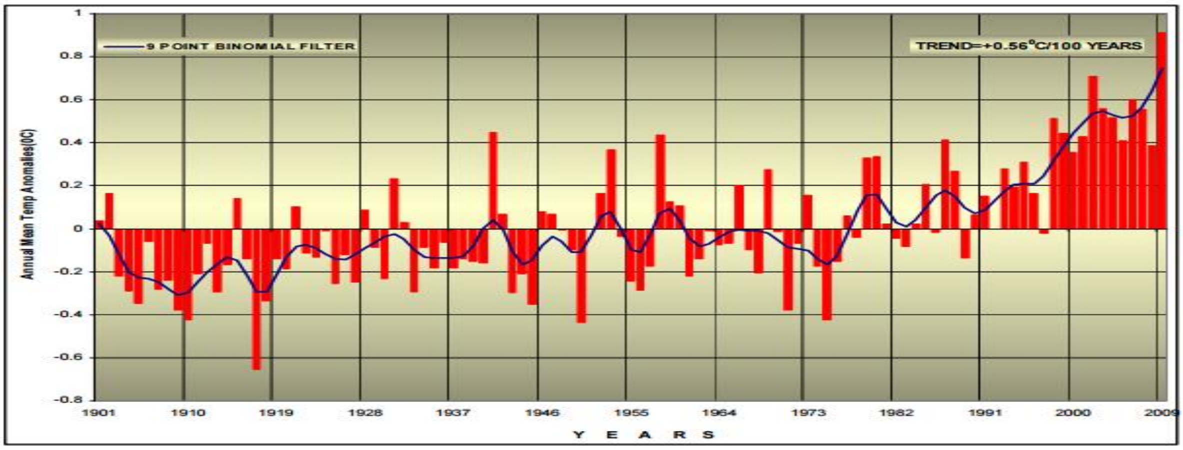


Figure 10: Annual Mean Temperature Anomalies for the period 1901-2009 (Source: Attri and Tyagi, 2010)

Table 6: Heat Wave Fatalities

Year	Fatalities
1992-2001	7,203 deaths
2002-2011	8,618 deaths
2012-2015 (4 years)	6,562 deaths
2016-18	1143 deaths

Heat Wave is a period of abnormally high temperatures, more than the normal maximum temperature that occurs during the summer season. Heat Waves typically occur between March and June, and in some rare cases even extend till July. The extreme temperatures and resultant atmospheric conditions adversely affect people living in the affected regions as they cause physiological stress, sometimes resulting in death.

Heatwave casualties were abnormally high in 2015. Since 1992, more than 22,000 people have died of heat-related causes in India (NDMA 2015). Ahmedabad, Bhopal, and Bhubaneswar are highly vulnerable as the temperature there goes beyond 45^0C.

India has experienced recurring incidences of heatwave since 2006. Heatwave and heat stress has emerged as the greatest global climatological problem with 2014-19 being the hottest years ever and June and July 2019 have been the hottest month on record globally. International agencies like ISA's National Oceanic and Atmospheric Administration have confirmed that June was the hottest June on record, 0.95 Celsius above the normal average. It was followed by the hottest month on record in 140 years — 0.95 Celsius above normal average (Deccan Chronical, 2019) [44].

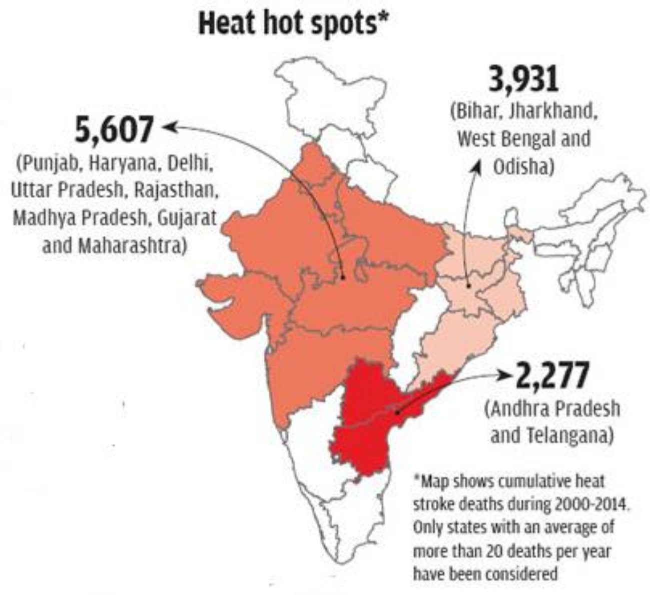


Figure 11: Heat Hot Spots – 2000-2014

Source: NCRB

Table 7: Heat Stress Mortality Record

Year	Death Record (NDMA)
2010	1274
2011	798
2012	1247
2013	1216
2014	1677
2015	2422
2016	1111
2017	220
2018	25

Since 2010, India records loss of nearly 10,000 lives owing to Heat Stress

According to a study by the Indian Institute of Technology (IIT), Gandhinagar, the frequency of severe heat waves in India will increase 30-fold by 2100 under a 2°C warming scenario. Under a business-as-usual scenario, heat-wave frequency might increase 75-fold. On identifying the number of days that heatwaves were expected to last and the estimates of increase in population exposure, the researchers estimated that population exposure to heatwaves is expected to increase by around 18-fold by the end of the century under a 1.5°C warming scenario. Under a 2°C warming scenario, the exposure will increase 92-fold. A massive 200-fold increase in exposure is likely under business-as-usual scenario (Down to Earth, 2018)

The term **temperature anomaly** means a departure from a reference value or long-term average. A positive anomaly indicates that the observed temperature was warmer than the reference value, while a negative anomaly indicates that the observed temperature was cooler than the reference value.

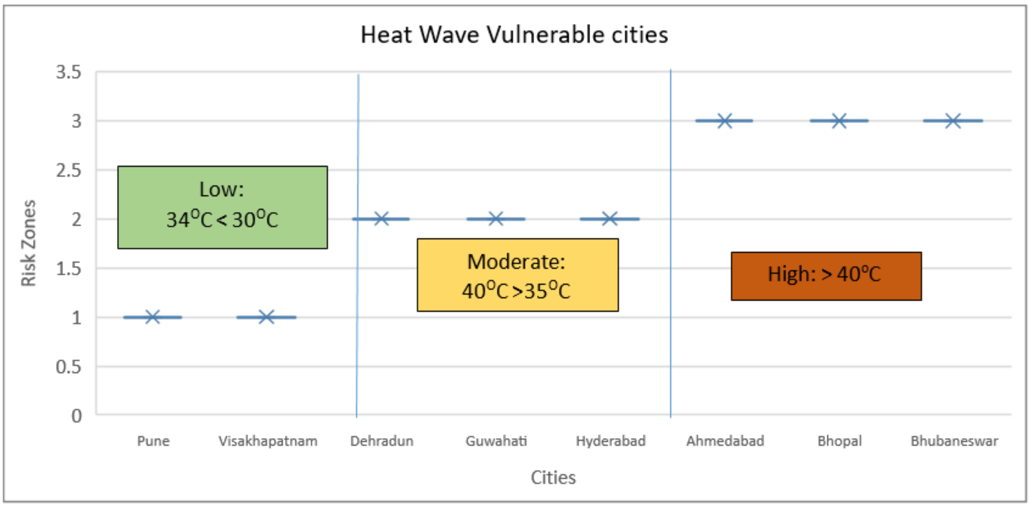


Figure 12: Heat Wave Vulnerable cities

Ahmedabad, Bhopal, and Bhubaneshwar are highly vulnerable to heatwaves as normal temperatures during summers soars above 40^{O}C, whereas Pune and Vishakhapatnam experience relatively low temperature ranges.

It is observed that cities like Srinagar, Ahmedabad, Dehradun, Guwahati, and Visakhapatnam are among the most vulnerable as they are exposed to numerous natural and man-made hazards (according to the data available). Apart from the mentioned hazards, there are certain other hazards faced by Indian cities like water scarcity or drought conditions, cold waves and industrial hazards/ fires. For instance, water scarcity is a hazard waiting to become a disaster in Ahmedabad where the groundwater table has gone extremely low (90 m bgl). Cities with million-plus population like Hyderabad, Pune, Bhopal, and Visakhapatnam are at risk of depleting groundwater, if not managed. Industrial towns of Ahmedabad, Bhopal, Guwahati, Shillong, and Visakhapatnam are highly prone to industrial hazards. All the cities need to have stringent safety standards and quick responding emergency operating centers.

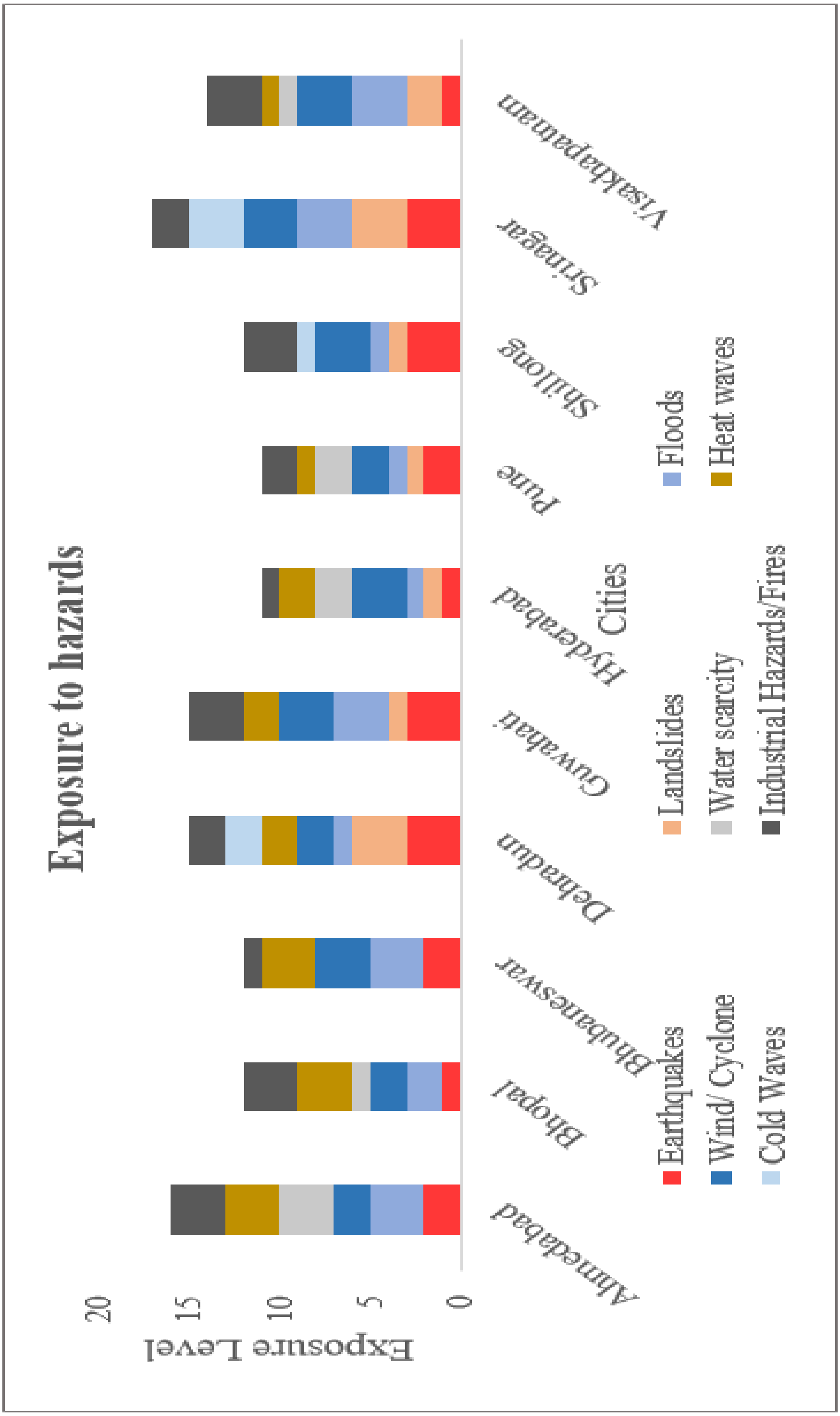


Figure 13: Cities exposed to Hazards

Figure 13 shows the various likely hazards of cities in India. Almost all the cities are in flood risk zone, and with unplanned development leading to encroachment of the water bodies, the risk just amplifies.

Heightened vulnerabilities to disaster risks can be related to expanding the population, unplanned urbanization and industrialization, development within high-risk zones, environmental degradation and climate change. Besides natural factors discussed in the preceding text, various human-induced activities like increasing demographic pressure, deteriorating environmental conditions, deforestation, unscientific development, faulty agricultural practices and open grazing, unplanned urbanization, construction of large dams on rivers are also responsible for an increase in the frequency of disasters in the country.

3.2 Urban Population Growth

Population growth, especially an increase in population density and urbanization, increases vulnerability to disasters (Perrow 2007). Severity of any disaster is usually related to the population it affects. The impact of natural disasters is always worse if the proportion of the population affected by it is large. High population density in any city makes the impact of the disaster disproportionately worse.

India’s population has increased by more than 181 million during the last decade 2001-2011. For the first time since Independence, the absolute increase in population has been more in urban areas than in rural areas. The level of urbanization has increased from 27.81% in 2001 Census to 31.16% in 2011 Census. The overall population growth rate of India has slowed down from 21.54% (1991-2001) to 17.64% (2001-2011) due to the sharp decline in the rural growth rate; however, the urban growth rate remains almost the same (31.5% - 31.8%).

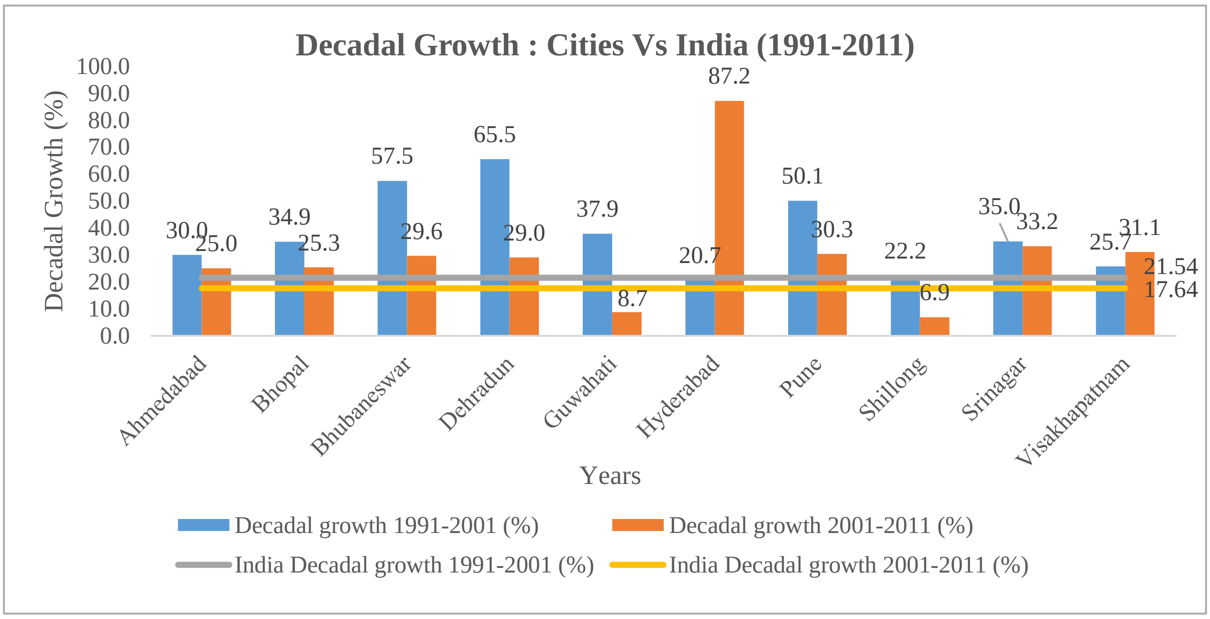


Figure 14: Decadal Growth: Cities Vs India (1991-2011)

Over the last decade, the cities (except for Hyderabad and Vishakhapatnam) have projected declining population growth. The increase in population growth of Hyderabad (87.2%) and Vishakhapatnam (31.1%) was due to an increase in their respective municipal areas. As compared to the national growth rate of 17.64% all the cities expected for Shillong and Guwahati, who experienced the least annual growth in population in the last decade, (6.9% and 8.7% respectively), other cities recorded higher growth rates.

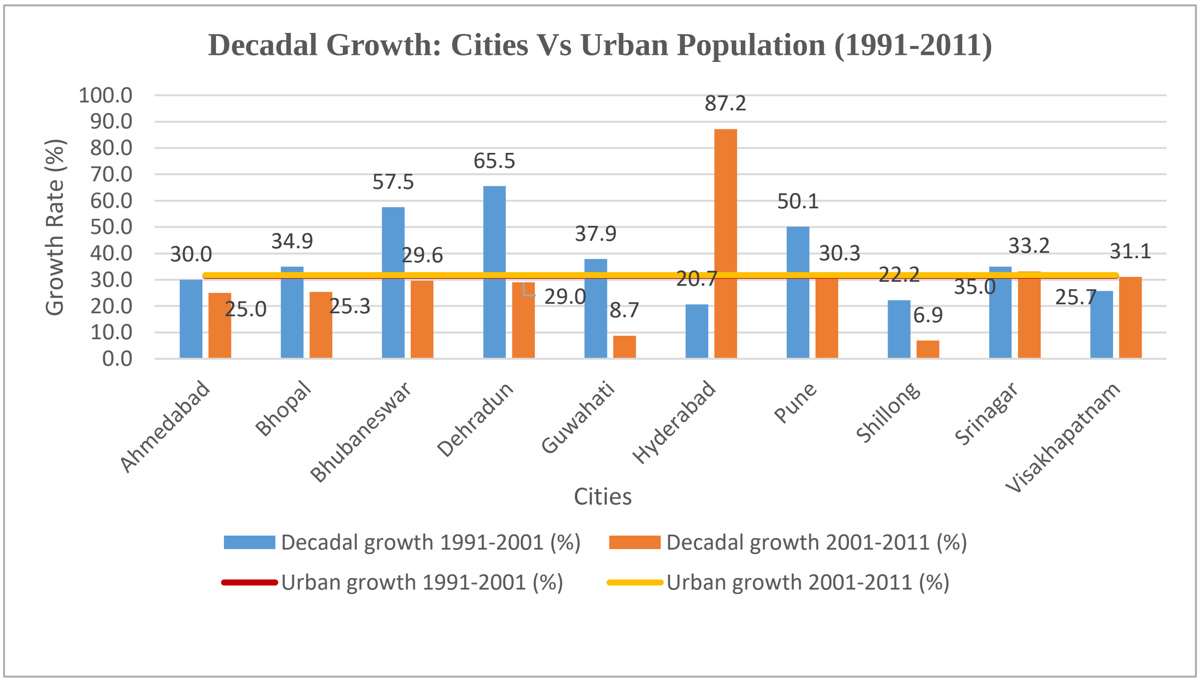


Figure 15: Decadal Growth: Cities & Urban Population (1991-2011)

Hyderabad and Srinagar recorded a higher growth rate of 87.2% and 33.2%, respectively, when compared to the decadal urban growth rate of 31.8% for the year 2001- 2011. Urban population has increased in all the cites over the decade. This growing urban population increases the population exposed to disasters and it affects the changing demographics and socio-economic character of the city at large.

3.3Slum Population

Slums have been a constant feature of urban landscape in India. Slums manifest the worst form of deprivation that transcends income poverty. Under Section-3 of the Slum Area Improvement and Clearance Act, 1956, slums have been defined as mainly those residential areas where dwellings are unfit for human habitation by reasons of dilapidation, overcrowding, faulty arrangements and designs of such buildings, narrowness or faulty arrangement of streets, lack of ventilation, light, sanitation facilities or any combination of these factors, which are detrimental to safety, health and morals (Primary Census Abstract for Slums, India)

A **Notified Slum** is defined as a compact area of at least 300 population or about 60-70 households of poorly built congested tenements, in the unhygienic environment usually with inadequate infrastructure and lacking in proper sanitary and drinking water facilities.

Identified Slums are compact areas of at least 300 population or about 60-70 households of poorly built congested tenements, in an unhygienic environment usually with inadequate infrastructure and lacking in proper sanitary and drinking water facilities.

Recognized Slums are the ones which may not have been formally notified as slums under any act but are recognized by States, UTs and Local bodies.

Source: Primary Census Abstract for Slums, 2011

The slum population in India has increased from 2001 to 2011. Three types of slums have been defined in Census 2011, namely, notified, recognized and identified. The census reports slum population of 65.49 million, including slum population from the notified, recognized and identified slum pockets, with a total number of towns reported slums being 2613. The highest slum population is recorded in the identified slums (22.82 million).

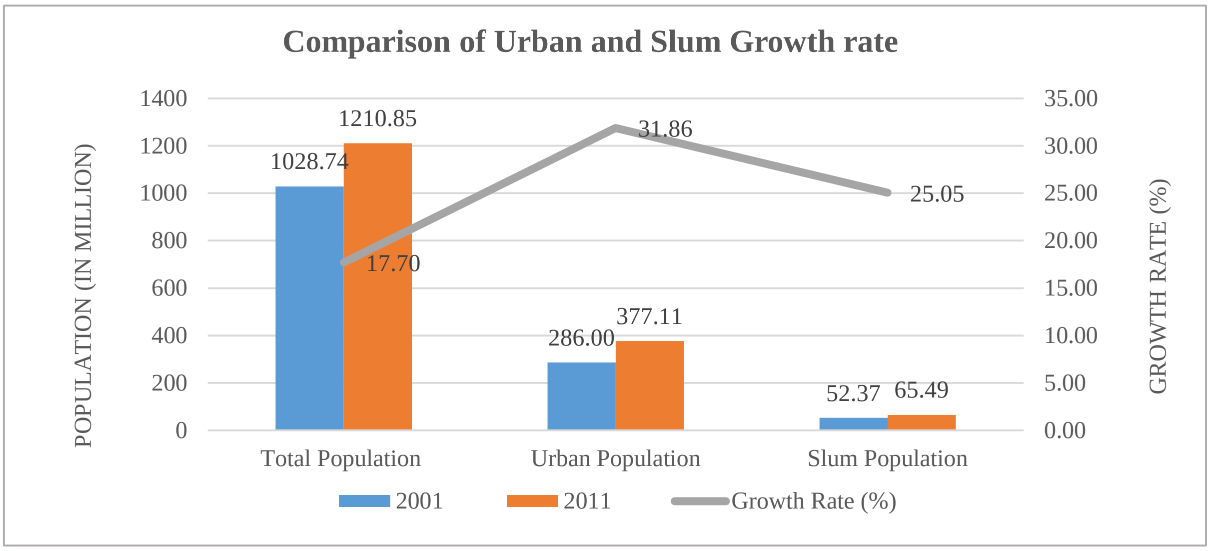


Figure 16: Comparison of Urban & Slum growth rate

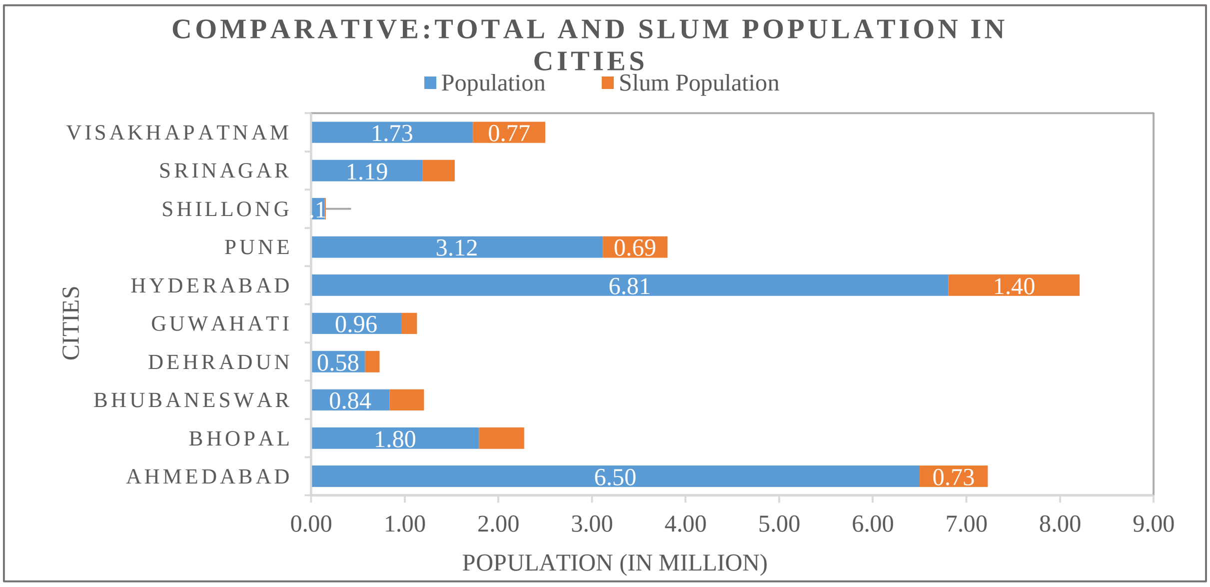


Figure 17: Comparative: City & Slum Population

In India, the population growth of the cities and slum expansions are co-related and play an important role in determining the vulnerability level of cities from the hazards. The slum population in Indian cities has increased during 2001-11; nearly 17.34 % of the urban population lives in the slums and slum-like conditions in India.

Rapid urbanization, industrialization and the negative consequences of urban pull result in the formation of slums, which in the metropolitan cities create conditions that can turn a hazard into a disaster. In the absence of basic facilities, the slum population is the most vulnerable group in the times of disaster.

Bhubaneshwar and Vishakhapatnam have the highest share of slum population to the total population of the cities, (44% and 45% respectively), whereas Bhopal (27%), Dehradun (26%) and Srinagar (29%) also have more than a quarter of their population living in the slums. The slums are usually located in low lying areas, with a housing shortage and critical inadequacies in public utilities, overcrowding, unhygienic conditions. According to a report submitted by a technical committee to the Ministry of

Housing and Urban Poverty Alleviation (MHUPA), India's urban housing shortage is estimated at nearly 18.78 million households in 2012 (MoHUPA, 2012)

3.4Urban Infrastructure

Urban Infrastructure and services provide the basic foundation for a city's economic, social, cultural and environmental dynamics. The urban infrastructure provides a backbone for the functioning of a city and its preparedness towards disaster resilience is directly dependent on the present status of its physical infrastructure and services. However, the existing urban infrastructure in many cities is in a relatively poor state (especially in non-metropolitan cities). Over the years, various schemes of the Central and State governments have come in force to bridge the infrastructure and services deficit.

In the context of this study, the infrastructure and services studied in detail against the MoUD Service Level Benchmarks (SLBs) are water supply, sewerage, solid waste management, and storm water drainage facilities in the cities under study purview. The benchmark encompasses 28 indicators reflecting multiple facets of service delivery performances (MoHUA, 2012).

	Indicator	National Benchmark
	WATER SUPPLY	
1	Coverage of Water Supply Connections	100%
2	Per capita availability of water at consumer end	135 lpcd
3	Extent of metering of water connections	100%
4	Extent of non-revenue water	20%
5	Continuity of water supply	24*7
6	Adequacy of Treatment and Disinfection and Quality of water supplied	100%
7	Efficiency in redressed of customer complaints	80%
8	Cost recovery in water supply services	100%
9	Efficiency in collection of water supply related charges	90%
	SEWAGE MANAGEMENT	
1	Coverage of toilets	100%
2	Coverage of sewerage network services	100%
3	Collection efficiency of waste water network	100%
4	Adequacy of wastewater treatment capacity	100%
5	Quality of sewage treatment	100%
6	Extent of reuse and recycling of sewage	20%
7	Efficiency in redressed of customer complaints	80%
8	Extent of cost recovery in sewage management	100%
9	Efficiency in collection of sewerage charges	90%
	SOLID WASTE MANAGEMENT	
1	Household level coverage of solid waste management services	100%
2	Efficiency of collection of municipal solid waste	100%
3	Extent of segregation of municipal solid waste	100%
4	Extent of municipal solid waste recovered/recycled	80%
5	Extent of scientific disposal of municipal solid waste	100%
6	Efficiency in redressed of customer complaints	80%
7	Extent of cost recovery in solid waste management services	100%
8	Efficiency in collection of SWM charges	90%
	STORM WATER DRAINAGE	
1	Coverage of Storm Water Drainage Network	100%
2	Incidence of water logging/flooding	0%

3.4.1 Water Supply

As per Census 2011, nearly 70% of urban households have access to tap water. Of these, 62% have access to treated tap water. Thus, nearly 40 percent of urban households have no access to public supply and have to depend on other sources of water (IIHS, 2014). Moreover, not all households that have access to public supply have access to it within the premise. Only 49% of households have access to piped water supply within their premises. Comparing Census 2001 and 2011, one can see that nearly 18 million additional households have obtained access to tap water, whereas the overall share across different water sources appears to have changed only marginally.

In 1951, the per capita availability of potable water was about 5177 m^3. This had reduced to about 1545 m^3 in 2011 (TERI) and according to WRI India, almost 54% of India is facing high to extreme water stress and more than 100 million of its people live in areas of poor water quality (WRI, 2017). The problem has compounded with increased concretization as a result of urban development that has choked groundwater recharge. Water is neither being recharged nor stored to optimize its use and conservation while also retaining its natural goodness.

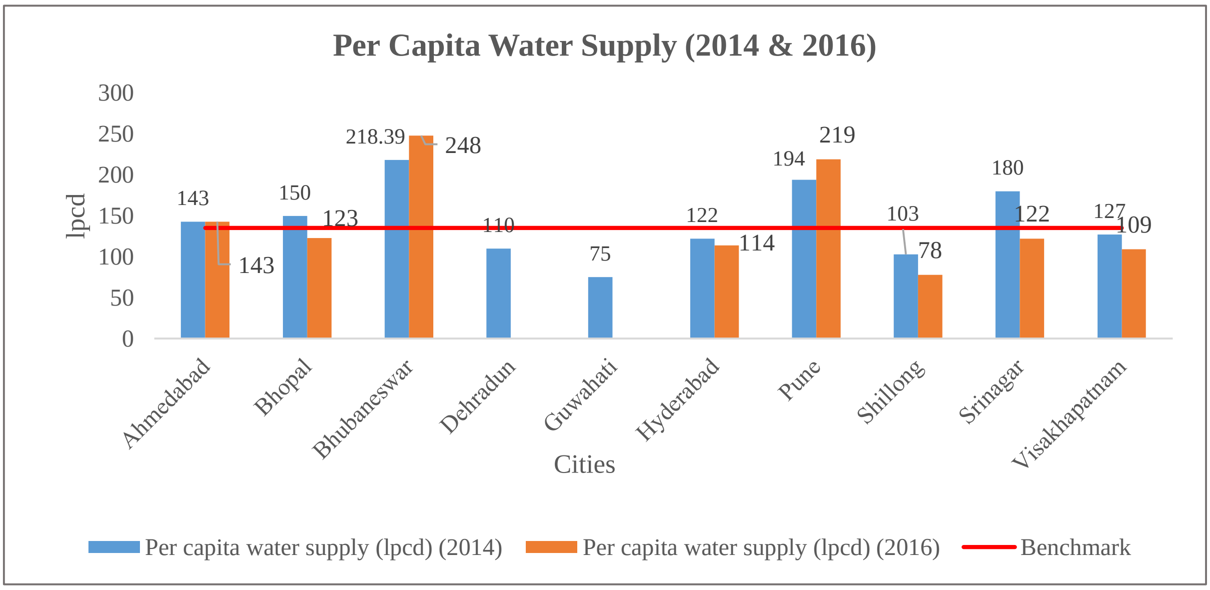


Figure 18: Per capita water supply

In terms of the per capita water supply, most of the cities exceed the benchmark (SLB) set by MoHUA of 135lpcd. However, water received at the consumer end is lower in many cities due to huge distribution losses. For instance, in Bhubaneswar per capita supply is 218lpcd, of which 62% is lost in distribution. In Guwahati and Hyderabad distribution losses account for more than 30% of the supplies. Ahmedabad and Vishakhapatnam have more efficient distribution networks with only 23% distribution losses.

The 2016 (NIUA, 2016-17) data indicates that the cities like Bhubaneshwar and Pune, which were already providing water above the benchmark set at 135lpcd, have been successful in increasing per capita water supply to 248 lpcd and 219 lpcd respectively. However, other cities have not shown any improvement in water supplies, as a result, their per capita water supply has decreased over the years.

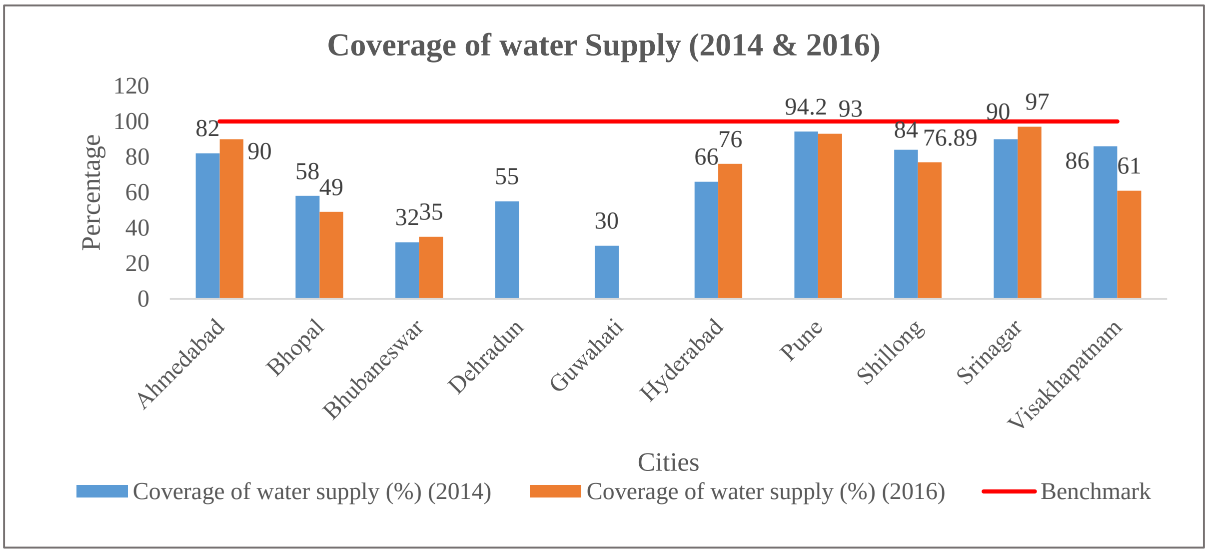


Figure 19: Coverage of water supply

While most of the cities have more than 80% coverage of water supply against 100% benchmark set by MoHUA. However, there are a few exceptions like Bhubaneswar and Guwahati with only 32% and 30% coverage, respectively. The coverage area has increased in the cities of Ahmedabad, Bhubaneshwar, Hyderabad and Srinagar.

Metering of water supply is inadequate in all the cities and almost no city in India provides 24-hour water supply. A four-to-five-hour water supply seems to be the norm [29]. The SLB data indicates that the duration of supply is only 2–3 hours on an average.

3.4.2 Sewerage and Sanitation

As per the Census 2011, at the country level, there is no drainage facility in 48.9% households, while 33% of households have only an open drainage system. According to a statement tabled in the Lok Sabha by the minister of state for environment, Mr. Anil Madhav Dave (2017), only three Indian states meet their demand for sewerage treatment. The national average for waste treatment capacity as a proportion of sewage generated in urban India is around 38%.

National Family Health Survey-3 (2005-2006) reported that 52.8% of the households in urban areas have 'improved sanitation', which means that their flush or pour toilet latrine is connected to piped sewer or septic or other systems, while 41% of the households still have no latrine within household premises, with 24.2% of them depending on public latrine and other 16.8% practicing open defecation. The bulk of sewage treatment capacity exists in metropolitan cities with 40% of wastewater generation. The cities of Delhi and Mumbai generate some 17% of all the sewage in the country [32].

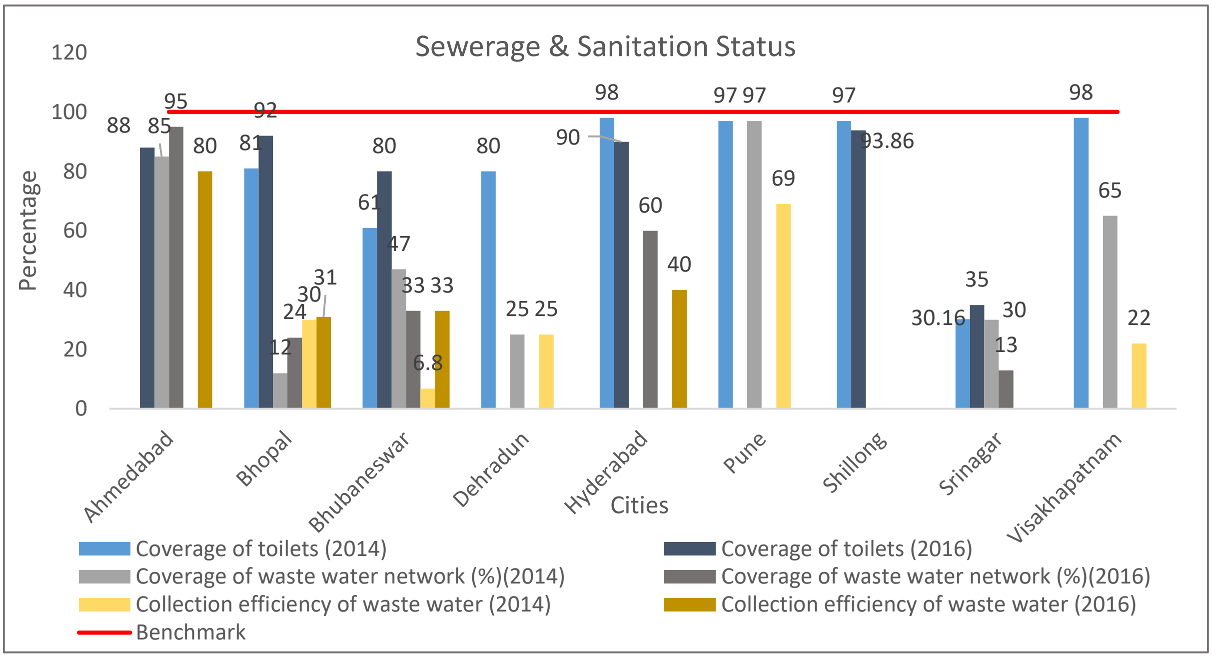


Figure 20: Sewerage & Sanitation Status, 2014 & 2016

In reference to the coverage of toilets at the household or community level, Figure 20 shows that almost all the cities have achived a target of 80% and above, expect for Srinagar (30.18% & 35%). However, none of the cities have achieved the SLBs of 100% in any of the categories. Over the years, the cities have not much improved their efficiency in collecting wastewater. In this area, their efficiency is between 30-40%. However, Ahmedabad has shown improvements with over 80% efficiency.

3.4.3 Storm Water Drainage

In today's urban India water logging is a common concern that can lead to disaster as there is no city with 100% coverage of storm water drainage. Urban storm water management is an important aspect of urban development, planning and expansion. Urbanization of an area invariably leads to an increase in the overall imperviousness of the area. When the land becomes impervious, storm water will stagnate on the surface thereby affecting the infrastructure, transportation and causing inconvenience to the general populace. One way to handle this is through a proper well-maintained storm drainage system (Kumar. K.P et al, 2015).

In 2010-11, MoHUA surveyed 13 states for storm water drains. In 56 of 104 cities surveyed, 745 of 1,383 urban areas that responded the coverage was below 50%—a level the ministry terms as "immediate action for improvement" (NIUA, SMARTNET) Storm water drains, which are designed to address high rainfall concentrated in a short period of time, face clogging with garbage and sewage. About 50% of 1,383 urban areas that responded to the survey, storm water drainage coverage was below 50%; in 1,142, it was below 75%. Under this consideration Odisha, Kerala, and Chhattisgarh were the worst. Among the better ones, relatively speaking, were Maharashtra, Rajasthan and Andhra Pradesh.

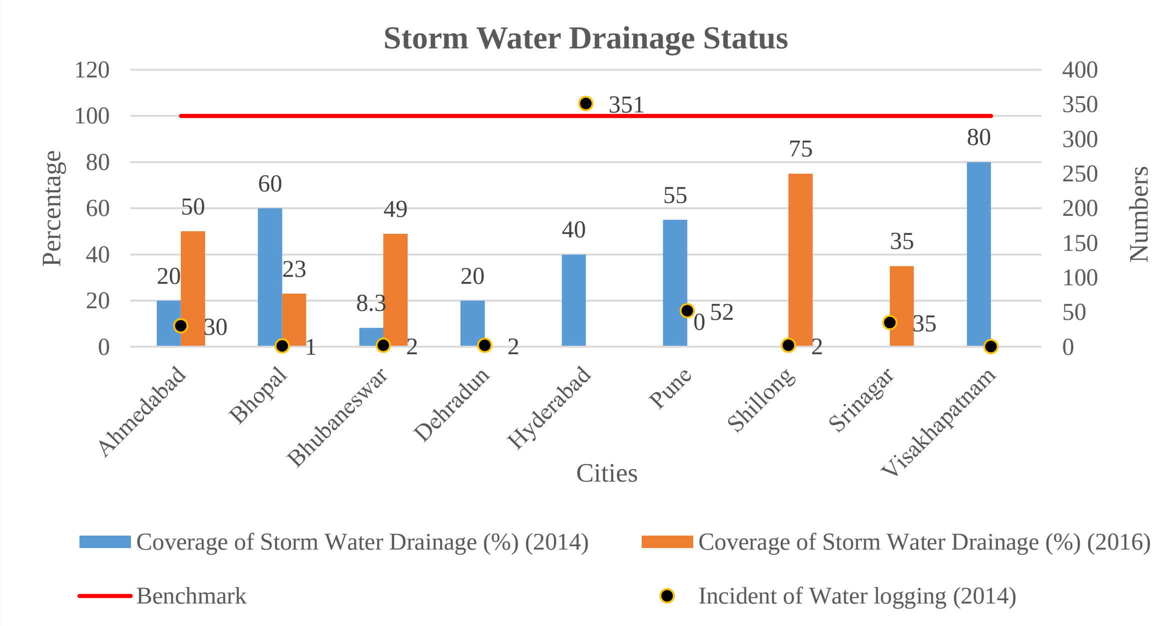


Figure 21: Storm water Drainage Status, 2014 & 2016

Ahmedabad and Hyderabad being million-plus cities need immediate attention as they are far behind in managing storm water, with Hyderabad recording as high as 351 incidences of waterlogging in the past decade. Storm water retrofit designs are required to overcome waterlogging and flooding situations and to achieve successful groundwater recharge.

Bhubaneswar and Dehradun at 8.3% and 20% respectively have the least network reach. However, in 2016 the city of Bhubaneshwar and Ahmedabad improved their respective storm water drainage coverage to 49% and 50%. Cities like Guwahati, Shillong and Srinagar were unable to provide optimal data for storm water management for the year 2014, however, 2016 data reveals that almost 75% of Shillong has storm water drainage cover.

3.4.4 Solid Waste Management

Solid Waste Management is defined as discarded solid fractions, generated from domestic units, trade centers, commercial establishments, industries, agriculture, institutes, public services and mining activities (NIUA, 2012). Urban India generates more than 1,00,000 MT of solid waste per day (CPHEEO 2002).

The National Plan for Municipal Waste Management in India

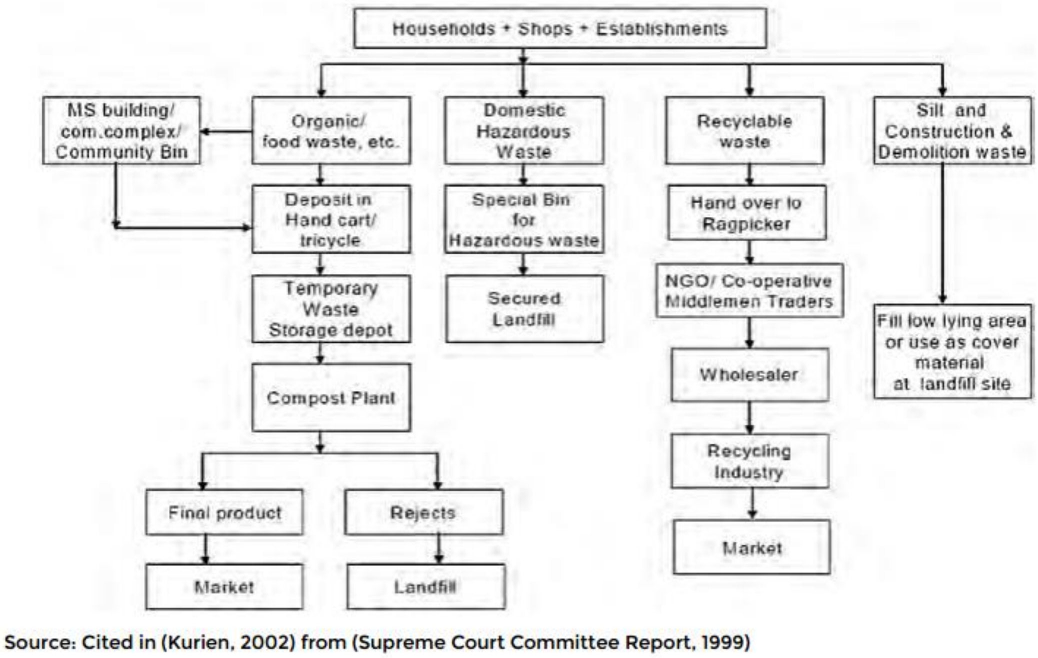


Figure 22: National Plan for Municipal Waste Management in India

Solid waste Management (SWM) system includes collection, segregation, transportation, processing and disposal of waste. Collecting, processing, transporting and disposing municipal solid waste (MSW) is the responsibility of the urban local bodies in India.

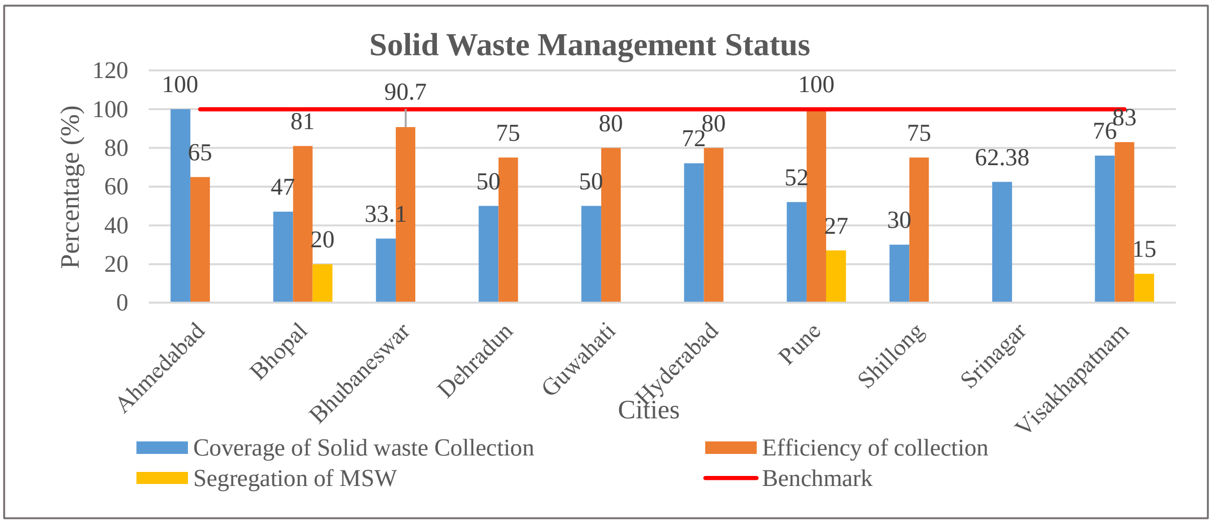


Figure 23: Solid Waste Management Status, 2014

The Municipal Solid Waste (Management and Handling) Rules, 2000, are applicable to all ULBs in India for collection, segregation, transportation, processing, and disposal of solid waste. As per the rules, appropriate systems and infrastructure facilities are required to undertake the scientific collection, management, processing and disposal of waste. However, the ULBs are unable to provide the required services owing to technical, managerial and financial deficiencies along with lack of engagements from private sectors, local NGOs.

Large cities like Ahmedabad and Pune generate waste in range of 1600-3500 MT per day (PMC 2014). The coverage of solid waste collection is almost 100% for the cities of Ahmedabad and Pune. Though these cities show above average efficiency in waste collection, waste segregation at source is not practiced in most of the cities, hence sufficient data was not available.

3.5 Disaster Preparedness and Mitigation Strategies

The super cyclone in Orissa in October 1999 and the Bhuj earthquake in Gujarat in January 2001 underscored the need to adopt a multi-disciplinary, multi-sectoral and multi-dimensional endeavor involving diverse scientific, engineering, financial and social processes for risk reduction in the developmental plans and strategies (UNISDR, 2005).

In the past decade (1991-2000), natural disasters killed 66,59,598 people globally, accounting for 88 percent of all deaths due to disasters. Similarly, man-made disasters killed 86,923 people during the decade. Nearly two-thirds of the people killed in these disasters hail from developing countries like India, with only four percent of the casualties being reported from the developed countries (IFRCRCS, 2001).

Variables	Ahmedabad	Bhopal	Bhubaneswar	Dehradun	Guwahati	Hyderabad	Pune	Shillong	Srinagar	Visakhapatnam
Adaptation Strategies in the cities										
Prevention(preparedness drills/mock drills, regular training)		H		L	L	L	L	L	L	M
Human Resource-trained workforce for community interaction, community awareness initiative etc	L	H	L	L	L	M	L	L	L	M
Early warning system and rehabilitation	M	H	L	L	L	L	L	H	L	M
Updated previous disaster database	L	H	M	L	M	M	M	M	L	M
Mitigation Actions by Category										
Emergency Services- like dedicated control room for information dispensation and coordination and Necessary equipments in place and functioning	L	H	L	L	L	L	L	L	L	L
Natural Resource Protection				M	M			M	M	M
Building codes for current and future construction	L	H	L	L	L	L	L	L	L	H

Figure 24: Disaster Preparedness & Mitigation Status of city

Besides various measures for putting in place institutional and policy framework, disaster prevention, mitigation and preparedness initiatives being taken by the Central and State Governments, the community, urban local bodies and media also have a key role to play toward safer cities. For vulnerability reduction and rapid professional response to disasters, mitigation and preparedness measures work simultaneously.

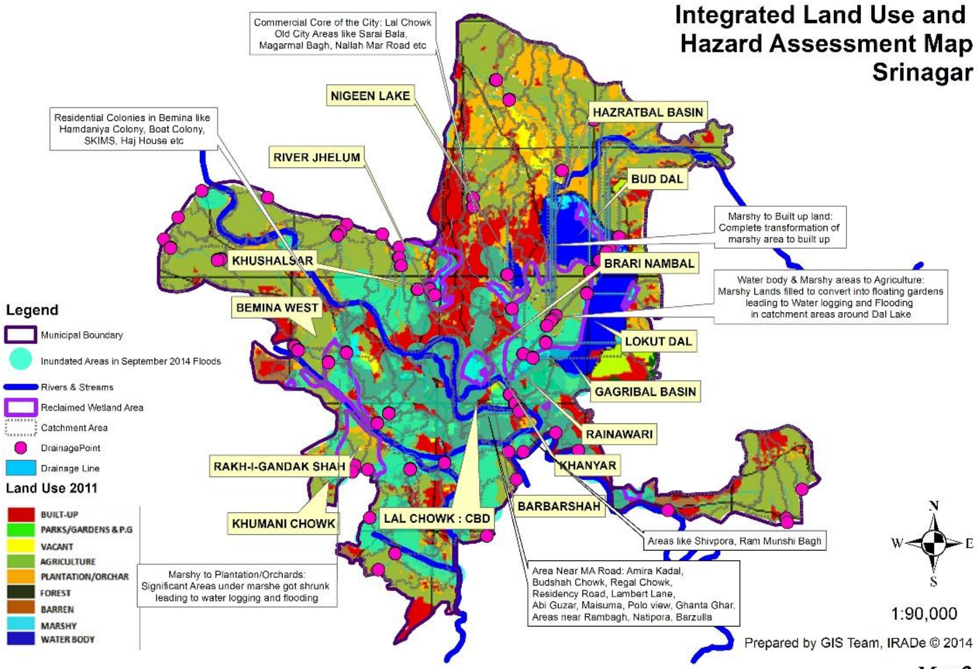
Disaster preparedness needs to be in regard to planning and preparing the strategy to tackle and mitigate disasters in a responsible and effective manner. Almost all the cities have established a disaster response system and a management team, within their existing governance and city institutional framework. However, Bhopal remains to be at high vulnerability end due to the unavailability of the proper governance towards disaster response and management.

Cities like Dehradun have adopted optimal adaptation strategies through mock drills, capacity building of the officials, database updates, early warning and rehabilitation of the community pre and post disasters. Building codes have been provided to all cities for current and future construction. However, the cities have not implemented the same extensively as a part of the disaster mitigation strategy.

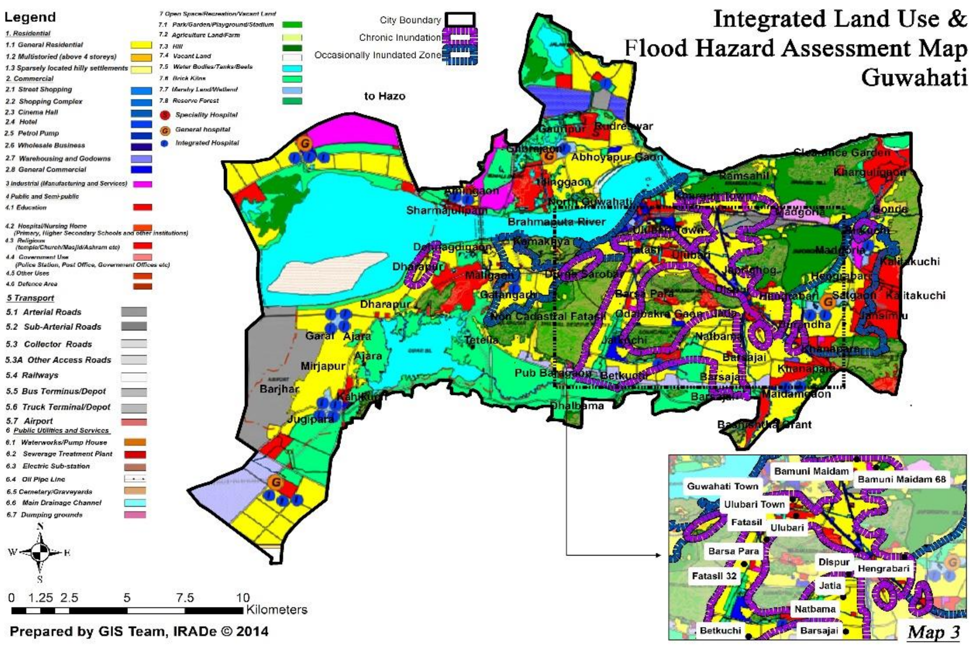
3.6 Land use and Hazard Vulnerability Assessments using GIS tool

Land use and urban planning are widely recognized as key non-structural risk mitigation measures with the potential to avoid exposure in the most hazardous zones and to decrease overtime exposure and vulnerability in already urbanized areas (UNISDR). The land use plans provide relevant information about environmental features including natural hazards of the areas to be developed or redeveloped.

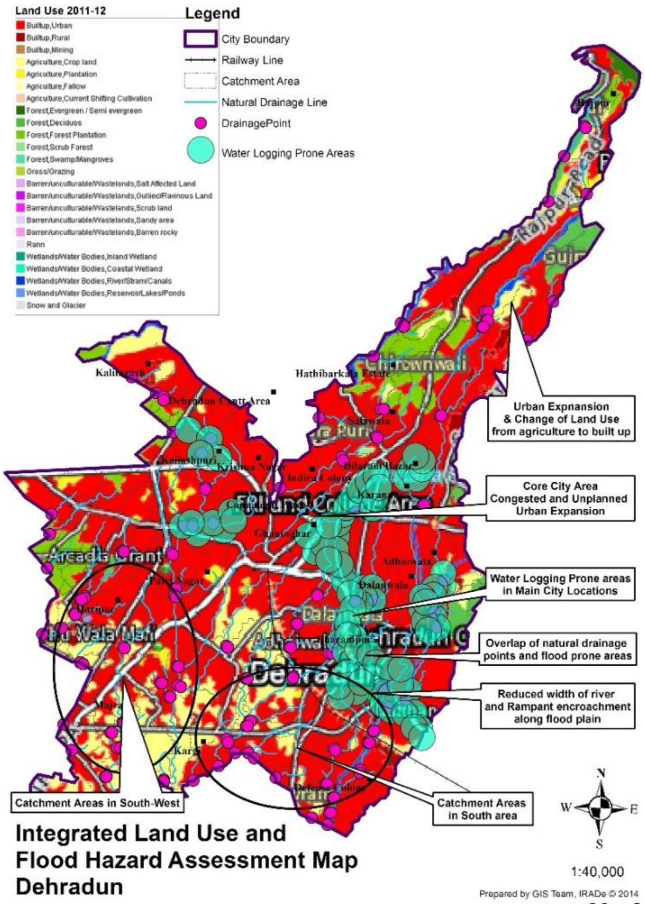
Land use and hazard vulnerability of each of the 10 cities were assessed to develop Integrated Land-Use-Vulnerability maps, indicating the precise location of sites where people, the natural environment or property are at risk due to a potentially catastrophic event that could result in death, injury, pollution or other destruction.


Integrated Land Use and Hazard Assessment Map Srinagar
Commercial Core of the City: Lal Chowk Old City Areas like Sarai Bala, Magarmal Bagh, Nallah Mar Road etc
NIGEEN LAKE
HAZRATBAL BASIN
Residential Colonies in Bemina like Hamdaniya Colony, Boat Colony, SKIMS, Haj House etc
RIVER JHELUM
BUD DAL
Marshy to Built up land: Complete transformation of marshy area to built up
KHUSHALSAR
BRARI NAMBAL
Water body & Marshy areas to Agriculture: Marshy Lands filled to convert into floating gardens leading to Water logging and Flooding in catchment areas around Dal Lake
BEMINA WEST
LOKUT DAL
GAGRIBAL BASIN
RAINAWARI
RAKH-I-GANDAK SHAH
KHANYAR
BARBARSHAH
KHUMANI CHOWK
LAL CHOWK : CBD
Areas like Shivpora, Ram Munshi Bagh
Marshy to Plantation/Orchards: Significant Areas under marshe got shrunk leading to water logging and flooding
Area Near MA Road: Amira Kadal, Budshah Chowk, Regal Chowk, Residency Road, Lambert Lane, Abi Guzar, Maisuma, Polo view, Ghanta Ghar, Areas near Rambagh, Natipora, Barzulla
Legend
Municipal Boundary
Inundated Areas in September 2014 Floods
Rivers & Streams
Reclaimed Wetland Area
Catchment Area
DrainagePoint
Drainage Line
Land Use 2011
BUILT-UP
PARKS/GARDENS & P.G
VACANT
AGRICULTURE
PLANTATION/ORCHAR
FOREST
BARREN
MARSHY
WATER BODY
N
W
E
S
1:90,000
Prepared by GIS Team, IRADe © 2014

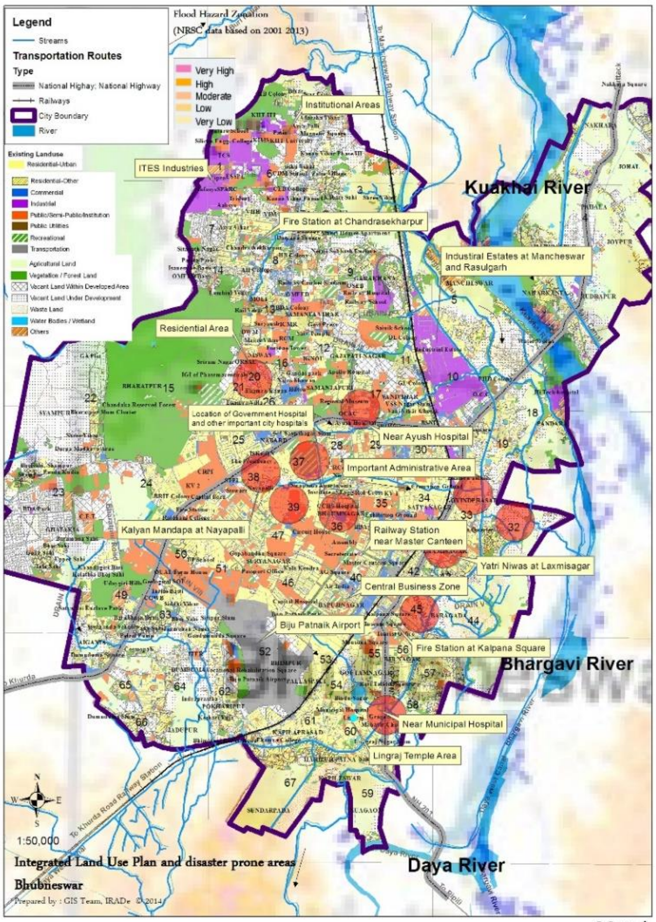
Map 6


Integrated Land Use & Flood Hazard Assessment Map Guwahati
Legend
1. Residential
1.1 General Residential
1.2 Multistoried (above 4 storeys)
1.3 Sparsely located hilly settlements
2. Commercial
2.1 Street Shopping
2.2 Shopping Complex
2.3 Cinema Hall
2.4 Hotel
2.5 Petrol Pump
2.6 Wholesale Business
2.7 Warehousing and Godowns
2.8 General Commercial
3 Industrial (Manufacturing and Services)
4 Public and Semi-public
4.1 Education
4.2 Hospital/Nursing Home
5 Transport
5.1 Arterial Roads
5.2 Sub-Arterial Roads
5.3 Collector Roads
5.3A Other Access Roads
5.4 Railways
5.5 Bus Terminus/Depot
5.6 Truck Terminal/Depot
5.7 Airport
6 Public Utilities and Services
6.1 Waterworks/Pump House
6.2 Sewerage Treatment Plant
6.3 Electric Sub-station
6.4 Oil Pipe Line
6.5 Cemetary/Graveyards
6.6 Main Drainage Channel
6.7 Dumping grounds
7 Open Space/Recreation/Vacant Land
7.1 Park/Garden/Playground/Stadium
7.2 Agriculture Land/Farm
7.3 Hill
7.4 Vacant Land
7.5 Water Bodies/Tanks/Beels
7.6 Brick Kilns
7.7 Marshy Land/Wetland
7.8 Reserve Forest
Speciality Hospital
General hospital
Integrated Hospital
City Boundary
Chronic Inundation
Occasionally Inundated Zone
to Hazo
Brahmaputra River
Dharapur
Garal
Ajara
Mirjapur
Barjhar
Jugipara
Betkuchi
Dhalbama
Bamuni Maidam
Bamuni Maidam 68
Guwahati Town
Ulubari Town
Fatasil
Ulubari
Barsa Para
Dispur
Hengrabari
Fatasil 32
Jatia
Natbama
Betkuchi
Barsajai
N
W
E
S
0 1.25 2.5 5 7.5 10
Kilometers
Prepared by GIS Team, IRADe © 2014

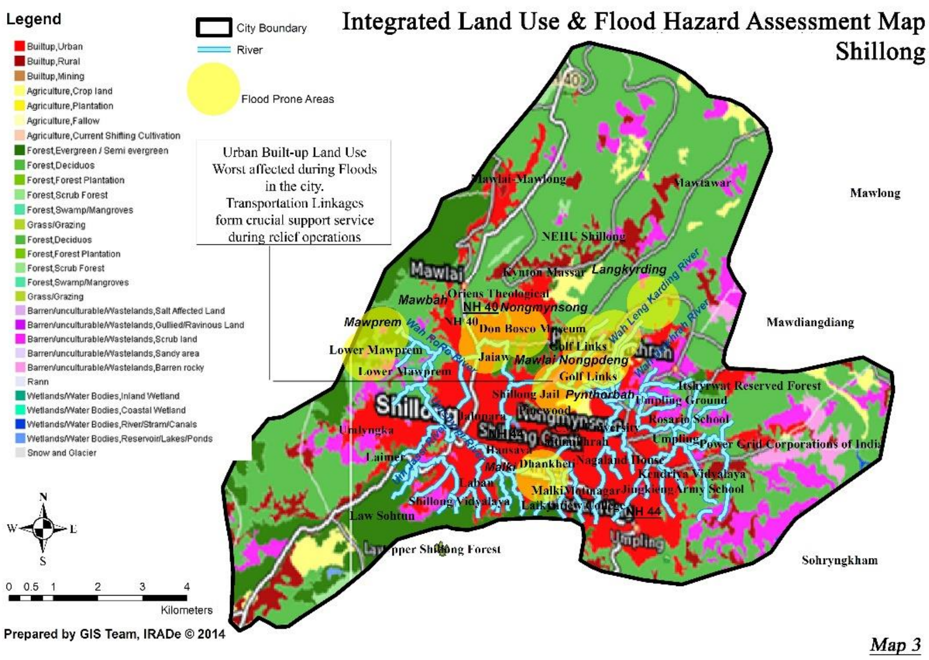
Map 3



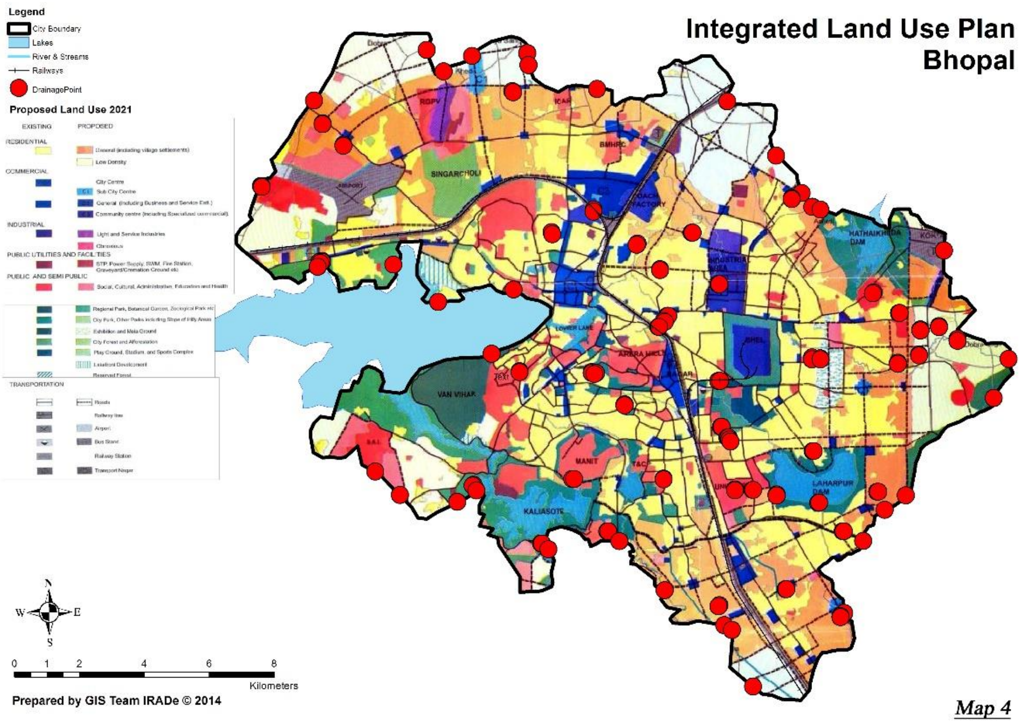
Map 5



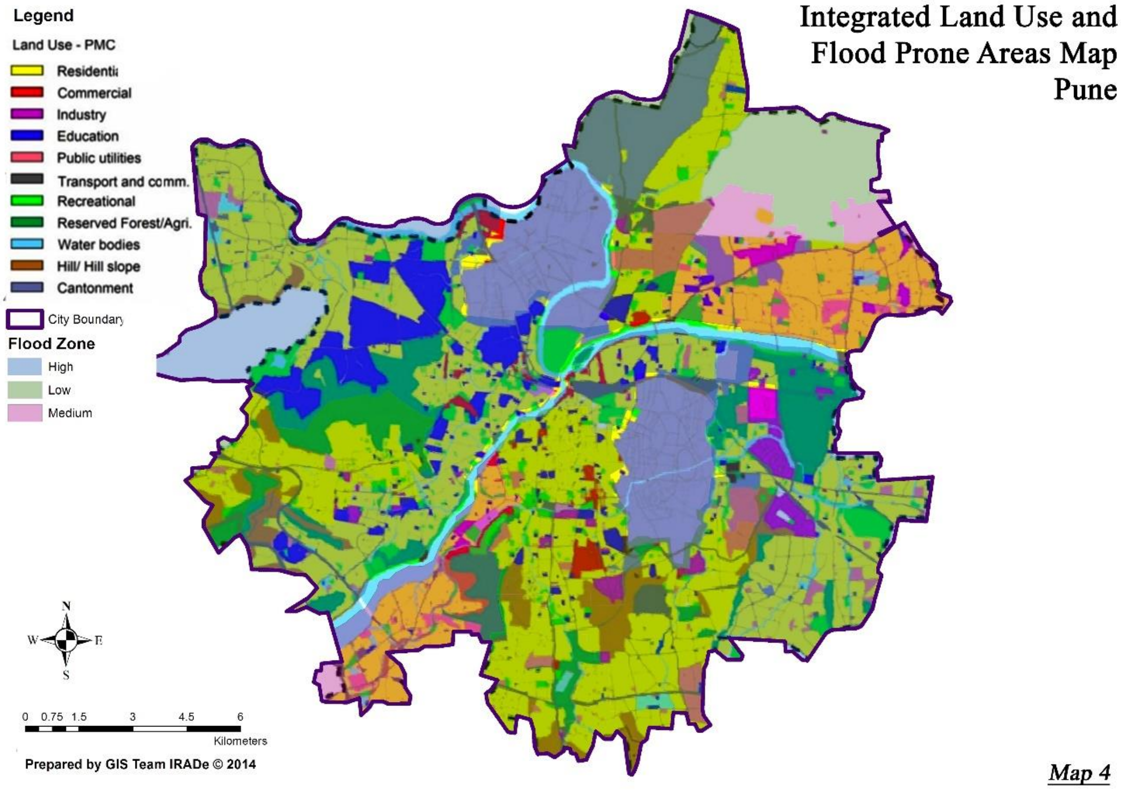
Map 4



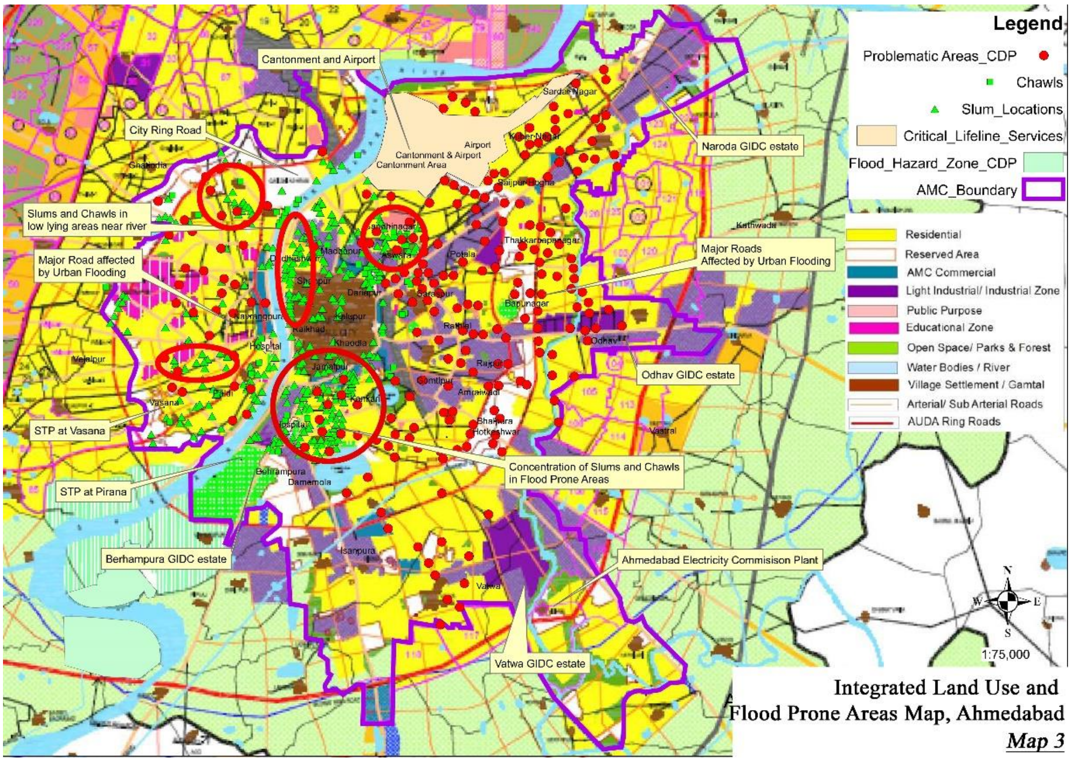
Map 3


Integrated Land Use Plan
Bhopal
Legend
City Boundary
Lakes
River & Streams
Railways
DrainagePoint
Proposed Land Use 2021
0 1 2 4 6 8
Kilometers
Prepared by GIS Team IRADe © 2014

Map 4


Integrated Land Use and
Flood Prone Areas Map
Pune
Legend
Land Use - PMC
Residenti
Commercial
Industry
Education
Public utilities
Transport and comm.
Recreational
Reserved Forest/Agri.
Water bodies
Hill/ Hill slope
Cantonment
City Boundary
Flood Zone
High
Low
Medium
0 0.75 1.5 3 4.5 6
Kilometers
Prepared by GIS Team IRADe © 2014

Map 4



Integrated Land Use and Flood Prone Areas Map, Ahmedabad
Map 3

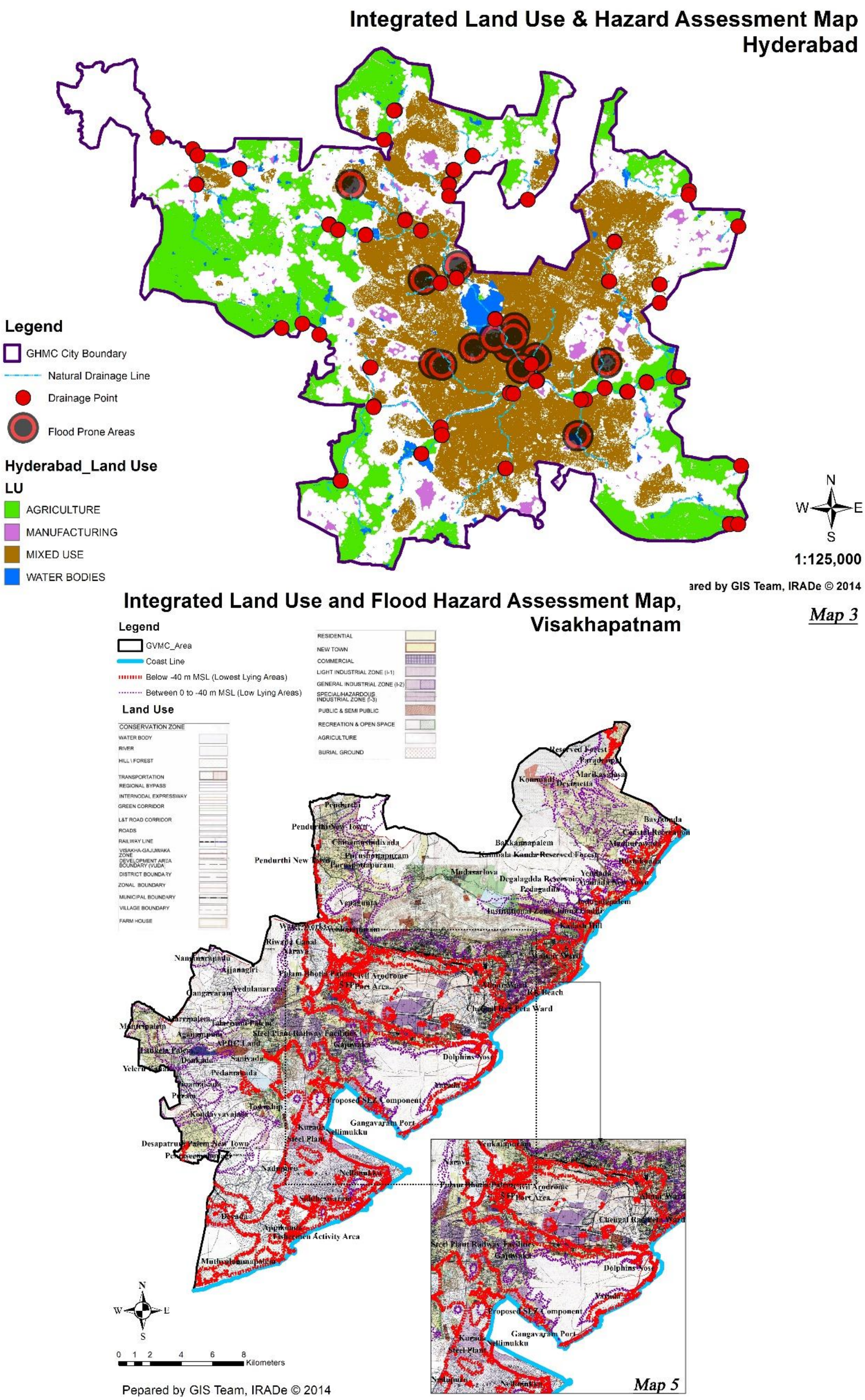


Figure 25: Integrated Land-use & Hazard Assessment Maps

These maps can help planners and decision-makers in developing appropriate strategies for risk reduction and mitigation and build upon robust knowledge base on different components of the risk function − hazards, exposure, vulnerability, and resilience.

These integrated maps provide information that can lead to disaster impact reduction through safety and environmentally conscious land use management. Local authorities and planners can use the information to complement and improve their land use policies and practices and consider the vulnerability of areas such as coastal zones or locations with a high number of residents

4. Conclusion/ Recommendation

The analysis showed that cities like Srinagar, Ahmedabad, and Guwahati are among the most vulnerable, while Ahmedabad remains vulnerable to urban floods, heatwaves and drought occurrences, Guwahati and Srinagar remain vulnerable to earthquakes, cyclones and landslides. Hence natural hazards such as flood, drought, extreme temperature, storm surge, and cyclone events already impact cities and these will be further exacerbated by climate change variability (CVV).

4.1 Disaster Risk Reduction (DRR)

Natural hazards such as floods, drought, extreme temperature, storm surge, and cyclone events already impact cities and these will be further exacerbated by climate change and variability. The cost of ignoring disaster risks is substantial for long-term growth and development, for example, floods in Chennai in 2015 and 2018 reportedly caused US$ 3 and US$ 4 billion losses to the economy (World Bank). Therefore, Disaster Risk Reduction (DRR) must be an integral part of masterplans/development plans.

Using GIS assisted spatial analysis, the vulnerability assessment of a city can be done to aid vulnerability mapping and planning instruments for building disaster resilience of the city. Vulnerability mapping allows improved communication about risks and what is threatened. It allows for better visual presentations and an understanding of the risks and vulnerabilities. Vulnerability maps are of use in all phases of disaster management: prevention, mitigation, preparedness, operations, relief, recovery and lessons learned

As per the Sendai Declaration, 2015, of UNISDRR, the cities are required to work towards reducing disaster mortality, reducing socio-economic losses due to disasters, reducing damage to critical infrastructure and basic services, and increase the access of the urban local bodies to multi-hazard early warning systems and disaster risk information and assessments

The use of indigenous knowledge alongside scientific knowledge is increasingly advocated to reduce community vulnerability to environmental hazards (Mercer J. et al, 2009). A framework is required for identifying how indigenous and scientific knowledge may be integrated to reduce community vulnerability to environmental hazards. Using GIS assisted spatial analysis, mapping can be used as a planning instrument for building disaster resilience in cities.

The above framework indicates how a city can identify its vulnerable sections and how its urban bodies can identify strategies and integrate them to formulate adaptive and mitigation options. This would, however, require investment in research and use of technology to enhance the development and use of hazard early warning and mitigation systems, preparedness, response, recovery, rehabilitation and reconstruction.

Reducing disaster risk and promoting a culture of disaster resilience lies in the knowledge of the hazards and the physical, social, economic and environmental vulnerabilities to disasters that most societies face, and of the ways in which hazards and vulnerabilities are changing in the short and long term, followed by action taken on the basis of that knowledge. Disasters can be substantially reduced if people are well-informed and motivated towards a culture of disaster prevention and resilience, which in turn requires the collection, compilation, and dissemination of relevant knowledge and information on hazards, vulnerabilities and capacities (Hyogo Framework for Action, 2005-15)

Identification of the Vulnerability Factors within city	→	**Community Engagement**	→	**Identification of Strategies**	→	**Integrated Strategies**
• Components contributing to hazard vulnerability		• Collaboration with community, vulnerable sections and city stakeholders		• Strategies from land-use planning, building bye-laws, environment strategies.		• Addressing all components of hazards to reduce Vulnerability to environment hazards

The *Sendai Framework* was adopted by UN Member States on 18 March 2015 at the Third UN World Conference on Disaster Risk Reduction in Sendai City, Miyagi Prefecture, Japan. It aims for the following outcome:
The substantial reduction of disaster risk and losses in lives, livelihoods and health and in the economic, physical, social, cultural and environmental assets of persons, businesses, communities and countries.

4.2 Database Management

In Indian cities, the lack of reliable data often results in little/partial action towards establishing disaster resilience and mitigation plans. Database of history and management capacity needs to be maintained for all hazards to aid in future planning and developments. The database will provide inundation information about the onset, duration, and passing of a hazard event like floods. Such information can be critical for land-use planning, for mapping evacuation egress routes, and for locating suitable emergency shelters to name only a few risk treatments.

City Disaster Management Plan (CDMP) needs to be prepared for cities like Bhopal and Hyderabad to not only provide with the past data and information on the disaster in the city but also to provide a platform for better governance and optimum available resource utilization. Efforts need to be made to incorporate risk and vulnerability assessment data into the National Urban Information System (NUIS) of the Ministry of Urban Development to make this information accessible to all. The data available can then be easily accessed by all government agencies and can be verified and updated regularly.

A team can be set up within the Municipal and Development Authority of the city, for collecting and updating the data at every stage of the crisis — before, during and after their occurrence. New application software can be incorporated to support value-added data and information requirements of disaster management units and coordinators of disaster relief.

4.3 Natural Resource Management through Macro and Regional Planning

The cities are characterized by varied natural resources which include water-bodies, wetlands, forests and rich biodiversity. For sustainable use of these resources, the cities need to understand the types of resources available within a region, their quality and quantity, and how to manage the same for a long period of time.

Cities like Shillong with a rich natural resource base and biodiversity, Natural Resource Plan can play a key function in not only upgrading the human index of the city but also how to make these resources resilient to disasters. A comprehensive resource plan is therefore essential for the city for managing its natural resources given its climate change vulnerabilities.

While Government schemes like JnNURM, Smart City Mission, AMRUT deal with city-level infrastructure and service development, city level natural resource management plan and regional plan can make the city well-informed about its hazards. The plan will serve as a guide to the Government agencies, local government bodies, NGOs, business and community so that timely action can be prepared to mitigate climate change and other natural hazards.

4.4 Governance and Institutional Framework

Urban local bodies, government organizations, and institutions play an important role in disaster risk management; the structures of individual institutions also need to adapt to be able to pursue disaster risk reduction more effectively. Policies and operational programs alike must be supported by appropriate organizational structures, systems, and attitudes.

The Urban Local Bodies (ULBs) need to develop financial independence and self-sustainability to achieve disaster resilience. As the governance structure is multi-layered with overlaps and duplication of functions, coordination among various departments is key to disaster mitigation plan's effectiveness and efficiency.

The status of the Governance and Institutional framework in the cities is indicated in Fig. 26. As can be seen, Bhopal is highly vulnerable as it lacks in its self-sustainability to achieve disaster resilience. The urban local body needs to assign responsibilities to update the disaster data with loss figures (impact). The city has an urgent need to integrate disaster resilience to revised Development Plans to increase investment utilization efficiency and make the city more disaster resilient along with development. The city administration is also required to take different convergence programs with other line departments and make them aware of the hazards in the city.

As discussed earlier, since the governance structure is multilayered with overlaps and duplication of functions, the city of Vishakhapatnam needs to develop a well-coordinated disaster response system integrating various departments. Integrated project management covering disaster resilience, adaptation, environment, and sustainability, is highly required as the city is being upgraded on all fronts.

Variables	Ahmedabad	Bhopal	Bhubaneswar	Dehradun	Guwahati	Hyderabad	Pune	Shillong	Srinagar	Visakhapatnam
Governance and Institutional Framework										
Disaster response system	L	H	L	L	L	M	L	L	L	M
City Disaster Management department	L	H	L	M	L	M	L	L	M	H
Dedicated persons to handle and update Disaster Risk Reduction (DRR) data	L	H	L	H	M	M	M	M	M	M
DRR in urban planning	L	H	L	M	M	M	M	M	H	M
Top down approach or Bottom up approach	M	H	L	L	L	L	L	L	L	M

Figure 26: Governance & Institutional Framework

For a strong institutional framework, the Municipal Authorities, Development Authorities and State Disaster Management Authorities of the cities are required to work in close collaboration. Efforts are required to strengthen 'institutional machinery' to ensure appropriate individual structures, mandates, and roles and responsibilities and encourage the communities to become more resilient to and cope better with the hazards that threaten their development gains.

4.5 Technical Capacity at Urban Local Body Level (ULBs)

As per the United Nations International Strategy for Disaster Reduction (UNISDR) definition, "*Capacity is the combination of all the strengths and resources available within a community, society or organization that can reduce the level of risk or the effects of a disaster*." Capacity building is integral to disaster management. The programs in disaster mitigation and recovery cannot be successful without building adequate capacities. Though the focus on capacity building has revived with the new vision on disaster management, the efforts toward building capacities have not been very systematic.

Variables	Ahmedabad	Bhopal	Dehradun	Guwahati	Hyderabad	Shillong	Srinagar
Investments and Intervention to improve urban services							
Investments in water sector (%)	M	M	M	L	L	L	M
Investments in sanitation sector (%)	L		M	H	L	H	M
Investments in solid waste sector (%)	L		H	L	L	H	H
Investments in storm water drainage sector (%)	L	M	H	H	L	L	H
Investments in BSUP (%)	M	M	M	L	L	H	M
Is there any dedicated budget in place for DRR	M	H	H	L	M	L	H
Incentive to house owners, business houses and public sector who comply to DRR		H	H	H		H	H
Budget for low income group to make them disaster resilient		H	H	M	L	M	H

Figure 27: Investments & Intervention to Improve urban services

The city of Guwahati can strengthen its resilience by improving its financial health. The financial capacity of all ULBs must improve to help them plan better. To strengthen the revenues and financing mechanisms for ULBs, there is a need for capacity-building programs for the ULB staff. The training need assessments should be taken up and the training should be conducted for the same. Capacity-building is required to efficiently track meteorological patterns, forecast impacts, and assess risks to make decisions and provide timely information on city disaster management capacity needs.

A city can build capacities of the grassroots level stakeholders in disaster management and follow a comprehensive and scientific approach to achieve its goals. The capacity for monitoring and forecasting climate change can significantly improve its disaster response management.

On June 22, 2016, the Compact of Mayors and the Covenant of Mayors announced the Global Covenant of Mayors for Climate and Energy, a newly merged initiative to bring these two efforts together. 639 cities, representing 483,836,581 people worldwide and 6.68% of the total global population have committed to the Compact of Mayors. At present 3 Indian cities, Gwalior, Shimla, and Rajkot are part of the Compact.

"Cities are the drivers of progress and innovation, and through the Compact of Mayors, they can help nations set new, aggressive climate targets over the next year."
– Michael R. Bloomberg, UN Secretary-General's Special Envoy for Cities and Climate Change

4.6 Robust Infrastructure

Physical infrastructure development of a city is very critical in building a stronger transportation system, water supply, sanitation and power infrastructure with optimum physical resilience. Most of the Indian cities have an inadequate and inefficient infrastructure. Storm water drains and water bodies are often chocked with garbage causing waterlogging and flooding; unregulated development in the river catchment areas has led to obstructing the natural flow of the stream. The storm water drainage system and sewerage can be augmented by improving service capacity and delivery efficiency. The cities are required to reconsider their urban designs and enforce building codes and land-use plans to reduce buildings in the risk-prone areas and reinforce structures to make them resilient to various hazards.

Variables	Ahmedabad	Bhopal	Bhubaneswar	Dehradun	Guwahati	Hyderabad	Pune	Shillong	Srinagar	Visakhapatnam
Infrastructure condition (basic services)										
Water supply (lpcd)	L	L		L	M	L	L	L	M	M
Sewerage system coverage	H	L	H	L	H	L	L	H	M	M
Solid waste management system coverage	L	M	H	M	M	M	M	H	H	M
Drainage (coverage & water logging incidences)	H	M	H	L	H	M	M	L	H	M

Figure 28: Infrastructure status in cities

The existing condition of infrastructure indicates that the city of Ahmedabad lacks in proper sewerage coverage and drainage network system. It also needs to manage its green areas and water bodies so that effluents do not accumulate and water quality is maintained. Rainwater recharge can also be made mandatory for the city to revive its depleting groundwater. Bhubaneshwar being prone to heavy rain and cyclonic activities needs to improve its existing major and minor drains and channels, improve channel sections of major drains and reconstruct and widen major drains. solid waste management in the city. Other cities like Guwahati, Shillong, and Srinagar also are inadequate in their provision of the basic services.

Important civic services and supporting infrastructure needs to be optimally working prior and post-natural and other disasters to ensure a rapid recovery from any natural disaster. Some infrastructure such as emergency response teams, hospitals and waste treatment and disposal facilities must be prepared to deal with the consequences of disasters. Substandard construction practices must be stopped; city authorities must provide an incentive for enforcing building codes as it would reduce the cost of the recovery phase and strive toward designing and developing more sustainable infrastructure.

4.7 Improving Socio-economic Conditions

Urban poor are more directly exposed to natural hazards compared to the other sections of society and face problems with urban expansion and limited infrastructure. It has been observed over time that slum-dwellers are one of the most vulnerable and marginal sections of the urban population and are often located in places with high hazard/ risk potential with no or inadequate means to reduce its impact. Slums are particularly vulnerable to flooding, often due to clogged drains, subsidence and are also more vulnerable to heatwaves and consequent health risks. In cities like Bhopal and Bhubaneswar, 26% to 44% of urban poor dwell in hazard-prone areas, riverbanks, low-lying areas and poor housing conditions thus being most exposed to the risks of floods and heatwaves. Again, in cities like Ahmedabad waterlogging in the low-lying slum areas gives rise to water-borne diseases. Hence, it becomes important to relocate these urban poor to more sustainable areas with the provision of affordable housing.

According to estimates of the Technical Group constituted by the Ministry of Housing and Urban Poverty Alleviation and National Building Organization (MOHUPA and NBO, 2013), the urban housing shortage in the country during the 11th Five Year Plan, by the end of 2012, was to the tune of 26.53 million dwelling units for 75.01 million. Central Government has launched several programs aimed at catering to the needs of the poor. Some of the recent programs for housing for poor include: Housing for All by 2022, Rajiv Awas Yojana (RAY), Affordable Housing in Partnership (AHP) Scheme, Jawaharlal Nehru National Urban Renewal Mission (JnNURM), Interest Subsidy for Housing the Urban Poor (ISHUP), and Valmiki Ambedkar Awas Yojana (VAMBAY). The cities need to implement these schemes to improve socio-economic conditions, the standard of living, and housing ownership of their poor.

4.8 Investments and Intervention through Public Private Partnership

UNISDR's 2013 *Global Assessment Report on Disaster Risk Reduction: From Shared Risk to Shared Value, the Business Case for Disaster Risk Reduction,* stresses on the need for private sector investment in disaster risk reduction. Public-private partnerships (PPP) have become a popular way for governments to engage private actors in the delivery of government infrastructure and services with the aim of increasing quality and providing better value for money. Corporate sector is a one of the key stakeholders in disaster risk reduction and can play an important role in awareness generation, disaster preparedness, and mitigation, planning through sensitization and co-opting the corporate sector in planning and response mechanism.

Fig. 27 indicates that most of the cities have resource constraints in making investments into better urban services, like investments in basic services, dedicated budget allocation for DRR, incentives to business houses who comply with DRR. In this scenario, disaster risk management in PPP mode can deliver socio-economic benefits such as reduced uncertainty in economic forecasts and growth projections, and reduced risks to life and personal property. An effective coordination between public and private stakeholders requires to be established to initiate improved information and communication, better planning and investments in building resilience.

The following framework can be implemented by the cities and their urban local bodies for an effective Investments and Intervention through Public Private Partnership for disaster resilience.

Virtual Cycle to increase PPP consultation for Disaster Resilience

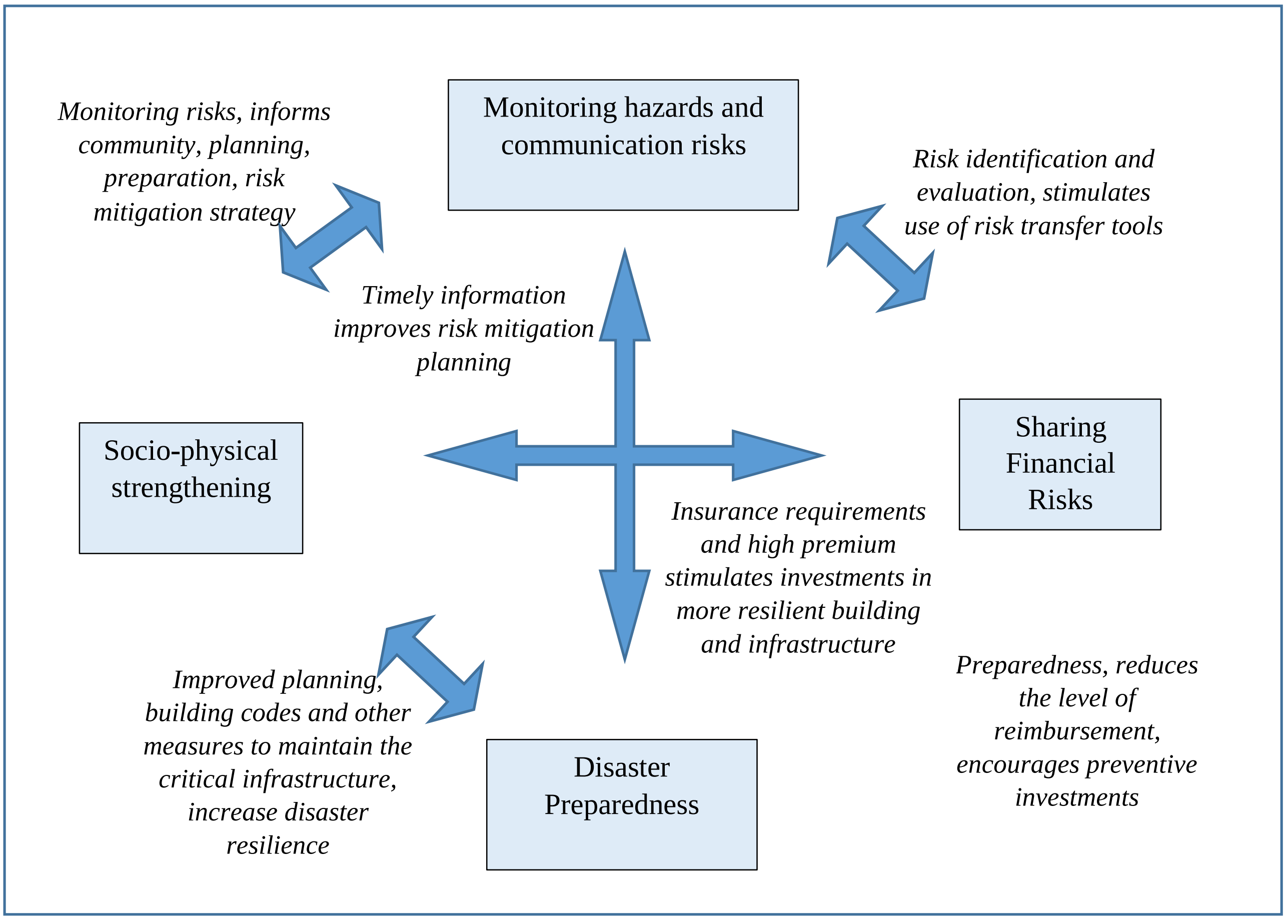


Figure 29: Virtual Cycle to increase PPP consultation for Disaster Resilience
Adopted from: Dalberg Development Advisors in World Economic Forum, 2008

Adaptive Action Plan and Mitigation Strategies are essential for efficient governance, updated disaster databases, early warning systems and rehabilitation systems. Disaster communication systems need to be strengthened for early warning to reach out to all citizens. GIS tools can be used to develop a ward wise Disaster zone maps and can be shared on a common platform.

Mitigation strategies, including improved building codes, for current and future construction, to avoid encroachments. The natural resource component needs to be considered with appropriate budget allocations for it. Additionally, there is a need for a dedicated emergency control room along with the required equipment for required services.

Reference

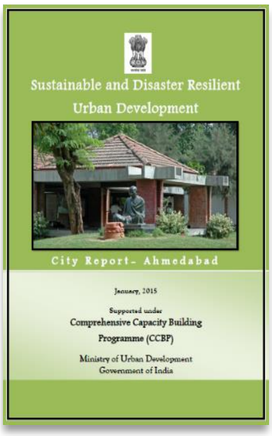
1. Prevention Web statistics, DMI, 2011
2. International Displacement Monitoring Centre, Norwegian Refuge Council and UNISDR, 2017
3. 2011 Revision of the World Urbanization Prospects – United Nations, 2012
4. Disaster management India, Ministry of Home Affairs, Govt. of India, 2011
5. Bansal N., Mukherjee M., Gairola A. (2017). Smart Cities and Disaster Resilience. In: Seta F., Sen J., Biswas A., Khare A. (eds) From Poverty, Inequality to Smart City. Springer Transactions in Civil and Environmental Engineering. Springer, Singapore
6. Disaster Risk Management in Asia and the Pacific Issues Paper, April 2013, A Joint Study of the Asian Development Bank and the Asian Development Bank Institute
7. Disaster management in India, Ministry of Home Affairs, GoI, 2011
8. Disaster Risk Reduction in the United Nations 2009, Roles, Mandates and Areas of Work of Key United Nations Entities (ISDR)
9. Vulnerability Atlas of India, Towards a Paradigm Shift from Post Disaster Reconstruction & Relief to Pre-Disaster Proactive Approach, NIDM, 2007
10. http://ndmindia.nic.in/disaster_management_in_india_09052017.pdf
11. NIDM, http://nidm.gov.in/PDF/safety/ppt/pres1.pdf
12. http://www.ndma.gov.in/en/disaster-data-statistics.html
13. Disaster Management in India, Ministry of Home Affairs, GoI, 2011
14. Gupta K. (2012). Issues of Urban Drainage - Present Status and the Way Forward. ENSURE 2012. Assam, India: IIT Guwahati; p. 18–21.
15. Seismic Hazards in India, http://www.newagepublishers.com/samplechapter/001449.pdf
16. http://agritech.tnau.ac.in/agriculture/agri_majorareas_disastermgt_landslide.html
17. NCRMP, http://ncrmp.gov.in/?page_id=6420
18. http://blogs.wsj.com/indiarealtime/2013/10/12/five-storm-disasters-that-hit-india/
19. "Accidental Deaths and Suicides in India (2014)" report by National Crime Records Bureau; Ministry of Home Affairs Government of India.
20. Seasonal Outlook update for the Temperatures during The Hot Weather Season (April to June), 2017. IMD
21. Perrow C. (2007). The Next Catastrophe, Princeton, NJ: Princeton University Press
22. http://censusindia.gov.in/2011-prov-results/data_files/india/Final_PPT_2011_chapter3.pdf
23. Primary Census Abstract for Slum, Office of the Registrar General & Census Commissioner, India
24. Report of the Technical Urban Group (TG-12) on Urban Housing Shortage 2012-17, Ministry of Housing and Urban Poverty Alleviation, September 2012
25. Service Levels in Urban Water and Sanitation Sector, Status Report (2010-11) MoUD, GoI, 2012
26. Urban Water Supply & Sanitation in India IIHS RF Paper on Water Supply and Sanitation, IIHS RF Paper on Water Supply and Sanitation, 2014
27. Water Resources Division, TERI
28. Betsy Otto is the Director of WRI's Global Water Program, ConnectKaro, 2017
29. Service Level Improvement Plans (SLIPS) submitted by states & cities for AMRUT, NIUA, 2016-17
30. McKenzie, D., & Ray, I. (2009). Urban water supply in India: Status, reform options and possible lessons. Water policy, 11(4), 442-460.
31. Census of India. 2011. http://censusindia.gov.in/2011census/hlo/hlo_highlights.html?drpQuick=anddrpQuickSelect=andq=Census+Drainage+facilities+in+households
32. http://www.hindustantimes.com/india-news/only-two-states-one-ut-equipped-to-treat-sewage-generated-in-urban-areas/story-6T90miICUREY89TL0bwYaI.html
33. Report of the working group on urban and industrial water supply and sanitation for the twelfth five-year-plan (2012-2017), http://www.planningcommission.nic.in/aboutus/committee/wrkgrp12/wr/wg_indu_sani.pdf

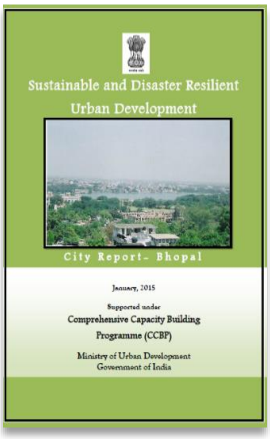
34. Kumar. K.P et al, (2015). ‘A Comparative Study of Storm Water Drainage Methods for Urban Storm Water Management’, Indian Journal of Science and Technology, Vol 8(33), DOI: 10.17485/ijst/2015/v8i33/78310
35. http://spaenvis.nic.in/index1.aspx?lid=2439&mid=1&langid=1&linkid=565
36. ‘Compendium of Good Practices, Urban Solid Waste Management in Indian Cities’, NIUA, 2015
37. CPHEEO. (2002). *Manual on Solid Waste Management*. New Delhi: MoUD
38. PMC. (2014 May). Solid Waste Management Overview. (UMC, Interviewer)
39. http://www.unisdr.org/2005/mdgs-drr/national-reports/India-report.pdf
40. International Federation of Red Cross and Red Crescent Societies (2001); "World Disaster Report - Focus on reducing risk"; IFRCRCS; Geneva
41. http://timesofindia.indiatimes.com/india/India-taking-lead-role-to-make-disaster-risk-reduction-a success/article show/46623884.cms
42. Mercer J. et al, (2009). ‘Framework for integrating indigenous and scientific knowledge for disaster risk reduction’ Disasters, Overseas Development Institute,http://onlinelibrary.wiley.com/doi/10.1111/j.1467-7717.2009. 01126.x/full
43. The Hyogo Framework for Action 2005-2015: Building the Resilience of Nations and Communities to Disasters.
44. Aditya Chunduru (2019) ‘Telangana: June was the hottest ever’ Deccan Chronicle. Nov 7, Telangana_%20June%20was%20the%20hottest%20ever.html

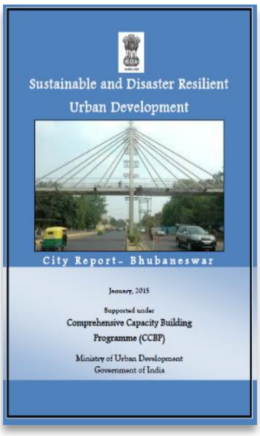
Climate and Disaster Resilient Smart Cities October 2015, New Delhi

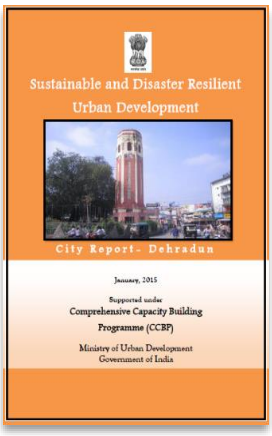
West India Regional Work Shop on Sustainable and Disaster Resilient Urban Development. September 2014, Ahmedabad, India

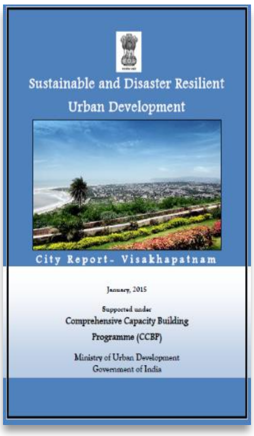
International Workshop on Sustainable and Climate Resilient Urban Development 2010 New Delhi

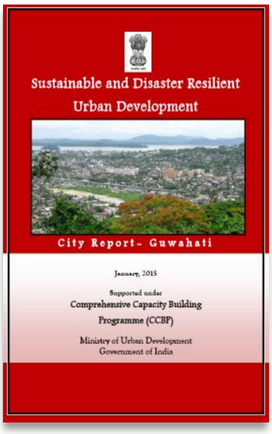


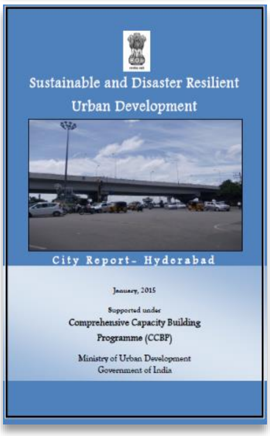


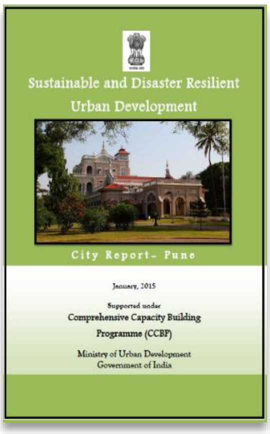


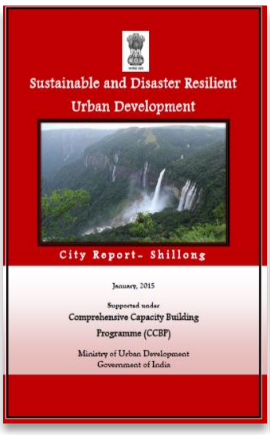


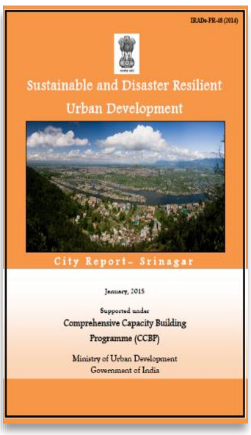












About IRADe

IRADe is an independent advanced research institute that aims to conduct research and policy analysis to engage stakeholders such as government, non-governmental organizations, corporations, academic and financial institutions. Energy, Climate Change, Urban Development, Poverty, Gender Equity, Agriculture and Food Security are some of the challenges faced in the 21st century. Therefore, IRADe research covers these, as well as policies that affect them. IRADe's focus is effective action through multidisciplinary and multi-stakeholder research to arrive at implementable solutions for sustainable development and policy research that accounts for the effective governance of techno-economic and socio-cultural issues.

IRADe was established under the Society's Act, in 2002 at New Delhi. It is certified as a Research & Development Organization by the Department of Scientific and Industrial Research (DSIR), Ministry of Science and Technology (MoST) and provides expertise to other ministries, national and international institutions, and partners with other reputed organizations.

About CoE

As a Centre of Excellence, IRADe is furthering the agenda of integrating various urban development efforts and documenting best practices and policy level prescriptions that could be understood and adopted by state and national level decision-makers; local administrations to help them link climate issues with the existing programmes in urban development. The project findings, results, methodology, cities covered and future strategy for India's Urban Climate Resilience has been delivered to various forums like IPCC-SREX, European Union and others.

Contact Us

Integrated Research and Action for Development (IRADe)

C-80 Shivalik, Malviya Nagar, New Delhi - 110017

Tel.: 91 (11) 2667 6180, 2667 6181, 2668 2226

Email ID: r.magotra@irade.org

IRADeNewDelhi @IRADe_Delhi Web: www.irade.org