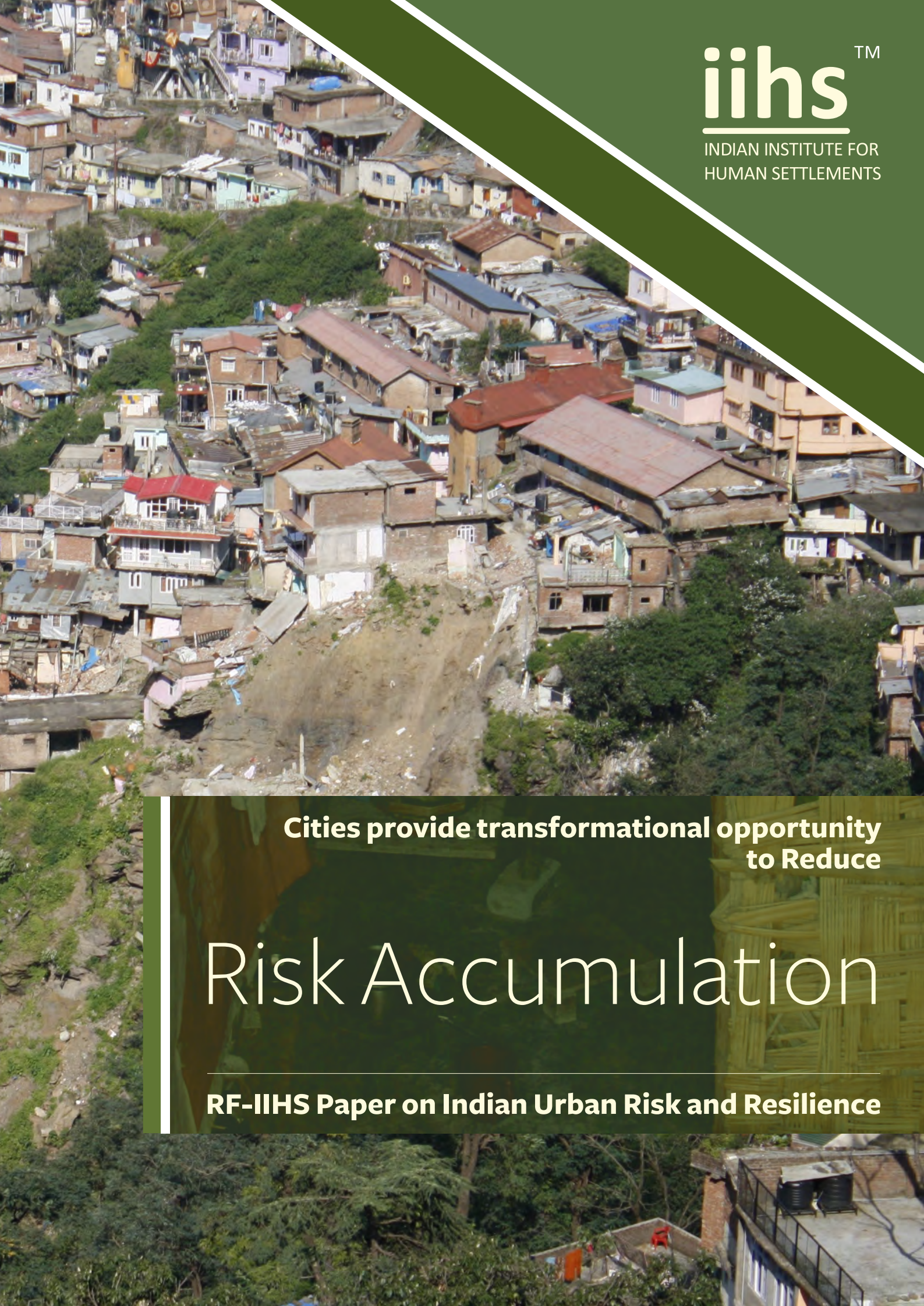

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Cities provide transformational opportunity to Reduce

Risk Accumulation

RF-IIHS Paper on Indian Urban Risk and Resilience

Cities provide transformational opportunity to reduce risk accumulation

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Abstract

It was only following the 1999 super cyclone in Orissa and the 2001 Gujarat earthquake, with the Hyogo Framework for Action adopted in 2005 in the backdrop, that India woke up to a national policy and act on disaster management. But despite the global move from hazard centric approach to a more holistic risk approach, programmes, policies and funding in India is still primarily emergency response and rehabilitation centric. It is also due to this approach and priority, disaster risk is perceived to be higher in areas that are more exposed to extreme hazards – namely the Himalyan region, the Indo-gangetic plains and the coastal areas, and not so much where vulnerabilities are inherent or capacities to respond low.

This paper is an attempt to analyse the current status of risk in India – how is risk defined, where is it concentrated and what are the current institutional and policy gaps – which if addressed holistically, can build a more resilient society. The primary objective is to identify policy interventions at various levels to enable urban resilience. Another motivation behind this research is to support the Rockefeller Foundation and ACCCRN's current work in India on resilience, and provide an overview of the status of risk in India.

The paper intends to move the current debates and policy frames from risk reduction, to a much larger goal of enhancing lives by building capabilities. It is argued that the capabilities approach is best thought of not as offering a detailed road map for policy, but as providing a critically different conceptualization of the purpose and principles of public policy (Orton, 2011). The paper seeks to underpin the ideological narrative in this idea, from which policy development can flow. The policy and programmatic focus needs to move from the idea of disasters to the concept of risks which are a composite of hazards (including climatic), vulnerabilities, exposure and capacities. Risks may accumulate over time or can be due to high intensity events. This paper also analyses where risk is accumulated in India, and the ways forward for reducing this risk

It builds on the fundamental risk equations (Peduzzi, Dao, Herold, & Mouton, 2009; Wisner, Blaikie, Cannon, & Davis, 2003) with an additional attribution to capabilities inherent to cities and their institutions. It uses disaggregated micro-level geographical data collected by various agencies such as ISRO-Bhuvan and Census at the national level, and global sources such as UNISDR's GAR 2013 (DesInventar, etc.) to arrive at an understanding of geographical concentration of risk in India. Geographical Information Systems (GIS) are used further to go beyond its city administrative boundaries, helping to identify urban agglomerations exposed to such risks. This paper systematically arrives at a priority set of locations, where risk can be addressed by either providing better early warning systems and planning, vulnerability reduction, exposure management or by building capacities. It further assesses the status of current institutional and planning systems adopted by them.[i]

In short, the paper attempts to: establish that risk is a composite of external and internal factors – incl. climate risks, natural hazards, as well as those that are human induced; establish that cities concentrate this risk in various forms and hold the potential for risk reduction; identify where in India is risk concentrated; assess the current institutional systems, policies and frameworks for risk reduction and resilience building; and, identify ways forward for various stakeholders towards a more resilient society primarily with two loci: (i) directing the policy discourse of reduction to the capabilities approach and, (ii) building a more integrated risk management system for building overall resilience.

Foreward

India is one of the more vulnerable and high-risk countries in the world (IFRC, 2005). Disaster loss is rising every year with grave consequences for the survival, dignity and livelihood of individuals, particularly the poor, and poses a severe setback to the hard-won development gains (HyogoFramework, 2005). Growing concentrations of people, built and economic assets in cities is exponentially increasing their propensity to disaster risk. While disasters are known to compound vulnerabilities, with increasing densities in cities and access to services and resources becoming more contested, this in turn is further accentuating people's vulnerabilities to disasters, making this a vicious cycle. Despite sufficient evidence presented by the International Panel on Climate Change (Aromar Revi et al., 2014) that there exists a strong correlation between changing climate and increasing frequencies and intensities of hazards, the level of preparedness for such events, particularly in developing countries like India, is still very low. With limited resources available to direct towards planning and resilience building, developing economies like India end up prioritising rehabilitation and rescue in the face of an event. Lack of data, access to technology and lack of technical and institutional capacities exacerbates this situation further. These changes and poor management makes them the locus of large and small scale disasters.

By 2011, there were 53 cities in India with population greater than 1 million. Many of these urban centres are exposed to multiple hazards, especially earthquake, cyclone, storm surge, drought, floods and fires. The impact is often multiplied due to multiple hazards occurring together and further aggravated by the growing socio-economic and climatic vulnerabilities. Additionally, the low perception of risk leads to even greater destruction due to lack of risk reduction practices. Public expenditure for relief on account of natural disasters can be taxing on the budgeted social sector expenses in successive years, which makes preparedness and mitigation pertinent.

While cities are collectors of risk, they also provide an immense opportunity to reduce this risk, if managed well in time. The number of cities where people and assets are concentrated is still very small - the number of rural settlements (0.64 million) exceeds that of urban areas (0.008 million) by nearly two orders of magnitude (Census, 2011). More risk can be mitigated by directing the research and other resources to the most vulnerable urban centres. Particularly interesting locations could be the second tier cities - which are in the process of developing and growing – planning ahead would not just safeguard their future, but it could actually provide for more enhanced lives for its forthcoming citizens.

Current Debates on Risk: Global and Indian

Theoretical perspectives on risks have undergone a shift over last couple of decades. During early part of 20th century, risks [referred to as disasters then] were attributed to natural forces, representing them as a departure from a state of normalcy to which a society returned to on recovery. This denied the wider historical and social dimensions of hazard and focused attention largely on technocratic solutions aimed at resisting these natural forces (Bankoff, 2001). Moreover, the measures relied on top-down command and control model. However this approach failed and vulnerability to disasters was seen to increase exponentially in spite of heavy investments in technology-centred measures.

Another implication of this approach was predominant focus on providing post disaster relief both in cash and kind, which resulted in instances of increased dependencies of the victims who were merely provided with readymade solutions. Reconstruction was mainly aimed at provision of shelters and infrastructure through large scale contractor driven reconstruction projects. However many of these reconstructed settlements and disaster resistant houses were found to be unsustainable and thus reinforced or sometimes even increased disaster vulnerability (Jigyasu, 2002). Also this approach did not adequately address the needs of developing countries that have limited resources and capacity to undertake capital intensive measures.

However over last few decades there has been a paradigm shift in this conceptual understanding of disasters that resulted from ineffectiveness of techno-centric approaches. In the eighties and nineties of the last century, disaster research took on a new meaning in the field of social sciences with research on the societal response to various disasters. Accordingly, disaster vulnerability extended beyond the mere probability that someone is killed, injured, or suffers loss. It was also seen to embrace the relative ease or difficulty with which an individual, family group or social group recovers following a disaster (Wisner et al., 2003). The new approach to disaster got rid of the overwhelming notion of agent such as earthquake. Starting from an analysis of disaster seen as a process tightly tied to social vulnerability, the new paradigm considers the causes of disaster are to be explained on structural as well as contextual grounds. (Hewitt, 1997)

The new paradigm is increasingly "vulnerability centred" as risks are understood as phenomenon linked to physical, social, economic and institutional vulnerability. Besides this approach also tends to look at specific vulnerabilities of various groups of people such as women, children, elderly, disabled, ethnic/racial or religious minorities, economically poor etc. (Enarson & Morrow, 1998; Hewitt, 1997; Wisner et al., 2003). Vulnerability is subsequently analyzed by identifying "underlying factors" and "root causes" embedded in everyday life, which give rise to dynamic pressures affecting particular groups, leading to specifically "unsafe conditions". (Wisner et al., 2003)

A consequence of this shift has been much closer linkage between disaster, risk and development. Disasters impede development but ill-conceived development may cause disaster. Rapid and unplanned urbanization in the developing world is a consequence of this so called development. The latter relationship is also particularly relevant when it comes to the vulnerability of urban and rural poor in the developing world who have little access to the resources, power and choice mechanisms needed to radically change their life circumstances. The mismatch between assets stock and consumption stock contribute towards aggravating vulnerability of those who are at the bottom end of the pyramid.

There has also been an increasing focus on capacity to reduce disaster risks, face them (resilience) and cope with their consequences. In fact both vulnerability and capacity are considered together as reduction in one can lead to increase in the other. Mary Anderson and Peter J. Woodrow (1989) have categorized these as physical/material, social/organizational and motivational/attitudinal (Anderson & Woodrow, 1989).

The employment of the concept of social vulnerability as a tool in and by the community also involves a thorough analysis with and by the residents of their own resources and capabilities. Therefore the new approach lays emphasis on community driven approaches for disaster risk management and engagement of various stakeholders. Vulnerability centred impact approach thus seeks to consider physical, social, psychosocial, economic and political causes as well as impacts of disasters.

Another implication of the changing paradigm is shift to a multi-hazard approach that seeks to consider all hazards that contribute towards risk in a given area. Rather than focusing on implications of a single hazard, the new paradigm considers key questions for complex disaster scenarios; (1) what might possibly happen? (2) how likely it is? (3) what damage, injury and loss may result? (4) what will be the impact of the event? And (5) what can be done about it? (Bhandari, 2006). Apart from these intensive hazards, there are additional implications of risks that accumulate over time such as health risks, exposure to bio hazards, etc. which may precede or succeed an intensive hazard, intensifying the risk impacts even further.

The implication of these conceptual shifts is being seen on the practice of disaster risk management, which has graduated from an earlier "relief" mode to "preparedness" for all phases of disaster, namely prevention, response and recovery.

Box 1 : Case for Preparedness – Orissa

There are examples that illustrate how better planning and preparation has reduced the impacts of hazards. For instance in Orissa, about 10,000 lost their lives post the 1999 super cyclone, and 154 in the very severe cyclone that just preceded that a few days before, requisite steps were taken at the state, city and village levels and the lives lost came down to as much as 21 people during the 2014 very sever cyclone.

Comparison of key parameters for three cyclones in State of Orissa

	Phailin	Paradip Cyclone / Cyclone 05B	Gopalpur / BOB 05 (04B)
Period	8-14 Oct 2014	25-23 Oct 1999	15-19 Oct 1999
Max. intensity	Very Severe Cyclonic Storm	Super Cyclonic Storm	Very Severe Cyclonic Storm
Max Wind (kts)	115	140	
Max Rainfall (cm)	53	39	
Storm Surge (m)	2-3	5-6	
Lowest Pressure (hPa)	940	912	
Lead Period (hrs)	120	24	
Forecasting Accuracy	100% Accurate	Moderate	
Loss of Human Life	21	9887	154
Ex-gratia paid by Govt @ INR 6Lakhs	1.26Cr	593Cr	9.24Cr
Stretch of Evacuation (km)	180	500	300
Cost of evacuation (Million) *(assumption: INR 1 Million/km)*	180	500	300

**Calculation is based on assumption that similar amount would have been spent for evacuation & payment of ex-gratia in 1999 as in 2013*

Source: Information cited form the presentation delivered by Dr M Mohapatra (IMD), Investment in DRR: strengthening Regional Mechanism for EWS | SAARC DM Centre, New Delhi, 21FEb2014

Furthermore, the critical link between disaster risk reduction and factors of urban sustainability are more likely to be addressed by local rather than central authority. Reaching out to local governments to help them build capacity, acquire knowledge and resources and provide them with decision-making authority is essential for loss reduction in hazardous events and building resilience in urban settlements (Bendimerad, 2006).

United Nations International Strategy for Disaster Risk (UNISDR) was adopted by United Nations Member States in 2000, aiming to guide and coordinate the efforts of a wide range of partners to achieve substantive reduction in disaster losses and build resilient nations and communities as an essential condition for sustainable development. The strategy played an important role in bringing out this conceptual shift from response to risk reduction.

The Hyogo Framework for Action adopted at the World Conference on Disaster Reduction in 2005 stated one of its strategic goals as the more effective integration of disaster risk considerations into sustainable development policies, planning and programming at all levels, with a special emphasis on disaster prevention, mitigation, preparedness, and vulnerability reduction. The follow up on this framework after 10 years is at Sendai in 2015 which will aim at furthering the work for global risk reduction.

In India, though most of the theoretical debates on disasters are rooted either within engineering field (earlier paradigm) or in geography and development theory (new paradigm). That is why the new paradigm has increasing focused on the analysis of socio-economic vulnerability conditions. Links with urban planning, design and management have not been strongly articulated in theoretical discussions on disasters. That is one of the reasons that disaster risk management has had predominant focus on rural areas while urban risk reduction initiatives leave much to be desired especially in the light of urbanization process that characterizes Indian settlements.

Theoretical reflections on disasters have largely focused on short term response and recovery following disaster. Longer perspectives on disasters would throw important light on differential impact on different sections of people. Longitudinal studies would also bring about important insights on links with slow and cumulative risks due to local development context as well as changes in the frequency and intensity of disasters that are partly explained by the growing phenomenon of climate change.

It is important to mention here that although paradigmatic shifts on disasters have taken place at theoretical level, these have not really translated into tangible results for disaster resilient settlements and communities. Rather the frequency and intensity of disasters is increasing exponentially, and the impacts are especially higher in developing countries [ii].

PART A: What is risk?

Components of risk

Historically, risk was primarily associated with an external force or agent. But it is now well accepted that risk is a composite of external as well as intrinsic characteristics of elements that affect their propensity to risk[iii]. It can arise out of natural (tectonic or climatic) as well as man-made hazards (unsustainable resource management, unsafe water supply and sanitation practices, etc.) These are exacerbated by the elements' physical location and specific characteristics making them more vulnerable to certain external forces. Often their ability to respond to these hazardous events puts them in better or worse situations as compared to some others, and these capacities need to be explored and improved in order to reduce overall impacts of risk. These risks vary over time – both in impact and their accumulation, and vary significantly by geographical location of the elements.

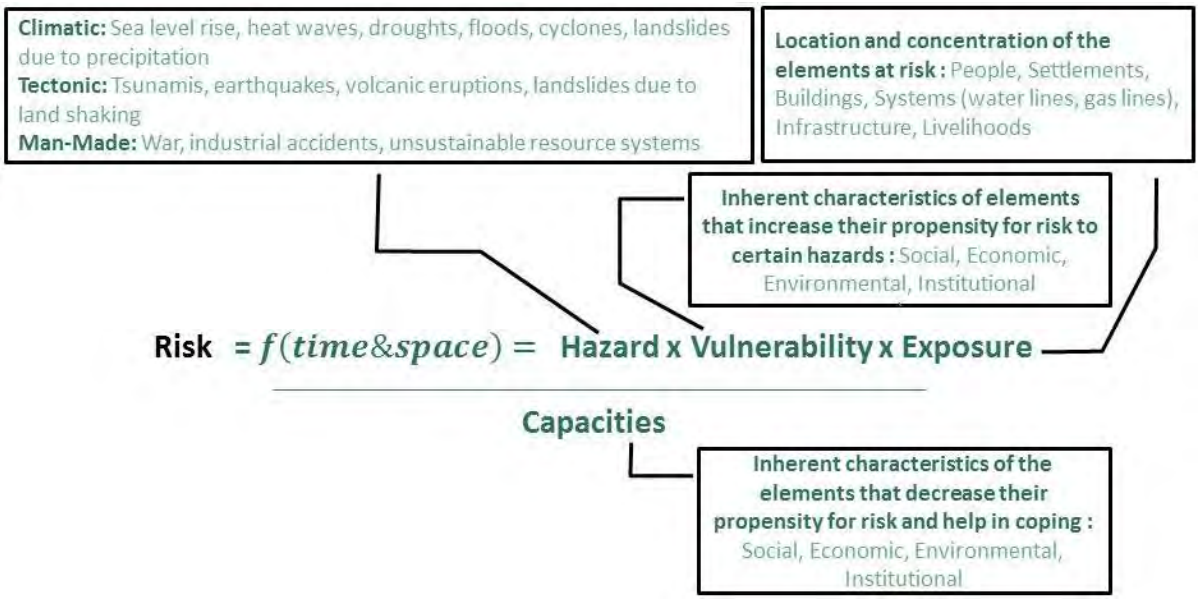


Figure 1 : Risk and its multiple dimensions
Sources: Adapted from (Peduzzi et al., 2009; Wisner et al., 2003)

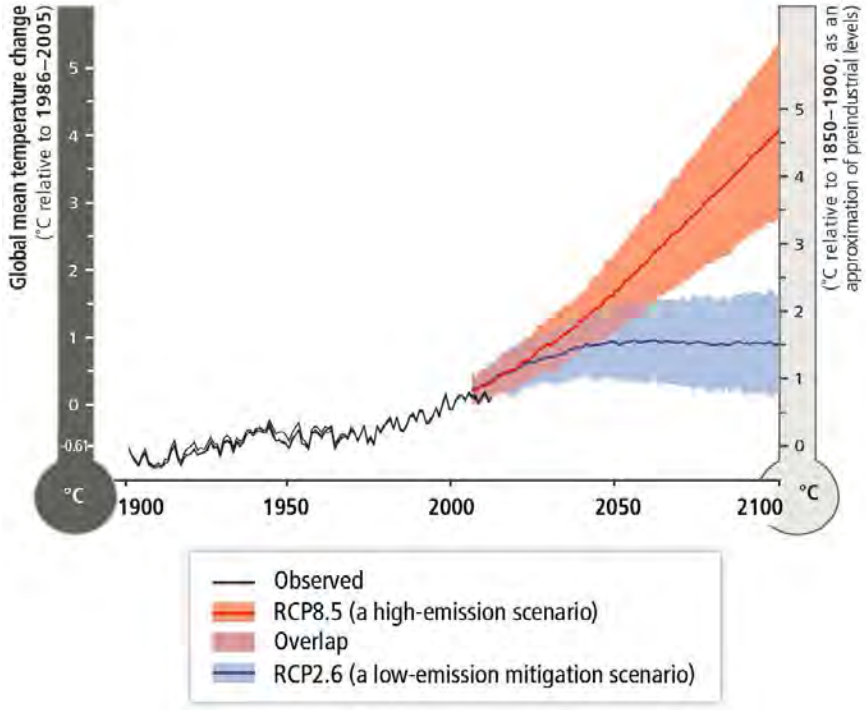
Risk is a composite of external factors as well as intrinsic characteristics that make a system and people vulnerable to these external agents. The underlying reasons for these vulnerabilities may arise out of socio-economic process, which may ultimately be quite remote from the hazard event itself. But it is due to these vulnerabilities, that the impacts felt by some people may be more severe than others. Often, there are deeper socio-political reasons that certain people are forced to live in areas which makes them more exposed to certain hazards, and thereby at greater risks. This lack of choice exacerbates their vulnerabilities, exposure and often also the abilities to respond, and in the face of an event leaves them even more vulnerable than before. It is this that Wisner called the cause and effect model of vulnerability (Wisner et al., 2003).

Intergovernmental Panel on Climate Change (IPCC) defines risk as the potential for consequences where something of human value (including humans themselves) is at stake and where the outcome is uncertain. Risk is often represented as probability of occurrence of hazardous events or trends multiplied by the consequences if these events occur: Risk = (Probability of Events or Trends) X Consequences

Climate induced risk

Climate change and variability are now known to have primary and secondary order impacts on cities and their populations. The risk of severe loss at multiple scales due to climate change-related hazards such as extreme events is particularly high in large urban areas. The IPCC's Fifth Assessment Report states with very high confidence, based on robust evidence that urban climate change-related risks are increasing (including rising sea levels and storm surges, heat stress, extreme precipitation, inland and coastal flooding, landslides, drought, increased aridity, water scarcity, and air pollution) with widespread negative impacts on people's health, livelihoods and economic assets. All risks are exacerbated for vulnerable populations who live in informal settlements or in hazardous areas and lack access to basic infrastructure and service provision (A. Revi et al., 2014).

For most hazards in urban areas associated with climate change, risk levels increase from the present (with current levels of adaptation) to the near term. High adaptation can reduce these risk levels significantly. However, for the longer term, especially under a global mean temperature increase of 4°C, adaptation is less effective (A. Revi et al., 2014).



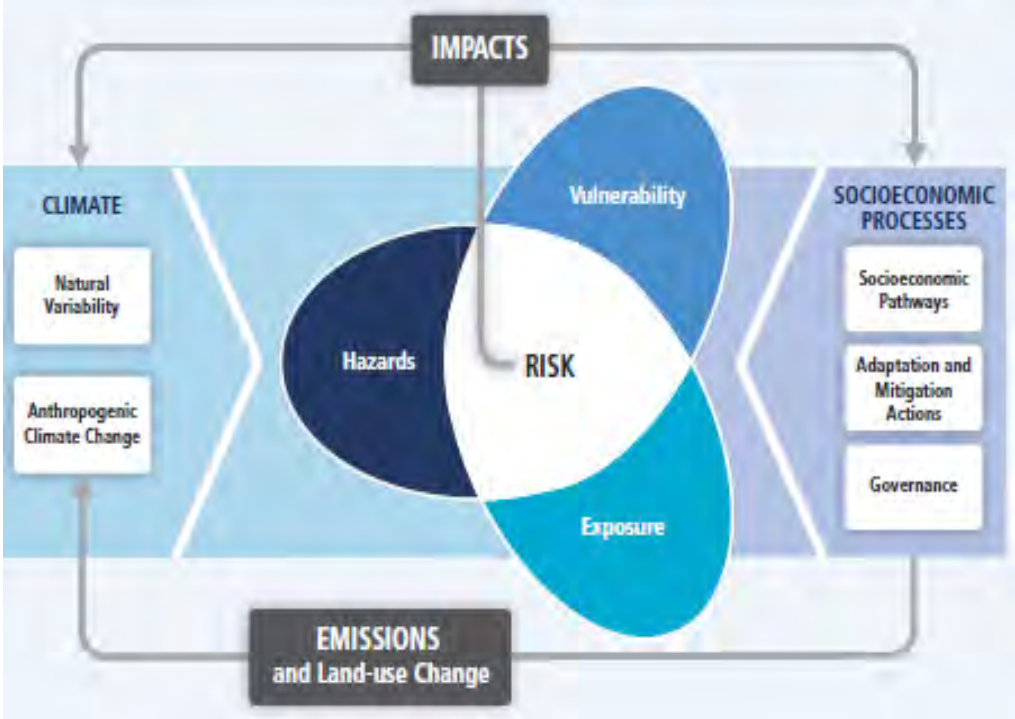
Observed and projected changes in annual average surface temperature. This figure informs understanding of climate-related risks in the WGII AR5. It illustrates temperature change observed to date and projected warming under continued high emissions and under ambitious mitigation. (IPCC, 2014b)

The IPCC's Fifth Assessment Report states with medium confidence that a wide range of infrastructure systems (water and energy supply, sanitation and drainage, transport and telecommunication), services (including health care and emergency services), the built environment, and ecosystem services are exposed to climate change-related risks (A. Revi et al., 2014). However, as per the core concept of the WGII AR5, risk of climate-related impacts results from the interaction of climate-related hazards with the vulnerability and exposure of human

and natural systems. Changes in both the climate system and socioeconomic processes including adaptation and mitigation are drivers of hazards, exposure, and vulnerability (IPCC, 2014b).

Figure 2 : Climate Risk and Socio-economic Processes

(IPCC, 2014b)



Risk of severe ill-health and disrupted livelihoods for large urban populations due to coastal and inland flooding is projected in some regions(IPCC, 2014a). Risk of mortality and morbidity during periods of extreme heat exist for vulnerable urban populations and those working outdoors in urban or rural areas(IPCC, 2014b).

Drought exposure can have many effects in urban areas, including increases in water shortages, electricity shortages (where hydropower is a source of energy), water related diseases (through use of contaminated water), and food insecurity from reduced supplies. For cities in arid and semi-arid regions, already struggling with water shortages and rising demand, changes in rainfall patterns and evaporation rates, may further reduce water availability(Gober, Kirkwood, Balling, Ellis, & Deitrick, 2010)

Over the longer term and through teleconnections to agricultural land, city populations also face the risk of climate change to human systems (agricultural and water resource systems) which is increased by the loss of ecosystem services (for water purification, protection from extreme weather events, preservation of soils, recycling of nutrients and crop pollination) (A. Revi et al., 2014). The impact of floods, droughts and heavy rainfall on agriculture may fall outside the jurisdiction of urban governments, but can increase food prices and food insecurity. (A. Revi et al., 2014) Under scenarios of prolonged drought conditions and resultant food price increases, a large number of urban poor, especially wage labourers, may shift from transient to chronic poverty (Ahmed, Diffenbaugh, & Hertel, 2009; Hertel, Burke, & Lobell, 2010)

The IPCC Fifth Assessment Report includes India in one of the 20 countries and regions that are most at risk from climate change exacerbating current risks and in turn further entrenching poverty (IPCC, 2014a). For example, based on low-level elevation zones, population density, and areas of storm surge zones, highest sensitivity to sea level rise by 2050 is expected for India, Indonesia, China, the Philippines, and Bangladesh (IPCC, 2014a). India is expected to experience an 80 percent increase in its population at risk from sea level rise(IPCC, 2014a).

Extensive and intensive risks

Risks are not limited to sudden ruinous events, but they also accumulate over time in the form of recurring conditions of moderate intensities. Intensive risks are risks associated with the exposure of large concentrations of people and economic activities to intense hazard events such as high intensity earthquakes, severe floods and cyclones, etc., which can lead to potentially catastrophic disaster impacts involving high mortality and asset loss. On the other hand, extensive risks are widespread risks associated with the exposure of dispersed populations to repeated or persistent hazard conditions of low or moderate intensity, often of a highly localized nature, which can lead to debilitating cumulative disaster impacts (UNISDR, 2009). According to the Desinvetar data on the State of Orissa, there were more economic losses and people affected by extensive risks as compared to intensive risks, although number of lives lost are still higher due to intensive risks.

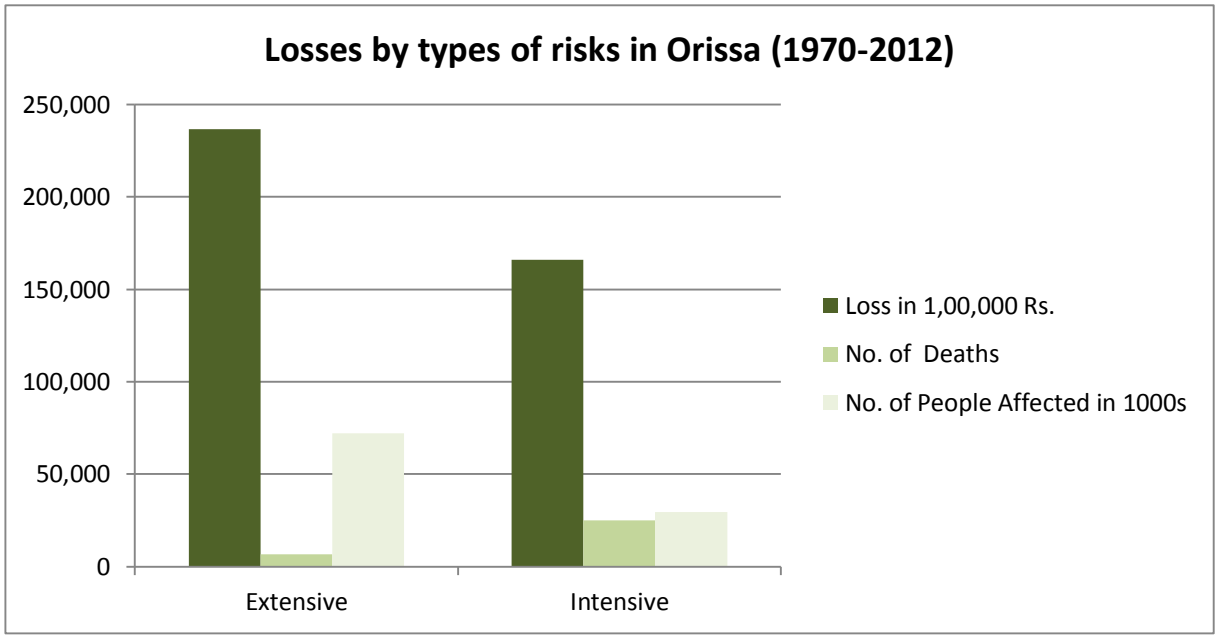


Figure 3 : Losses by types of risks in Orissa (1970-2012)
Source : Desinventar, 2013

Impacts of risks

Risks don't occur - they unfold. There is a fundamental difference in time between sudden severe events and slow-developing risks such as famine or pandemics (in which the most acute distress may extend over a period of months and years). Following a sudden impact which often only lasts for a few seconds or days, there are often longer ranging impacts on the quality of lives and livelihoods. But the pre-conditions for risks may have been forming over a long period aggravating the impact of the sudden occurrences. Slow-developing risks such as famine or pandemics may have smaller intensities, but due to their recurring characteristic, they often accumulate risks which are much larger and destructive than sudden impacts. While loss of lives and houses, sale of assets, livestock and jewellery are often seen within weeks of the sudden impacts, but other changes such as those in class relations, increased inequality, contested limited opportunities for livelihoods, adjusting the household budgets towards medical treatments and accessing food rather than investing in education and other assets – often leads to far reaching changes in the ways people would have lived.

Spatial convergence of impacts in different sectors creates compound risk in many Indian cities, often with associated health impacts. Cities and city regions are sufficiently dense that they influence their local micro-climate (A. Revi et al., 2014). A case in point is the urban heat island (UHI) effect. For cities in India, the implications of future climate for connections between urbanisation and the development of UHI have been established (Mohan, Kandya, & Battiprolu, 2011; Mohan et al., 2012; Mohan, Pathan, Narendrareddy, Kandya, & Pandey, 2011). Increased warming and physiological stress on human comfort level, and therefore productivity, is predicted in a variety of cities(Thorsson, Lindberg, Björklund, Holmer, & Rayner, 2011). Hot days are known to have significant health impacts, which can be worsened by both drought conditions and high humidity. Effects of high temperatures on morbidity and mortality have been shown for populations in India and Thailand (McMichael et al., 2008). In India, contaminated urban flood waters have caused exposure to pathogens and toxic compounds (Sohan et al., 2008). While malaria prevalence is often influenced by non-climate variability factors, studies from India and Nepal have found correlations with rainfall (Dahal, 2008; Dev & Dash, 2007; Devi & Jauhari, 2006).

Part B: What is the current status of risk and risk management in India?

India's Risk Profile

According to the data collected by the Centre for Research on the Epidemiology of Disasters[1] India, in the last millennium, has lost about 9 million people to nearly 620 large scale natural events. These disasters have also left many millions severely affected, of which many are affected multiple times over. The economic losses as documented by them are of the order of 58 billion USD, which amounts to nearly 0.03% of National GDP every year for 100 years. These numbers, however high, still do not capture secondary order and long term losses, such as those to health, quality of life with disabilities and effects on livelihoods. Also, due to lack of disaggregated data, it is hard to identify how much of these losses were in the urban locations. Yet, going forward with increasing urbanisation, these losses are going to increase and get more concentrated in cities.

[1] http://www.emdat.be/

Table 1 : Summary of Natural Disaster Losses in India from 1900 to 2014

	# of Events	Killed (in million)	Total Affected (in million)	Damage (in billion US$)	% of total Events	% of total killed	% of total affected	% of total damage
Drought	14	**4.25**	**1,061.84**	2.44	2.23	**46.58**	**52.50**	4.21
Earthquake & Tsunami	28	0.08	28.55	5.22	4.45	0.86	1.41	**9.01**
Epidemics	68	**4.54**	0.42	0.00	10.81	**49.80**	0.02	0.00
Extreme Temperature	53	0.01	0.00	0.54	8.43	0.16	0.00	0.94
Flood	**254**	0.07	**820.92**	**37.41**	**40.38**	0.74	**40.59**	**64.50**
Insect infestation	1			-	0.16			
Landslides & Avalanches	44	0.00	3.84	0.05	7.00	0.05	0.19	0.09
Storm	**165**	0.16	106.85	**12.32**	**26.23**	1.80	5.28	**21.25**
Wildfire	2	0.00		0.00	0.32	0.00	-	0.00
Total	629	9.12	2,022.43	57.99				

Source : "EM-DAT: The OFDA/CRED International Disaster Database, 2014

India with its large population and size represents a unique case. Owing to its geo-climatic location, India is exposed to multiple hazards and has experienced several disasters in the past. These disasters can be divided into extreme one-time events and regular every day events. In India, floods are most recurrent and destructive. Floods add up to nearly 40% of all natural disasters occurred in the country and account for 65 % of the total damages.

Indo-Gangetic Plains and Brahmaputra river delta are one of the high flood prone regions in the country, and flood is an annual feature in these regions. These snow-fed rivers, combined with heavy rainfall, cloud bursts during monsoons result in devastating floods and flash floods in this area. Krishna, Godavari, Cauvery and Mahanadi river deltas in the peninsular region are also prone to frequent flooding. These seasonal rivers get flooded because of heavy rainfall in the catchment region during the monsoon season. Maharashtra Floods (2005), Kosi floods (2008), Andhra Pradesh Floods (2009), Uttarakhand and Uttar Pradesh Floods (2013), Orissa (2013), Assam (2014) and Kashmir Floods (2014) are some of the devastating floods in the recent past. With flood forecasting and monitoring systems in place, the number of life's lost to floods is significantly reduced, but thousands of homes, livestock and vast areas of farm land get affected in these floods.

Heavy precipitation associated with cyclonic storms and depressions is one of the major causes for flooding, especially in the coastal regions. According to the EM-DAT data, cyclones killed more than 100 million people from 1900 -2014. With 165 occurrences, cyclones add up to approximately 25 % of the total disaster occurrences from 1900, and account for nearly 20% of total economic damage. 1999 Paradeep cyclone which hit the coast of Orissa, is one of the most intense cyclone in the recorded history and killed nearly 10,000 people. The cyclone had estimated wind speeds of 260 -270 km/h and the surge height was reported as approximately 20 feet (Kalsi, 2006). In a similar intensity event in 2013, Cyclone Phailin, state government evacuated nearly 1 million people from coast, and as a result of this total life loss reported in the event was 38 persons(Re, 2014). Cyclone Hud Hud (2014), Cyclone Nilofar (2014) Cyclone Thane (2011), Cyclone Laila (2010), Cyclone Nisha (2008) are some of the recent severe cyclonic storms in the country.

In comparison, east coast has more cyclonic activity and is more vulnerable to cyclonic storms than the west coast. Of all the 623 cyclonic and severe cyclonic storm reported (1891 – 2013), nearly 80 % of them were formed over Bay of Bengal. Nearly 50 % of all the reported cyclones were formed between October and December[2].

When a cyclonic or severe cyclonic storm hits the coast, some of the associated risks are heavy precipitation within short time period, damaging wind speeds, floods, flash floods and storm surge. In Paradeep Cyclone 1999, the estimated height of surge was nearly 20' (~ 7m)(Kalsi, 2006). Along with these, population living in the coastal regions are also exposed to hazards like tsunami, salt water intrusion, and coastal erosion. 2004 Indian Ocean Tsunami killed more than 10,000 people and affected more than 2.5 million people. The height of the wave reached upto 10 m in parts of Tamil Nadu and Pondicherry (MoHA, 2011).

In the last century, nearly 4.5 million got killed and 1 billion got affected because of drought in the country. Agriculture sector is the most affected in a drought event. The secondary impacts include loss of crop, malnutrition, loss of livelihood leading to suicides and migration, and other environmental impacts. In 2009, nearly 40% of land was affected by drought. In India, nearly 68% of land is drought prone, of which 33% is considered as chronically drought prone (MoHA, 2011).

In addition to drought, earthquake is another major hazard related to land. Nearly 60% (Zone V – 11.4%, Zone IV – 16.8 %, Zone III – 30.2 %) of land is prone to earthquakes of intensity MSK VII (MMI VII) or more. Himalayan region is considered to be one of the high earthquake risk zones, is vulnerable to earthquakes of magnitude 8 and above in the future (MoHA, 2011). Some of the major earthquakes in the past were Uttarkashi Earthquake (1991), Latur Earthquake (1993), Koyana Earthquake (1997), Chamoli Earthquake (1999), Bhuj earthquake (2001) and Sikkim earthquake (2011). Nearly 20,000 people got killed in the Bhuj earthquake of Magnitude 7.7. City of Ahmedabad, located nearly 350 km from epicentre also got severely affected. In comparison, North, North- West and and North Eastern reions are more seismically active than the peninsular region.

Landslides and rockslides are also considered as secondary disasters to earthquakes and heavy precipitation. The Himalayan region in particular is prone to landslides triggered by earthquakes. In addition to Himalayan region, Eastern and Western Ghats in the peninsular region are prone landslide hazards that are triggered by precipitation. Arunachal Pradesh, Manipur, Mizoram Nagaland Himachal Pradesh, J&K, Sikkim and Uttarakhand, located in the Himalayas are the most exposed to earthquake and precipitation induced landslide hazard.

Other significant natural disasters in the past in India were related to Cold Wave, Heat Wave, Epidemics, Soil Erosion, technological or human-induced hazards like chemical and industrial accidents, dam failure, excessive mining etc.With increasing population densities in the coastal regions and flood plains, more and more people are getting exposed to these hazards.

Using the GIS models, it is estimated that approximately 50% of the India's land mass and 15% of the total population are exposed to cyclonic wind speeds of damaging wind speeds greater than 100km/h. Nearly 60% of total land mass and 70 % of total population are exposed to moderate to very high earthquake hazard risk. More than 12% of the total population are living in flood prone

[2] Cyclone eAtlas- Indian Meteorological Department

areas with return period between 1-50 years. In total, 76% of the Indian population is exposed to high to medium hazards[iv], of which 29% lives in the 468 cities with population more than one lakh. With large number of population living in high dense locations and with associated socio-economic vulnerabilities, cities continue to grow as hotspots for hazard risks.

(Refer to Appendix 8: State-wise Population and Area Exposure *for state-wise population and area exposed to flood hazard, cyclonic wind speed hazard, earthquake hazard, earthquake and precipitation induced landslide hazard)*

Urban risk: urban and rural differentiators

We will argue in this section that while cities agglomerate risk, create risk and often serve as respondents to risk experienced elsewhere, they also offer transformational opportunity to address these risks - building on the established institutional and financial capacities of the cities as well as their limited numbers as compared to rural locations.

Cities agglomerate people and economic output in small geographic areas. Urban areas account for a disproportionately small amount of India's terrain when compared with their significant and rising share of economic output. According to the Census of India 2011 as well as calculations by the IIHS Geospatial Lab (Revi et al., 2011), the top 10 cities of India account for almost 8% of India's population, produce 15% of total economic output but only occupy approximately 0.1% of the total land area. Similarly, the 53 million plus cities are estimated to account for 13% of the population, produce about a third of total economic output and occupy approximately 0.2% of the land. The top 100 cities are estimated to account for 16% of the population, produce 43% of India's total output and occupy approximately 0.26% of the land. These estimates are necessarily rough given the absence of reliable disaggregated data for urban areas but the emerging economic importance of cities as well their increasing demographic presence is clear.

Poverty and vulnerabilities are growing in cities. There seems to be a persistence of poverty and inequality in urban areas, particularly looked through the lens of slums and unemployment. Although the proportion of the poor in the total population is falling both in urban and rural areas, the absolute number of urban poor is increasing (Chen & Raveendran, 2012). Million plus cities are indeed home to 40 per cent of the slum population. However, the majority of the poor are, in fact, concentrated in medium and small towns - 80 per cent of the urban poor reside in cities with populations less than one million (Revi et al., 2011). In terms of employment, the extent of informality in urban employment is high at around 70 per cent. It has remained largely unchanged over the course of the past decade. Almost 60 per cent of total urban employed are wage workers, and 67 per cent of this category are informal wage workers. The remaining are largely the urban self-employed, which include own account workers, employers, and contributing family workers (Chen & Raveendran, 2012). Much of urban India's infrastructure is in relatively poor shape, especially in the non-metropolitan cities. The JNNURM has started changing that for a fraction of the cities in the country, but the investment and absorption deficits are so large that it is becoming difficult even to catch-up with the expanding informality and growth in city sizes.

Distress migrants from rural to urban and non-migrants in the urban areas are more vulnerable due to lack of choices. While much of the research conducted in the fields of human migration, environmental climate change, development, economics and human health have done so

through a narrow disciplinary lens, a common vulnerability unites the impoverished and displaced in countries of South-Asia. Aromar Revi, a leader in the integrated study of economics, development, education, human health, migration and climate science, writes: *"Having limited skills, education, capital and access to the social networks that underpin much of economic and social mobility, in urban India, more of the landless and small and marginal farmers are forced to migrate, often forming the most vulnerable groups in cities. They often live in illegal, un-serviced settlements exposed to a wide range of environmental risks from flooding to fire, and continual cycles of demotion and eviction by civil authorities. They are, therefore, dual victims of existing natural hazards and emerging climate change - displaced from their original places of residence and occupations, and challenged by urban risks in their new urban places of residence."* (Revi, 2008). According to studies done based on NSSO data, rural to urban migration in India is increasing over the past 50 years (Revi et al., 2011). There are other studies that also show that rural to urban migrants have a greater risk of being below the poverty line than the urban to urban migrants and both these streams report a lower risk than non-migrants residing in urban areas (Kundu & Sarangi, 2007).

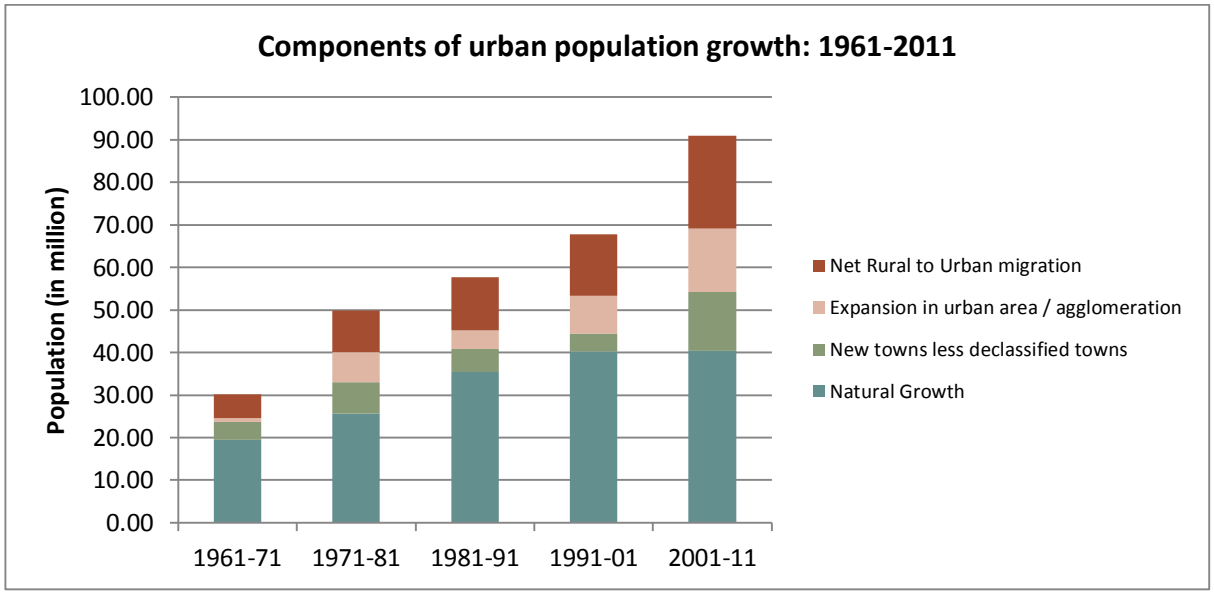


Figure 4 : Components of Urban Population Growth : 1961 – 2011
Source : (Revi et al., 2011)

There are more built and other physical assets in urban areas per household than in rural areas. NSSO data from 1991-1992 and 2002-2003 shows that households in urban areas on average own more built assets than their counterparts in rural areas. Rural households own more land than urban households. Over the last ten years, the values of both land holdings and built assets has increased by more than double (for both rural and urban) even the per cent distribution within the overall assets has remained somewhat the same. Other household assets, machinery and equipment are also proportionally more in the urban household. Livestock is marginally more in the rural household. More physical assets also imply more exposure to destructive events. But at the same time, urban households also seem to have higher financial assets and dues receivables – which may improve their capacities to cope and recover in case of a hazardous event.

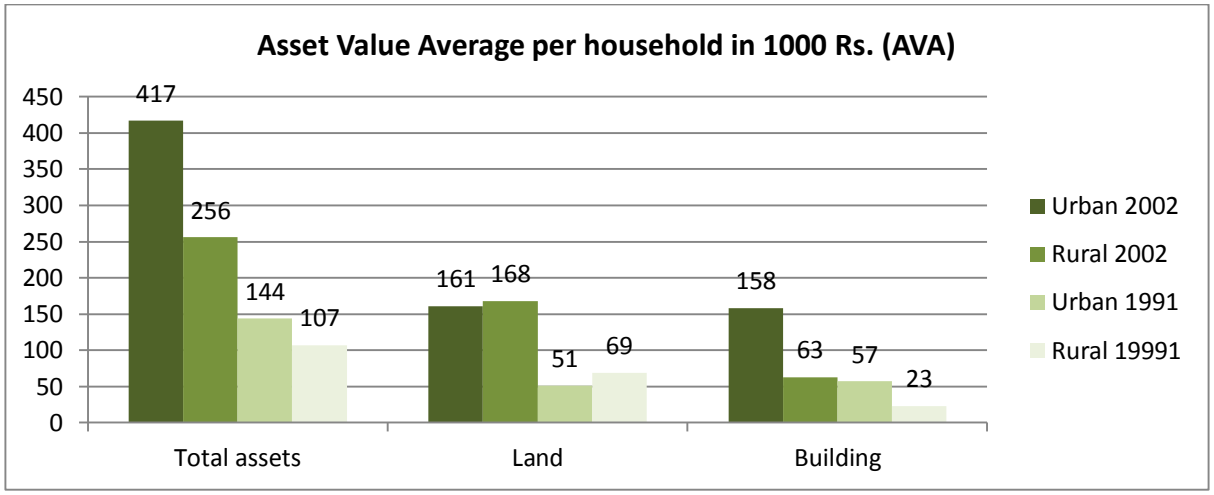


Figure 5 : Average value (Rs. 000) of land and building per household for 21 major states

Source : NSSO Household Assets Holding, Indebtedness, Current Borrowings and Repayments of Social Groups in India. All-India Debt and Investment Survey NSS 48th and 59th Round. (January - December 1992 and January–December 2003)

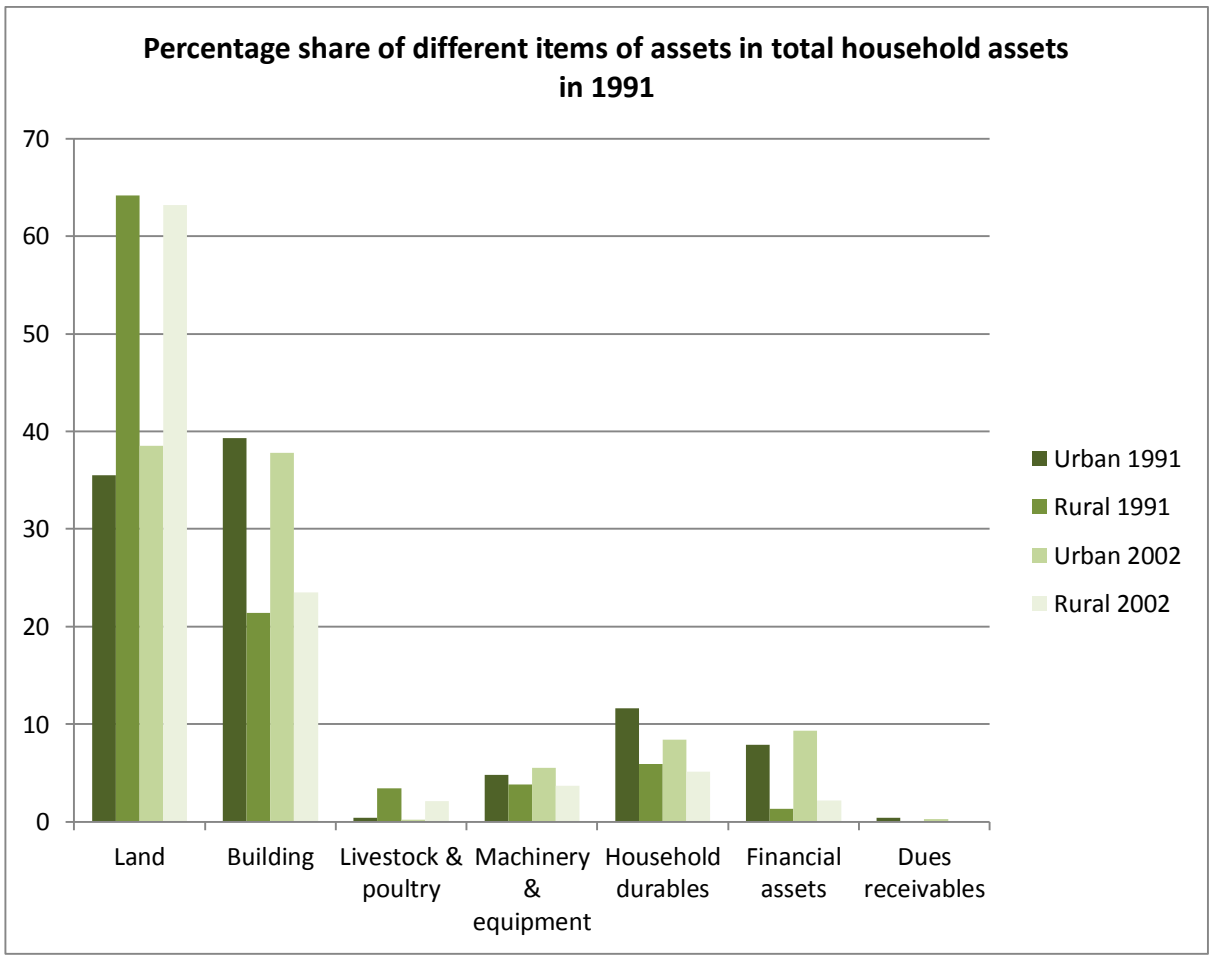


Figure 6 : Percentage share of different items of assets in total household assets for urban and rural areas

Source: NSSO Household Assets Holding, Indebtedness, Current Borrowings and Repayments of Social Groups in India. All-India Debt and Investment Survey NSS 48th and 59th Round. (January - December 1992 and January–December 2003)

Urban areas are not just victims, but also contributors to increasing environmental burden. Urban areas consume forest and agricultural lands and water resources (Sudhira, Ramachandra, Raj, & Jagadish, 2003). They produce more air pollution and heat island effects (Ramachandra & Kumar, 2010). Infrastructure choices (like transport choices or rolling stock) creates long-term risks[v]. These choices create a stress on climatic conditions towards enhancing the possibility of risk-scaling. By drawing on resources and using sinks from "distant elsewhere"(Rees, 1992) urban expansion over the last century has caused unprecedented anthropogenic transformation of ecosystems (A. Revi et al., 2014). Urban centres cover only a small proportion of the world's land surface—according to Schneider et al. (2009) only 0.51% of the total land area. Yet their physical and ecological footprints are much larger (IPCC, 2014b). The net ecological impact of urban centres includes the decline in the share of natural and semi-natural areas from about 70% to less than 50% of land area, primarily to appropriate crop and pastoral land for urban-based consumption. The ensuing land use and land cover change has resulted in a decrease in biodiversity, and fragmentation in much of the remaining natural areas, thus posing a threat to the continued provision of a wide range of ecosystem services. Future projections (Seto, Güneralp, & Hutyra, 2012) suggest that, if current trends continue, urban land cover will increase by 1.2 million km^2 by 2030, nearly tripling global urban land area between 2000 and 2030. This would contribute to the destruction of green infrastructure that is critical in helping settlements adapt to climate change impacts ((Seto et al., 2012) in (A. Revi et al., 2014)) and therefore increase the exposure of population and assets to higher risk levels. At the same time, a high proportion of global greenhouse gas emissions are generated by urban-based activities and residents.

Growing urban, shrinking rural. With an unprecedented rate of urbanisation, India is increasingly becoming more urban than rural. By 2050 majority of people living in India will reside in its urban areas, of which 138 of them will have populations above 500,000 people (World Urbanisation Prospects)[vi]. With people increasingly living in cities, the densities are bound to increase, and with them other assets and sources of economic output. The 2011 Census estimated that there are 8,000 urban centres amongst a deluge of over 6, 60,000 villages. There's a decline in the number of people and proportion living in hamlets and small villages, partially because of population growth, but also because of the clustering and agglomeration of settlements as mobility networks increased in coverage and settlement sizes grew (Revi et al., 2011). With this growing urban component, risk will begin to concentrate in urban areas, and owing to the fewer numbers of such locations, it can be argued that focusing attention to these areas to reduce risk can reduce the risk in the future.

Concentration of urban risk in India

Following the understanding so far that cities are increasingly becoming vulnerable, there is also a further need to understand where amongst these cities is risk concentrated, in order to prioritise certain risk reduction practices in those areas. Also, it is pertinent to know what aspects of these areas are lending them to a higher propensity to risk – hazard exposure, higher vulnerabilities or lower capacities, such that particular efforts can be made to address those issues. Most often the issues in mega cities are very different from those in second tier cities, and must be addressed according to the needs.

Within the urban areas, there exists a lot of variation in the characteristics of the elements at risk (Revi, 2008) and some areas must be invested into for building their resilience on priority. This section attempts to conduct a risk concentration analysis amongst urban areas to identify particular areas where risk is concentrated either owing to their location and exposure or specific prevalence of vulnerabilities and capacities of the various elements at risk to respond and cope with these exposures. Some studies have explored this using a simple set of representative cases (IRADe, ACCRN, & RockefellerFoundation, 2013) but this study looks at all urban areas having populations more than 1 lakh, which is 467 in number according to the 2011 census. This paper uses the fundamental risk equation adapted from that presented by Peduzzi et al. (2002). It uses disaggregated micro-level geographical data collected by various agencies such as ISRO-Bhuvan and Census at the national level, along with hazard data from global studies such as UNISDR's GAR 2013 (DesInventar, etc.), EM-DAT database, etc. to arrive at an understanding of geographical concentration of risk in India. Geographical Information Systems (GIS) are used further to go beyond its city administrative boundaries, helping to identify urban agglomerations exposed to such risks. It primarily looks at intensive risks, with an exception to the potential water-borne diseases, but going forward - using more robust data - can also integrate other extensive risks in the analysis. (*Refer to Appendix 2 for the detailed list of hazards, vulnerabilities, capacities and exposures considered in the analysis along with the sources of data. Some of the vulnerability and capacity indicators are influenced by the human development indicators* (Stanton, 2007))

The most vulnerable populations and elements (Revi, 2008) in a typical Indian city are identified as - the slum populations resident in traditional and informal settlements, which are often located in the most vulnerable locations; informal service sector workers, whose occupations place them at significant risk to natural hazards; buildings, especially traditional and informal housing that is especially vulnerable to wind, water and geological hazards; and lack of water, sewage, and power. Coping capacities are also identified as access to banking services; lifeline public and private infrastructure such as roads and hospitals; access to assets and telecommunication infrastructure; and city's status of planning and management. Hazard exposures are considered for earthquakes, wind pressure, cyclonic storm, landslides due to precipitation and earthquakes, droughts, tsunami, fluvial floods, and potential for water borne diseases. Two types of equations are used:

$$\text{Equation 1: } Risk = \frac{\left(\prod_l^i H \times \sum_m^j V \times \sum_n^k E\right)}{\sum_a^b C}$$

where the product of all hazard incidence indicators is multiplied by the sum of all vulnerability indicators and all exposure indicators. This is divided by the overall capacity indicator of the urban areas. This equation is called 'hazard sensitive equation'.

$$\text{Equation 2: } Risk = \left(\prod_l^i (Hl \times \sum_m^j \frac{V}{C}) \times \sum_n^k E\right)$$

where risk is defined as a product of hazard specific vulnerabilities and capacities with the hazard incidence, and thereupon the exposures. This equation is called 'vulnerability and capacity sensitive equation'.

100 cities most at risk resultant from each of the above equations are combined under one set of 117 cities. The key findings are as follows:

- If one were to look primarily at hazard exposure, as in some other existing risk analysis (University, NIDM, & SEEDS, 2010) (UNDP, 2002-2007), it would present a very different set of urban areas having high probability of risk. A composite hazard exposure analysis is represented in Figure 7 and areas primarily located in the coastal region or the Indo-Gangetic plains seem to be most exposed to natural hazards. But once vulnerabilities and capacities are integrated into the equation, cities with a higher propensity to risk change as shown in Figure 8 and Figure 9. Some of these areas are also located within poorer states of Bihar, Madhya Pradesh, Uttar Pradesh, Orissa and Maharashtra (UNDP, 1990).
- Some of the cities that are most at risk are Guwahati, Chennai, Aizwal, Greater Vishakhapatnam, Bhubaneshwar, Kolkata, Greater Mumbai, Surat, Malegaon and Hyderabad – primarily owing to their exposure to most major hazards coupled with high concentrations of people and assets.
- Other than the big cities that are at risk such as Mumbai and its environs, Delhi, Ahmedabad, Bangalore, Surat, Chennai, Kolkata and Hyderabad, there are many small and medium towns that face very high risks – Basirhat, Dimapur, Imphal, Kakinada, Bhagalpur, Vasai Virar City, Haldia, Bhiwandi, Bhubaneswar, Kanpur, Patna, Begusarai, Moradabad, Biharsharif, Vijayawada, Cuttack, Santipur, and Tiruchirappalli.
- Cities like Imphal, Jamshedpur, Bokaro Steel City, Baripada, Nabadwip, Mangalore, Vapi, Hardwar, Silchar, Anantnag, Bankura, Shillong, Port Blair, Panvel, Gandhidham and Gudivada show up in when using the hazard sensitive risk equation, since they are primarily exposed to higher hazards, even though their exposures of people and vulnerabilities maybe lower and/or coping capacities higher. Other cities such as Aligarh, Bhopal, Aurangabad, Maunath Bhanjan, Madurai, Allahabad, Sambhal, Hapur, Tiruppur, Mathura, Amritsar, Sasaram, Korba, Warangal, Bettiah, Amroha and Hardoi are amongst the high risk cities owing to the vulnerabilities and lack of coping capacities.

The table in Appendix 7 indicates the list of towns at high risk, and their key contributor to risk which can accordingly be addressed.

Scope and limitations of the analysis

To be noted, that this list is not a reflection of actual risk in cities in India, since the hazard exposure indicators are still probabilistic in nature. Also, there is no reliable geo-spatial data available for pluvial floods, storm surge, heat waves and other intensive risks, integration of which at a later stage, this analysis could be made much more robust. Further, even though some areas might have smaller populations, but being exposed to higher intensity hazards are still risk prone, even though they might not figure in the top list (eg. Shimla). Also, this analysis does not account for second order impacts following an event such as health risks and does not account for disability adjusted life years (DALYs) following a hazard.

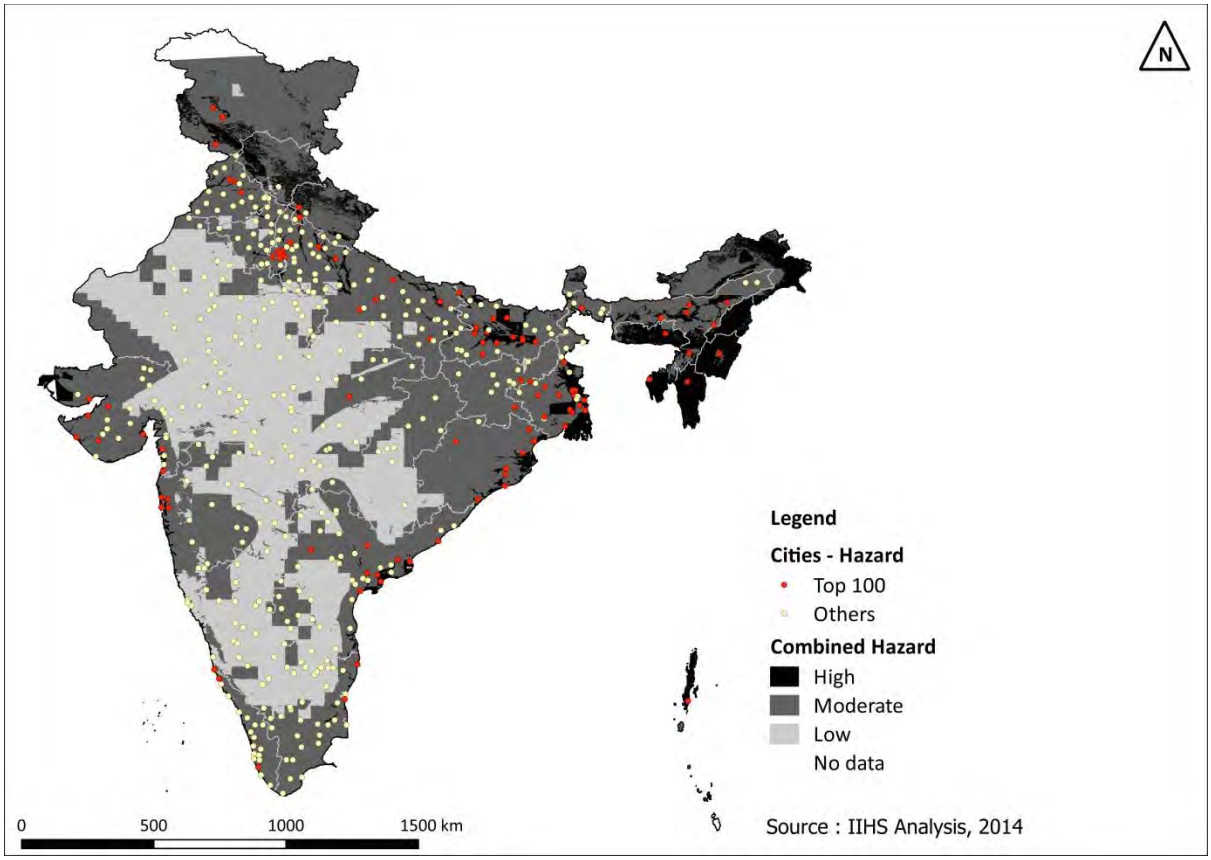


Figure 7 : Map showing 100 most hazard prone cities

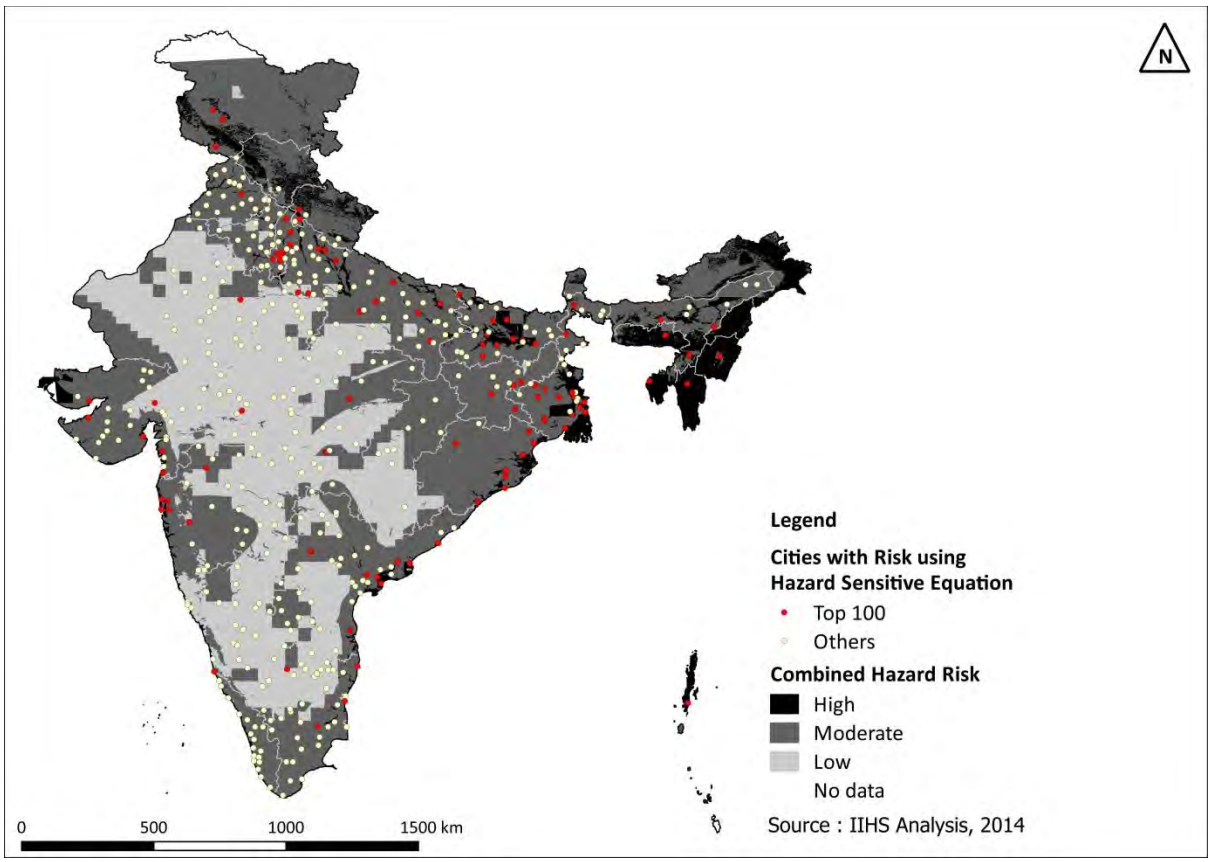


Figure 8 : Map showing 100 most risk prone cities using hazard sensitive equation

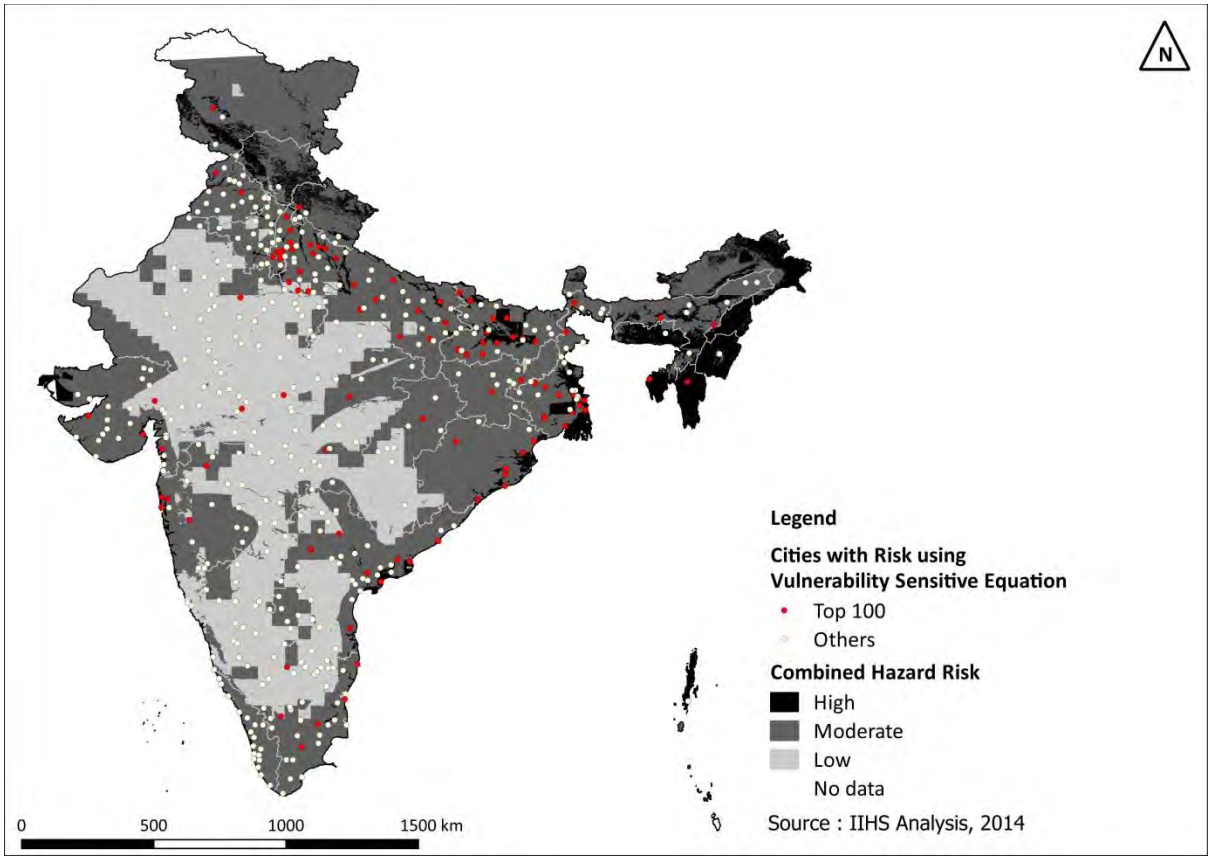


Figure 9 : Map showing 100 most risk prone cities using vulnerability sensitive equation

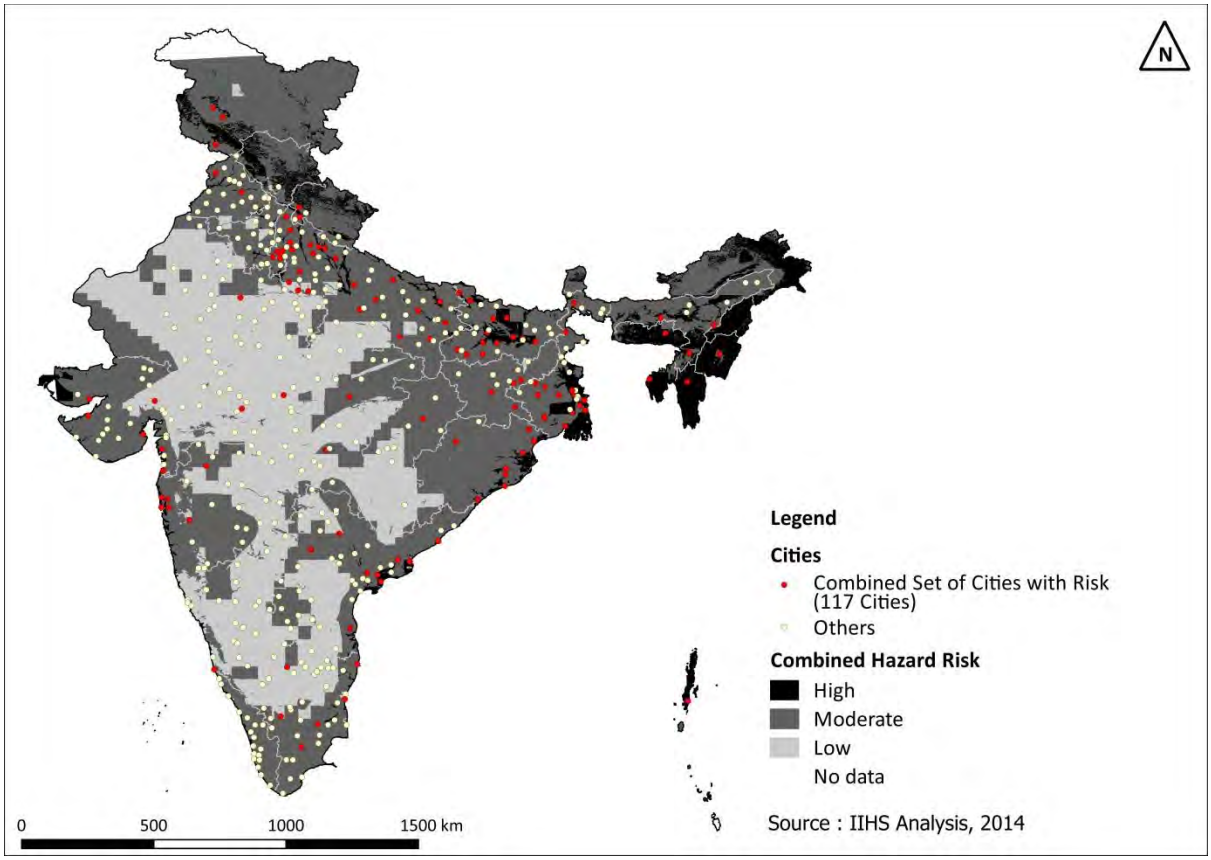


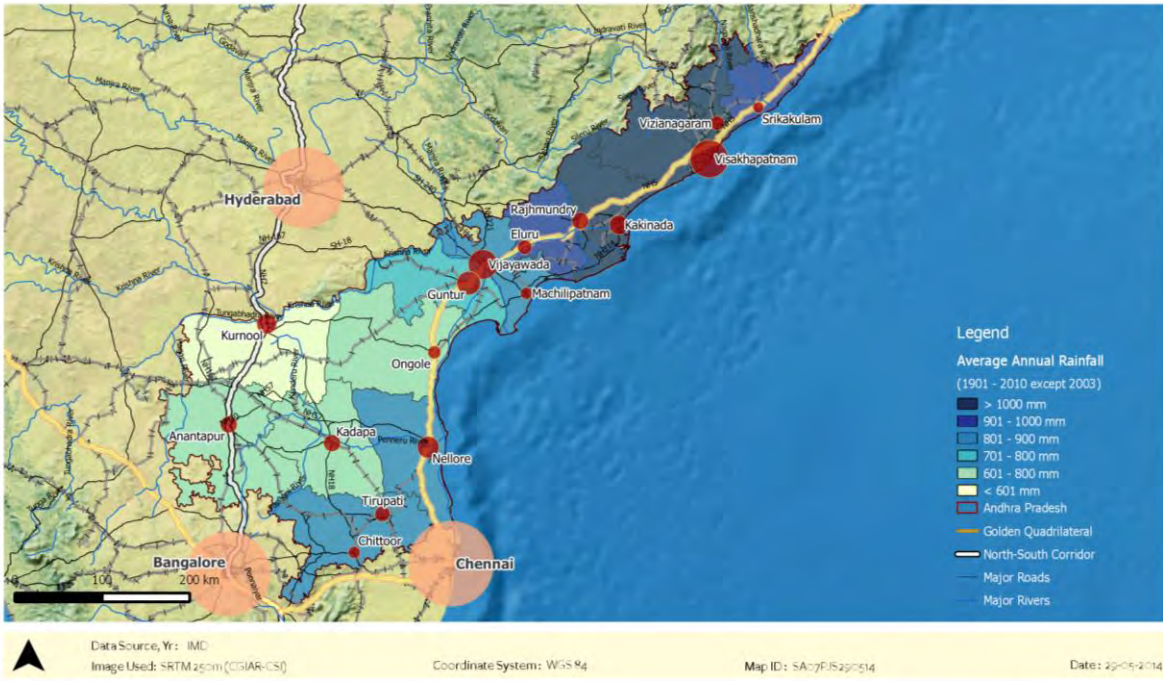
Figure 10 : Combined set of most risk prone cities

Box 2 : Andhra Pradesh - Locating the Capital

The above methodology could be used for assessing risk levels in various areas. During the consideration of Andhra Pradesh's new Capital City Project, for instance, some considerations of risk could be as follows:

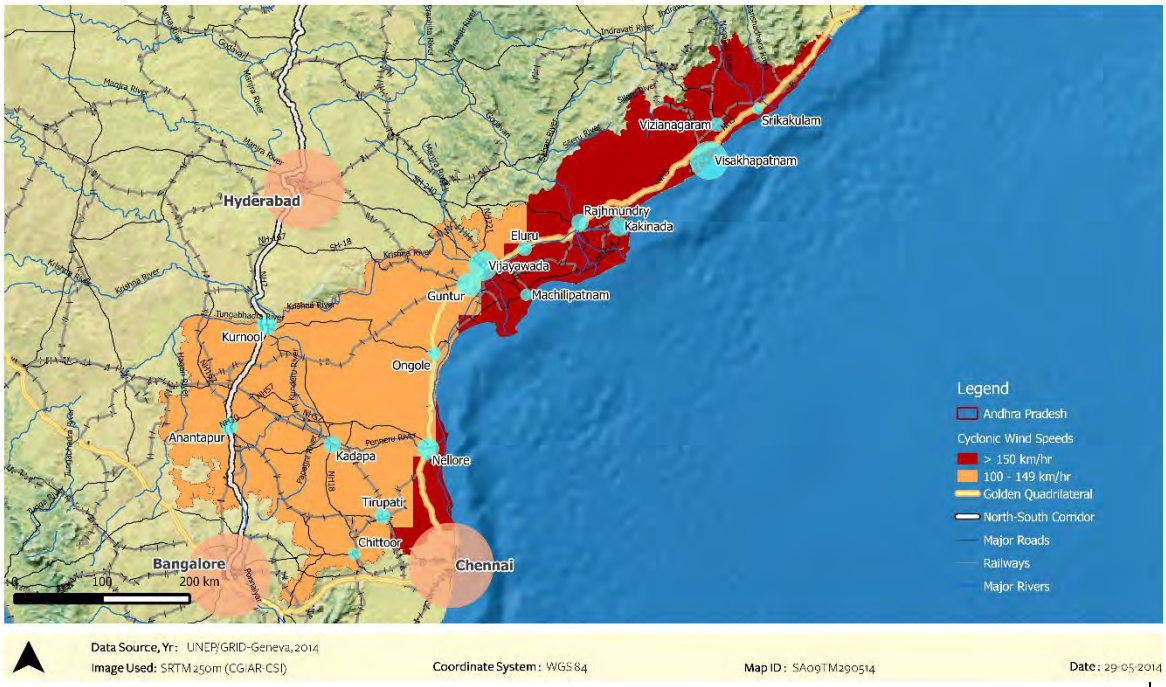
- Drought is the most severe risk that much of AP is exposed to. Hence secure and sustainable water supply would be a binding constraint for the Capital city project

Figure 11 : Average Annual Rainfall Map of Andhra Pradesh (District wise)



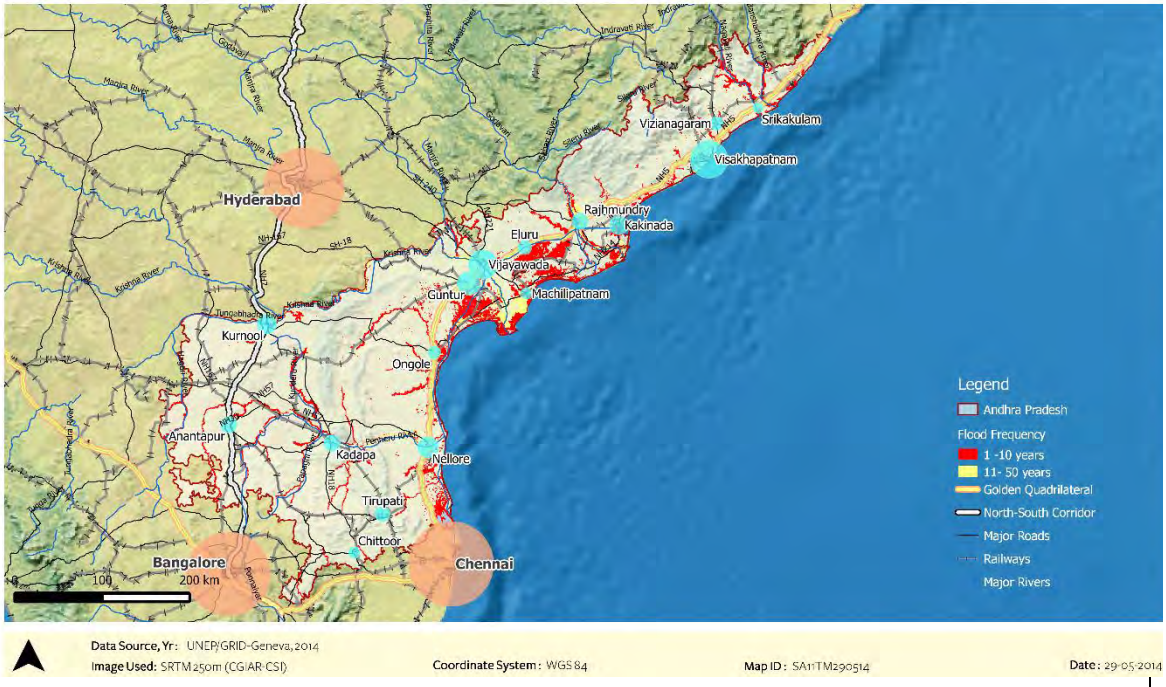
- Many segments of the AP coast are highly or very highly exposed to cyclonic storms, storm surge, which will be exacerbated over the century by climate change and sea level rise.

Figure 12 : Cyclonic Wind Map of Andhra Pradesh (250 yr. return period)



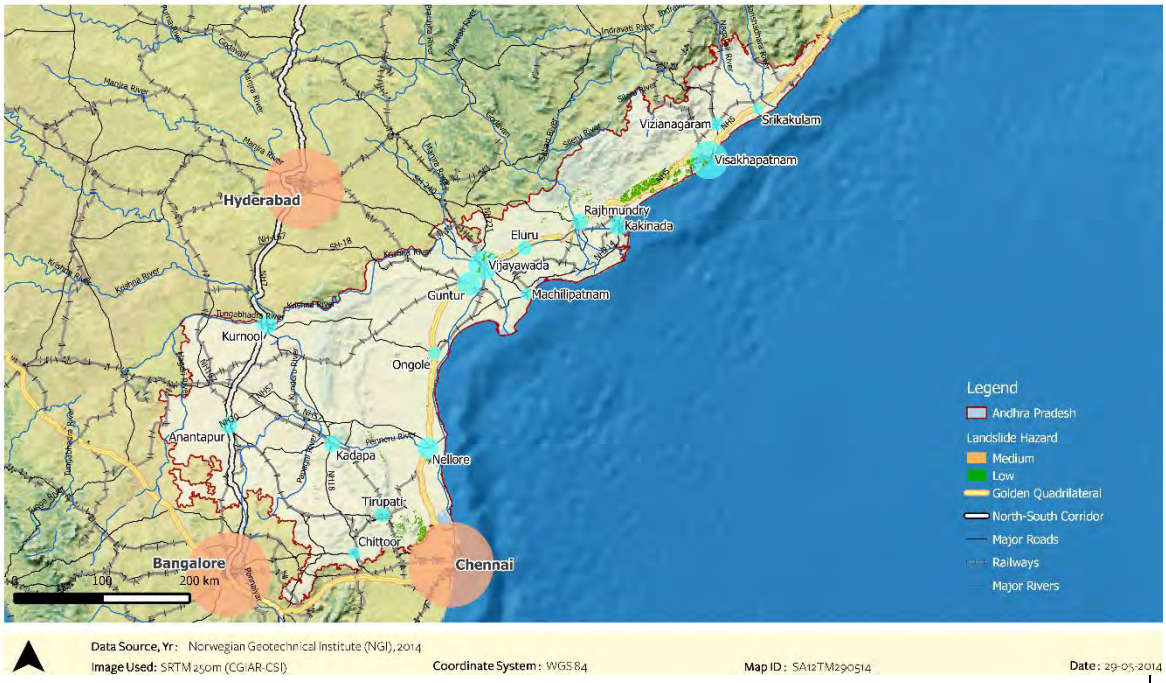
- Relatively large areas of the deltas and coasts in AP are exposed to severe to very severe, fluvial, coastal and local flooding.

Figure 13 : Fluvial Flood Frequency Map of Andhra Pradesh (50 yr. return period)



- Some sections of north and south coastal Andhra and exposed to precipitation induced landslide risk. This can impact transportation, logistics and particular sites.

Figure 14 : Landslide Hazard Map of Andhra Pradesh (precipitation induced)



Current Institutional, financial and techno-legal frameworks

With increasing people and capital concentrations in urban areas they are both accumulators of risk, as well as opportunities of risk management. But in the face of unprecedented urbanisation, risk reduction needs a two pronged approach - one by reduction of existing disaster risk and second by prevention of risk creation. While there are many measures that are being taken by national, state and local government to reduce vulnerabilities inherent in systems and communities, it is often beyond choice to reduce or manage exposure that has already manifested itself into brick and mortar / blood and bones. The post HFA draft for Sendai observes that "*exposure of people and assets in all countries has increased faster than vulnerability has decreased*". Planning is one instrument available that can help bring the vision of future growth in line with the idea of long term sustainable development such that new risks are avoided altogether. By the use of suitable hazard micro-zonation maps, growth projections, building standards, inevitable economic and demographic concentration can be manipulated before it transpires into hard reality. The Post HFA draft for Sendai notes that "*it is urgent and critical to anticipate, plan for and act on risk scenarios over at least the next 50 years*". Planning at the same time also provides the opportunity to 'build back better', following an event by the use of well-conceived resettlement/rehabilitation policies along with suitable reconstruction practices and building standards. At the institutional level, it is pertinent to ensure some accountability for risk creation at all levels of governance and planning, which is based on scientific knowledge in disaster risk assessment and rigorous data - dearth of which would lead to gaps in risk reduction. Promoting participatory planning practice is another way to build in this accountability.

Of the identified 117 high risk cities - 66 have climate change action plans at their respective state levels, 32 have disaster management plans, and 3 have other resilience strategies. Only 44 cities have city development plans – and there lies an opportunity to integrate risk reduction measures in development planning.

While disaster risk management has a history since 1999 for some states like Orissa and Gujarat and thereafter from 2005 at the National and other State levels, climate change is a comparatively new issue dealt by the institutional system. But the two are still understood singly from each other, and further away from the overall development planning systems. While the nodal ministry for disaster management is the Ministry of Home Affairs (MoHA), the nodal ministry for climate change is the Ministry of Environment and Forestry (MoEF). National Centre for Disaster Management (NCDM) and all national disaster response activities – including those in cities – are the responsibility of the Ministry of Agriculture. Development planning is a subject dealt by the rural and urban development ministries. Although, quite often some of these ministries are nodal agencies for some particular disasters as well as for some key climate change related missions being planned at the National Level, for instance – MoEF has the responsibility of coordinating and presenting the National Action Plan for Climate Change (NAPCC), it also is the nodal agency that looks after risks associated with extreme events such as forest fires and other chemical hazards; Ministry of Water Resources (MoWR) is responsible for the disaster management during floods, and is also the key agency developing the National Water Mission. But it is the Ministry of Urban Development that looks after the issues of urban development, as well as some major disasters such as urban floods and is the nodal agency responsible to present the National Mission for Sustainable Habitat (NMSH). Most other ministries either look at only climate change related issues, or extreme events, but not both. In this complicated structure of multiple ministries and agencies (Figure 15) – it is imperative to have one nodal agency that looks after all the matters of risk and resilience for an overall sustainable development – an agency that has representation from all the nodal agencies for disaster risk, climate change and rural and urban development.

The National Disaster Management Act came into being in 2005, and a National Disaster Management Authority (NDMA) was created under this Act. State and District level disaster management authorities were also required to be formed but states like Arunachal Pradesh, Manipur and Goa still do not have these in place. NDMA has identified 43 districts in 22 states for the UNDP-DRR Project, but these are identified on the basis of their seismic zonation, and not multi-hazard exposure or levels of vulnerabilities[vii]. Moreover, at the state and district level, there are many bodies created and instituted under the National Disaster Management Act, but it is noted by the Auditor General in their assessment, that most of these have been dysfunctional since their inception (Indian Audit and Account Department, 2012).

Box 3 : Delhi Master Plan, 2021

The Delhi Master Plan was formed in 1962 by the Delhi Development Authority (DDA) to ensure an organized and structured development of haphazard growth of Delhi. This Master Plan was revised in 1982 to formulate the Master Plan 2001 and then further revised in 2007 to form the Delhi Master Plan 2021. It lays down the basic infrastructure requirements for a city estimated to have a population of 12.8 million. Some of the salient features of the Master Plan for Delhi 2021, with respect to risk are:

- involving the private sector in the assembly and development of land
- facilitating PPPs
- developing 'influence zones' alongside Mass Rapid Transit System (MRTS) and major transport corridors
- removing controls in built where not stringently required especially height restrictions for construction in certain areas in an attempt to create 'modern contemporary and landmark structures' in Delhi.
- enhancing Floor Area Ratio / Floor Space Index (FAR/FSI)
- managing disasters by - disaster management centre provided in each administrative zone, building regulations for safety of structures as per seismic zone, land use zoning as per micro-zonation.

Some identified gaps :

- Although Disaster Management is highlighted as one of the critical areas of focus for the Master Plan 2021, yet the specific considerations of risk reduction and processes are still insufficient.
- There is very little integrated risk perspective suggested. Primarily, only earthquakes, and flood to some extent, are recognised as hazards for which some preparedness is planned, but others are not included.
- There is some mention of safety for critical infrastructure and large scale exposure, but it is also meant for earthquake safety, and not for other hazards.
- The nodal agency for disaster management is the Fire Services, but their technical and infrastructural capacities to deal with all the hazard Delhi is exposed to may be limited.

Besides, although the Master Plan notes these practices, it is still unclear the capacity of DDA officials in undertaking such actions in practice, and whether the current processes and roles include DRR. (Jain, 2014)

There's been a considerable growth in PPPs[viii] in India in last 15 years such as growing ecosystem for PPPs: Institutions, developers, financers, equity providers, policies and procedures. There have been several policy and institutional initiatives taken by centre and many states: PPP appraisal committee set up by Government of India (GoI) to manage project approvals and appraisals; support through project development funds, viability gap funding, user charge reforms, provision of long tenure financing and refinancing, institutional and individual capacity building. There's a National PPP Policy which is being drafted to ensure optimal risk allocation in project structuring with life cycle approach, besides other things. The

Ministry of Finance, India, issued amendments in 2009 to the Detailed Project Report requirements, to include disaster management concerns in the approval process of PPPs and large projects. It is now at the project approval stage itself that the developer is required to provide a detailed study of the risks that could be associated with the proposed development. This mechanism ensures the integration of DRR at the planning stage itself.

Reduction of existing disaster risk can also be undertaken by mainstreaming risk/vulnerability reduction measures into developmental planning agenda of better lives and livelihoods, particularly focusing on more vulnerable and deprived populations - by providing better access to basic services, better livelihood opportunities and health and education.

Considering a series of further developments in the field of building construction including the lessons learnt in the aftermath of number of natural calamities like devastating earthquakes and super cyclones witnessed by the country, a Project for comprehensive revision of National Building Code (NBC) was taken up under the aegis of National Building Code Sectional Committee, CED 46 of BIS and its 18 expert Panels; involving as many as 400 experts. As a culmination of the Project, the revised NBC has now been brought out as National Building Code of India 2005. NBC, a comprehensive building code, is a national instrument providing guidelines for regulating the building construction activities across the country. NBC was first published in 1970 at the instance of Planning Commission and then revised in 1983. Thereafter three major amendments were issued, two in 1987 and the third in 1997.

It serves as a 'Model Code' for adoption by all state and city agencies involved in building construction works - be they Public Works Departments, other government construction departments, local bodies or private construction agencies. NBC has 11 sections and mainly contains administrative regulations, development control rules and general building requirements; fire safety requirements; stipulations regarding materials, structural design and construction (including safety); and building and plumbing services.

Bureau of Indian Standards (BIS) has 14 departments. Like all other departments, the Civil Engineering Department (CED) has issued a set of Indian Standards and has listed different committees for each. While earthquakes and fire are given ample distinction by the CED, floods are left for the Water Resources Department (WRD). And since the latter are mostly concerned with water as a resource, the risk perspective is missing. Moreover, while the NBC is fairly exhaustive, it does lack an integrative approach to building design, construction and management. As per the BIS Rules, 1987, Rule 7(7)b - "Indian Standards are voluntary and available to the public. Their implementation depends on adoption by concerned parties. However, an Indian Standard becomes binding if it is stipulated in a contract or referred to in a legislation or made mandatory by specific orders of the Government." This implies that while these standards are made available to the public, their use is purely voluntary. They are not binding by regulation, unless they are made part of a legal contract, a law or a government order. Therefore, like all other Indian Standards, NBC is not a regulation, but it gets incorporated and implemented in the following ways:

1. It guides local building regulations and bye-laws, after suitable modifications.
2. It is utilised by professionals in the planning, designing and engineering fields.
3. It is referred by the public works departments and government construction agencies, as well as by Private Developers.

4. It is used as a Model Code by academic and training institutes as part of design, architecture and engineering curriculum.
5. It finds its way in legal documents and specifications.
6. It also has a set of forms, including a Structural Sufficiency Certificate, which the developers have to submit to their respective local authorities at the time of project completion.

While the Code prescribes the minimum standards of protection and safety of buildings, both in the interests of the occupants of the buildings and also in the public interests, nothing in it prohibits adoption of higher standards. But there need to be other incentives in place for the developer/designer to choose higher construction standards that correspond to longer term risk reduction. BIS is in the process of drafting a Certification for sustainability that attempts at addressing the various debates around the different "Green" ratings. While there is not enough inclusion of DRR in these ratings yet, but they plan to incorporate the same before the final draft. BIS also has a training institute, for capacity building programmes at the national level on Quality management and other Indian Standards trainings. Several private institutions nominate their employees for these training sessions.

The Insurance and Regulatory Development Authority (IRDA) regulates and develops the insurance industry in India. It was constituted by the act called Insurance Regulatory and Development Authority Act, 1999 and duly passed by the Government of India[ix]. According to Swiss Re in 2004 - "*China and India are arguably the two most challenging and promising emerging insurance markets. In tandem with robust economic development, their insurance markets have grown spectacularly. Average annual growth rates for insurance in India were 12.7% for life and 6.2% for non-life in the last decade. In 2003, China and India were respectively the 8th and 18th largest life insurance markets in the world. Their rankings are 13th and 28th in terms of non-life insurance. Despite these impressive growth rates, these two markets are still relatively small, accounting collectively for only 2.2% of global insurance premiums. Nevertheless, their huge economies and population sizes, coupled with rapid industrialisation and globalisation, should create ample opportunities for the development of insurance. In particularly, liberalisation and deregulation are rendering these newly de-monopolised markets more accessible and attractive to foreign insurers. India restricts foreign equity participation to 26% in joint ventures. At the same time, insurance regulations are maturing to levels commensurate with international best practice*".

While the vulnerability of various parts of the country to disasters is high, the current level of insurance penetration in India is less than 1 per cent across the country. Pooling of risk of disaster at the individual level is therefore a big challenge. IRDA's regulatory and development role – defining the concept, approving products, strengthening intermediary networks etc. – seems progressive, and has learnt from the recent incidences of disasters. There have been post-earthquake efforts in Gujarat for publicizing insurance/ obtaining insurance for socially weaker segments. There has been a debate raised around including an insurance premium in the property taxes, which could be especially beneficial for small-scale/individual private owners.

A proposal on establishing a National Insurance Fund was shot down because any insurance cover in which the premium is paid fully by the Centre and the states would not reduce the financial burden of the government in dealing with natural calamities, and expecting the

vulnerable, usually also the poorest of the poor, to pay insurance premiums would not be viable. Moreover, it is generally economical to pool risks arising out of low frequency-high intensity disasters, but it is not economical to pool risks arising out of high frequency-low intensity disasters.

There have been some positive undertakings by the NDMA since their inception. National Disaster Management Guidelines are issued by the NDMA to RBI on Ensuring Disaster Resilient construction of Buildings and Infrastructure. Structural design of the proposed buildings and structures were not required to be complete before submitting the application for a bank loan and no processes were in place at the banks to ensure that disaster resilience was indeed been incorporated in the assets during the design process at least before the construction begins. NDMA, therefore, issued guidelines to the Reserve Bank of India (RBI) and further to all commercial lending banks in India to ensure assessment of disaster resilient construction of buildings and infrastructure. The guidelines not only aim at addressing gaps in the current process of approving the loan applications, but also at creating a user-friendly, enabling environment for banks to facilitate compliance of the directives, by providing simple check memos to be filled by the client and the technical professionals at the time of submitting a detailed project report. If these checks and balances are made before the approval of loans, the banking system would contribute in a big way to creating a disaster-resistant built environment in the country. The implementation of these techno-financial provisions would require banks to equip themselves with the necessary technical expertise, by either developing suitable technical human resources internally or by outsourcing the peer review of technical documents by empanelled technical professionals. This approach would offer to the banks an independent verification of disaster-resilience of the project under consideration, in addition to ensuring multi-hazard resilience in all bank-financed construction and thereby securing the investments made in such construction and contributing to a multi-hazard resilient built environment in the country.

The Real Estate Regulation and Development bill was introduced at the Union level in the Parliament in 2011, but it is proposed that the right to enact the bill into an act should rest with the State Governments. The motivation for the bill was “to establish the Real Estate Regulatory Authority for regulation and planned development in the real estate sector and to ensure sale of immovable properties in an efficient and transparent manner and to protect the interest of consumers in the real estate sector and establish an Appellate Tribunal to adjudicate disputes and hear appeals from the decisions or orders of the Authority and for matters connected therewith or incidental thereto.” While the Bill requires the promoter / developer to furnish financial and other ownership proofs, she is not required to provide any hazard risk profile of their development. (“that he has furnished such other documents as may be prescribed by the rules or regulations made under this Act.”, but rules and regulations will not be published until the bill becomes a law.)

The Council of Architecture (COA) is a body corporate by the Government of India under the provisions of the Architects Act, 1972, enacted by the Parliament. The Act provides for registration of Architects, standards of education, recognized qualifications and standards of practice to be complied with by the practising architects. The Council of Architecture, besides maintaining the register of architects, regulates the education and practice of profession throughout India. Similarly, for Town Planners, an Act is being drafted by the Ministry of Urban Development, which would eventually regulate the practices and education of Town Planners as

well. But unlike Architects and Planners, Engineers are not regulated by any governing body and/or Act, and thereby are free from professional risk associated with irresponsible practice.

New Acts and policies are being drafted as a corrective measure for the future developments, but in most cases these acts and rules will not be applied for the existing developments. There should be a means or a mechanism within these new rules, such that the existing developments must also make amendments and make their developments secure.

Exiting programmes and initiatives

Risk management is not a part of development planning instruments such as master plans and city development plans, which is in turn creating future risks, instead of mitigating them ex ante. Recently, Ministry of Urban Development has issued a draft concept note on the NDA government's Smart City Scheme in September 2014. The 100 smart cities will include all state capitals and union territories, 44 cities in the population range of 1-4 million people, 9 satellite cities with a population of 4 million or more, 10 cities that are of religious and tourist importance and 20 cities in the 0.5 to 1 million population range. While the concept note recognises the need for sustainability, but it is weak in recognising the modalities for achieving this. Moreover, while it is envisioned to create new cities and upgrade the existing cities, there is no imagination of the what the future might be in which these cities will come into being – changing climatic realities, increasing (both in number and intensities) disaster risk, and other realities of changing culture and society. There is a minor mention of disaster management as part of the physical infrastructure development – but there is no understanding of the dimensions of risks these cities might have to face, and thereby no attempts to plan for them.

National and state programmes such as JNNURM and RAY are project focussed and do not have a holistic risk reduction perspective. RAY while making a decision for the Slum Redevelopment Model, does not consider in situ or relocation based on risk exposure of the sites (MoHUPA, 2012). While these developments are considered for better access to basic services, better access to finances, community participation and better livelihood opportunities, but these are often recreating the risk these settlements had in the first place. The Ministry of Urban Affairs' 1999 Draft National Slum Policy[x] makes no reference at all to the vulnerability of slum dwellers to natural disaster. Yet the same ministry estimates that each year 1 per cent of India's total housing stock is destroyed by natural disasters. (Sanderson, 2000).

The Industrial Corridor Projects, including the Delhi Mumbai Industrial Corridor (DMIC), "*seek to create a strong economic base with a globally competitive environment and state-of-the-art infrastructure to activate local commerce, enhance investments and attain sustainable development. New DMIC Cities will help to meet pressures of urbanisation and also lead India's economic growth for the next 20 -30 years. The project aspires to double employment potential, triple industrial output and quadruple exports from the region in the next seven to nine years*."[xi] While the outcomes are imagined for 2050, there is not inception of what the climate risks will be in that time, or even what the current risks facing these locations are.

National Mission on Sustainable Habitat is one of the 8 missions under the NAPCC to promote energy efficiency as a core component of urban planning. Report of the Sub Committee on the development of Sustainable Habitat Parameters in the field of urban planning (TCPO & MoUD, 2011) notes that "*urban development, by virtue of its very nature of concentrating human population and activity, creates risks for itself and the environment. These risks, when unmitigated,*

result in disasters involving significant loss to life and property, not to mention the environment. It is important therefore to integrate risk mitigation into all urban development practices. Ensuring safety in an urban area involves planning for urban development in low risk areas, developing norms to integrate measures to reduce vulnerability, creating mechanisms to absorb the impacts of disasters (financial), management of the law and order situation in a city, etc." It also notes that adoption of land suitability analysis, including disaster risk assessment and inclusion of features of risk mitigation measures are important indicators to measure the effectiveness of a plan document while planning for sustainability. This Mission offers a great opportunity to build a holistic vision of a sustainable development, integrate and mainstream risk reduction measures into planning cities of the future, and go way beyond energy efficiency which is currently its central objective.

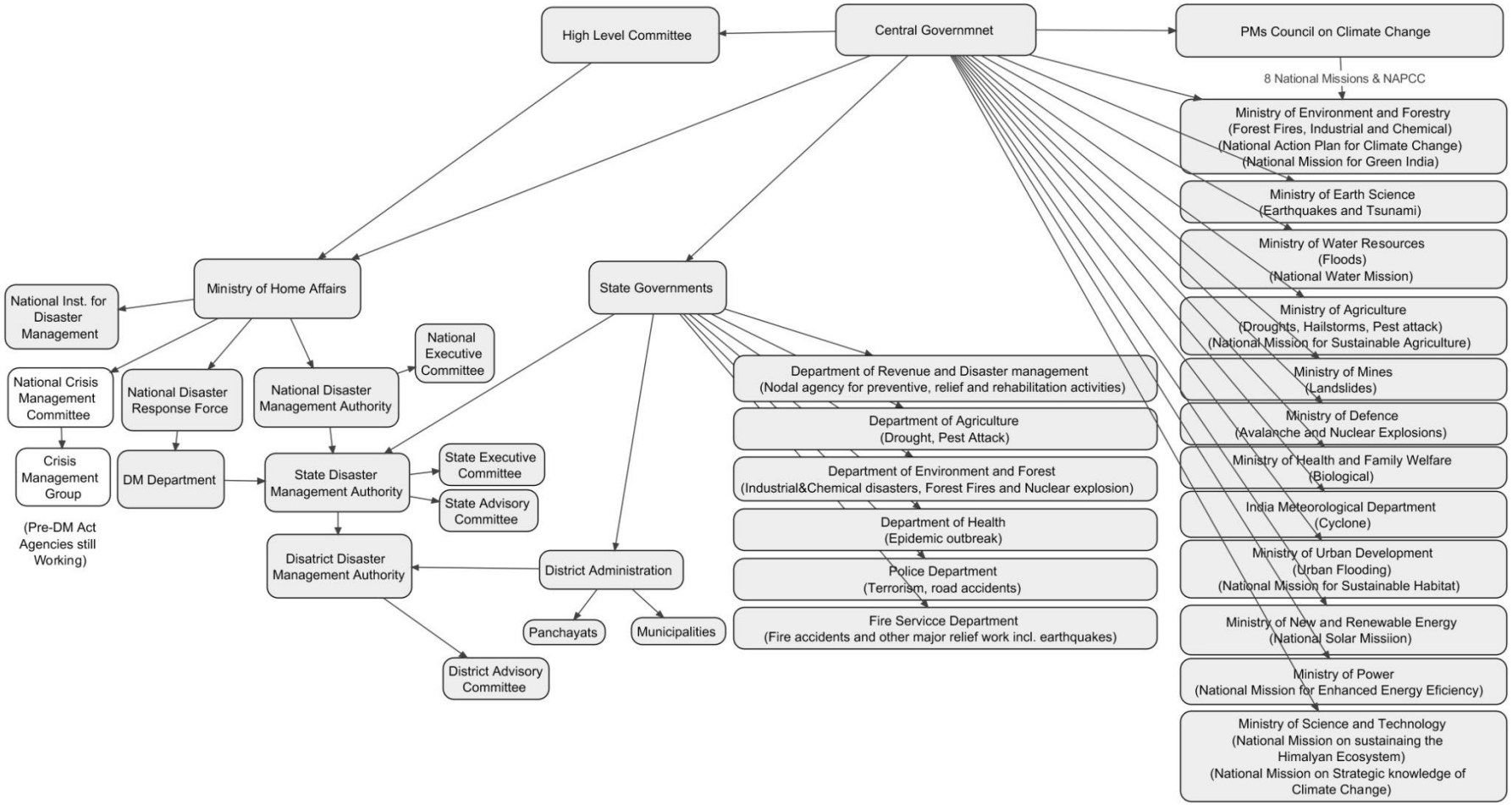


Figure 15 : Current Institutional System for DRR and CC

Source : (Indian Audit and Account Department, 2012; Prime Ministers Council on Climate Change, 2008)

Part C: Where are the Gaps?

Regulatory environment may offer incentives to the stakeholders for including risk reduction measures in planning and implementation of projects, but the gaps within the framework could also threaten safety of people, buildings, economy and systems.

There are **theoretical gaps** in the understanding of risk as a composite of not just external hazard factors, but also intrinsic characteristics which may act as vulnerabilities or capacities for systems, people, economy and built environment to help them cope with the external forces. The top down approaches also lack a focus on building these capacities by improving peoples' choices. The imagination of holistic development which is resilient and offers a sustainable development is currently missing.

There are several gaps in **planning decisions and processes**. Location decisions are still based on political economy and ease of engineering, and not directed by hazard exposure. Project and plan approval processes are devoid of any risk mitigation expertise and clearances. Building bye laws are still limited to a few hazard risks such as earthquakes, but not to others such as cyclones, floods, which in many cities form the bulk of risk. The processes are still specific hazard centric and not multi-hazard approach.

A National Disaster Response Fund (NDMF) is constituted under the NDM Act, 2005. It is applied by the National Executive Committee (NEC) towards meeting the expenses for emergency response, relief and rehabilitation, in accordance with the guidelines laid down by the Central Government in consultation with the NDMA. While the Act also recommends a **National Disaster Mitigation Fund** (NDMF) exclusively for the purpose of mitigation, it is yet to be constituted and modalities of its sources and uses of funds need to be formulated.

To embark on a low-carbon growth path along with building resilience of society to adverse impacts of climate change, the national government needs to invest into adaptation measures. But studies show that the **expenditure on adaptation** estimated by the study across all the sectors for adaptation stands at 1.7 per cent of GDP for 2006-07 which increased to 2.68 per cent of GDP as per 2009-10 budget estimates. Expenditure on human capabilities viz. poverty alleviation, health improvement and disease control and risk management, constitutes more than 80 per cent of the total expenditure on adaptation in India and scant focus is being devoted to strengthening of ecosystem services. The study also finds that sectors that are crucial to any adaptation intervention such as food security, rural and urban housing for the poor and educational infrastructure have received inadequate attention in the policy response on adaptation (Ganguly & Panda, 2010).

Physical prevention measures alone do not suffice to build a resilient city, since damage from the most severe catastrophes cannot be fully averted. An important part of resilience is how well urban societies are able to cope with the financial consequences of a disaster, which includes access to the requisite funding for relief, recovery and reconstruction (Sundermann, Schelske, & Hausmann, 2014). **Risk transfer through insurance** is one such means, yet, the gap between economic and insured losses is large because insurance penetration is relatively low and city infrastructure is often not insured at all. Risk sharing is skewed with more risk resting with the public (authorities and users), primarily due to disproportionate risk sharing clauses in the contracts between public and private entities in delivering large scale infrastructure projects (Jain, 2014). At present, insurance schemes do not provide an adequate alternative to

government funding for disaster relief, especially for high frequency – low intensity disasters. For low frequency – high impact disasters, financing through insurance mechanisms maybe feasible.

Perception of potential risk by the people and authorities is widely underestimated primarily because of recent experiences and history of an event. Often it is driven by the lack of choices to be able to avoid risks due to other socio-economic and political reasons. But such lack leads to no action for preparedness, and often leaves rescue and response as the preferred means of action in the face of an event. While inclusions are being made in master plans to include risk reduction, but **technical and institutional capacities** within the development authorities are still lacking. There is a severe lack of expertise on critical infrastructure and its protection. Often it's the hospitals, electricity and transportation disruptions that exacerbate the risk impacts after an event than the impact itself. There are severe **data gaps** which add further road blocks in the adoption of risk reduction measures at the outset. The return periods and probabilistic data for al hazards is not available and hence not used for planning. **Economic models to assess potential avoided losses** of first, second and third order are not easily accessible to institutions and not put into practice.

Part D: What are the new imaginations for approaches and frameworks?

Building Urban Resilience with an Integrated Risk Reduction Approach

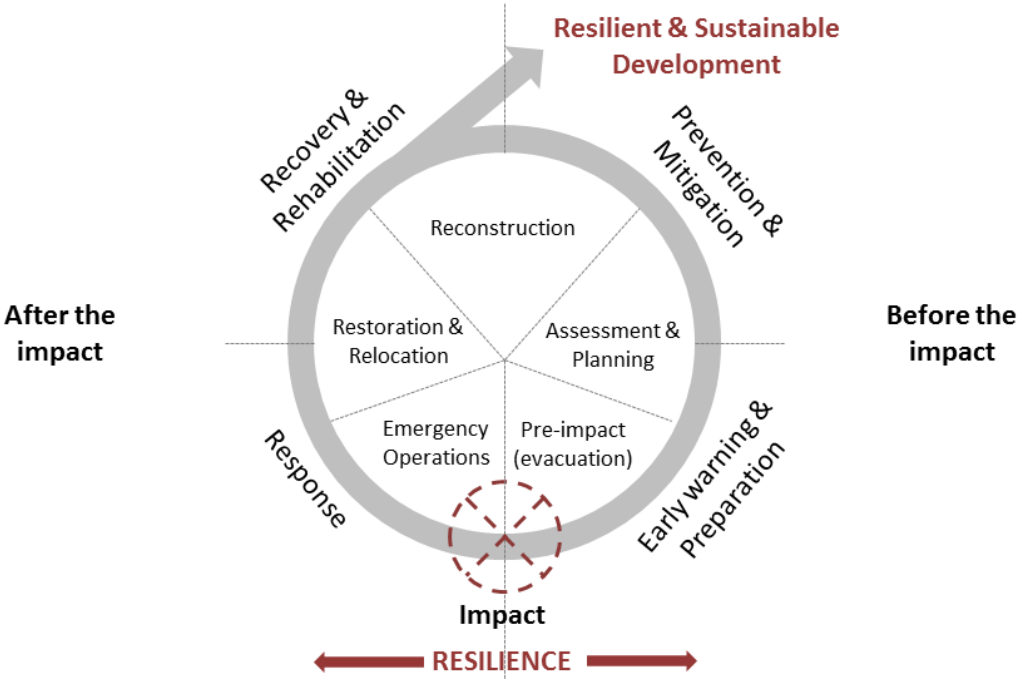
Resilience is the capacity to absorb shocks and ways to reorganize or adapt in order to return to the original state of functionality. Resilience can be both incremental return to the same state, or transform into a new state. City resilience describes the capacity of cities to function, so that the people living and working in cities – particularly the poor and vulnerable – survive and thrive no matter what stresses or shocks they encounter (Silva, 2014).

City Resilience Framework as provided by Jo Da Silva, aligns with the Systems approach for addressing risk and building resilience. It is a holistic framework that combines the physical aspects of cities with the less tangible aspects associated with human behaviour; that is relevant in the context of economic, physical and social disruption; and that applies at the city scale rather than to individual systems within a city. It outlines the following as characteristics of a resilient city – (a) Minimal human vulnerability, (b) Diverse livelihoods and employment, (c) Adequate safeguards to human life and health, (d) Collective identity and mutual support, (e) Social stability and security, (f) Availability of financial resources and contingency funds, (g) Reduced physical exposure and vulnerability, (h) Continuity of critical services, (i) Reliable communications and mobility, (j) Effective leadership and management, (k) Empowered stakeholders, and (l) Integrated development planning.

Risk reduction process outlined by Wisner, et al. (Wisner et al., 2003) also align with this resilience framework as follows: (1) Understand and communicate the nature of hazards and vulnerabilities and capacities, (2) Conduct risk assessment by analysing hazards, vulnerabilities and capacities, (3) Reduce risks by addressing root causes, dynamic pressures and unsafe conditions [a, c, e], (4) Build risk reduction into sustainable development [l], (5)Reduce risks by improving livelihood opportunities [b], (6) Build risk reduction into disaster recovery [h], and (7) Build a safety culture [d].

While the cities resilience framework outlines the objectives, Wisner gives some direction of how that can be done. Taking these frameworks into account, the following is proposed. While

prevention and mitigation measures can reduce the impacts of an external event, good early warning systems can prepare people and cities to respond better before the impact. But good recovery and rehabilitation measures taken in response to an event but in a way that bring people and systems out of reasonable exposure and thereby onto a path of sustainable development. This requires good risk assessment and planning, pre-impact evaluations, efficient and equitable emergency operations and planned restoration, relocation and transformative reconstruction.



Adaptation measures that also reduce exposure to compound risks are therefore aimed at reducing basic service deficits, improving housing, and building resilient infrastructure systems. The IPCC Fifth Assessment Report notes with medium confidence that opportunities to do so are high in many rapidly growing cities where institutions and infrastructure are being developed (A. Revi et al., 2014). However, evidence for these opportunities is low and transformative adaptation strategies may include reversing some of the current urbanisation and development trends that expose city populations to risk from sea level rise, urban floods, water scarcity and extreme weather events.

A central focus on risk reduction is a strong foundation on which to unlock the potential of urban adaptation that enhances economic comparative advantage while reducing exposure and vulnerability for enterprises, households and communities. There is high agreement among practitioners that ecosystem-based adaptation is a key contributor to urban resilience. In particular, effective urban food-security related adaptation measures (such as social safety nets, urban and peri-urban agriculture, local markets, and green roofs) can reduce climate vulnerability especially for low-income urban dwellers(A. Revi et al., 2014).

Implementing effective urban adaptation is possible and can be accelerated (A. Revi et al., 2014). City-wide climate change adaptation which minimizes current exposure and loss, especially for those who are most at risk or vulnerable, includes:

- Good quality, affordable, well-located housing; possibilities for such adaptation rest with owners and public, private, and civil society organizations
- Reducing basic service deficits and building resilient infrastructure systems (water supply, sanitation, storm and waste water drains, electricity, transport and telecommunications, health care, education, and emergency response)
- Integrating adaptation into local investments, policies, and regulatory frameworks
- Good governance with universal provision of infrastructure and services
- Building human and institutional capacity for adaptation
- Coordinated support from higher levels of governments, the private sector, and civil society and horizontal learning through networks of cities and practitioners
- A scientific evidence base in each urban centre, including local risk and vulnerability assessments and information and data with which to consider current and future risk and adaptation and development options.

Urban adaptation benefits from effective multi-level urban risk governance, alignment of policies and incentives, strengthened local government and community adaptation capacity, synergies with the private sector, and appropriate financing and institutional development (A. Revi et al., 2014). Experience from cities that have successfully implemented risk management strategies suggests that increased capacity, voice, and influence of low-income groups and vulnerable communities and their partnerships with local governments also benefits adaptation (For example Durban and Dar es Salaam).

Capabilities approach

While risk reduction can be approached via reducing vulnerabilities and managing exposure, resilience can also be induced by increasing people's, communities' and institutions' capacities to act and react in the face of an event. Sen has long argued for the capability approach which is evaluating a person's advantage over his or her actual ability to achieve various valuable functionings as a part of living and that could bring him or her the freedom to well-being. This may involve upgrading the ability to satisfy certain crucially important functionings such as hunger and poverty up to certain minimally adequate levels, or going beyond to more complex abilities such as self-respect and dignity (Sen, 1993). It is this freedom to well-being which is of policy relevance – whereby the state should provide for adequate opportunities to the people to choose and act on what is necessary and important to them. This may involve improving their awareness, perceptions and priorities, but is an argument for choices and against top-down paternalism. Orton further provides a compelling argument for the capabilities approach as a framework for new thinking about employment, work and welfare in the 21st century and a way towards flourishing lives (Orton, 2011). In short, it can be argued that while capabilities approach can reduce risk by improving people's ability to act and react, it can also lead to better and more flourishing lives.

National programmes such as National Urban Livelihoods Mission (NULM), National Urban Housing and habitat Policy (NUHHP) and National Urban Health Mission (NUHM) have the beginnings of this capabilities approach, whereby each ofthem aims at improving people's lives by expanding people's choices. Each of them aims at addressing the different component of urban poverty. The dimensions of urban poverty can be broadly divided into three categories: (i) residential (access to land, shelter, basic services, etc.); (ii) social (deprivations related to factors like gender, age and social stratification, lack of social protection, inadequate voice and participation in governance structures, etc.) and (iii) occupational (precarious livelihoods, dependence on informal sector for employment and earnings, lack of job security, poor working conditions, etc.).

NUHHP (2007) aims to promote sustainable development of habitat in the country with a view to ensure equitable supply of land, shelter and services at affordable prices to all sections of the society (MoHUPA, 2007). NUHM (2013) aims to address the health concerns of the urban poor through facilitating equitable access to available health facilities by rationalizing and strengthening of the existing capacity of health delivery for improving the health status of the urban poor (MoHFW, 2013). NULM aims to reduce poverty and vulnerability of the urban poor households by enabling them to access gainful self-employment and skilled wage employment opportunities, resulting in an appreciable improvement in their livelihoods on a sustainable basis, through building strong grassroots level institutions of the poor (MoHUPA, 2014).

Part E: What are the ways going forward?

Players	Short Term Actions	Medium Term Actions	Long Term Actions
National Government	Departments of urban development and poverty alleviation (jointly managing JNNURM) should become the nodal agencies for urban resilience and programme design at the national level – along with suitable capacities at the state and city levels. National Level Resilience Cell can engage with the coastal zone regulation in coordination with state level ministries. National Cell must cumulate state level Risk Atlases to	Ministry of Finance could define fiscal and financial measures like domestic market for carbon credits linked via appropriate institutions to the global market. Develop a National Resilience Programme of Action and a Technical Mission for Sustainable Cities MoUD and BIS should collaborate to develop a new series of national building, service delivery and lifeline infrastructure risk mitigation standards, like the existing earthquake mitigation standards	Functions of climate change and disaster risk management should be relocated from MoEF to the Cabinet Secretariat or the Planning Commission along with the Ministry of Finance. This would require an amendment to the Allocation of Business Rules, 1961. Climate Change and DRR communities should mobilise political will for this.

	develop a National Risk Atlas that maps all elements of risk including climate change related risks, vulnerabilities and exposures. It should also estimate potential national losses to economic activity and capital stocks. Apex institutions that bring together knowledge, research and action oriented networks need to be activated at national, state and city levels.	but unlike them, these standards must be mandated within bye laws and requirements for plan approvals.	
State Government	All states must instate a State Risk Management Authority (SRMA/SDMAs), on the lines of the Gujarat State Disaster Management Authority. These SRMAs must develop a State Risk Atlas that maps hazard risks including climate change related risks, vulnerabilities and exposures, down at the district level. It should also estimate potential losses to economic activity and capital stocks.	Boards of departments of finance and planning need to integrate risk management into their medium term expenditure frameworks. Appropriate changes at the state housing, urban development, town planning and infrastructure legislations. Training and capacity building also required at these various departments.	
City Level Authorities	Planning authorities to re-examine CDPs to include risk management measures. Transportation, building and energy sectors to be enabled for city-led adaptation and mitigation strategies.	Develop public entitlements and service delivery to the poor and vulnerable to address existing asymmetries and structural vulnerabilities. Interventions in the real estate and housing markets and	

	Department of finance should create appropriate fiscal and financial incentives for a multi-stakeholder engagement and strategic risk sharing. Public-private-resident partnership to finance, build and retrofit housing and infrastructure to risk-resistant standards – and develop strategic hazard defences at the city level. [e.g. Work done by Micro Home Solutions in Delhi]	public service delivery. Multi-lingual online GIS-based city and zonal risk management plans (RMPs) linked with public land records, real estate information, building permissions and public investments in infrastructure.	
Neighbourhood Level Stakeholders	Cities should promote a network of risk management initiatives especially from slum squatters and informal settlements in vulnerable and exposed locations – eventually leading into an implementable city resilience programme of action.		
Private Sector	Develop appropriate risk assessment, adaptation and mitigation plans or resilience plans for clusters of enterprises in vulnerable areas. Delineate CSR (corporate social responsibility) funds towards resilience building activities, particularly for settlements in the more vulnerable and exposed locations.	Develop private enterprise led building and infrastructure upgrading, retrofitting and technical support initiatives to enable and scale resilience activities. Help propagate business continuity plans as a basic requirement for any enterprise of any size. Build and promote the use of templates which consider impact on enterprises by external forces.	Promote the use of insurance and re-insurance products.
Civil Society	Take a lead on advocacy and	NGOs can provide independent feedback,	

	mobilisation of resilience building activities centred on the provisions and extensions of basic services and entitlements. Promote and propagate neighbourhood pilot projects to test new methods – and use these to promote risk related awareness in local people.	checks, balances, technical advice to public and private sector institutions.	
Other International and National Funding Agencies			

APPENDICES

Appendix 1: Definitions

(Field, 2012)

Adaptation: In human systems, the process of adjustment to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities. In natural systems, the process of adjustment to actual climate and its effects; human intervention may facilitate adjustment to expected climate.

Adaptive capacity: The combination of the strengths, attributes, and resources available to an individual, community, society, or organization that can be used to prepare for and undertake actions to reduce adverse impacts, moderate harm, or exploit beneficial opportunities.

Capacity: The combination of all the strengths, attributes, and resources available to an individual, community, society, or organization, which can be used to achieve established goals.

Climate change: A change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcings, or to persistent anthropogenic changes in the composition of the atmosphere or in land use.

Climate variability: Climate variability refers to variations in the mean state and other statistics (such as standard deviations, the occurrence of extremes, etc.) of the climate at all spatial and temporal scales beyond that of individual weather events. Variability may be due to natural internal processes within the climate system (internal variability), or to variations in natural or anthropogenic external forcing (external variability).

Disaster: Severe alterations in the normal functioning of a community or a society due to hazardous physical events interacting with vulnerable social conditions, leading to widespread adverse human, material, economic, or environmental effects that require immediate emergency response to satisfy critical human needs and that may require external support for recovery.

Disaster risk management (DRM): Processes for designing, implementing, and evaluating strategies, policies, and measures to improve the understanding of disaster risk, foster disaster risk reduction and transfer, and promote continuous improvement in disaster preparedness, response, and recovery practices, with the explicit purpose of increasing human security, well-being, quality of life, and sustainable development.

Disaster risk reduction (DRR): Denotes both a policy goal or objective, and the strategic and instrumental measures employed for anticipating future disaster risk; reducing existing exposure, hazard, or vulnerability; and improving resilience.

Disaster risk: The likelihood over a specified time period of severe alterations in the normal functioning of a community or a society due to hazardous physical events interacting with vulnerable social conditions, leading to widespread adverse human, material, economic, or environmental effects that require immediate emergency response to satisfy critical human needs and that may require external support for recovery.

Exposure: The presence of people; livelihoods; environmental services and resources; infrastructure; or economic, social, or cultural assets in places that could be adversely affected.

Hazard: The potential occurrence of a natural or human-induced physical event that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, and environmental resources.

Mitigation (of climate change): A human intervention to reduce the sources or enhance the sinks of greenhouse gases.

Mitigation (of disaster risk and disaster): The lessening of the potential adverse impacts of physical hazards (including those that are human-induced) through actions that reduce hazard, exposure, and vulnerability.

Resilience: The ability of a system and its component parts to anticipate, absorb, accommodate, or recover from the effects of a hazardous event in a timely and efficient manner, including through ensuring the preservation, restoration, or improvement of its essential basic structures and functions.

Return period: An estimate of the average time interval between occurrences of an event (e.g., flood or extreme rainfall) of (or below/above) a defined size or intensity.

Transformation: The altering of fundamental attributes of a system (including value systems; regulatory, legislative, or bureaucratic regimes; financial, institutions; and technological or biological systems).

Vulnerability: The propensity or predisposition to be adversely affected.

Appendix 2: Methodology for modelling urban risk concentration in India

Indicators for risk

(Pelling, 2004)

Geospatial urban agglomeration boundaries

(Deichmann, 2011)

Hazard

Hazard Exposure is mapped onto cities (not yet boundaries) using the below listed data sets. Each hazard is assigned an indicator, depending on the severity. Indicators for each hazard are further multiplied, to arrive at an overall Hazard Indicator for the city. These are not added, like the exposure, vulnerabilities and capacity indicators, since they often occur simultaneously, and have exaggerated impacts.

- **Earthquake (BMTPC)- Zones**
- **Wind Pressure(NBC) - m/sec based on 50 yr return period**
- **Cyclonic Storm (UNEP) - km/hr based on 250 yr return period**
- **Landslides (PR)(UNEP)**
- **Landslides (EQ)(UNEP)**
- **Droughts(FAO / UNEP) - Past Events**
- **Tsunami(UNEP)Past Events + XXX return period**
- **Fluvial Floods (Dartmouth / UNEP) - Return Period in Years**
- **Potential for Disease Incidence (Census 2011 data on the number of households consuming water not from a treated source as proxy)**

Exposure
Indicators are used for people (density) and economy (working population, since city GDPs are not available). These are added together to arrive at an overall exposure indicator for the city.

- **Population**
- **Area**
- **Density (Assuming 9k-10k ppl/sq.km. is an optimum serviceable density)**
- **Economy - Working Population as a proxy for productive labour**

Vulnerability
Vulnerable people, buildings and systems are measured using the % of slum population (as a proxy of poverty), number of houses with temporary roofs (as a proxy for poor construction), number of households without access to sanitation systems and electricity (as a proxy for poor access to services). Each of these is added together to arrive at an overall Vulnerability Indicator for the city.

- **People:**
  - **Slum Population (Census 2011)**
  - **Lack of Access to Assets (No. of households having no assets - mobile phones, landlines, television, vehicles, internet, radio, banking services (Census 2011)**
- **Buildings:**
  - **Number of houses with temporary walls (Census 2011)**
  - **Number of houses with temporary Roofs (Census 2011)"**
- **Systems:**
  - **Number of households without access to sanitation systems (Census 2011)"**
  - **Number of households without access to electricity (Census 2011)"**
  - **Number of households consuming water not from a treated source (Census 2011)**

Capacities
Capacities of a city are measured two folds - disaster, climate or city planning status as a proxy for preparedness, and availability of roads and hospital beds as a proxy for response. These indicators are combined together to arrive at an overall Capacities Index for the cities.

Once these indicators are in place, these are combined together using the risk equation, to arrive at an overall Risk Indicator for the cities.

- **Critical Infrastructure:**
  - **"Roads in km 2001)"**
  - **Hospital Beds(2001)**
- **Socio-Economic Assets:**
  - **Access to banking Services (% of households availing banking services) (2011)**
  - **Access to telephones and/or cellular phones (% of households) (2011)**
  - **% of households with access to internet (2011)**
  - **% of households with televisions (2011)**
- **Plan Status:**
  - **City Development Plan**
  - **City Disaster Risk Management Plan**
  - **State Action plan on Climate Change**

100 cities with the highest Risk Indicator are indicative of the concentration of risk in the country, contingent on quality of data available.

Appendix 3: Sources of data

Some Hazard specific data sets that are referred to for the analysis are as follows:

1. Earthquake Hazard Map
   - BMTPC Vulnerability Atlas of India (although the data is now a bit dated, not probabilistic and not very granular)
   - UNEP 250 yr PGA data (GAR 2013)
2. Landslides
   - UNEP (Both precipitation and earthquake)
   - BMTPC - Landslide Atlas Zonation Atlas (http://www.bmtpc.org/topics.aspx?mid=56&Mid1=186) (Although this too is not too granular, and is event based, and not probabilistic)
3. Floods
   - IWMI (http://waterdata.iwmi.org/FloodMapping.php)
   - Dartmouth Data (also only historic event data and not probabilistic)
   - UNEP
   - BMTPC Vulnerability Atlas of India
   - NRSC (http://www.dsc.nrsc.gov.in/DSC/Flood/HistoricFloods.jsp# - but no GIS data, and also only historic event data)
4. Wind Pressure
   - National Building Code Wind Pressure Map
   - BMTPC Wind and Cyclone Hazard Map
   - UNEP Wind Data
5. Cyclonic Storm
   - UNEP Cyclonic Wind Speed 50,100, 250 years
   - BMTPC Wind and Cyclone Hazard Map
6. Droughts
   - UNEP (also event data - binary - does not give severity, return, etc.)
   - NRSC (Agriculture focused, only for 13 states of India) - National Agricultural **Drought** Assessment and Monitoring System (NADAMS) - http://dsc.nrsc.gov.in/DSC/Drought/CONTENT/AGRLDROUGHT%20REPORTS/2012/JUNE/NADAMS-June12_Report.pdf
   - IWMI (http://waterdata.iwmi.org/droughtmap.php)
   - Some data in IPCC 2011, but not very granular. FAO seems to have the same data set.
7. Elevated Temperature

Appendix 4: Hazard Risk Maps

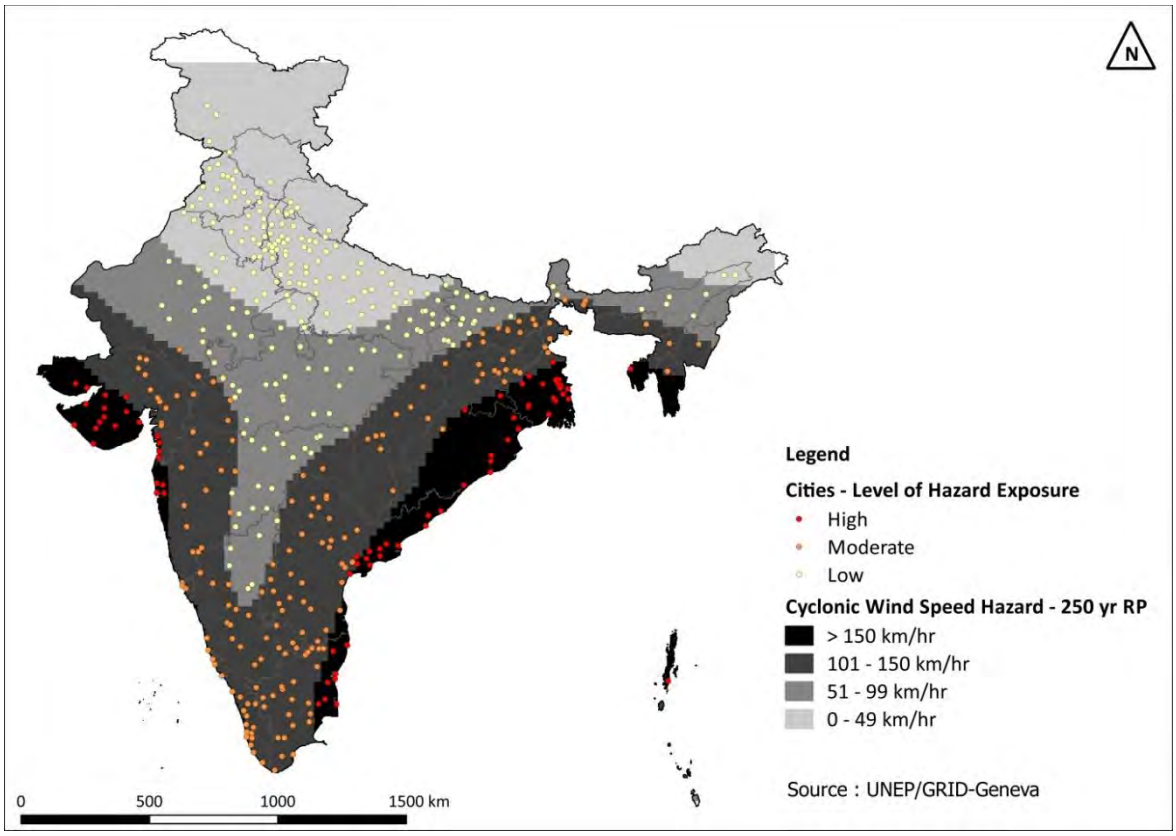


Figure 16 : Cyclonic Wind Speed Map

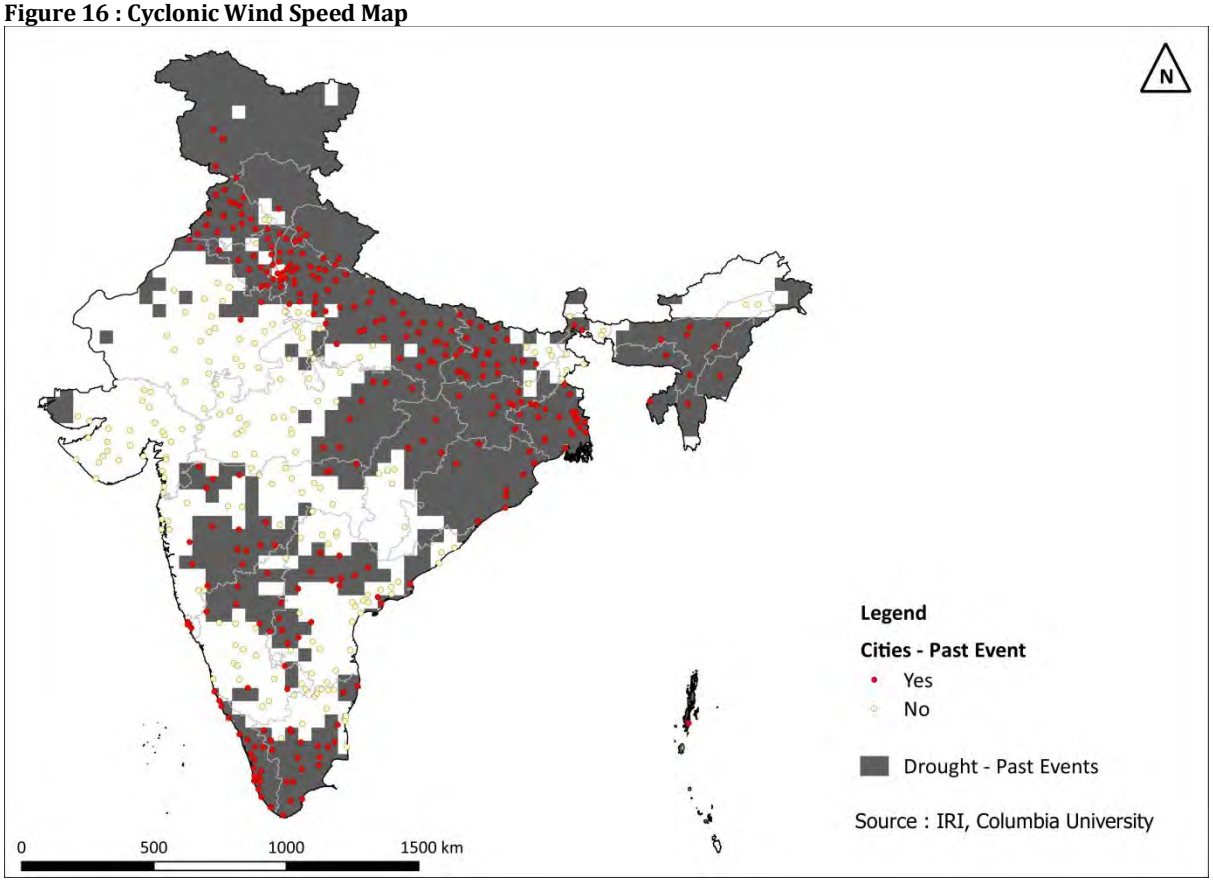


Figure 17 : Drought Map (Past Events)

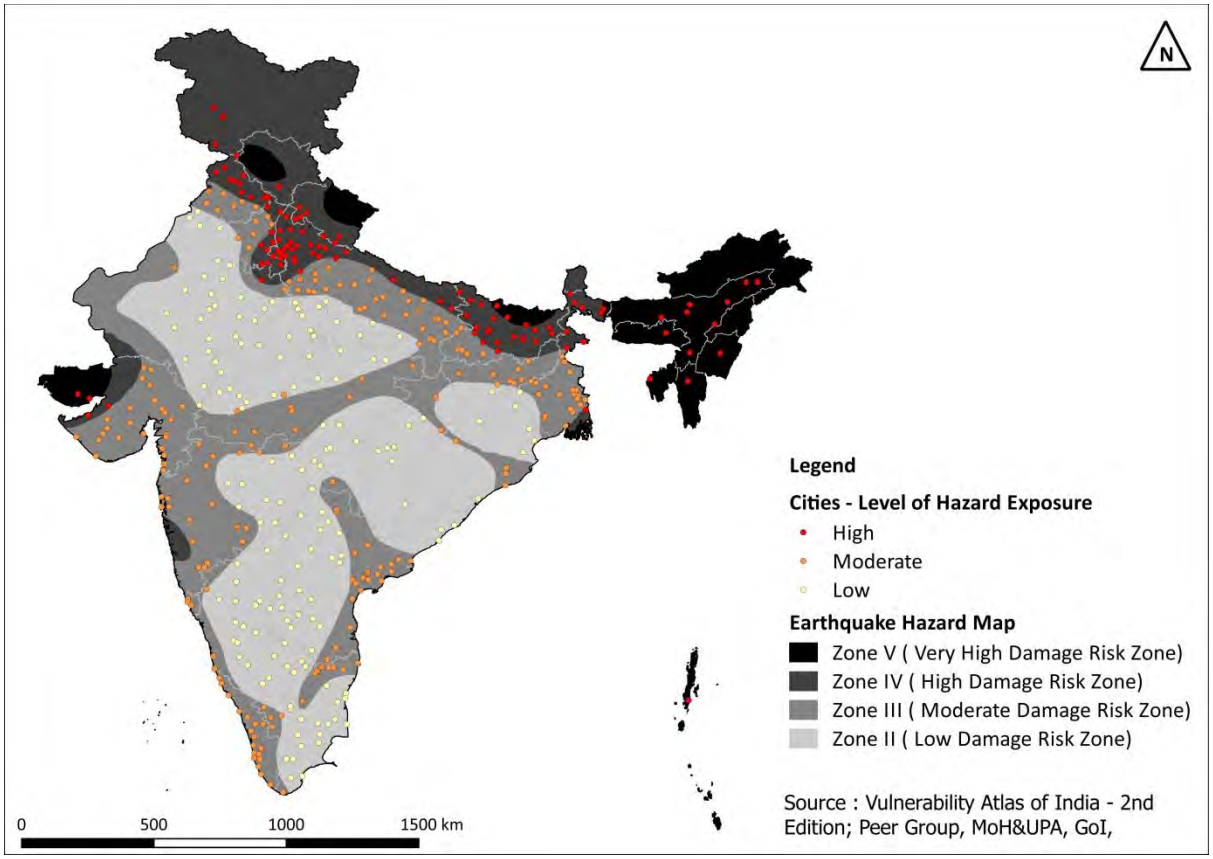


Figure 18 : Earthquake Hazard Map

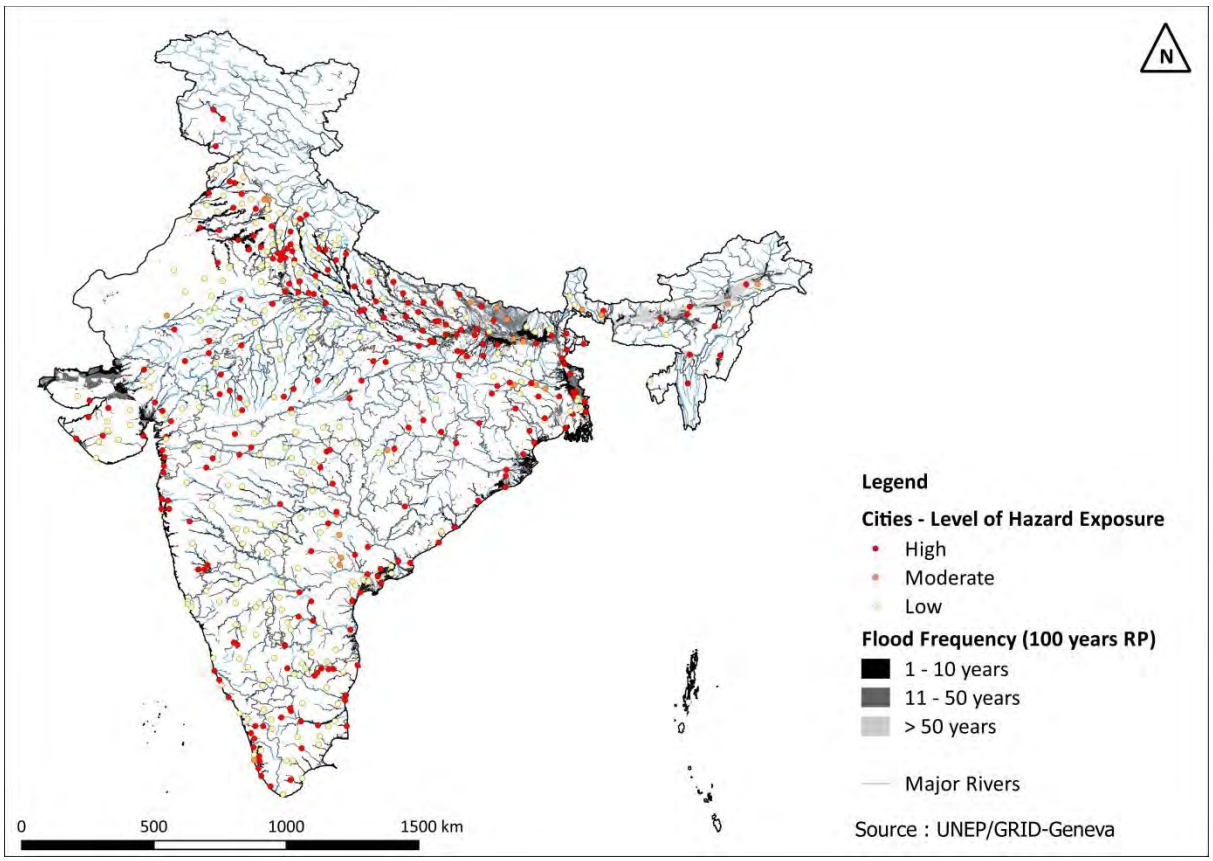


Figure 19 : Flood Map (Fluvial)

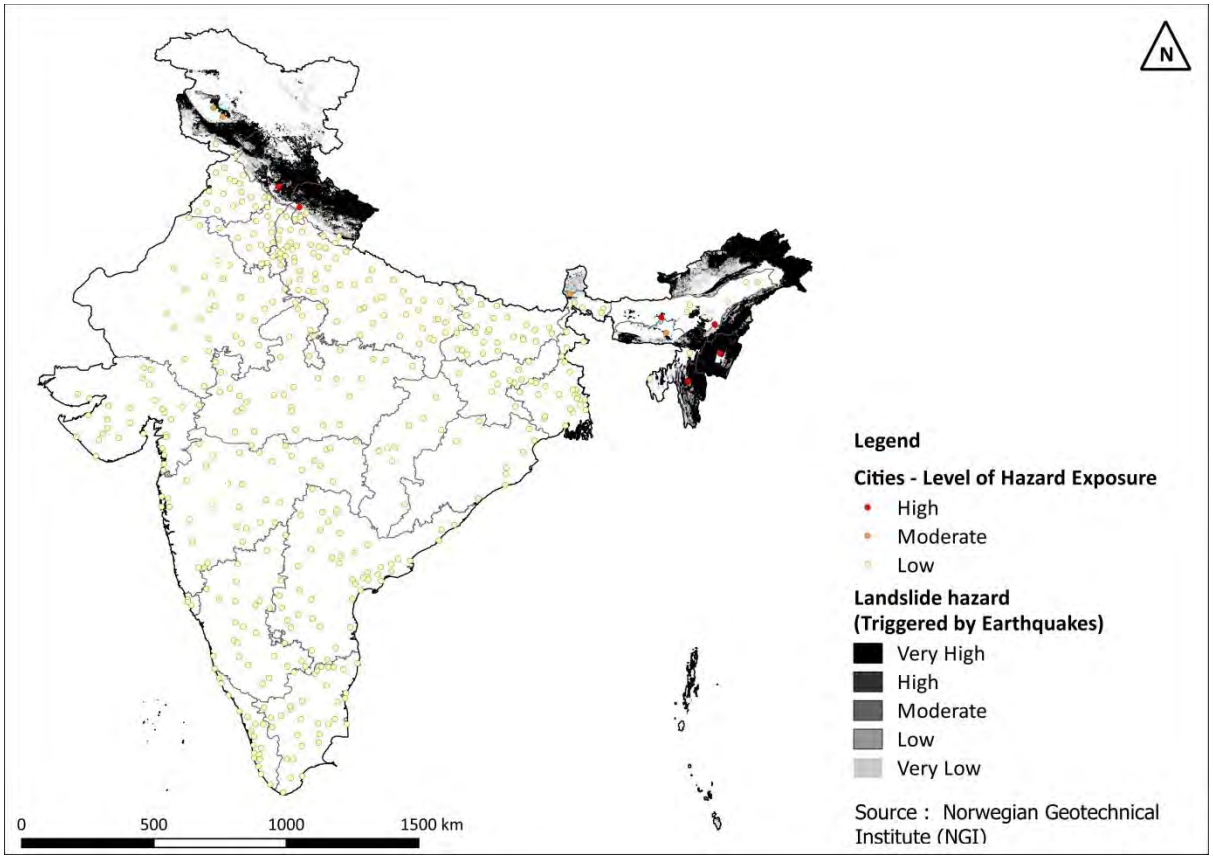


Figure 20 : Landslide Hazard Map (triggered by earthquakes)

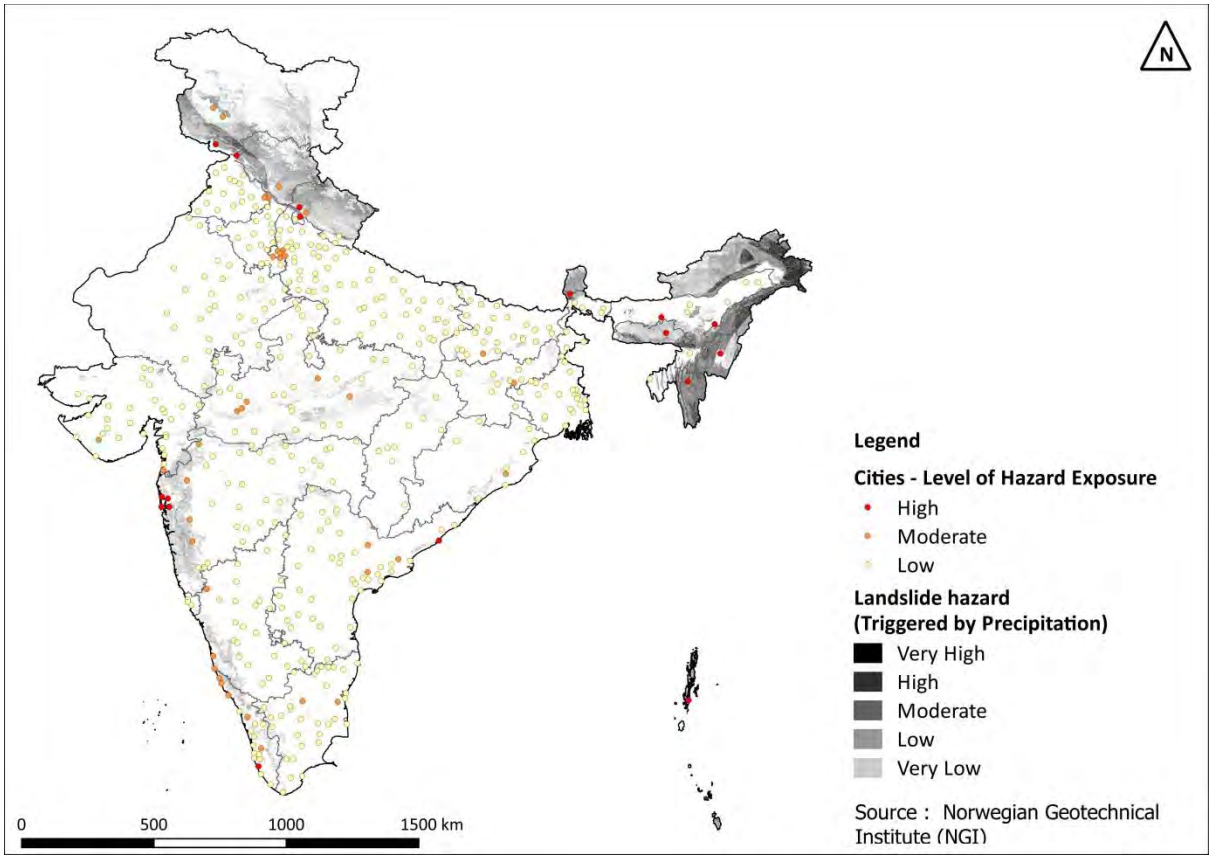


Figure 21 : Landslide Hazard Map (triggered by precipitation)

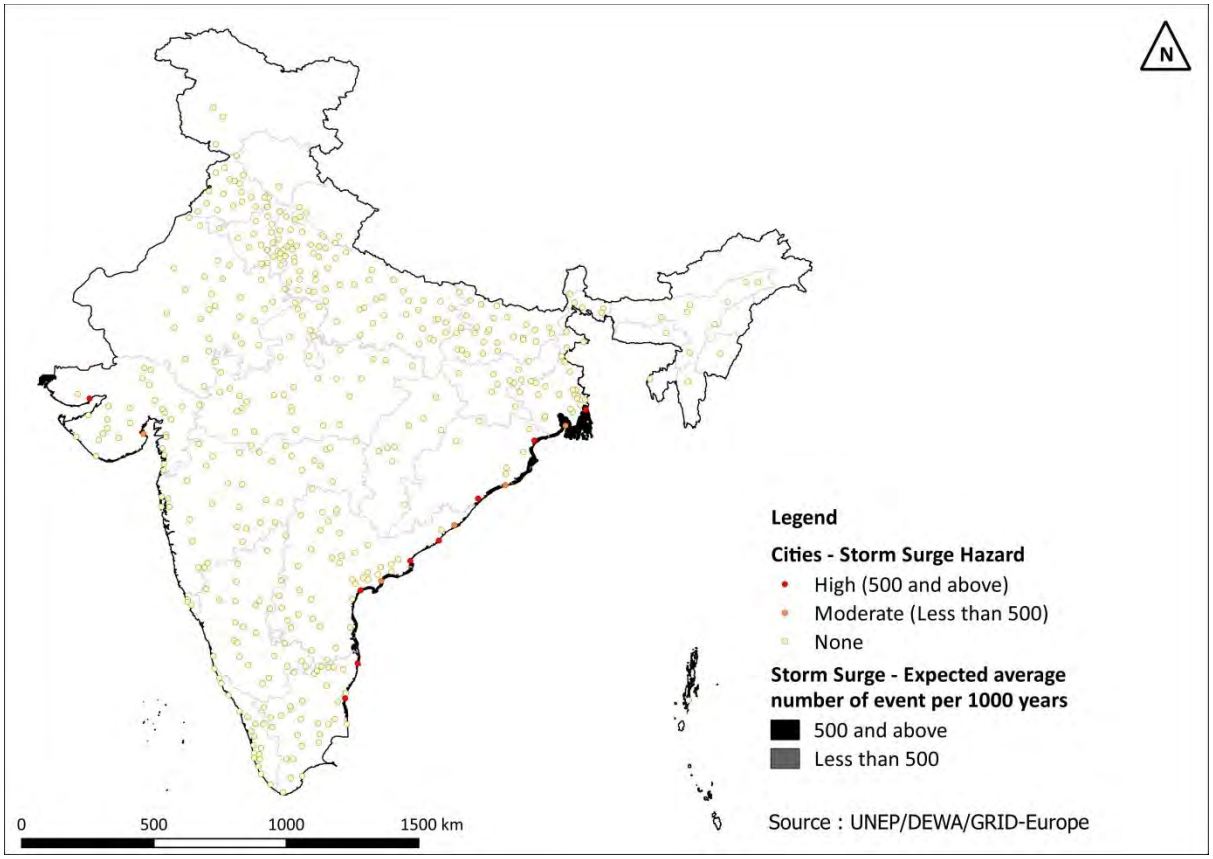


Figure 22 : Storm Surge Hazard Map

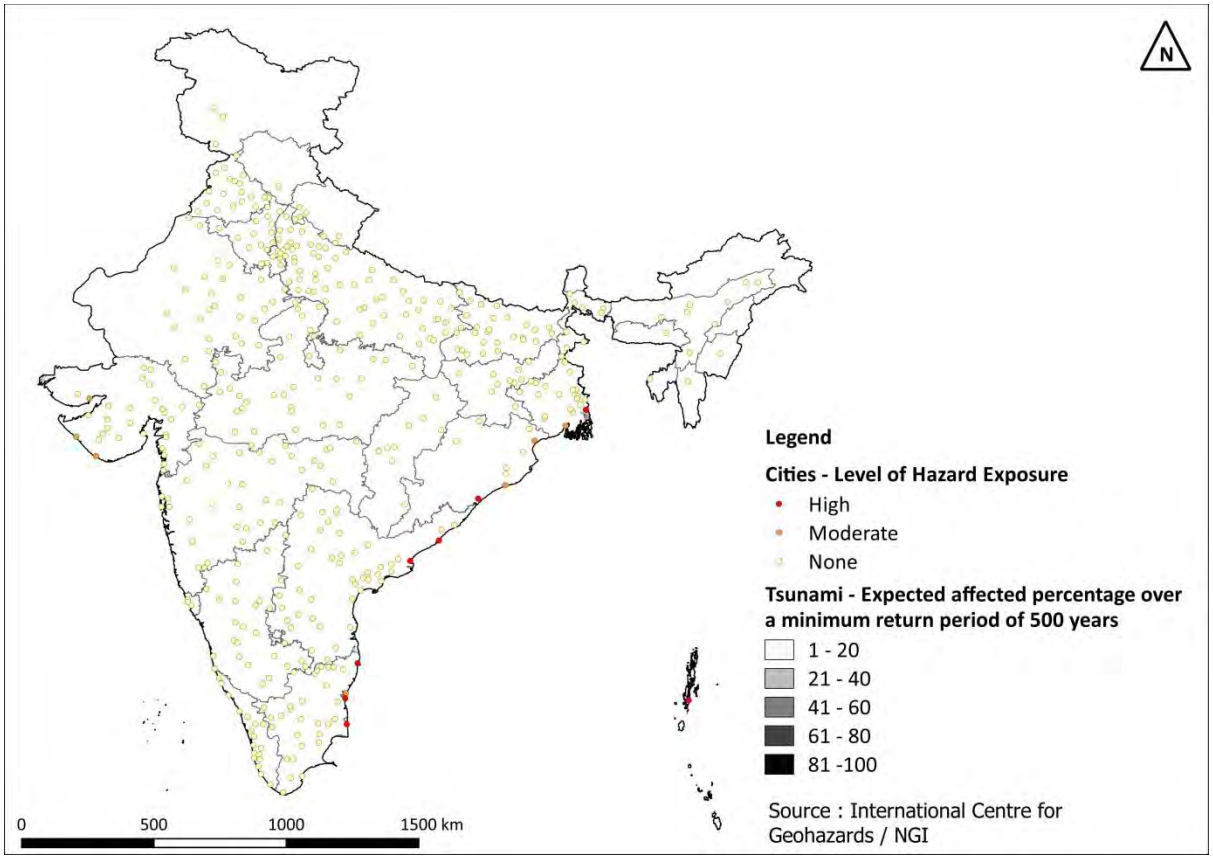


Figure 23 : Tsunami Hazard Map

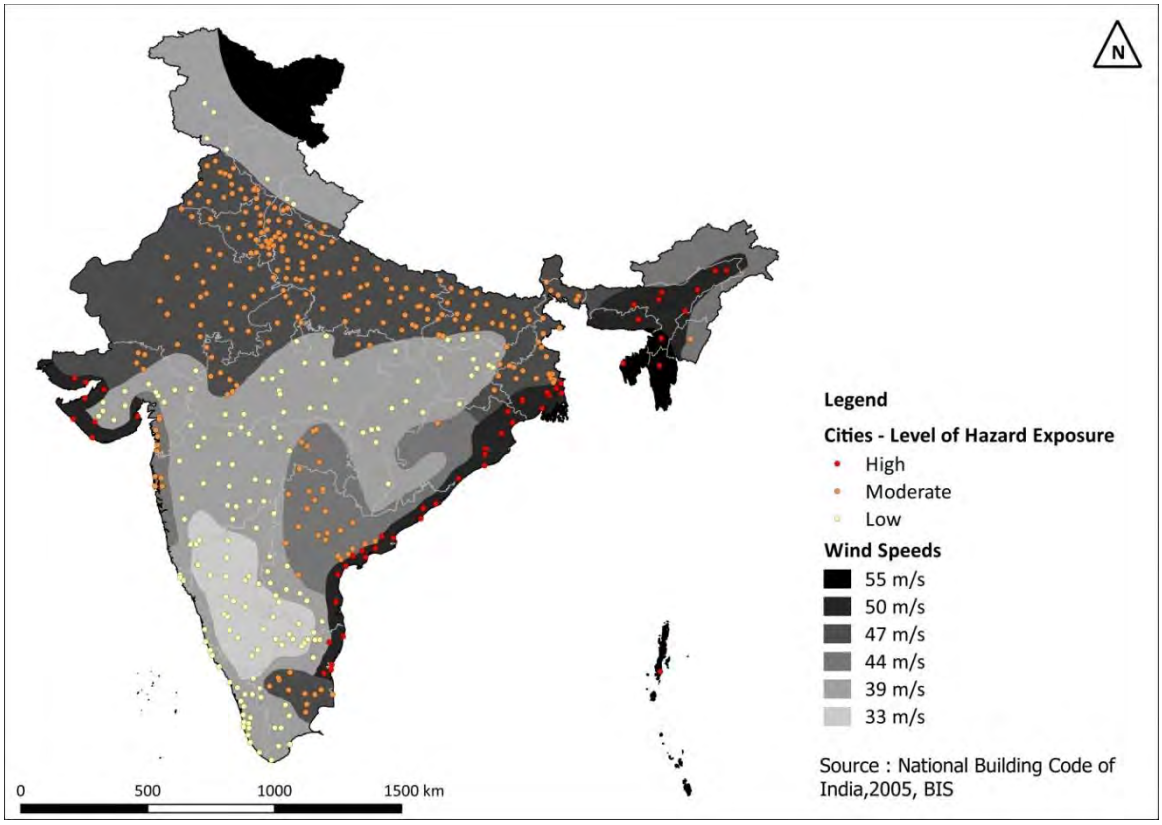


Figure 24 : Wind Hazard Map

Appendix 5: Urban Vulnerability and Exposure Maps

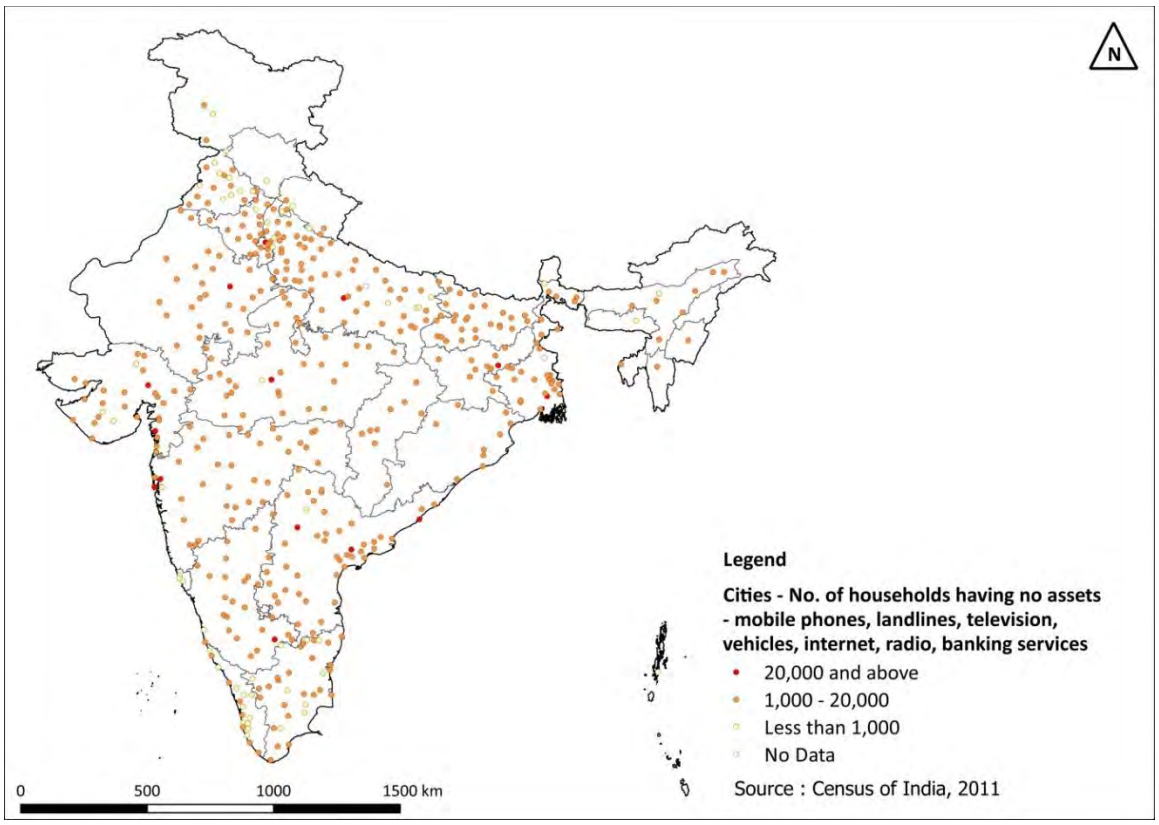


Figure 25 : Map showing Asset Ownership of Households

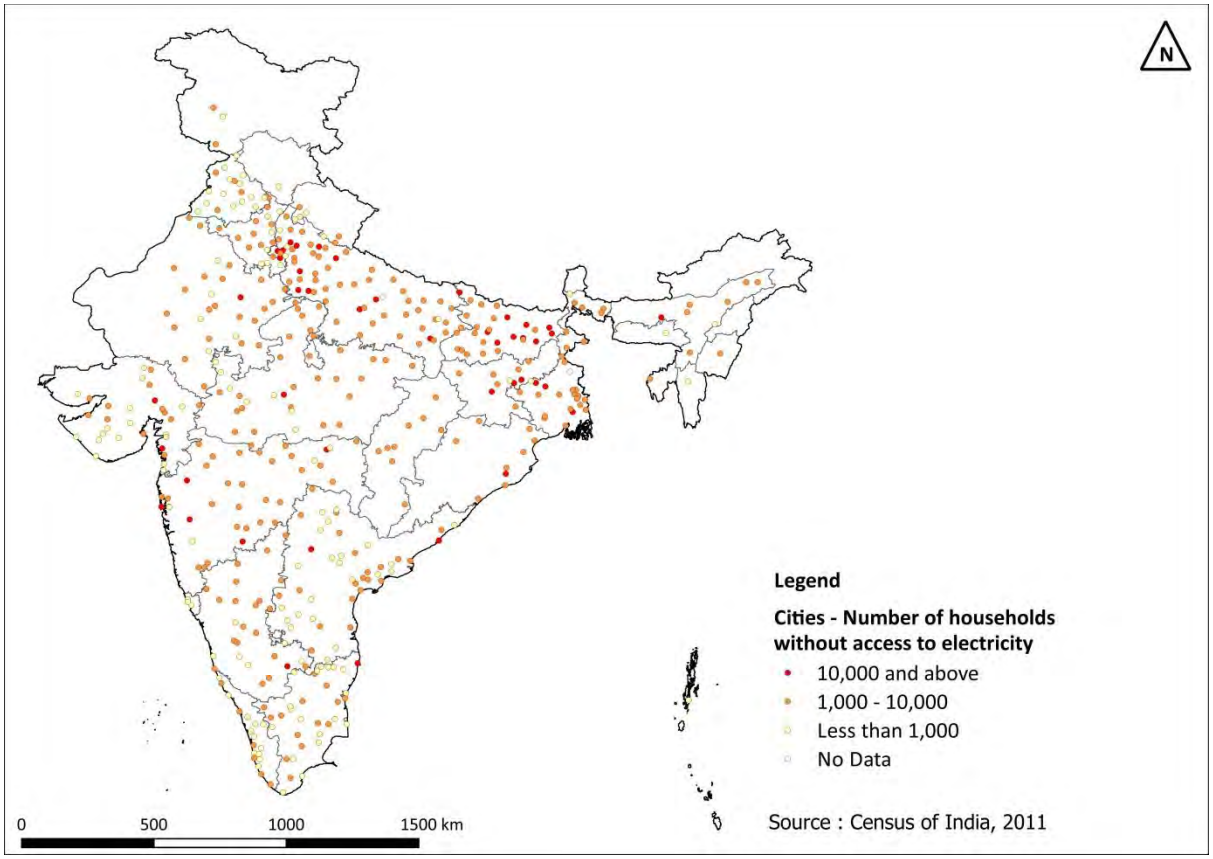


Figure 26 : Map showing access to electricity

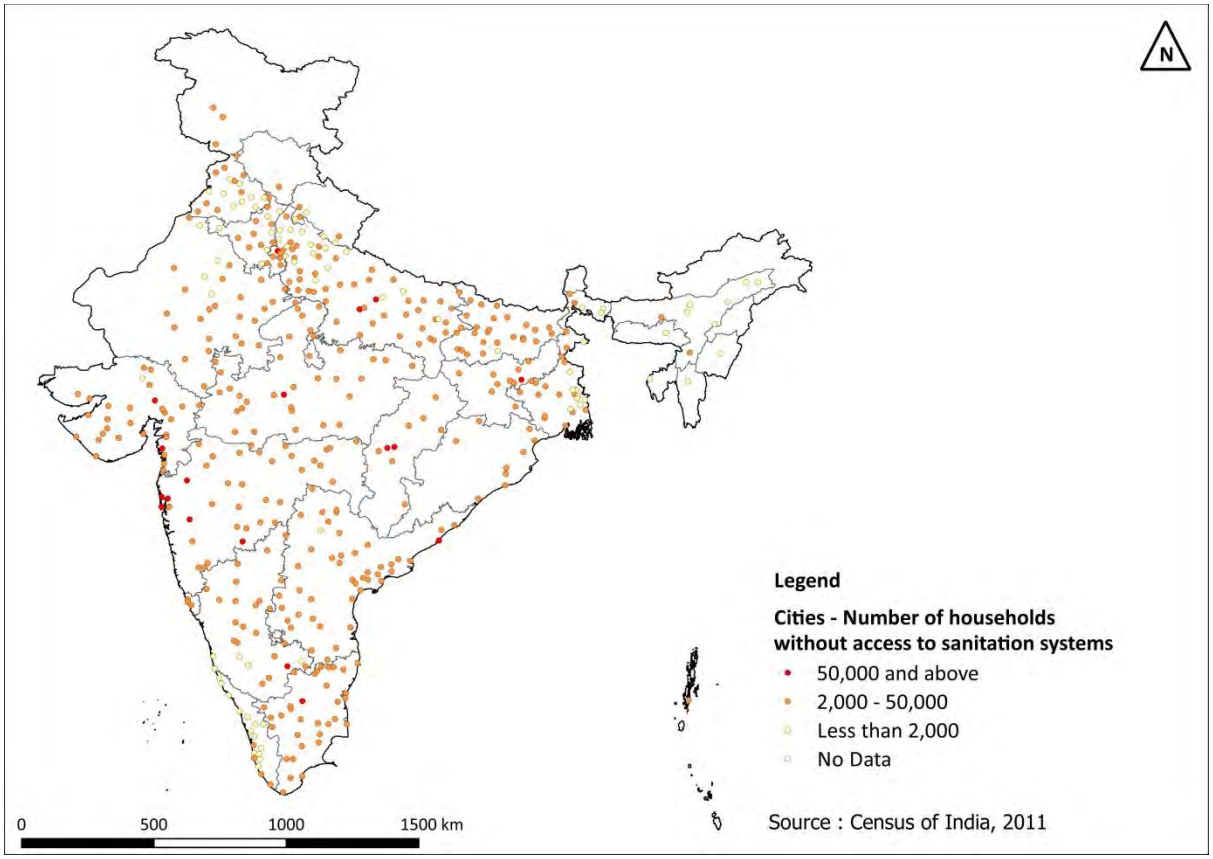


Figure 27 : Map showing access to sanitation system

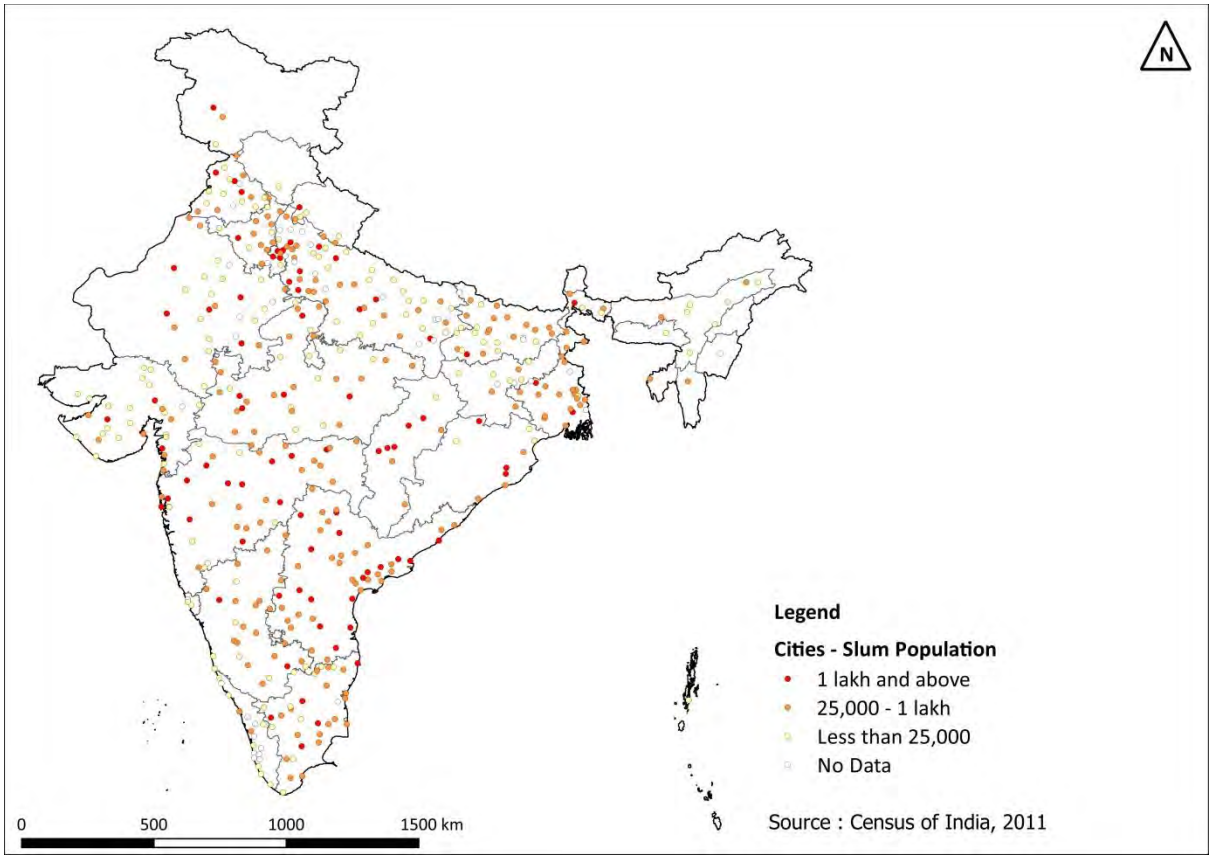


Figure 28 : Map showing Slum Population

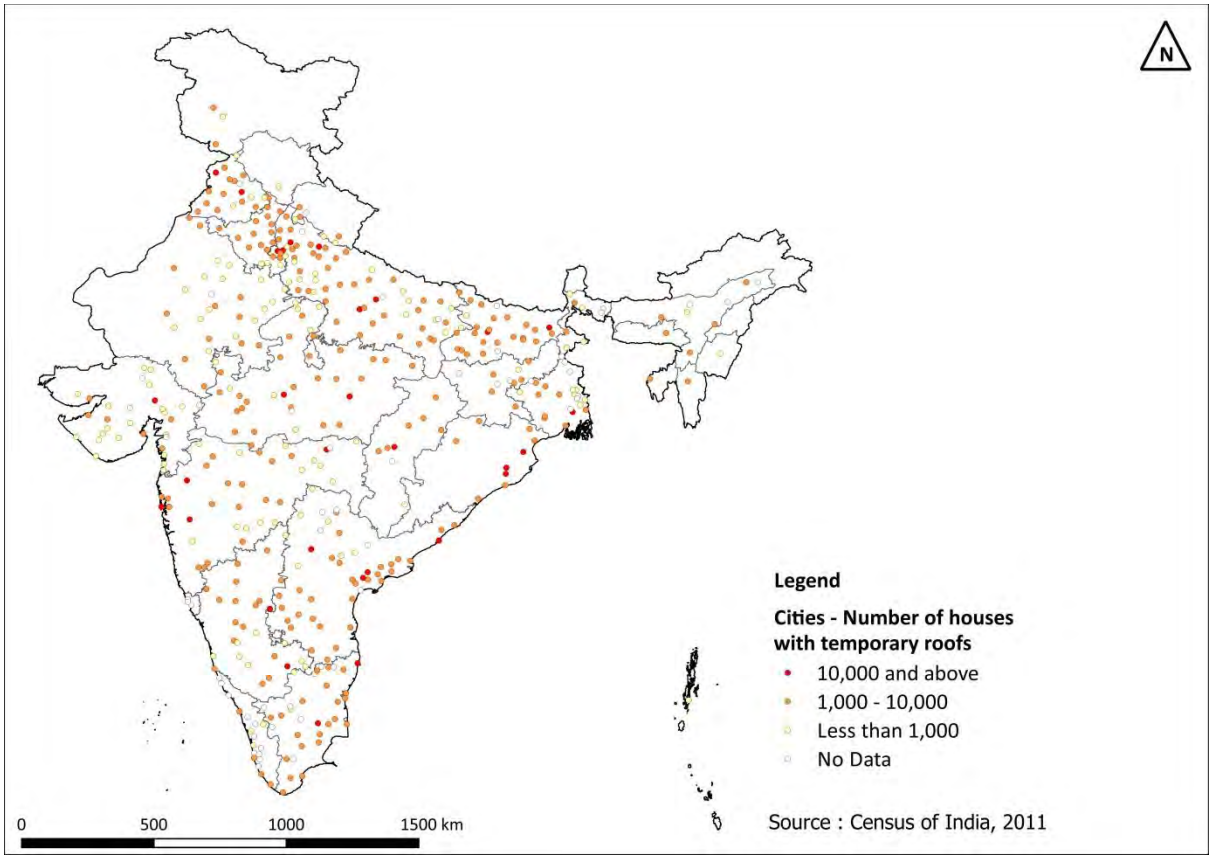


Figure 29 : Map Showing number of households in a city with temporary roofs

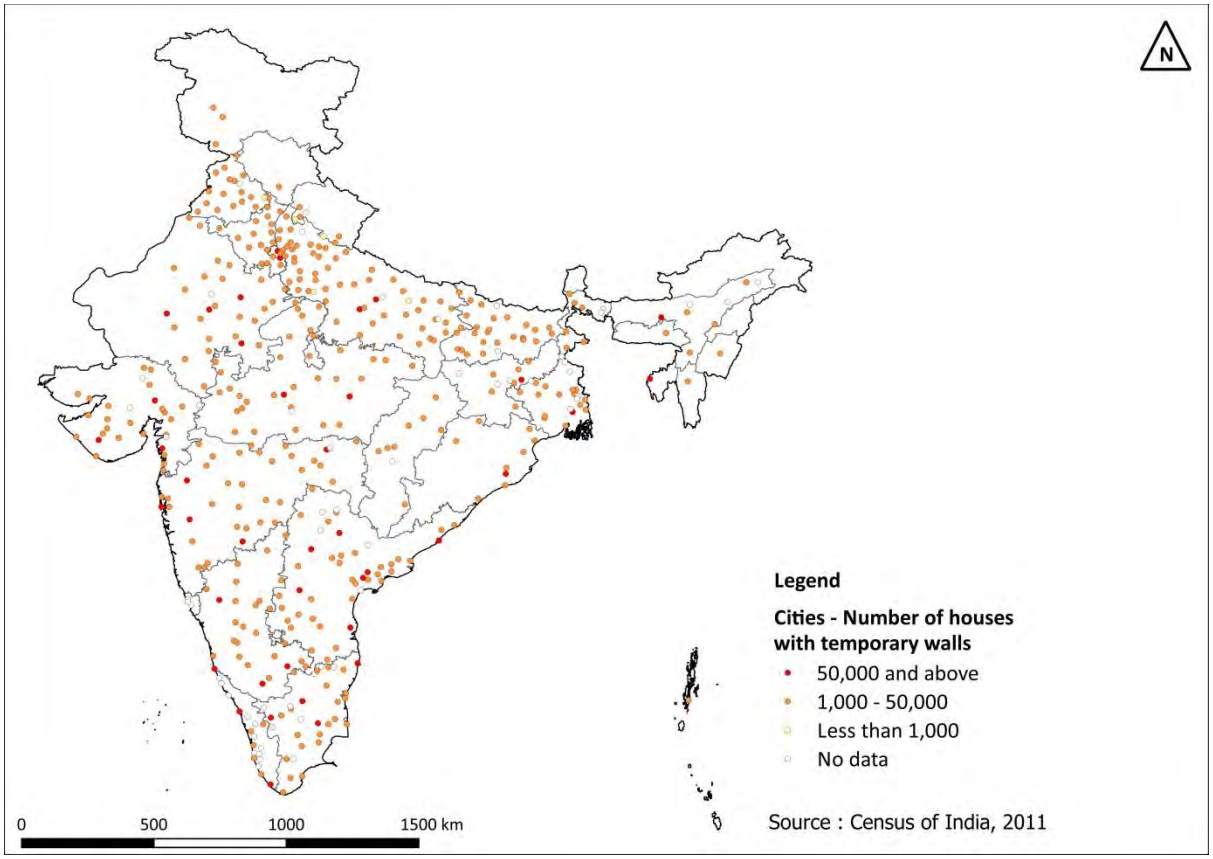


Figure 30 : Map Showing number of households in a city with temporary walls

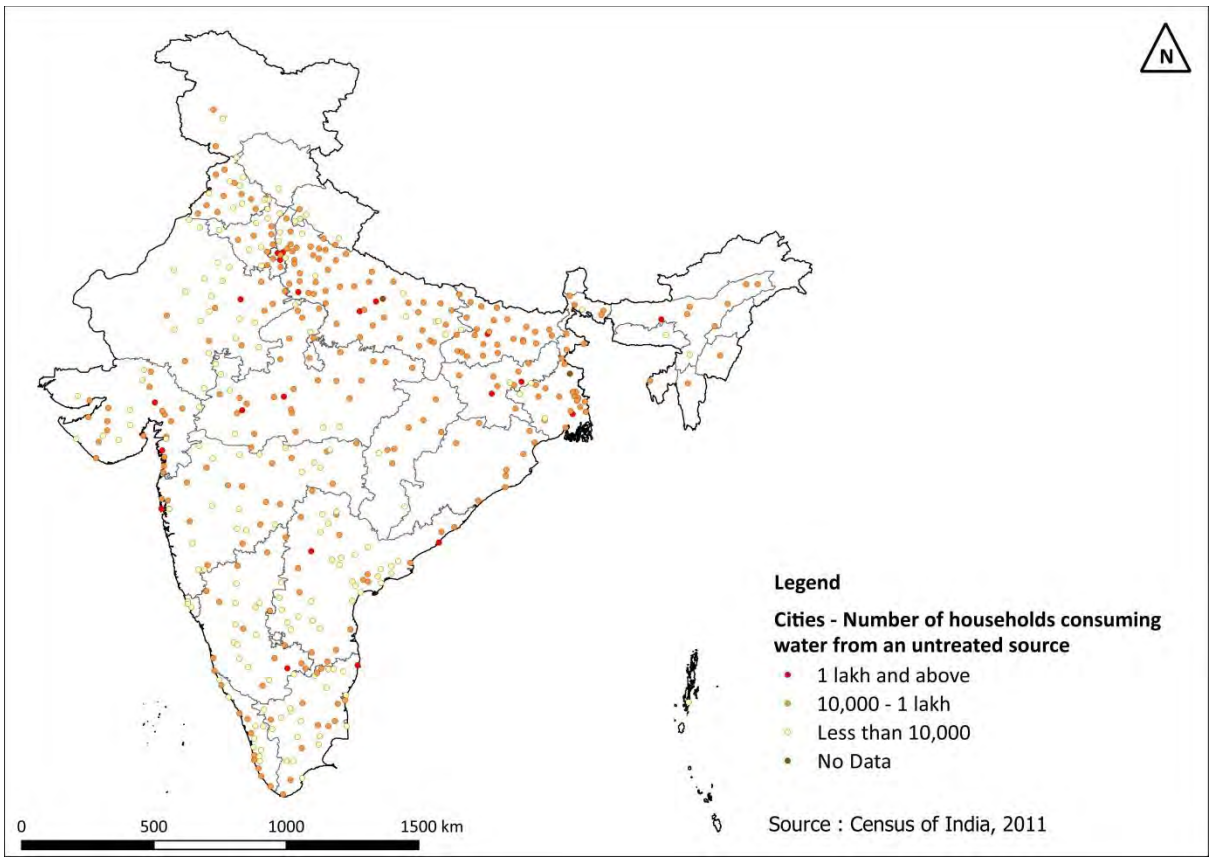


Figure 31 : Map Showing number of households in a city consuming water from untreated source

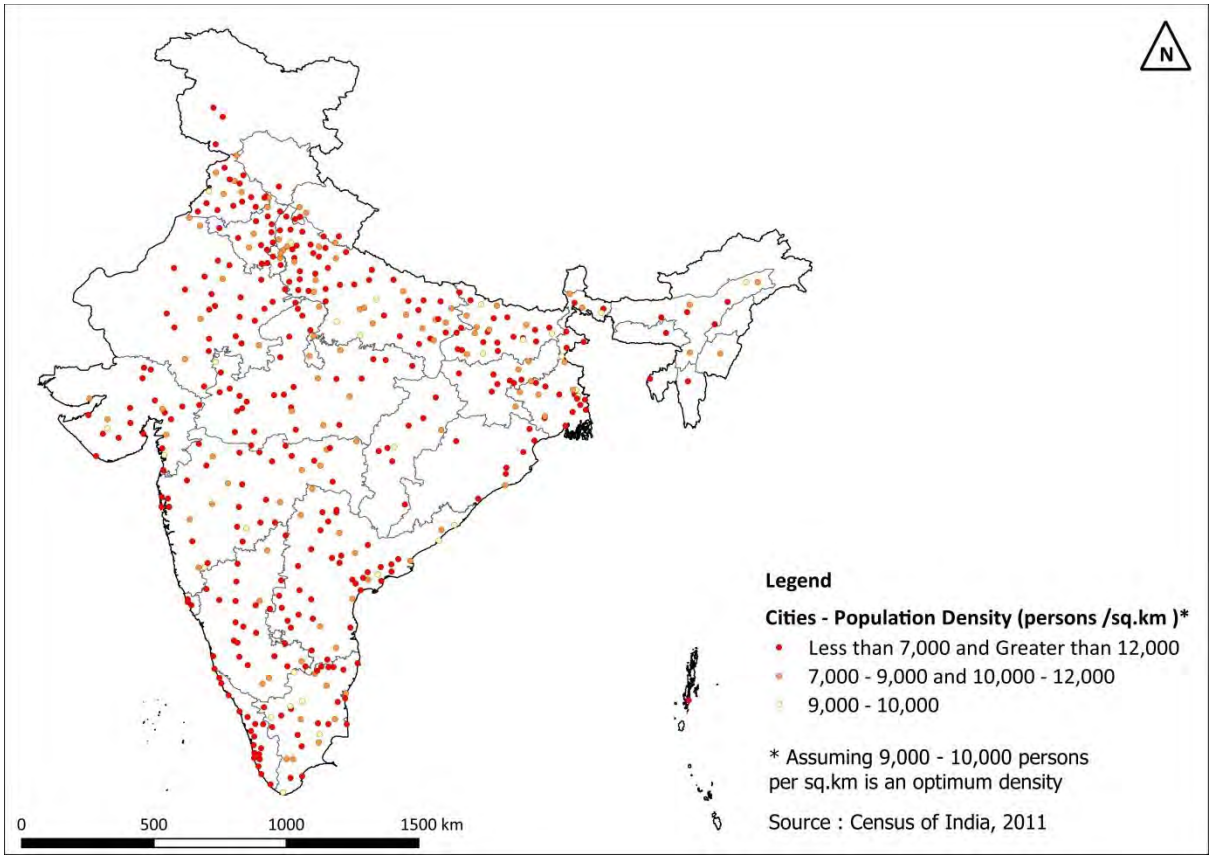


Figure 32 : Map showing Population Densities of Cities

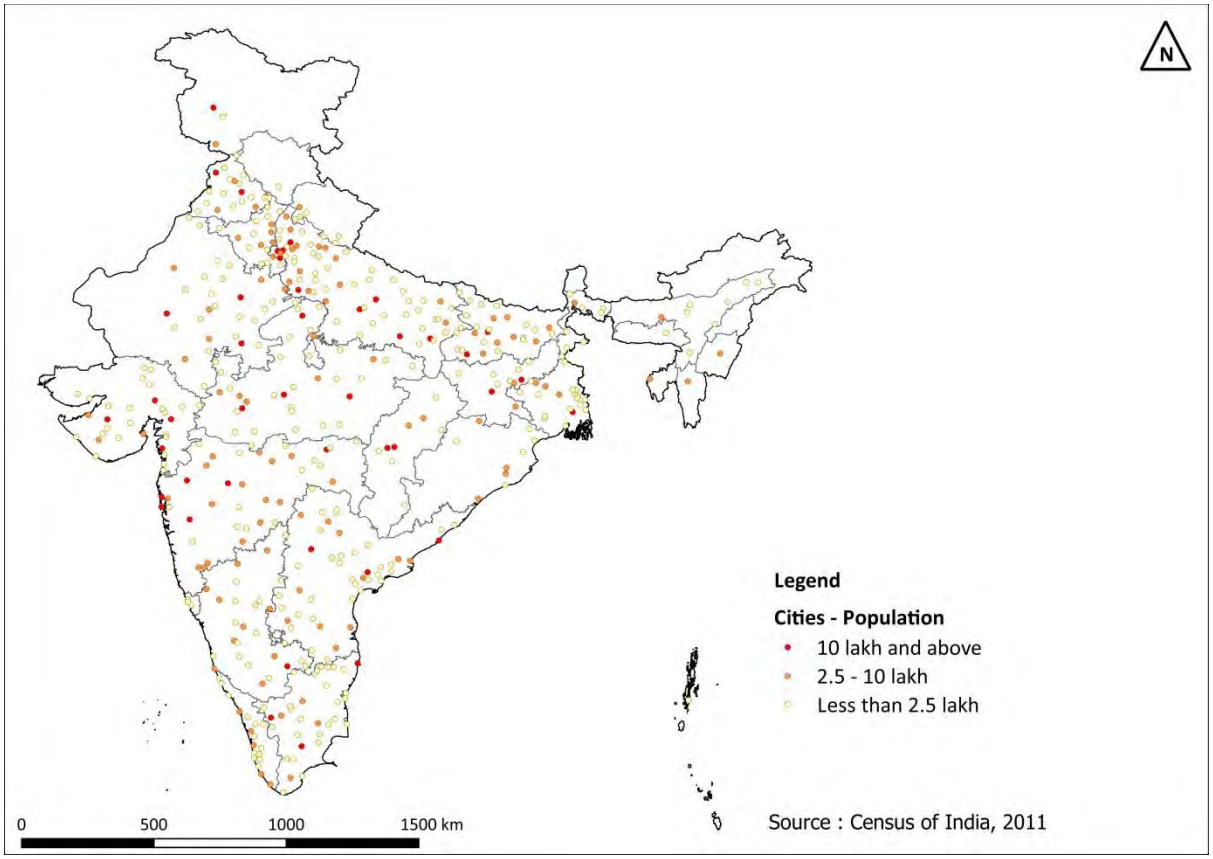


Figure 33 : Map showing City Populations

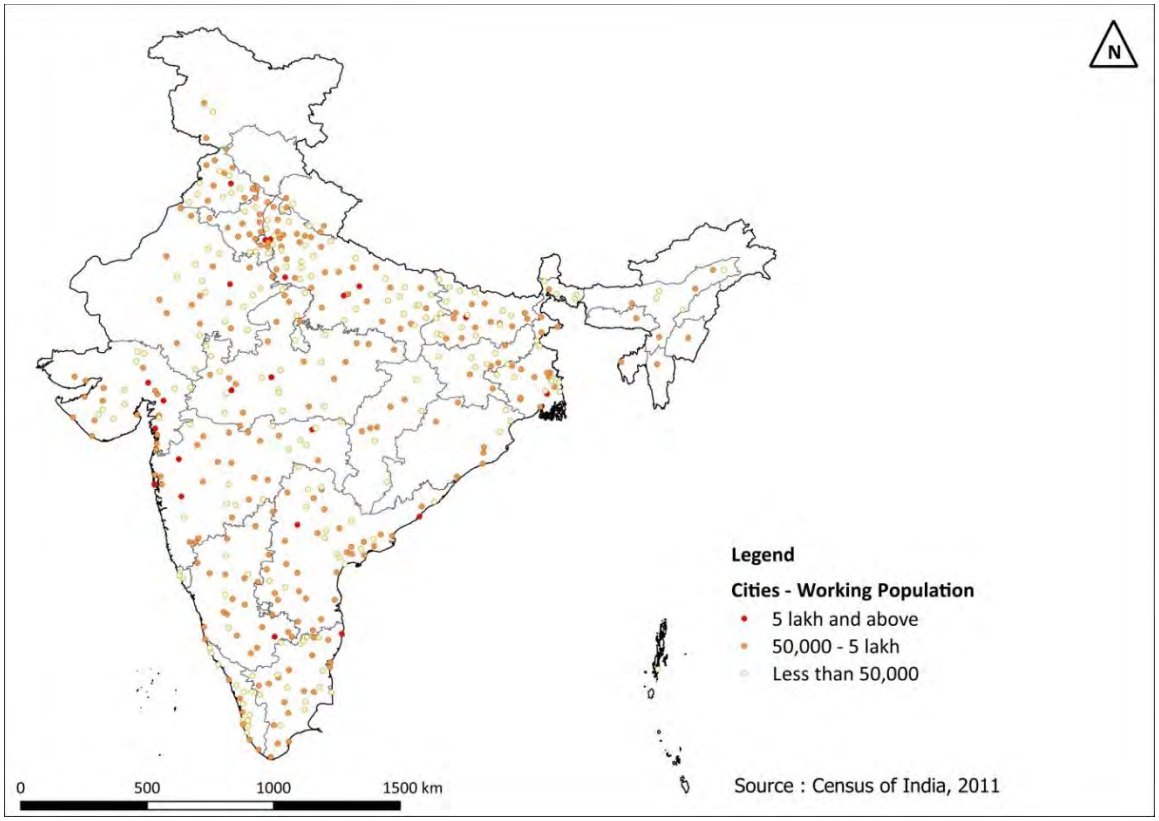


Figure 34 : Map showing number of people working in cities

Appendix 6: Urban Capacities Maps

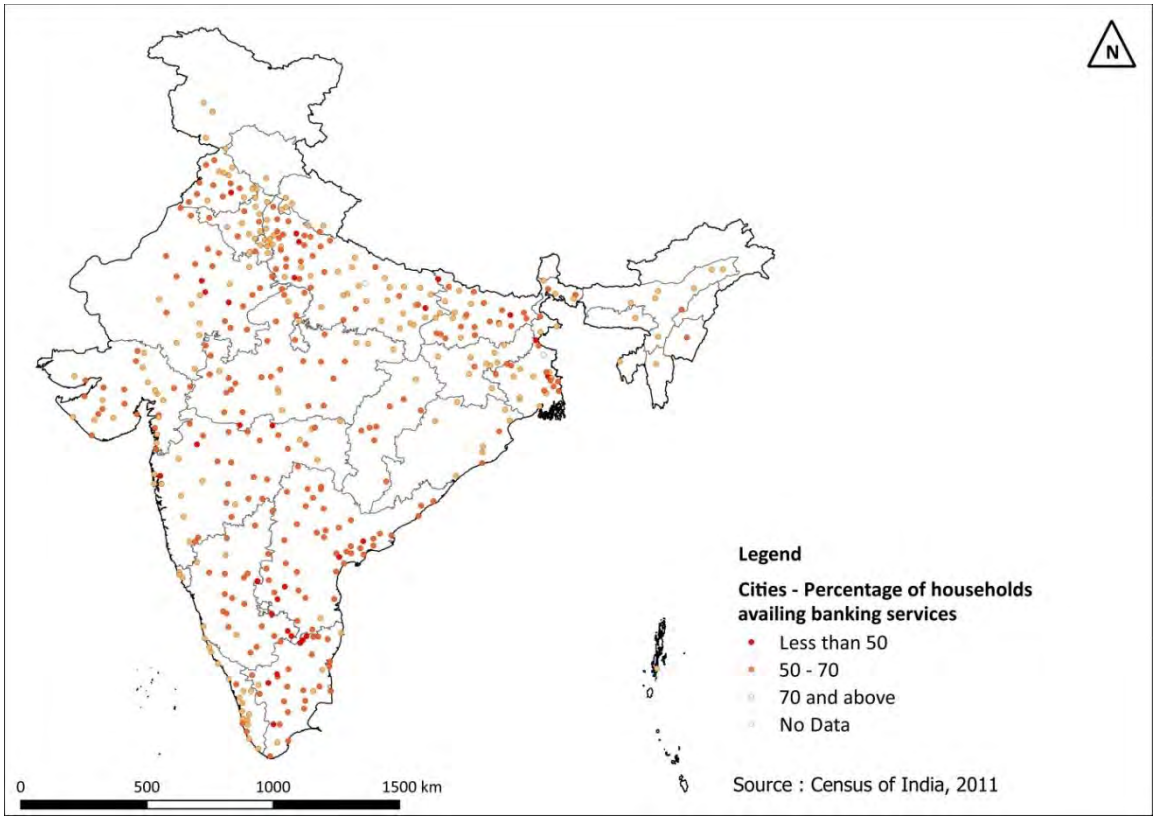


Figure 35 : Map showing cities with percentage of households availing banking services

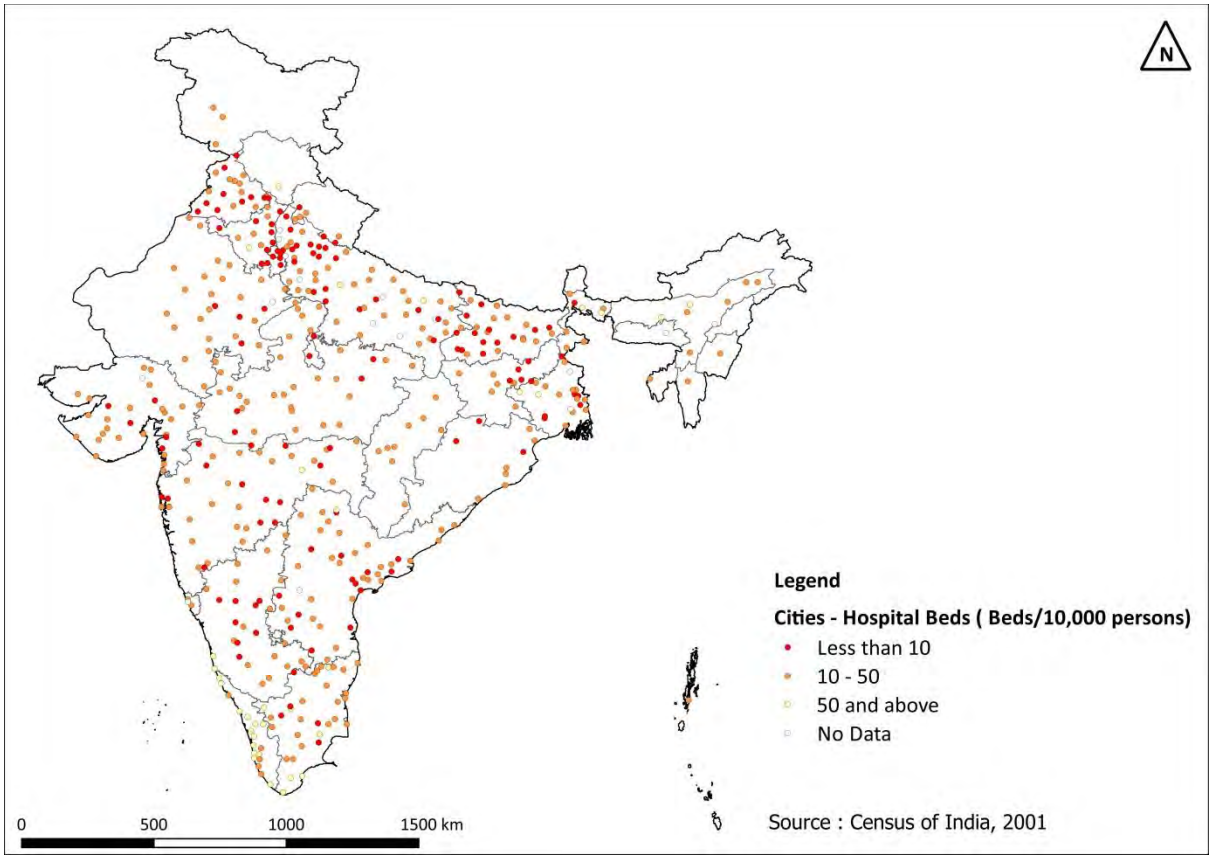


Figure 36 : Map showing number of Hospital beds per 10,000 people in each city

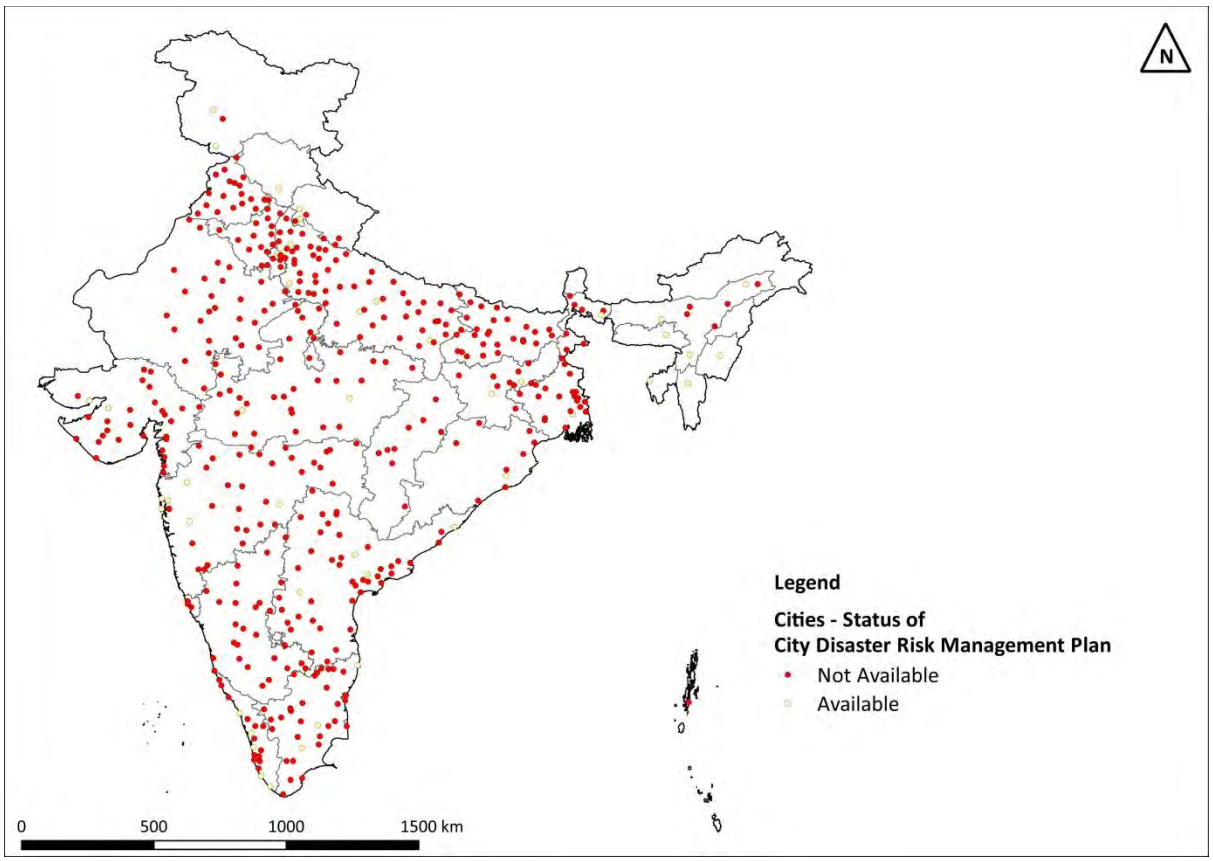


Figure 37 : Map showing the Status of City Disaster Risk Management Plan

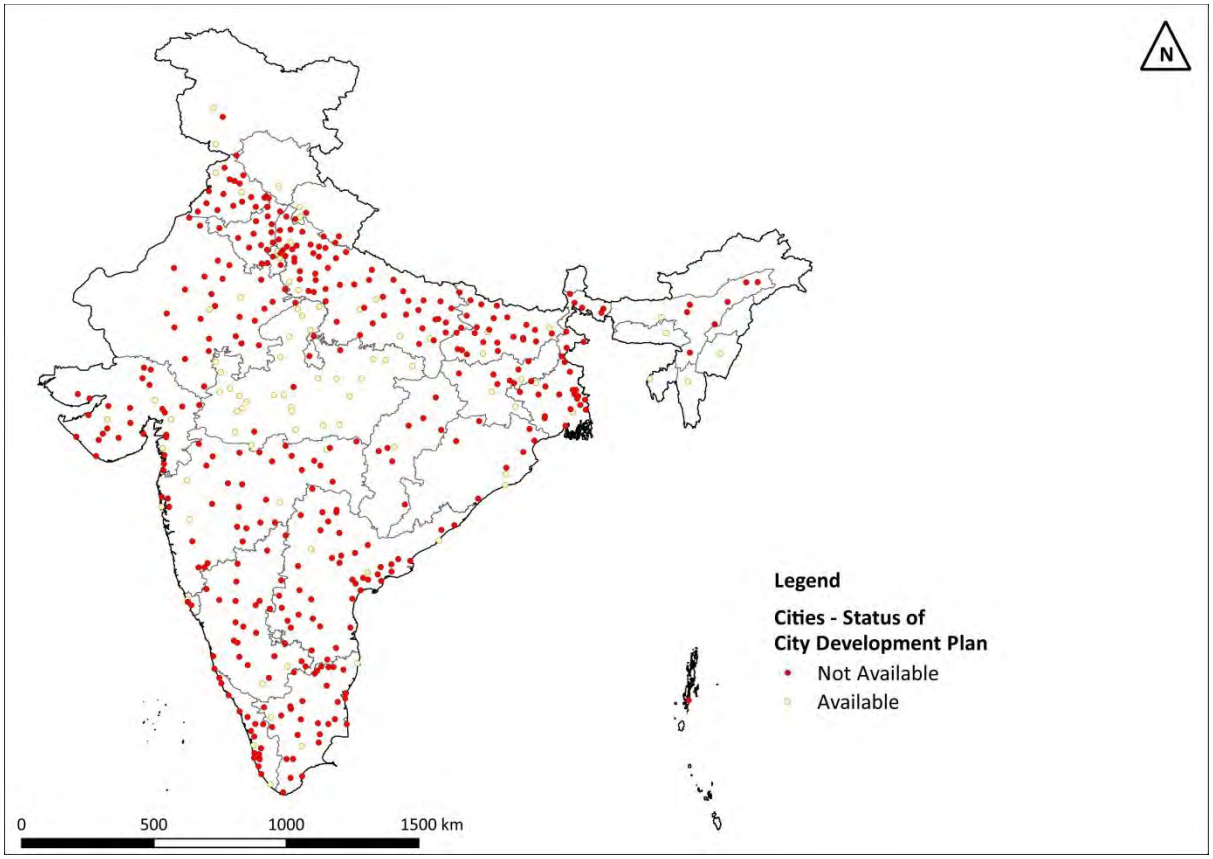


Figure 38 : Map showing the status of a City Development Plan

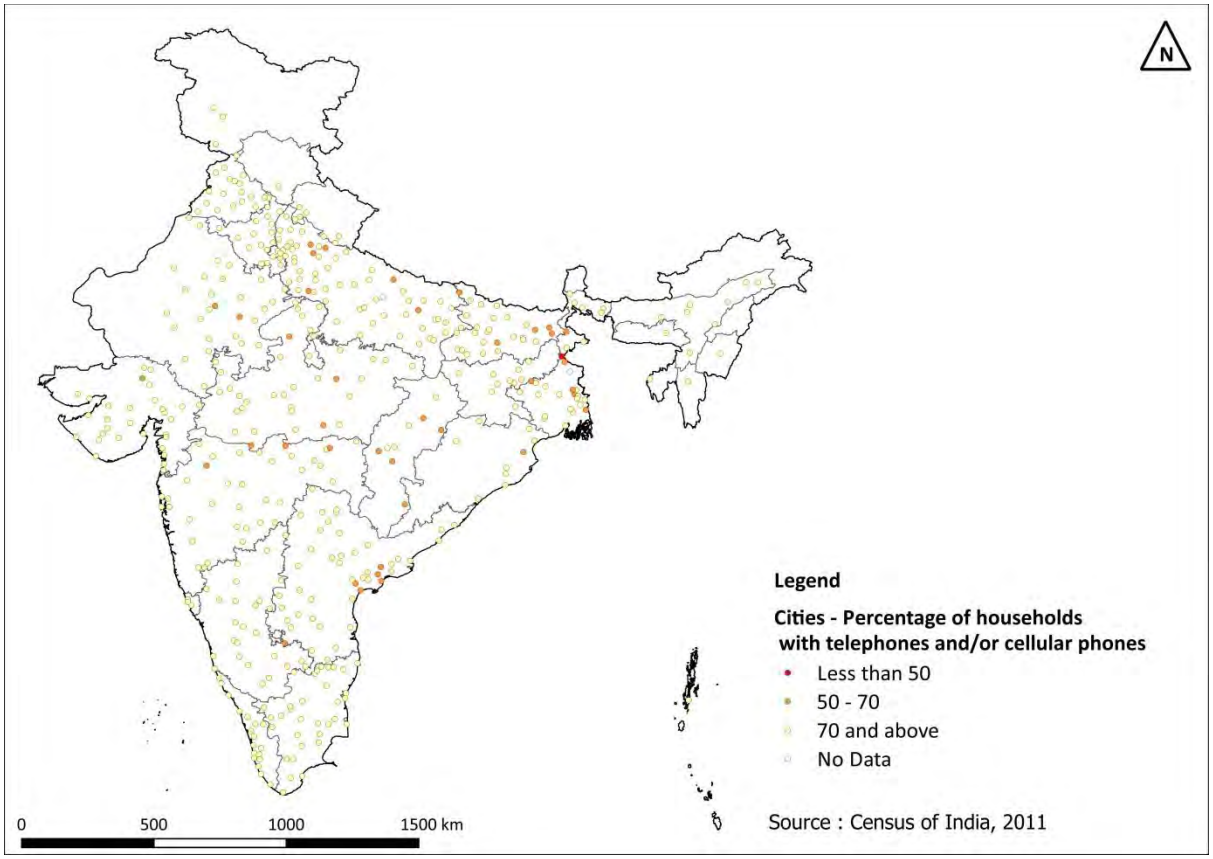


Figure 39 : Map showing the percentage of households with telephones and/or cell phones

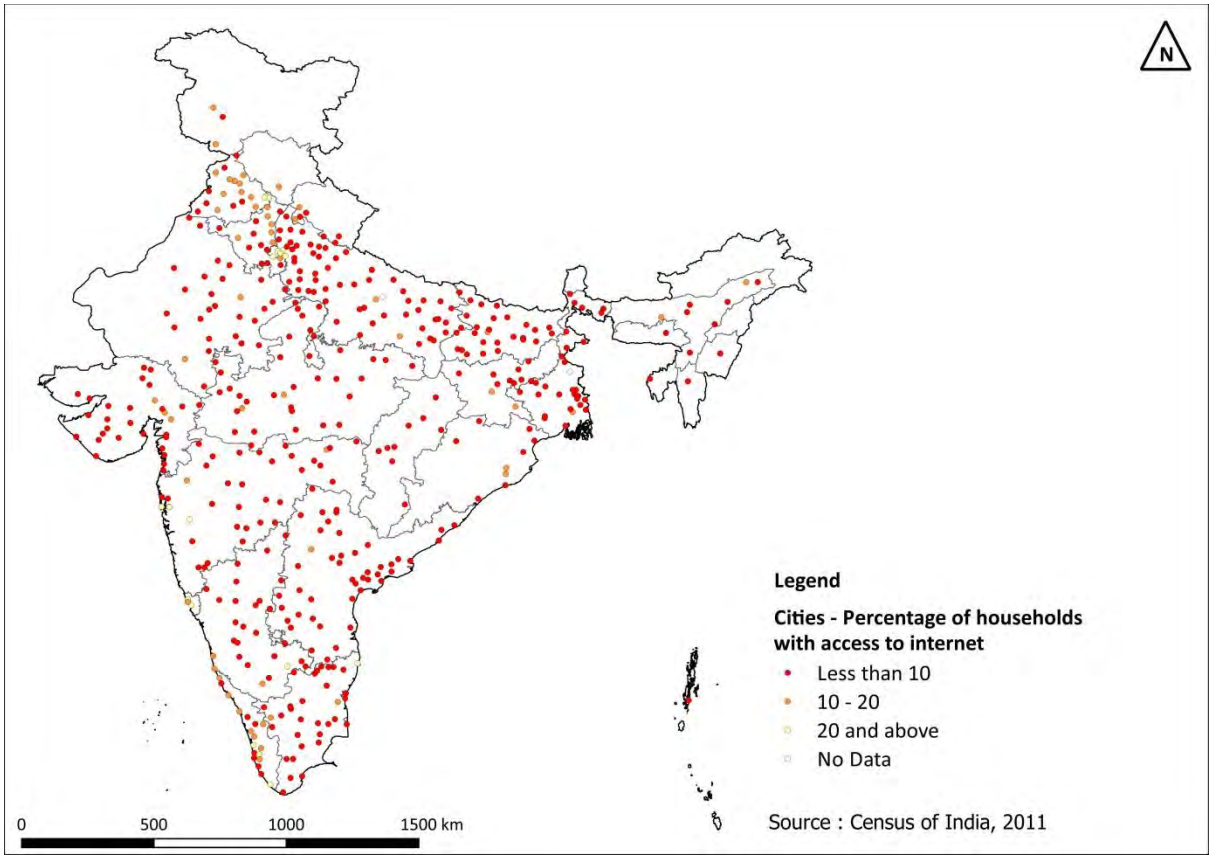


Figure 40 : Map showing household level access to internet

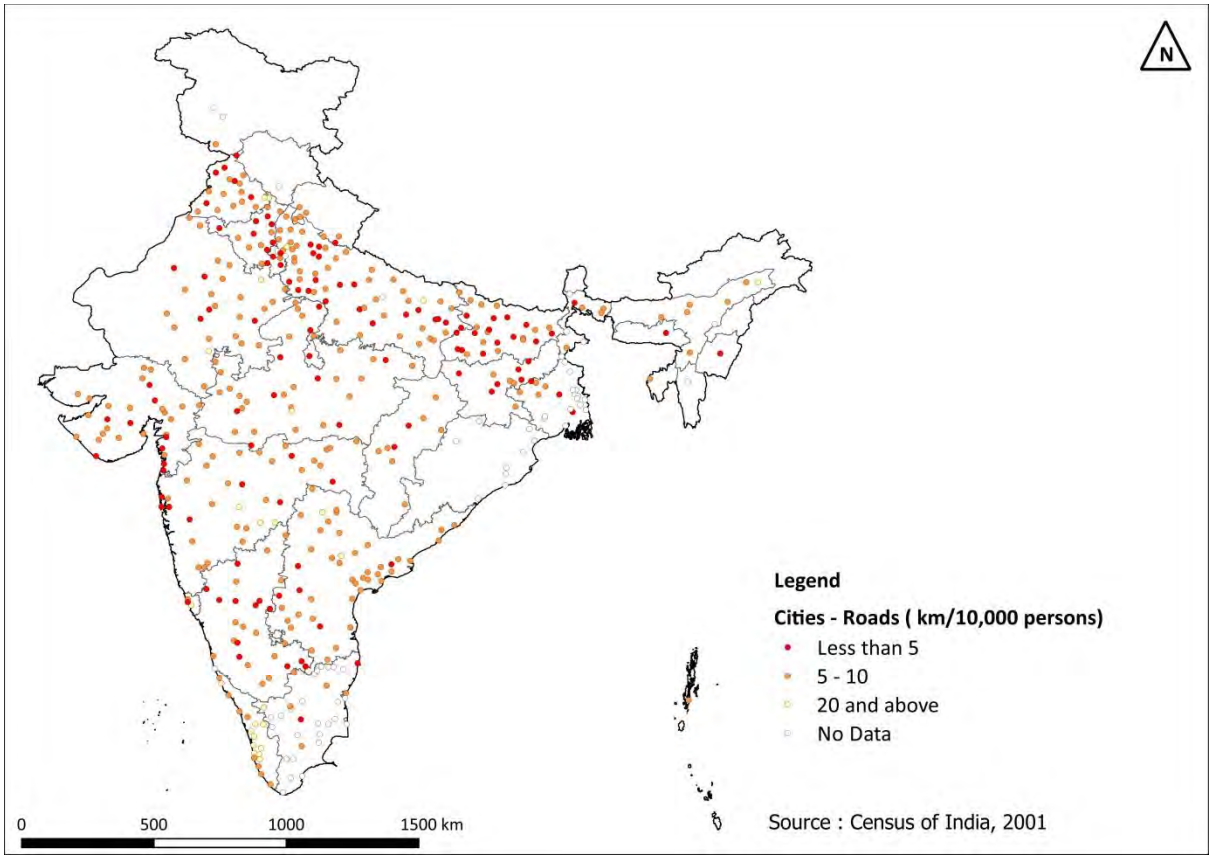


Figure 41 : Map showing lengths of Road in kilometers per 10,000 pesons

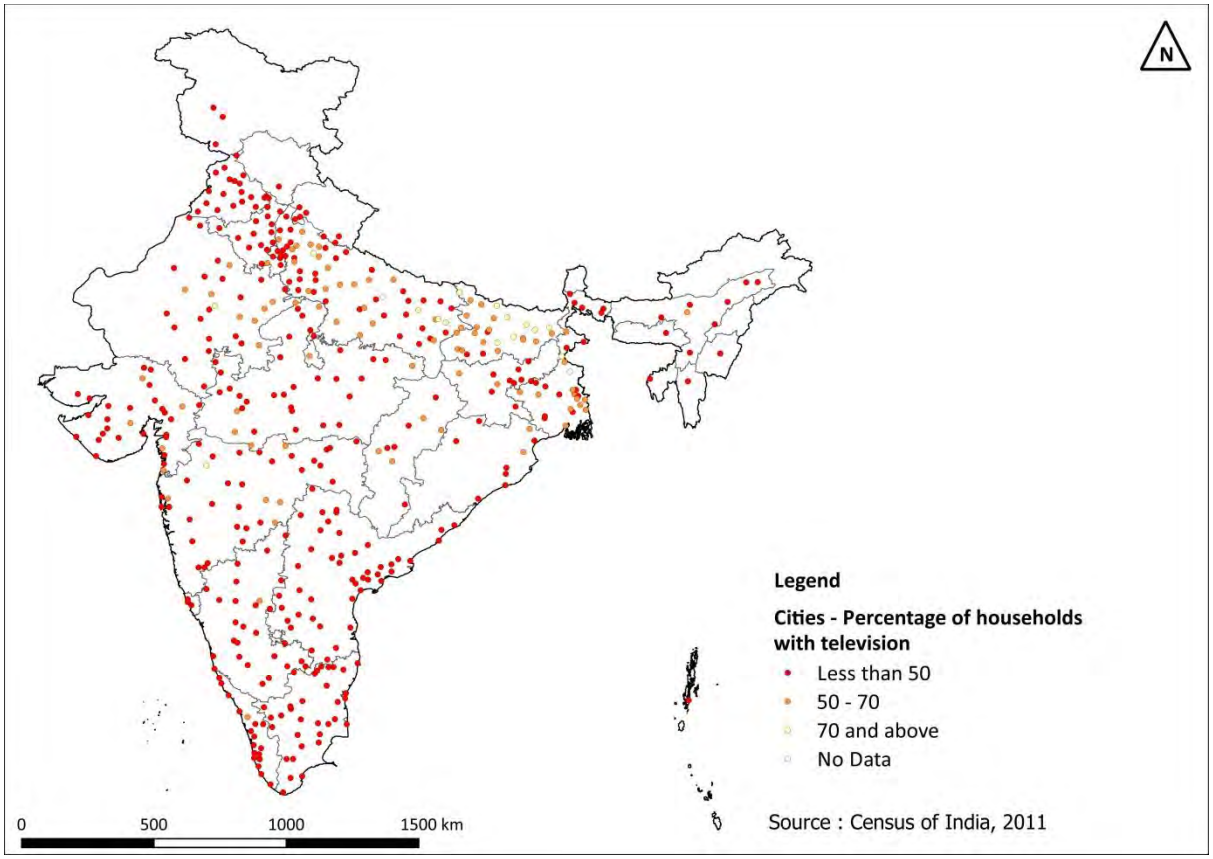


Figure 42 : Map showing percentage of households owning televisions

Appendix 7: Urban Risk Indicators

No.	Hazard Sensitivity	Vulnerability Sensitivity	Town/City Name	State	Vulnerabilities							Capacities									Exposure			Hazard Exposure								
					A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AB	AC
1	1	23	Guwahati	Assam	2	2	4	2	2	4	4	2	5	5	5	2	5	1	1	1	3	5	3	2	2	0	2	2	2	0	2	3
2	2	1	Chennai	Tamil Nadu	5	3	5	5	3	4	5	1	3	4	5	4	5	1	1	0	4	5	5	1	2	2	0	0	1	2	2	3
3	3	33	Aizawl	Mizoram	3	2	3	2	1	1	2	0	2	4	5	1	5	1	1	1	2	5	3	2	2	1	2	2	2	0	2	1
4	4	8	Greater Vishakapatnam	Andhra Pradesh	4	4	5	5	4	4	4	2	2	3	5	1	5	1	0	1	4	1	4	0	2	2	2	0	0	2	2	3
5	5	9	Bhubaneswar	Orissa	4	3	4	5	3	5	3	0	3	4	5	3	4	1	1	1	3	5	3	1	2	2	1	0	2	0	2	2
6	6	5	Kolkata	West Bengal	5	4	4	4	3	5	4	1	3	5	5	2	5	1	1	1	4	5	5	1	2	2	0	0	2	0	2	3
7	7	2	Greater Mumbai	Maharashtra	5	5	5	5	5	5	4	1	2	5	5	4	5	1	1	0	5	5	5	1	1	2	2	0	0	2	2	3
8	8	35	Basirhat	West Bengal	0	2	2	2	2	3	2	0	2	2	3	1	2	0	0	1	1	5	1	2	2	2	0	0	2	2	2	1
9	9	61	Dimapur	Nagaland	1	2	3	2	1	1	2	0	0	3	5	1	4	0	0	1	1	5	1	2	2	0	2	2	2	0	2	1
10	10	102	Imphal	Manipur	0	2	3	1	1	3	2	1	2	2	5	1	5	1	1	1	2	2	3	2	1	1	2	2	2	0	2	1
11	11	31	Kakinada	Andhra Pradesh	4	2	3	3	3	2	2	3	2	2	4	1	4	0	0	1	2	2	3	1	2	2	0	0	2	2	2	1
12	12	12	Bhagalpur	Bihar	1	3	3	3	3	4	3	1	2	3	4	1	2	0	0	0	2	5	3	2	1	1	0	0	2	0	2	2
13	13	13	Delhi	NCT of Delhi	5	5	5	5	5	4	5	0	1	5	5	4	5	1	1	1	5	0	5	2	1	0	1	0	1	0	2	3
14	14	18	Vasai Virar City	Maharashtra	2	3	3	2	4	3	3	1	1	4	5	1	4	0	1	0	4	5	3	1	1	2	2	0	0	2	2	2
15	15	42	Haldia	West Bengal	2	2	3	2	2	3	2	0	2	4	4	1	2	0	0	1	1	5	2	1	2	2	0	0	2	2	2	1
16	16	3	Surat	Gujarat	4	5	4	3	4	4	5	1	1	2	5	1	3	1	0	1	4	5	5	1	1	2	0	0	0	2	2	3
17	17	28	Faridabad	Haryana	4	3	4	3	3	4	4	2	1	4	5	3	5	1	0	1	4	3	3	2	1	0	1	0	1	0	2	3
18	18	14	Patna	Bihar	3	3	3	5	3	4	4	3	2	5	5	2	5	1	0	0	4	5	4	2	1	0	0	0	2	0	2	3
19	19	34	Ghaziabad	Uttar Pradesh	4	2	3	4	2	4	4	3	1	5	5	4	5	0	1	0	4	3	4	2	1	0	1	0	1	0	2	3

20	20	6	Bhiwandi	Maharashtra	4	4	3	2	4	2	2	2	1	1	4	1	2	0	1	0	3	5	3	1	1	2	2	0	0	2	2	1
21	21	47	Brahmapur Town	Orissa	3	2	2	2	2	2	2	0	3	4	5	1	5	0	0	1	2	5	3	0	2	2	0	0	2	2	2	1
22	22	21	Cuttack	Orissa	4	2	3	4	3	3	2	0	3	4	5	2	5	0	0	1	3	5	3	1	2	2	0	0	2	0	2	1
23	23	10	Kanpur	Uttar Pradesh	4	4	4	5	4	5	5	1	1	4	5	1	4	1	1	0	4	2	4	1	1	0	0	0	2	0	2	3
24	24	193	Port Blair	Andaman & Nicobar Islands	1	1	2	1	2	1	1	3	3	5	5	1	5	0	0	0	1	4	1	2	2	2	2	0	2	2	0	1
25	25	97	Puri Town	Orissa	3	2	2	3	2	2	2	0	3	3	5	1	4	1	0	1	1	3	2	1	2	2	0	0	2	2	2	1
26	26	7	Hyderabad	Andhra Pradesh	5	4	5	5	3	5	4	2	1	3	5	3	5	1	0	1	5	5	5	0	1	1	0	0	1	0	2	3
27	27	32	Gurgaon	Haryana	4	3	3	3	3	3	3	1	1	4	5	5	5	0	0	1	3	5	3	2	1	0	1	0	1	0	2	2
28	28	17	Moradabad	Uttar Pradesh	4	3	3	4	2	5	3	1	1	3	4	1	3	0	0	0	3	2	3	2	1	0	0	0	2	0	2	2
29	29	19	Biharsharif	Bihar	1	2	3	3	2	4	2	1	1	2	3	1	1	0	0	0	2	4	2	2	1	1	0	0	2	0	2	1
30	30	22	Santipur	West Bengal	3	2	2	1	2	3	2	0	1	1	2	1	2	0	0	1	1	4	2	1	1	2	0	0	2	0	2	1
31	31	30	Lucknow	Uttar Pradesh	4	3	4	5	4	5	4	3	1	4	5	2	5	1	1	0	4	1	4	1	1	0	0	0	2	0	2	3
32	32	25	Bareilly	Uttar Pradesh	4	3	3	3	2	4	3	2	1	3	4	1	4	0	0	0	3	2	3	2	1	0	0	0	2	0	2	2
33	33	40	Muzaffarpur	Bihar	3	2	3	3	2	3	3	1	3	4	5	1	3	0	0	0	2	5	3	2	1	0	0	0	2	0	2	2
34	34	81	Agartala	Tripura	2	2	4	2	1	2	3	2	2	4	5	1	5	1	1	1	2	5	3	2	2	2	0	0	2	0	0	2
35	35	16	Begusarai	Bihar	2	2	3	3	3	4	2	1	1	2	4	1	1	0	0	0	2	5	2	2	1	1	0	0	2	0	1	1
36	36	180	Shillong	Meghalaya	1	1	2	2	1	1	1	1	0	5	5	1	5	1	1	1	1	5	2	2	2	1	2	1	2	0	0	1
37	37	27	Dhanbad	Jharkhand	1	4	4	3	4	4	4	1	1	4	4	1	4	1	1	1	4	5	3	1	1	1	0	0	2	0	0	3
38	38	20	Vijayawada	Andhra Pradesh	4	4	5	4	3	3	2	3	1	2	5	1	4	1	1	1	4	5	3	1	1	2	1	0	0	0	2	1
39	39	49	Meerut	Uttar Pradesh	4	3	3	4	3	4	3	2	2	3	5	1	4	1	1	0	4	1	3	2	1	0	0	0	2	0	2	2
40	40	41	Ludhiana	Punjab	4	3	3	4	2	2	3	2	2	3	5	2	5	1	0	1	4	2	4	2	1	0	0	0	2	0	2	2

41	41	48	Gorakhpur	Uttar Pradesh	2	2	3	3	3	3	3	3	2	5	5	1	5	0	0	0	3	5	3	2	1	0	0	0	2	0	2	2
42	42	75	Noida	Uttar Pradesh	2	2	3	2	3	2	3	1	1	4	5	5	5	0	0	0	3	3	3	2	1	0	1	0	1	0	2	2
43	43	73	Machilipatnam	Andhra Pradesh	3	2	3	2	2	2	1	3	2	2	3	1	4	0	0	1	1	4	2	1	2	2	0	0	2	2	2	1
44	44	53	Barddhaman	West Bengal	3	2	3	2	3	3	2	1	3	4	5	1	4	0	0	1	2	5	3	1	1	2	0	0	2	0	2	1
45	45	99	Baleshwar	Orissa	1	2	2	3	2	2	2	0	2	4	4	1	4	0	0	1	1	5	1	0	2	2	0	0	2	2	2	1
46	46	39	Darbhanga	Bihar	2	2	3	3	3	4	3	1	3	3	4	1	1	0	0	0	2	5	2	2	1	0	0	0	2	0	1	2
47	47	57	Srinagar	Jammu & Kashmir	4	2	3	2	2	2	2	0	3	5	5	2	5	1	1	1	4	5	3	2	0	0	1	1	2	0	2	1
48	48	69	Rajahmundry	Andhra Pradesh	4	2	3	3	2	2	1	3	1	2	4	1	5	0	0	1	2	4	3	1	2	2	1	0	0	0	2	1
49	49	91	Medinipur	West Bengal	3	2	2	2	2	3	1	0	1	4	4	1	4	0	0	1	1	3	2	1	2	2	0	0	2	0	2	1
50	50	95	Bongaon	West Bengal	2	2	2	1	1	2	2	0	2	3	4	1	3	0	0	1	1	5	1	1	2	2	0	0	2	0	2	1
51	51	96	Gaya	Bihar	2	2	3	2	3	3	3	1	1	4	5	1	4	1	0	0	2	1	3	1	0	1	1	0	2	0	2	2
52	52	72	Navi Mumbai Panvel Raigad	Maharashtra	4	2	3	3	4	2	1	1	1	5	5	4	5	0	0	0	4	2	3	1	1	2	2	0	0	2	2	1
53	53	43	Bhadrak	Orissa	2	2	2	4	2	2	2	0	1	2	3	1	2	0	0	1	1	5	1	0	2	2	0	0	2	0	2	1
54	54	76	Munger	Bihar	1	2	3	2	2	4	2	2	2	3	4	1	2	0	0	0	1	4	2	2	1	1	0	0	2	0	2	1
55	55	44	Varanasi	Uttar Pradesh	4	2	3	2	2	4	3	2	2	4	5	1	5	1	1	0	4	5	3	1	1	0	0	0	2	0	2	2
56	56	15	Ahmadabad	Gujarat	4	5	4	4	4	4	5	1	1	4	5	2	5	1	0	1	5	5	5	1	0	1	0	0	0	0	2	3
57	57	4	Malegaon	Maharashtra	4	3	3	3	3	3	2	2	1	1	3	1	1	0	0	0	2	5	3	1	0	1	0	0	2	0	2	1
58	58	55	Durgapur	West Bengal	2	2	3	2	3	5	2	2	2	4	5	1	4	0	0	1	3	5	3	1	1	2	0	0	2	0	1	1
59	59	11	Bangalore	Karnataka	4	4	5	5	4	5	5	1	2	3	5	4	5	1	0	1	5	5	5	0	0	1	0	0	1	0	2	3
60	60	56	Jabalpur	Madhya Pradesh	4	3	4	4	3	3	3	2	2	3	4	1	5	1	1	1	4	2	3	1	0	0	1	0	2	0	2	2
61	61	65	Jamnagar	Gujarat	3	2	3	2	3	2	2	2	3	3	5	1	5	0	0	1	3	5	3	2	2	2	0	0	0	0	2	1
62	62	26	Bagaha	Bihar	0	2	3	3	3	4	2	2	1	1	2	1	1	0	0	0	1	5	1	2	1	0	0	0	2	0	2	1
63	63	161	Silchar	Assam	1	2	3	2	2	3	1	2	2	4	5	1	4	0	1	1	1	3	2	2	2	1	0	0	2	0	2	1

64	64	37	Pune	Maharashtra	4	3	5	4	5	4	2	1	2	5	5	4	5	1	1	0	4	3	5	1	0	1	1	0	1	0	2	1
65	65	46	Ranchi	Jharkhand	3	3	3	3	3	4	4	1	2	4	5	2	4	1	1	1	4	4	3	0	0	1	0	0	2	0	2	3
66	66	156	Hardwar	Uttarakhand	1	2	2	2	2	1	1	2	2	4	5	1	5	1	1	1	1	5	2	2	1	0	2	0	2	0	2	1
67	67	122	Nabadwip	West Bengal	2	2	2	1	1	3	2	0	2	2	3	1	2	0	0	1	1	2	2	1	1	2	0	0	2	0	2	1
68	68	86	Sambalpur	Orissa	1	2	3	2	3	2	2	0	1	4	4	1	4	0	0	1	1	5	2	1	1	1	0	0	2	0	2	1
69	69	94	Cuddalore	Tamil Nadu	2	2	3	3	3	2	2	0	3	3	5	1	5	0	0	0	1	4	2	0	2	2	0	0	0	2	2	1
70	70	59	Asansol	West Bengal	4	2	3	2	3	4	2	2	3	3	4	1	4	1	0	1	3	5	3	1	1	1	0	0	2	0	1	1
71	71	52	Agra	Uttar Pradesh	4	2	3	2	3	4	4	1	2	4	5	1	5	1	0	0	4	5	4	1	1	0	0	0	0	0	2	3
72	72	24	Tiruchirappalli	Tamil Nadu	4	2	4	4	3	3	2	0	1	3	5	1	5	0	1	0	3	5	3	0	1	1	0	0	2	0	2	1
73	73	71	Bhavnagar	Gujarat	3	2	3	2	3	2	2	2	2	3	4	1	4	0	0	1	3	4	3	1	2	2	0	0	0	2	2	1
74	74	212	Gandhidham	Gujarat	1	2	2	2	2	2	2	3	2	3	5	1	4	0	1	1	1	2	2	2	2	2	0	0	0	2	2	1
75	75	45	Jaipur	Rajasthan	4	4	5	2	3	4	4	2	2	4	5	2	5	1	0	1	4	4	4	0	1	0	0	0	1	0	2	3
76	76	85	Dehradun	Uttarakhand	4	2	2	2	2	2	2	2	1	5	5	2	5	1	1	1	3	3	3	2	0	0	2	2	2	0	0	1
77	77	36	Nagpur	Maharashtra	4	3	5	4	3	4	3	2	2	4	5	2	5	1	0	0	4	3	4	0	1	0	0	0	2	0	2	2
78	78	60	Rampur	Uttar Pradesh	1	2	2	2	1	2	2	2	1	2	3	1	4	0	0	0	2	5	3	2	1	0	0	0	2	0	2	1
79	79	29	Firozabad	Uttar Pradesh	3	3	3	2	3	4	3	1	2	1	3	1	3	0	0	0	3	5	3	1	1	0	0	0	0	0	2	2
80	80	113	Jammu	Jammu & Kashmir	1	2	2	3	2	2	2	2	3	5	5	3	5	1	1	1	3	5	3	2	0	0	2	0	2	0	2	1
81	81	117	Baripada	Orissa	1	2	2	2	2	2	2	0	2	4	4	1	3	0	0	1	1	5	1	0	2	2	0	0	2	0	2	1
82	82	74	Kharagpur	West Bengal	3	2	3	2	2	3	2	0	1	4	4	1	4	0	0	1	1	5	2	1	2	2	0	0	2	0	0	1
83	83	127	Mangalore	Karnataka	1	2	5	2	1	2	2	0	4	5	5	3	5	0	0	1	2	5	3	1	0	1	1	0	2	2	2	1
84	84	70	Indore	Madhya Pradesh	4	3	3	3	3	3	4	2	2	3	5	2	5	1	1	1	4	4	4	0	1	0	1	0	0	0	2	3
85	85	174	Bankura	West Bengal	2	2	2	2	3	3	2	2	4	4	4	1	3	0	0	1	1	3	1	1	1	2	0	0	2	0	2	1
86	86	64	Nellore	Andhra Pradesh	4	2	4	3	3	2	2	2	1	2	4	1	5	0	0	1	3	4	3	1	2	1	0	0	0	0	2	1
87	87	38	Saharanpur	Uttar Pradesh	3	2	2	3	2	3	3	2	1	3	5	1	4	0	0	0	3	5	3	2	1	0	0	0	2	0	0	2

88	88	92	Habra	West Bengal	2	2	3	1	1	3	2	0	1	3	4	1	2	0	0	1	1	4	2	1	2	2	0	0	2	0	0	1
89	89	143	Vapi	Gujarat	2	2	2	1	2	1	2	1	2	3	5	1	3	0	0	1	1	5	2	1	1	2	1	0	0	2	2	1
90	90	51	Siliguri	West Bengal	4	2	3	2	2	3	3	1	1	3	5	1	4	0	0	1	3	4	3	2	1	0	0	0	2	0	0	2
91	91	170	Anantnag	Jammu & Kashmir	2	1	2	1	2	1	1	0	2	4	5	1	5	0	0	1	1	5	1	2	0	0	1	1	2	0	2	1
92	92	58	Akbarpur	Uttar Pradesh	3	2	2	2	3	3	2	1	1	3	3	1	1	0	0	0	1	5	1	1	1	0	0	0	2	0	2	1
93	93	88	Bahraich	Uttar Pradesh	1	2	2	2	2	3	2	3	3	2	3	1	3	0	0	0	1	5	2	2	1	0	0	0	2	0	2	1
94	94	200	Panvel	Maharashtra	1	1	2	2	2	1	1	1	2	5	5	4	5	0	0	0	1	5	2	1	1	2	2	0	0	2	2	1
95	95	244	Gudivada	Andhra Pradesh	2	2	3	2	2	1	1	3	2	2	3	1	4	0	0	1	1	1	1	1	2	2	0	0	2	0	2	1
96	96	100	Muzaffarnagar	Uttar Pradesh	0	2	2	3	1	2	2	3	1	3	5	1	4	0	0	0	2	5	3	2	1	0	0	0	2	0	2	1
97	97	98	Jehanabad	Bihar	1	2	2	2	2	2	2	2	1	3	4	1	2	0	0	0	1	5	1	2	1	0	0	0	2	0	2	1
98	98	79	Raiganj	West Bengal	3	2	3	2	2	3	2	0	2	3	3	1	3	0	0	1	1	5	2	2	1	1	0	0	0	0	2	1
99	99	115	Bokaro Steel City	Jharkhand	0	2	3	2	3	4	2	3	2	5	5	1	4	0	0	1	2	5	3	1	0	1	1	0	2	0	1	1
100	100	109	Jamshedpur	Jharkhand	2	2	3	2	3	3	2	2	2	5	5	2	5	1	0	1	3	3	3	0	1	2	0	0	2	0	2	1
101	101	50	Aligarh	Uttar Pradesh	4	3	3	2	3	4	3	2	3	2	4	1	4	0	0	0	3	5	3	2	1	0	0	0	1	0	0	2
102	103	63	Maunath Bhanjan	Uttar Pradesh	3	2	2	2	3	3	2	1	2	1	4	1	1	0	0	0	2	2	2	1	1	0	0	0	2	0	2	1
103	107	82	Amritsar	Punjab	4	2	2	4	3	2	3	1	2	3	5	2	5	1	0	1	4	2	3	2	1	0	0	0	2	0	0	2
104	109	77	Hapur	Uttar Pradesh	3	2	2	2	2	2	2	3	1	3	4	1	3	0	0	0	2	5	2	2	1	0	0	0	1	0	2	1
105	110	54	Bhopal	Madhya Pradesh	4	4	4	4	4	4	4	2	2	3	4	2	4	1	0	1	4	4	4	1	0	0	0	0	0	0	2	3
106	115	78	Tiruppur	Tamil Nadu	3	2	3	2	3	2	1	0	1	1	5	1	5	0	0	0	2	5	3	1	1	1	0	0	0	0	2	1
107	116	93	Hardoi	Uttar Pradesh	3	2	2	2	2	3	2	1	2	4	5	1	3	0	0	0	1	5	2	1	1	0	0	0	2	0	2	1

108	117	80	Mathura	Uttar Pradesh	4	2	2	1	2	2	2	1	2	3	5	1	5	1	1	0	2	5	3	1	1	0	0	0	2	0	2	1
109	118	83	Sasaram	Bihar	3	2	2	2	2	2	2	1	1	3	5	1	2	0	0	0	1	5	1	1	1	0	0	0	2	0	2	1
110	119	89	Bettiah	Bihar	2	2	2	2	2	3	2	2	2	2	4	1	2	0	0	0	1	5	1	2	1	0	0	0	2	0	1	1
111	129	68	Sambhal	Uttar Pradesh	1	2	2	3	1	3	2	1	1	1	3	1	1	0	0	0	1	5	2	2	1	0	0	0	2	0	0	1
112	141	67	Allahabad	Uttar Pradesh	3	2	3	3	3	3	2	3	0	5	5	2	5	1	0	0	4	5	3	0	1	0	0	0	2	0	2	1
113	142	66	Madurai	Tamil Nadu	4	2	3	2	3	2	2	2	2	3	5	1	5	1	1	0	4	5	3	0	0	1	0	0	2	0	2	1
114	144	62	Aurangabad	Bihar	4	3	3	3	3	2	2	2	2	3	5	1	4	0	0	0	4	2	3	1	0	0	0	0	2	0	2	1
115	148	87	Warangal	Andhra Pradesh	4	3	4	3	3	3	2	2	2	2	5	1	4	0	0	1	3	3	3	0	1	1	0	0	1	0	1	1
116	149	90	Amroha	Uttar Pradesh	0	2	2	3	1	2	2	1	1	1	3	1	2	0	0	0	1	5	2	2	1	0	0	0	2	0	0	1
117	174	84	Korba	Chhattisgarh	4	2	3	2	3	3	2	2	2	3	3	1	3	0	0	1	2	5	3	0	0	1	0	0	1	0	2	1

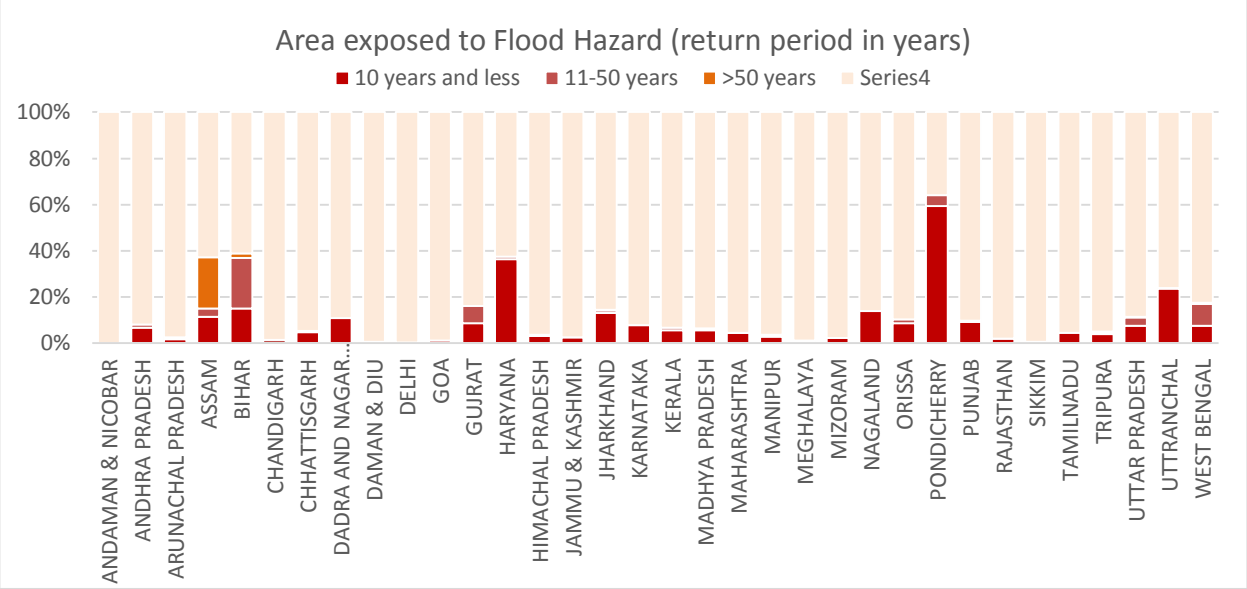
A	**Slum Population**		
B	**Lack of Access to Assets (No. of households having no assets - mobile phones, landlines, television, vehicles, internet, radio, banking services 2011)**		
C	**Number of houses with temporary walls(2011)**		
D	**Number of houses with temporary Roofs (2011)**		
E	**Number of households without access to sanitation systems (2011)**		
F	**number of households without access to electricity (2011)**		

G	number of households consuming water not from a treated source (2011)		
H	km / 10,000 people		
I	Hospital Beds / 10,000 people		
J	Access to banking Services (% of households availing banking services) (2011)		
K	Access to telephones and/or cellular phones (% of households) (2011)		
L	% of households with access to internet (2011)		
M	% of households with televisions (2011)		
N	City Development Plan		
O	City Disaster Risk Management Plan		
P	State Action plan on Climate Change		
Q	(Census, 2011)		
R	persons / sq.km.		
S	Working Population		
T	Earthquake		
U	Wind Pressure		

V	**Cyclonic Storm**		
W	**Landslides (PR)**		
X	**Landslides (EQ)**		
Y	**Droughts**		
Z	**Tsunami**		
AB	**Fluvial Floods**		
AC	**Potential for Disease Incidence**		

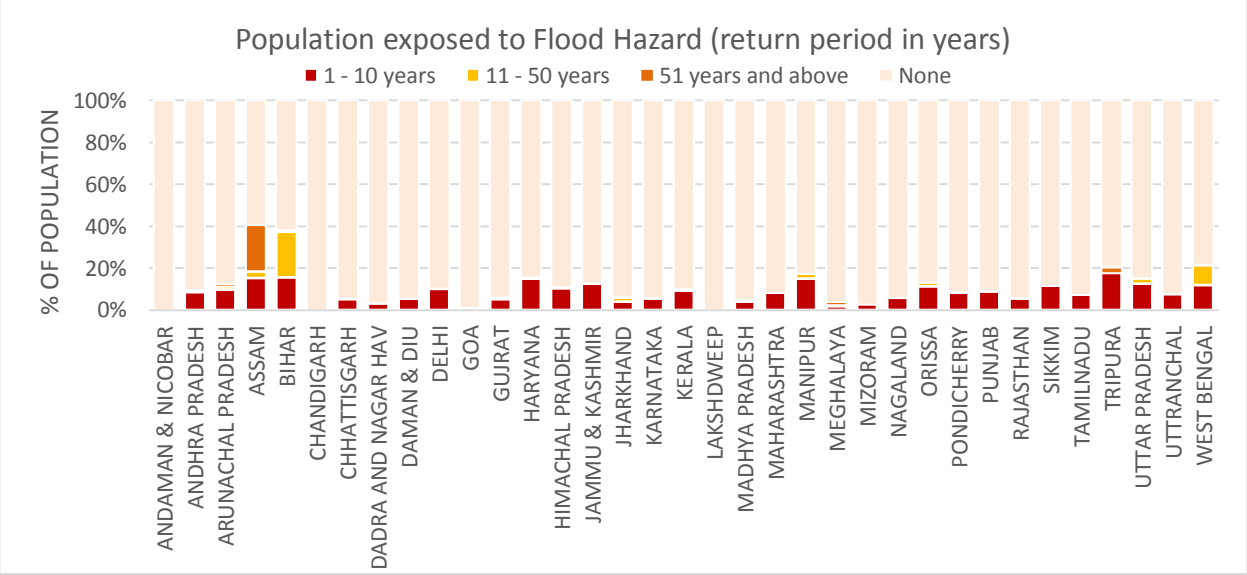
Appendix 8: State-wise Population and Area Exposure

Figure 43 : State-wise area exposed to flood hazard



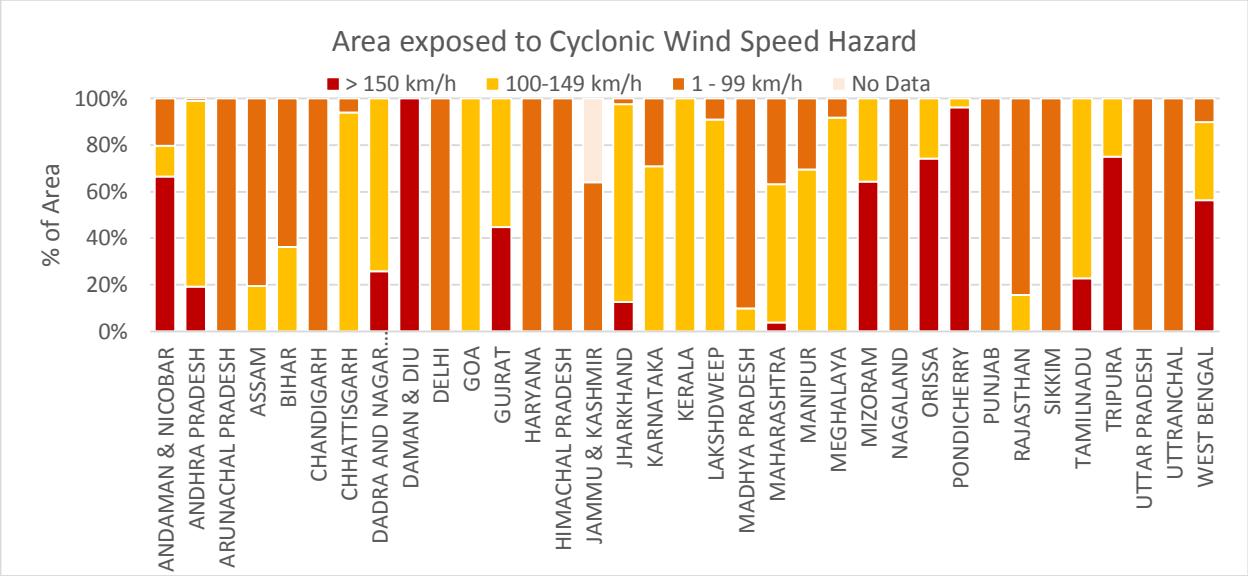
Source: UNEP/GRID-Geneva, 2014; IIHS Analysis, 2014.

Figure 44 : State-wise population exposed to flood hazard



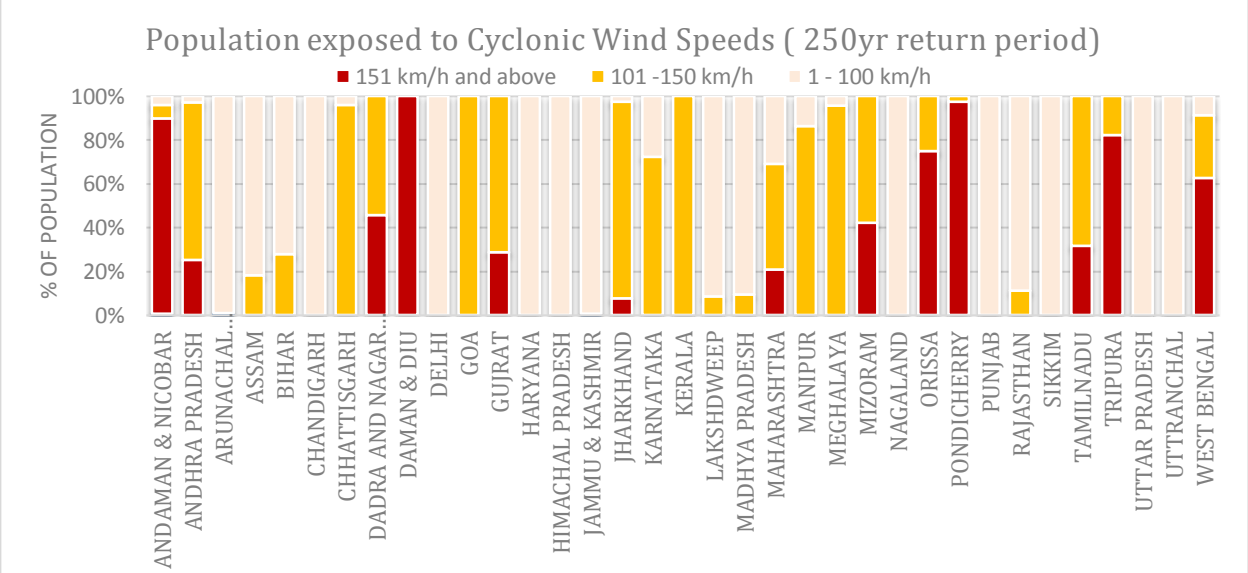
Source: UNEP/GRID-Geneva, 2014; LandScan Global Population Database (2012) ; IIHS Analysis, 2014.

Figure 45 : State-wise area exposed to cyclonic wind speed hazard



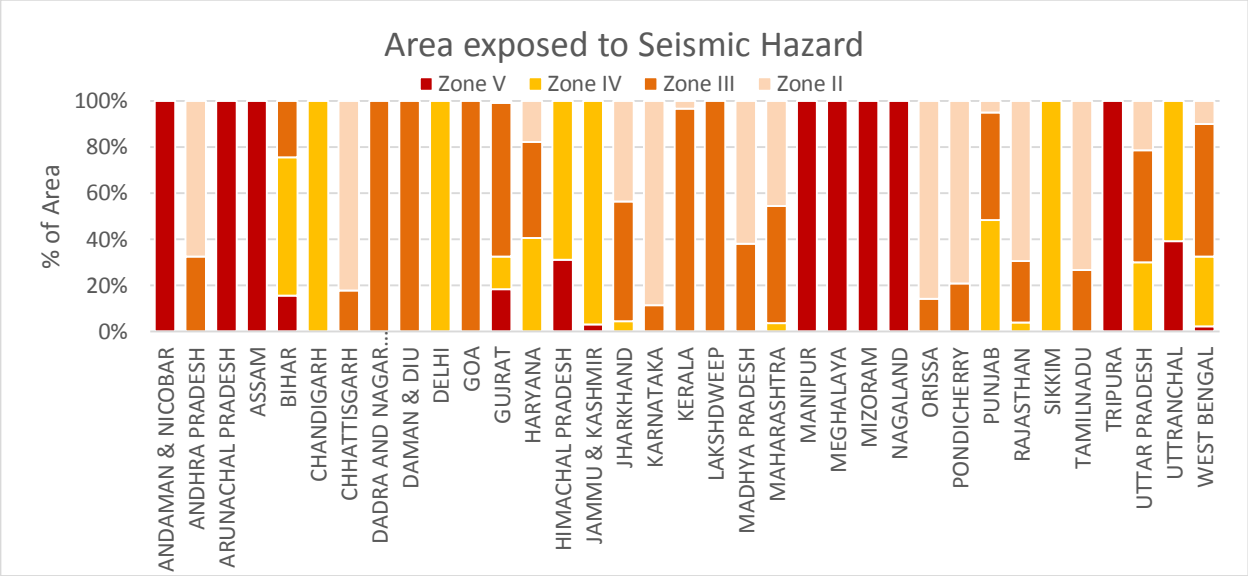
Source: UNEP/GRID-Geneva, 2014; IIHS Analysis, 2014

Figure 46 : State-wise population exposed to cyclonic wind speed hazard



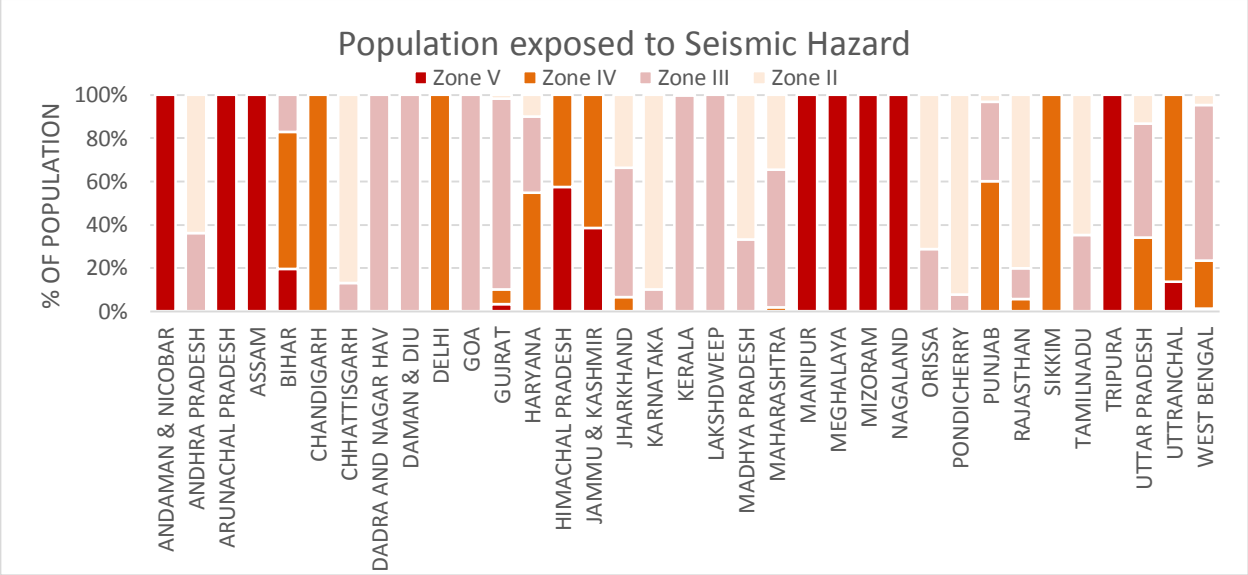
Source: UNEP/GRID-Geneva, 2014; LandScan Global Population Database (2012); IIHS Analysis, 2014.

Figure 47 : State-wise area exposed to seismic hazard.



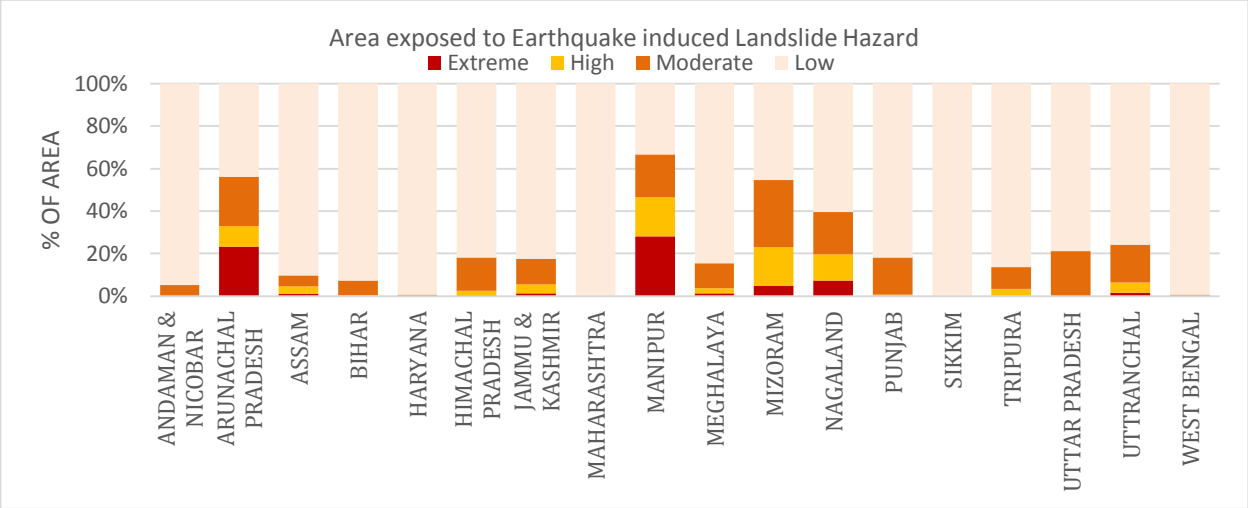
Source: BMTPC Seismic Hazard map of India, BIS, 2006; IIHS Analysis, 2014

Figure 48 : State-wise population exposed to seismic hazard.



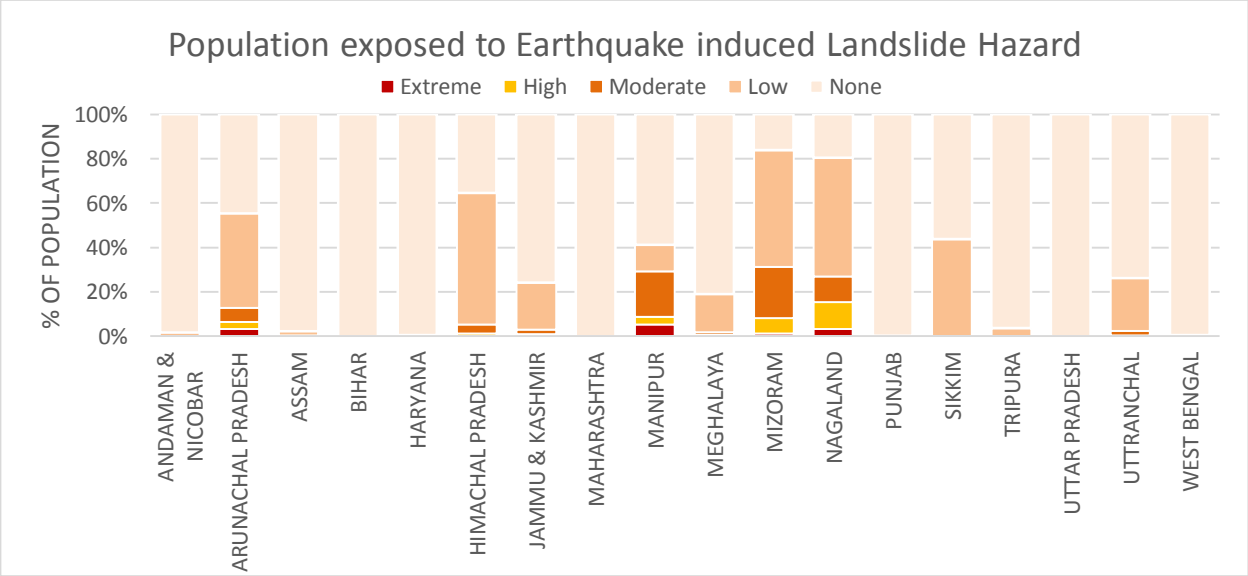
Source: BMTPC Seismic Hazard map of India, BIS, 2006; LandScan Global Population Database (2012); IIHS Analysis, 2014.

Figure 49 : State-wise area exposed to earthquake induced landslide hazard.



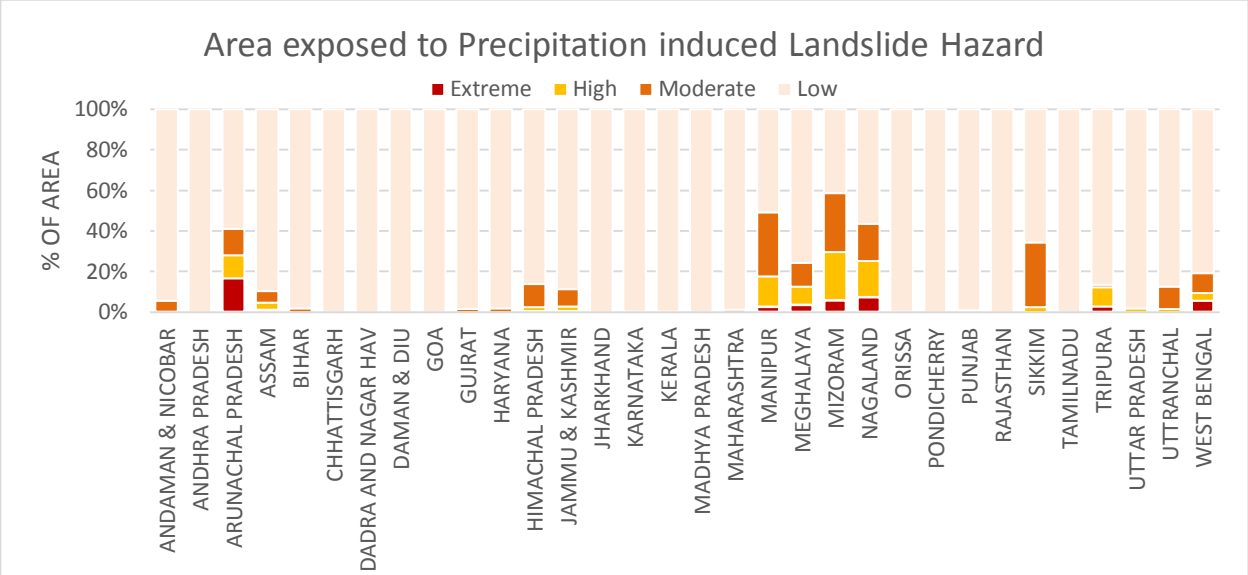
Source: Norwegian Geotechnical Institute (NGI),2014; IIHS Analysis, 2014.

Figure 50 : State-wise population exposed to earthquake induced landslide hazard.



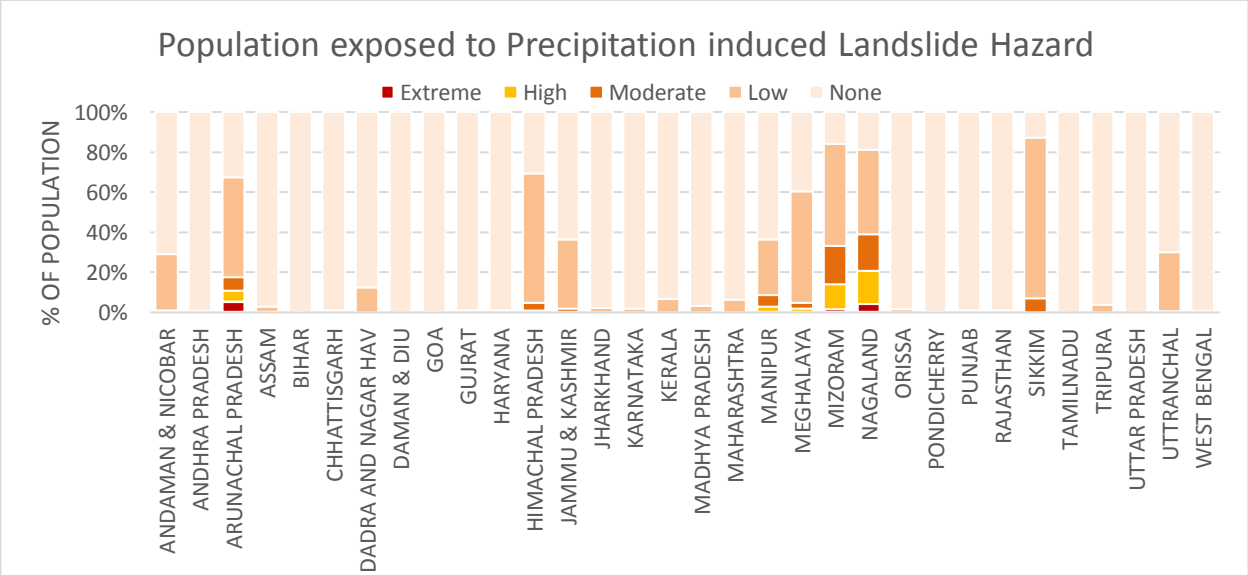
Source: Norwegian Geotechnical Institute (NGI),2014; LandScan Global Population Database (2012); IIHS Analysis, 2014.

Figure 51 : State-wise area exposed to precipitation induced landslide hazard.



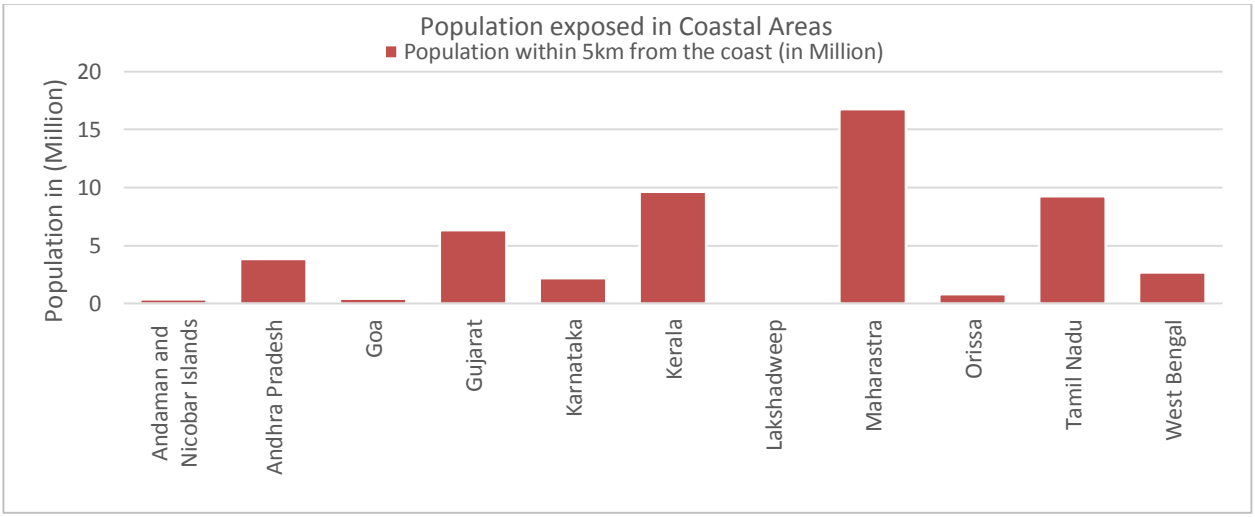
Source: Norwegian Geotechnical Institute (NGI),2014; IIHS Analysis, 2014.

Figure 52 : State-wise population exposed to precipitation induced landslide hazard.



Source: Norwegian Geotechnical Institute (NGI),2014; LandScan Global Population Database (2012); IIHS Analysis, 2014.

Figure 53 : State-wise population living within 5 km from the coast.



Source: LandScan Global Population Database (2012); IIHS Analysis, 2014

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[i] The authors are vary of the implications of disseminating risk related information about cities – those that are otherwise competing with each other for political and economic primacy - which could suffer traumatic consequences in the shorter term. But it credits that there would be gains in the long term if policies and planning is directed to integrate risk mitigation following such awareness.
[ii] DRM Concentration Note, IIHS
[iii] UNISDR defines risk as *the probability or threat of quantifiable damage, injury, liability, loss, or any other negative occurrence that is caused by external or internal vulnerabilities, and that may be avoided through preemptive action*.

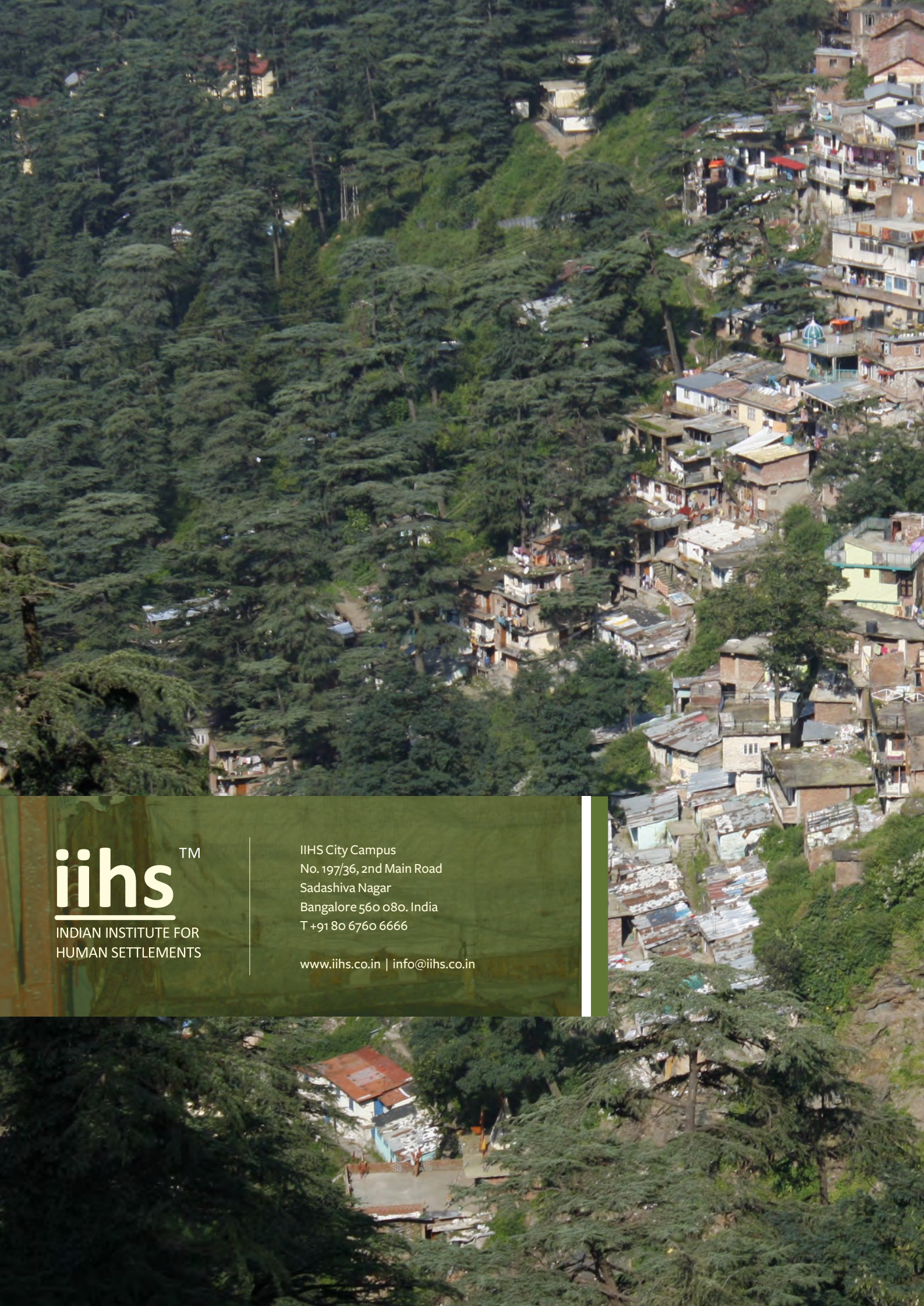
[iv] Many of them are exposed to more than one hazard.
[v] http://www.unep.org/transport/lowcarbon/24%20-25_AUG12_PRESENTATIONS/Session%202/KRCL_case_study_Prof.%20Amit_Garg.pdf
[vi] http://esa.un.org/unup/unup/p2k0data.asp
[vii] http://www.ndma.gov.in/en/disaster-data-statistics.html

[viii] Definition of PPP (as per the Draft National PPP Policy, 2011) : An arrangement between a government/ statutory entity/government owned entity on one side and a private sector entity on the other, for the provision of public assets and/or public services, through investments being made and/or management being undertaken by the private sector entity, for a specified period of time, where there is well defined allocation and risk between the private sector and the public entity and the private entity receives performance linked payments that conform (or are benchmarked) to specified or pre-determined performance standards, measurable by the public entity or its representatives.

[ix] www.irda.gov.in

[x] Ministry of Urban Affairs and Employment (1999), Agenda 21, Report on Promoting Sustainable Human Settlement Development, 17th session of the UN Commission on Human Settlements, Nairobi, May 1999, Indian government publication, page 21.

[xi] http://www.makeinindia.com/live-projects-industrial-corridor/



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