



URBANISATION AND NATURAL DISASTER - A SYSTEMATIC REVIEW

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LIST OF ABBREVIATIONS

ACCRA	African Climate Change Resilience Alliance
ADB	Asian Development Bank
ADPC	Asian Disaster Preparedness Centre
ALNAP	Active Learning Network for Accountability and Performance
CBDRM	Community-Based Disaster Risk Management
CBRMA	Community-Based Risk Management Arrangements
CBDRR	Community-Based Disaster Risk Reduction
CCA	Climate Change Adaptation
CECI	Centre for International Studies and Cooperation
CENESTA	Centre for Sustainable Development, Iran
DFID	Department for International Development (UK)
DRR	Disaster Risk Reduction
DRM	Disaster Risk Management
FAO	Food and Agriculture Organization of the United Nations
GFDRR	Global Facility for Disaster Reduction and Recovery
HFA	Hyogo Framework for Action
icddr,b	International Centre for Diarrhoeal Disease Research, Bangladesh
ICIMOD	International Centre for Integrated Mountain Development
IFRC	International Federation of Red Cross and Red Crescent Societies
IPCC	Intergovernmental Panel on Climate Change
LMIC	Low and Middle Income Countries
MFI	Microfinance Institution
NGO	Non-Governmental Organisation
SAARC	South Asian Association for Regional Cooperation
SIAS	South Asia Institute of Advanced Studies

UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNSW	The University of New South Wales, Australia
UNICEF	United Nations Children’s Fund
UNISDR	United Nations International Strategy for Disaster Reduction

SUMMARY

In recent decades the rate and extent of urbanisation has increased markedly and the majority of the world's people now live in urban areas. These trends are clearly apparent in low and middle income countries, particularly those in South and East Asia (World Bank recent list of LMIC by region). Much of this urban growth is relatively unplanned and has increased the vulnerability of the urban population to the increasing risk of natural disasters and extreme weather events. In addition, vulnerability is further aggravated by other risk factors such as widespread poverty and illiteracy, population migration, increased population density, poor access to services, inadequate nutrition, and poor water and sanitation.

Major gaps exist in information on the interface between urbanisation and natural disasters, especially if the added dimensions of risk, vulnerability and resilience are considered. The concept that the impact of disasters is an outcome of ongoing risk processes interacting with hazards, exposure and vulnerabilities is comparatively recent. It is suggested that there are valuable lessons to be learnt from local level initiatives, people's participation or adaptation of suitable and applicable legislations in the face of such hazards and disasters happening in these cities, countries and regions.

RESEARCH QUESTIONS

This review aimed to answer two key questions:

- i. What is the impact of urbanisation on risk of, and vulnerability to, natural disasters?
- ii. What are the effective approaches for reducing exposure of urban populations to disaster risks?

The review aimed to understand the complex relationship between urbanisation, natural disaster, risk and vulnerability. The project approach was based on the concept that risk arises at the interface of four intersecting domains: urbanisation, natural disasters, vulnerability and risk reduction. This was supplemented by a more detailed proposed framework (Theory of Change) capturing the relationships and influences among these dynamic issues and their impacts on risk, vulnerability and resilience.

METHODOLOGY

A two stage review was undertaken:

1. Stage 1 mapped the range, extent and diversity of literature on these issues.
2. Stage 2 was based on the emergent findings from Stage 1 and sought to examine in more depth the impact and the interrelation of urbanisation with natural disasters with a particular emphasis on the availability of evidence of effective interventions.

The findings were further strengthened by a more in-depth analysis of a subset of studies graded as high to medium quality study identified in the Stage 2 review.

The **Stage 1 scoping review** examined 363 studies after primary screening and focused on urban and peri-urban populations from low and middle income countries, **all types of natural disaster**, along with evidence of any programmes and **interventions** implemented by governments, NGOs, international organisations or donor agencies.

The Stage 2 review synthesized evidence from 32 studies identified from the Stage 1 scoping review focused on the relationships between variables of interest (risk and vulnerability), including the analysis of outcomes and impact of interventions. This helped in documenting the range of risk mitigation approaches that have been described and contributed to deriving lessons concerning their applicability to different contexts, especially those in South and East Asia. The **Stage 2 review focused on all disaster types in South and East Asia LMIC countries**. All included studies for Stage 2 review were coded according to pre-defined (identified in the proposed theory of change) and emerging codes.

The included qualitative and descriptive studies were assessed using a modified qualitative research quality assessment tool adopted from Hawker *et al.* (2002) and Lorenc *et al.* (2014). Data extracted from each study were grouped under common themes. Matrices were developed using data extracted from the studies in relation to the different themes. A 'framework analysis' was used to combine evidence from the included studies and helped not only to identify the key themes but also to make cross study comparisons of variation in the themes, their meanings and/or implications.

In a **further step a more in-depth analysis of six high and medium quality studies** was undertaken to better understand and examine approaches for reducing exposure of urban populations to disaster risk.

KEY FINDINGS FROM SCOPING REVIEW

The scoping review found a rich body of literature with a strong East and South Asian focus. Large-scale disasters have a high impact on populations living in cities where both population growth and population densities are high. Furthermore, in this period of intensified urbanisation, at-risk and vulnerable populations migrating to cities often congregate in areas or zones known to be 'risky'. A substantive set of studies covered the natural, environmental and social science aspects of these phenomena.

The review found a large body of literature focused on risk (n=208) and vulnerability to disasters (n=178). Studies with a resilience focus were much fewer and often presented theoretical case studies and modeling including the use of DRM guidelines. General findings from the scoping review were of value in structuring the next stage.

- About 67% of the publications concerned three major natural hazards: **floods, earthquakes and tsunamis**.
- From a disciplinary perspective environmental science and related studies were most frequent (n=157), followed by the social sciences (n=117), urban planning (n=41) and the natural sciences (n=38).
- A wide variety of methodologies was employed drawing on quantitative, qualitative and mixed methods.
- Most studies covered the **population** as a whole, with only a few studies investigating particular social group such as women, children, elderly populations or an ethnic group as a marginalized population.

- In terms of vulnerability mapping, the review identified a range of studies using GIS based mapping and modelling, mathematical modelling and demographic modelling. The literature also included a set of studies on seismic risk assessments and studies that tested the use of other tools.
- Much of the literature was grouped around a specific and extreme event.
- The literature mostly comprised peer reviewed journal articles with limited reach to broader audiences such as policymakers or practitioners.

STAGE 2 REVIEW FINDINGS

In total 32 studies were included in the Stage 2 review. Our search did not reveal any experimental or quasi experimental approaches. All 32 studies were considered for research question 1 and 21 of those for research question 2. Floods and earthquakes were the dominant focus in included studies. Among these studies, 13 discussed only floods, nine focused only on earthquakes, one discussed tsunami and the remaining nine focused on other types of natural disaster (landslide, flash flood, typhoon, and cyclone).

Review Question 1: What is the impact of urbanisation on risk of, and vulnerability to, natural disasters?

The impact of disasters in urban areas was assessed mostly in terms of economic loss, physical damage or health hazards. We identified very few studies that explicitly set out to assess impact and outcomes of DRM programmes or initiatives. When impact was assessed, it was described based on data reported in newspapers or other reports.

The impact of urbanisation on the risk of and vulnerability to disaster was studied as direct impact including the loss of infrastructure, mortality and morbidity, economic and social losses. When explored, impact was studied in more depth in terms of the dynamics of its relationship with urbanisation. These studies can be categorised as addressing the areas of:

- 1) Physical vulnerability, including geographic and climatic exposure to natural disasters
- 2) Collective vulnerability, mostly discussing the process and result of rapid and unplanned urban growth; and
- 3) Social vulnerability, addressing the vulnerable populations who are at combined risks of both urbanisation and disaster.

These factors may influence the type and degree of impact alone or in concert with other factors.

Section 3.2 described in details the physical loss, where possible in economic terms and social outcomes, when available. Section 3.2 also described the findings on the dynamics of the relationship between urbanisation, disaster and impact.

1. *Physical vulnerability: Geographic locations and climatic exposure:* Evidence from almost all high to low quality studies indicated that impact of urbanisation on risk and vulnerability to disasters varied by location of urban settlements.
 - a. When cities developed along riversides or expanded onto lowland plains, the risk of cyclic and seasonal floods increased. The studies highlighted the complex interaction between social and

natural processes. The physical location of high risk communities was determined by the social and political context as more vulnerable populations were forced to live in high risk areas because of existing social and economic inequities and a lack of robust governance and urban planning.

- b. Cities were more at risk if situated in climactic zones or coastal areas with impacts from monsoons, cyclones and tsunamis.
 - c. Cities located in high seismic risk areas were also more exposed to the impacts and risks of earthquake.
2. *Collective vulnerability: Rapid, unplanned urban growth:* Rapid growth in urban areas was identified as a key feature which influenced the impact of natural disasters in urban areas. The process of urbanisation and a lack of effective governance and policy responses has aggravated the impact and vulnerability to natural hazards in several ways in cities in South and East Asia. These include urban growth and expansion of population settlements into high risk areas, especially the growth of informal settlements and slums; poorly managed water sources, water management and drainage systems; an increase in water runoff and poor natural drainage caused by the increase in paved surfaces in the built environment; and the degradation of environmental buffers. Other factors found to increase risk of disasters in urban areas included low quality infrastructure and housing; poorly planned solid waste management systems (sewerage and garbage); and rapid, unplanned and managed changes in land use, especially the shift from agricultural to urban uses. All of these factors in different combinations were found to influence disaster outcomes.
3. *Social vulnerability: High risk populations:* The impact of natural disaster especially affected populations who were already at risk socially, economically or demographically. Slum dwellers and low income people ran the risk of both economic vulnerability and location in risky zones of the city. Similarly, children and the elderly, as well as women, were more vulnerable than others in both physical and social terms. Marginalised populations like migrants, refugees and IDPs (Internally Displaced Persons) or minority ethnic groups suffered most after disasters, especially during relief and rehabilitation processes. In many cases, they were excluded or neglected by the authorities or others. In big cities one group that was particularly vulnerable to the immediate and long term impact of disaster were household tenants.

Review Question 2: What are the effective approaches for reducing exposure of urban populations to disaster risks?

The Stage 2 key findings are primarily based upon a subset of six medium and high quality studies. The findings are at times supplemented by other study findings where appropriate. The details of findings are described under each section of research questions.

Approaches identified in the reviewed articles can be divided into nine major thematic areas. All of these areas were found to interact with one another and function against the backdrop of other crosscutting factors.

1. Addressing information needs
2. Regulate and manage urban development

3. Approaches for immediate response
4. Monitoring and responding to cumulative or unfolding disasters
5. Coordination among all levels (national, regional, local, etc) and stakeholders
6. Active engagement with community, civil society and local government
7. Population level education and training / drill
8. Supportive and proactive leadership
9. Addressing access and inequities

The following key findings and recommendations are based on these identified thematic areas.

1. *Addressing information needs*: Information needs are substantial and must be addressed prior to, during and after disasters.
 - Immediate and accurate information is required and can reduce disaster risk
 - Particular value is found in forecasting and warning systems
 - Action taken on the basis of local evidence can contribute to reducing risks and vulnerability and/or enhancing resilience. Prior detailed information about local vulnerabilities is of value

Policy relevance and implications

- Systems need to be in place to collect and utilize accurate information from all levels
- Necessary to create an effective communication system

2. *Regulate and manage urban space and development*

- Design and establish effective DRR policy frameworks and monitor their progress and implementation
- Ensure relocation strategies for disaster affected population

Policy relevance and implications

- Policy to support, regulate and manage the space and pattern of urban settlement

3. *Approaches for immediate response*: Immediate response is enhanced when appropriate systems are working and available.

- Ready response and recovery systems
- Mapping of disaster zones and affected populations
- Systematically analyse disaster risk, social and physical vulnerabilities and potential impact to produce evidence based decisions
- Explore innovative technology for effective communication: Use of Mobile phone / GIS / electronic systems, cash incentives

Policy relevance and implications

- Need for comprehensive assessment, rather than only assessing risk and vulnerability of affected people
- Resources need to be allocated to sustaining effective response and relief capacities such logistics, vulnerability assessments, information management and ICT

4. *Monitoring and responding to cumulative and unfolding/emerging effects/impact of disasters on people and systems "is crucial"*

- Dissemination of assurances and information to minimize panic
- Solutions to legal, political and socio-economic problems

Policy relevance and implications

- Enabling environment needs to be created (policy support, ensuring funds, capacity building emphasizing on local government)
- Regulate and manage the spacing and patterning of urban settlements to avoid high risk locations
- Appropriate communication and information mechanisms
- Establish link with all types of media (to provide up to date information to people at risk, risk mitigations, instructions, etc.)

5. *Coordination among all stakeholders is essential and must be strengthened*

- Engage all stakeholders from relevant fields (One Approach)
- Resources (time, personnel, supplies) are ineffective without good coordination
- Constraints to local level decision-making and resource allocation compromise responses
- Invest in local government and empower them to take leadership at local level

Policy relevance and implications

- Coordination and engagement between all levels of government (local, regional, national, and armed forces) is required for effective implementation of DRR programmes

6. *Active engagement with civil society and communities brings a wide range of benefits*

- Identifying and avoiding risky areas/land use and promoting safer and lawful construction activities
- Facilitates communication with communities - awareness campaigns, planning, information dissemination, recognition of community concerns
- Enhances implementation of DRR guidelines and activities
- Can strengthen facilitating agency of vulnerable populations

Policy relevance and implications

- Environmental protection and eco-resilient climate change adaptation and supportive activities or regulations
- Strengthened involvement with CSOs at all levels and in all activities

7. *Population-level education training and drills on disaster preparedness and response can be effective in reducing the impacts of disasters*

- Value in immediate (and post-immediate) response
- Educational curriculum - disaster preparedness and response in schools, engineering colleges and other institutions

- Range of communication strategies will be required - electronic media, GIS warning systems, automated SMS information and advice

Policy relevance and implications

- Involving academicians, institutions and policy relevant public / private representatives.

8. Leadership is key to bring changes

- Active leadership plays an important part in pro-actively reducing risks and vulnerabilities, and strengthening resilience
- Local level and other forms of representative leadership are important and need to be recognised
- Central level leadership facilitates

Policy relevance and implications

- Enabling a supportive environment for local representatives and local initiatives

9. Agenda to address Inequity and vulnerabilities in post-disasters

- Housing and other supports to reconstruction are available to land and house owners but not tenants
- Relocation of undocumented and marginalised migrants/populations may further limit access to services
- Forced resettlement worsened access to livelihoods, education, transport
- Marginalised populations may be further marginalised through policy responses

Policy relevance and implications

- Ongoing monitoring to determine whether inequities are worsening or being reduced over time
- Clear policy environment devoting attention to equity issues and to monitoring and evaluation to ensure no one is left behind

METHODOLOGICAL IMPLICATIONS

This review identified a large volume of literature focused on disasters and urban settings, including those focused on South and East Asia. The review, however, also uncovered a significant gap in literature linking the dynamics of urbanisation with hazards and disasters. Their intersection is complex and multifaceted, but the evidence base demonstrated an absence of robust evidence upon which to base policy and practice.

This research was undertaken in a number of phases resulting in a more rigorous analysis of a small number of medium to strong studies with a focus on approaches addressing urbanisation processes, disasters, and insights related to reducing risks and vulnerabilities and/or enhancing resilience. Our efforts led to insights regarding approaches that appear to be effective and are based upon evidence from South Asia and East Asia. These have been clearly specified along with the evidence upon which this is based. This has been further complemented by consideration of policy and practice implications

which have in turn sought to incorporate understanding of the context of disasters in Nepal and Bangladesh in particular. A number of questions requiring further research have been identified and reported.

LIMITATIONS

Most of the selected studies were of low quality in terms of methodology and information. The key findings were based on a subset of medium to high quality studies, however the conclusions were found to vary little even if other less robust study findings were considered.

CONCLUSION

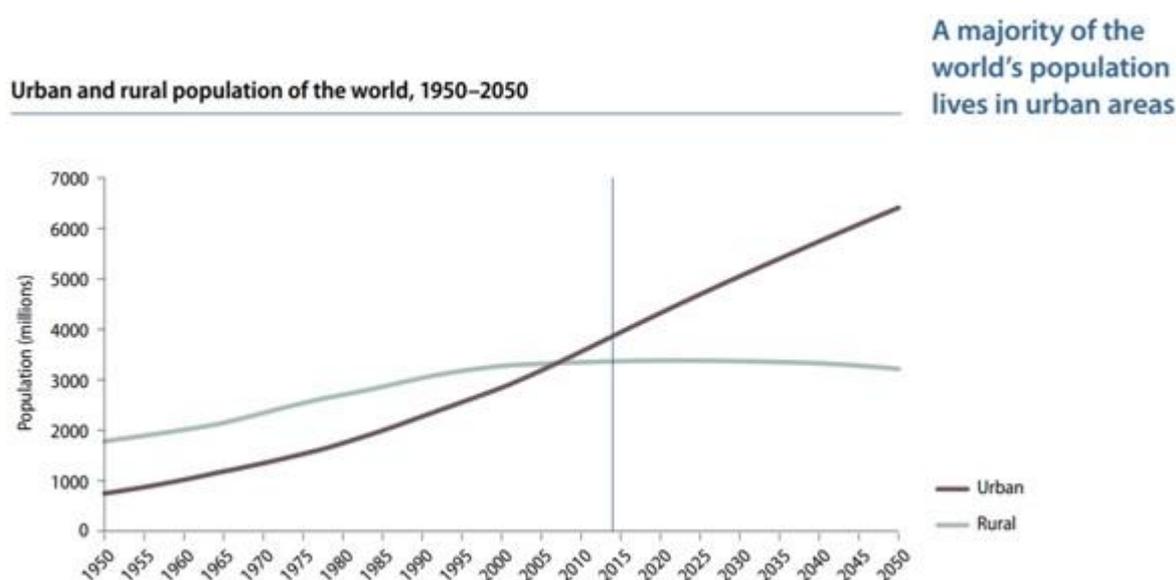
This review offers valuable insights into the complex links between urbanisation and natural disasters in relation to risk and vulnerability. The analysis indicates that urban populations are exposed and vulnerable to a dual process of urbanisation and natural disaster, one reinforcing the other. While geographical or seismological vulnerability is to some extent predictable, the intricate process of changes due to urbanisation and its impact on natural disaster, including intensity and persistence, is difficult to capture and measure. However, it is clear from the review that people living in the risky zones, socially and economically marginalized and in a poorly governed and unregulated society, are victims of both urbanisation and natural disaster. The common findings direct actions towards changing the concept from “response and recovery” to “risk reduction and vulnerability management”, actions that consider disaster risk and vulnerability as a developmental issue and an agenda for the present and future.

1. BACKGROUND

In recent decades the rate and extent of urbanisation has increased. In 2014, the majority of the world's population (54%) resided in urban areas (UN, 2014). Given the current pace of growth, by 2050, it is anticipated that 66% of the world's population will be living in urban areas with the pace of urbanisation greater in low and middle income than developed countries (UN, 2014). The rate of population growth in urban areas will continue and add 2.5 billion people to world's population by 2050 with a nearly 90% increase in Asia and Africa (see Figure 1).

In many cases this urbanisation is unplanned and unrestricted and leads to many physical, social and economic vulnerabilities (Malalgoda et al., 2013). Densely populated urban areas suffer overwhelming impacts even with small scale naturally occurring disasters.

Figure 1: Comparison of urban and rural population growth



[Source: World urbanisation prospects 2014 revision UN]

While cities fuel the economic growth and development of a population, they are also considered as “hot spots” for natural disaster. The exposure of large cities to cyclones and earthquakes will increase as their populations double by 2050. Large cities when impacted with natural disaster usually take long periods to recover. In the case of the Kobe city earthquake in 1995 the city's per capita GDP remained 12% lower when efforts measured in 2008, despite huge recovery and sound economic foundations (DuPont and Noy, 2012). The Asia Pacific region is reported to be the world's most disaster affected area. About 41 per cent of all natural disasters over the last two decades happened in this region, which accounted for 91 per cent of the world's deaths due to natural disasters in the last century. It was estimated that from 1970 to 2010 the average number of people exposed to annual floods increased from 30 million to 64 million, while those affected by cyclones jumped from 72 million to 121 million. In 2011, six of the ten countries most vulnerable to climate change were in Asia and the Pacific and by 2070 the top Asian cities in terms of population exposure to coastal flooding will be

Bangkok, Dhaka, Guangzhou, Kolkata, Mumbai and Shanghai. Economic loss due to disasters increased from US\$52 billion in 1970s to above US\$523 billion in ten years from 2005 – 2014 (UNEA, 2017).

The nature and form of urbanisation influence “risk of” and “vulnerability to” natural disasters in a number of ways. These include environmental degradation, extreme weather and geological events due to increased population vulnerability and concentration, and, at times, reduced resilience (Lankao and Qin, 2011). Underpinning complex interactions between physical, socio-cultural, economic, and institutional conditions (Gencer, 2013) influence risk, vulnerability and resilience. Environmental and climate-related changes may precipitate storms, floods, wild fires and other forms of disaster. These primary disasters may also lead to secondary crises such as landslides and land erosion, fires, flash floods, tsunamis and the release of hazardous materials.

In developing countries, urban populations are vulnerable to natural disasters due to the unplanned growth of cities with large population densities. In addition, the rapid rate and pace of urban growth not only attracts people from other areas but also consumes lands, food, water and energy in a continuously increasing amount. This leads to increased forms of vulnerability including poverty, inadequate nutrition, illiteracy, and poor water and sanitation, which are further aggravated by the occurrences of natural disasters. However, this complex phenomenon also gives rise to certain opportunities, which help to overcome these risks and to build resilience. In this current review, we tried to understand the impact of urbanisation on risk of, and vulnerability to, natural disasters and to find out the effective practices to reduce those exposures to risk and vulnerability due to natural disasters.

1.1 THE RELEVANCE AND IMPORTANCE OF THE REVIEW (POLICY AND PRACTICE)

Countries facing the threat of extreme weather events and other natural disasters are already taking measures to reduce their vulnerability by adopting and implementing global level guidelines as well as local level initiatives. A wide range of guidelines have already been developed by various organisations to inform the field (Hyogo Framework, UNISDR 2015; Zwi et al., 2013) including NGOs, UN agencies, and other international and local organisations.

Disaster risk reduction is now firmly on the development agenda and frames how disasters are to be prevented, mitigated and addressed in coming decades (Yodmani, 2001; UNISDR, 2015). This has most recently been recognized within the Sendai Framework. The Sendai Framework for Disaster Risk Reduction 2015-2030 was adopted following the 2015 Third UN World Conference on Disaster Risk Reduction (WCDRR). Sendai is the successor to the Hyogo Framework for Action (HFA) 2005-2015: Building the Resilience of Nations and Communities to Disasters. Synergies and agreements are also observed in three global policy frameworks adopted in 2015: the post-2015 Framework for Disaster Risk Reduction (March 2015), The Sustainable Development Goals (September 2015; SDGs) and the Climate Change Agreements (December 2015: COP21). There are 25 disaster risk related targets in 10 out of 17 SDGs. Disaster related indicators are major cross cutting theme in the SDG 2-5, 10-12, 14 and 16. Particularly, SDG 11 is focused to ‘Make cities and human settlements inclusive, safe, resilient and sustainable’ (UNISDR, 2015, p (8)).

Regionally, the SAARC Disaster Management Centre (SDMC) developed twelve SAARC (South Asian Association for Regional Cooperation) Road Maps for regional cooperation and in process to develop three more roadmaps to deal with regional disaster in comprehensive ways. Nepal is a naturally disaster prone country sitting on high seismic risk zone and at the convergence of several rivers. Ministry of Home Affairs developed the National Disaster Response Framework (NDRF) 2013 to provide a comprehensive framework to deliver a more effective and coordinated national response to disasters. The Ministry of Federal Affairs and Local Development have initiated efforts to comply with the Sendai Framework, Goal 2 - *Risk reduction: actions to address and reduce pre-existing disaster risk*. Despite this it is to be noted in Nepal still there is no national disaster management authority (Carpenter and Grünewald, 2015).

Like Nepal, Dhaka, the capital of Bangladesh, is one of the most densely populated cities in the world and is considered as being at medium to high seismic risk and regularly subjected to floods and cyclones. The high pace and rate of urbanisation has impacted in many forms: During 1960 to 2005 agricultural land decreased by 55%, wetlands by 47%, vegetation cover by 38%, and water bodies by 29%. All these changes exposed Dhaka to uncontrollable physical, social and economic vulnerabilities and at increased risks to natural disaster (Dewan et al., 2012).

Bangladesh considers disaster risk reduction with climate change adaptation as a win-win opportunity. The Draft National Policy on Disaster Management has emphasized strategies to manage both risks and consequences of disasters by involving the government machinery as well as the community. Bangladesh is a signatory of the United Nations Framework Convention on Climate Change (UNFCCC) and adopted a National Adaptation Action Plan (NAPA) accordingly. Similarly, Bangladesh along with Nepal, India and other countries, advocated these action plans globally and regionally, and developed a regional SAARC Framework for Action (SFA-2006-2015) including all six South East Asian countries.

The Asia-Pacific region continued to be the world's most disaster prone region. In the past decade alone, a person living in Asia-Pacific was twice as likely to be affected by a natural disaster as a person living in Africa, almost six times as likely as someone from Latin America and the Caribbean, and 30 times more likely to suffer from a disaster than someone living in North America or Europe. Geologically, the region is situated over the active tectonic plate movements in the Pacific and Indian Oceans, which have been the source of major earthquakes and tsunamis, as well as the Indian and Pacific oceans, also regularly generate tropical cyclones and typhoons. The region is also home to many mountain ranges which activate earthquakes, landslides, flash floods, avalanches and other natural outbursts. Most of the major cities are located either by the ocean or river side or on highlands and several rivers flow through across several countries where these cities are situated. In 2015 alone, 160 disasters were reported in the region, accounting for 47 per cent of the world's 344 disasters. The economic loss was estimated to be around US\$ 45.1 billion, not considering much more of indirect cost and cost of slow onset disasters like droughts , heat wave, forest fires, etc (ESCAP, 2015).

While there is dearth of evidence as a whole on the risk estimates in these countries, major gaps exist in information on urbanisation and natural disasters. Apart from direct loss estimates of catastrophic disasters, most of the indirect losses are either not reported or when reported were over or underestimated. Policies adopted in these countries are mostly in concert with global initiatives (SDGs, Sendai framework etc.), however, their translation and local level implementation and implications

are less examined. The concept that natural disaster is an outcome of ongoing risk processes accentuated by the prevailing state of hazards, exposure and vulnerabilities that together produce disaster risk is comparatively new and yet not well perceived. The risk may grow and accumulate over time, and can cause greater losses when a hazard event happens. Yet bits and pieces of evidence and studies (also from scoping review, Appendix 17) suggest that there are valuable lessons to be learnt from local level initiatives, people's participation or adaptation of suitable and applicable legislations in the face of such disasters happening in these cities, countries and regions.

In the scoping review (Appendix 17) most of the studies were in the areas of environmental or social sciences, only a few studies focused in-depth on public administration or urban planning. This draws attention to the need for an expanded review in order to better understand the current extent of the public sector engagement, involvement and coverage in the domain of urban planning when dealing with natural disaster related events.

The purpose of this review was to explore and understand the complex relationships between the three intersecting domains of urbanisation, natural disasters and vulnerability. While examining their complex interplay, the review also sought to identify effective efforts and processes that address this complexity and contribute to mitigating the risks of natural disaster. Therefore, this current review also aims to effectively disseminate lessons learned and current best practices found in the evidence base.

The review adopted a mixed-methods systematic review approach and was conducted in two stages. Stage 1 constituted of a scoping or mapping review which aimed to assess the nature and extent of the available literature and evidence addressing the research questions (report available in Appendix 17).

The scoping review (Stage 1) identified, retrieved and screened a wide range of literature from diverse disciplinary perspectives and databases. The review team also drew upon grey literature from key agencies and their websites. The scoping review helped refine the research questions and enabled the team to decide which areas of the disaster-urbanisation interface and associated literature should form the basis for the second, in-depth synthesis stage (Stage 2). The scoping review also helped identify existing models and conceptual frameworks which underpin urbanisation–disaster links that informed the review and context analyses.

1.2 RESEARCH BACKGROUND

Disaster risk reduction is now firmly on the development agenda; this has most recently been recognized within the Sendai Framework (Yodmani, 2001; UNISDR, 2015) that frames how disasters are to be prevented, mitigated and addressed in coming decades. Recently, the UN development agenda Sustainable Development Goals (SDGs) extensively highlighted DRR in at least 10 out of 17 SDGs adopted. Particularly, the SDG 11 focused solely on urban risk reduction and resilience development (UNISDR, 2015).

The existing literature connecting urbanisation with disaster is often conceptual while the empirical data encompasses two of the elements of the Disaster Risk Management Framework – pre and post-

disaster. In relation to the pre-disaster tier, many of the studies we have identified to date describe the vulnerability to hazards in urban areas (Bhattarai and Conway, 2010; Lelieveld et al., 2013; Rajbhandari et al., 2002; Yazdi and Neyshabouri, 2012; Yodmani, 2001). Vulnerability was explored differently and the scoping review (annex 17z) found a set of articles using GIS based mapping and modelling (Apa et al., 2012; Armaş, 2012; Aryal, 2012; Aryal, 2014; Yong et al., 2001), mathematical modelling (Brata et al., 2014, Chardon, 1999) and occasionally demographic modelling specifically in relation to elderly people (Ardalan et al., 2010; Ardan et al., 2011; Chan and Griffiths, 2009). Social vulnerability was also modelled in some studies in terms of economic loss and areas of habitation (Apa et al., 2012; Chardon, 1999; Zhang and You, 2014; Zhou et al., 2014a; Zhou et al., 2014b).

Risk assessment and planning approaches applying GIS and remote sensing techniques were numerous (Klimeš and Escobar, 2010; Taubenböck et al., 2011; Wieland et al., 2012); these fall in the realm of applied sciences. The literature also included a set of studies on seismic risk assessments (Chaulagain et al., 2015; Parvez, 2013; Yousefi and Taghikhany, 2014; Zobin and Ventura-Ramírez, 2004) and studies that tested the use of other tools such as the Urban Risk Assessment tool (URA) or mathematical models (Brody et al., 2013; Brody et al., 2015; Browning and Thomas, 2016; Budiyo et al., 2015). Another observation was that the literature tended to group around one specific extreme event (ASIA Tsunami 2007-08), geographic location (e.g. Pearl River floods in China) or urban area (e.g. Shanghai or Kathmandu) (Chan et al., 2012; Chan et al., 2013a; Chan et al., 2013b).

The impact of disasters in urban areas was assessed mostly in terms of economic loss (Bibbee et al., 2000; Zoleta-Nantes, 2003), physical damage (Bono and Gutierrez, 2011; Bulut et al., 2005; Chen and Yang et al., 2014; Shi and Cui, 2012; Yilmaz, 2004) or health hazards (Cerdá et al., 2013; Cheng et al., 2013; Chinnarasri and Porkaew, 2015). Several studies looked at disaster preparedness, including evaluation of interventions, mostly employing social science principles. A cross-sectional survey in Kuala Lumpur found that level of preparedness varied with socioeconomic indicators; men fared much better than women with higher income and more highly educated groups also having higher preparedness. Several studies dealt with Nepal: evaluating disaster education in Kathmandu (Shiwaku et al., 2007), evaluating women's empowerment initiatives in disaster risk reduction (Dhungel and Ojha, 2012), evaluating mental health aspects of disaster preparedness (Green, 2013; Acharya et al., 2006), and looking at community perceptions of disaster preparedness.

There were several resilience-related studies that described how urban communities coped with disaster (Braun and Aßheuer, 2011; Carlin et al., 2014; Schaer, 2015). Studies with a resilience focus also presented theoretical case studies and modelling including the use of DRM guidelines (Caddis et al., 2012), locating cities on floodplains (Chang et al., 2007; Chatterjee, 2010) and community based approaches (Shakib et al., 2011; Siebeneck et al., 2015; Zaré and Nazmazar, 2013; Zhang, 2012). Two studies looked at how urban populations cope with disasters: one study in Nepal (Bhandari et al., 2011) and one in Tanzania (Sakijege et al., 2012). A World Bank report conducted a social and livelihood impact assessment of the Yogyakarta earthquake in Indonesia (Narain, 2012) and another proposed a framework for rapid impact assessment (Gilbuena et al., 2013). However, the large bulk of the studies shed light on the causal chain of urban activities and disaster through increasing levels of environmental stress such as increased pollution (Akpoborie et al., 2015; Pandey and Choudhry, 2013) and health hazards (Lelieveld et al., 2013; Gonçalves and Alecrim, 2004; Hassanzadeh-Rangi et al., 2014; Kroll et al., 2014).

Some studies aimed at creating broad conceptual or statistical frameworks for disaster management. These include a review of disaster management in global cities (Prior and Roth, 2013), a policy analysis concerning urban resilience and climate change (Galderisi and Ferrara, 2012), and a conceptual framework for urbanisation and disaster risk (Oliver et al., 2008). Another lens to look at the existing literature is the perception and/or involvement of various stakeholders in disaster risk management, as emphasis grows on management capacity. The role of government in building urban resilience is highlighted in some studies from Sri Lanka (Malalgoda et al., 2013), and Nepal (Jones et al., 2013). Garima Jain (2015) discusses the role of the private sector in DRR in her study; an important issue deserving greater understanding and analysis.

Previous systematic reviews have looked at specific aspects of disaster risk management. Members of our team Zwi et al., (2013) looked at the effect of community based disaster risk management initiatives on social and economic costs arising from disasters. They identified mechanisms which contributed to reducing risk, reducing vulnerability and enhancing resilience. This review did not have an urban focus but elements of the framework developed and the realist approach was of value and adaptable to the current review. The Systematic Review (SR) of Health Impacts of Mass Earth movements (Kennedy et al., 2015) reported that mental health impacts, in particular the prevalence of PTSD, may be higher after landslides than other types of disaster (Kennedy et al., 2015). Another SR on health and disaster looks at medication loss due to evacuation (Ochi et al., 2014). These SRs also do not have an urban focus and could not answer the question posed here but contributed useful insights.

The literature was comprised mostly of peer reviewed journal articles with limited reach to a broader audience in particular policymakers or practitioners. However, it is evident that the impact of natural disasters on urban populations has been studied across a diverse set of disciplines and approaches. Even so, urbanisation's impact and relationship with disaster is still an emerging field and worthy of more in-depth investigation.

1.3 REVIEW OF THE KNOWN FRAMEWORKS

Hyogo Framework: The 10 year periodic “**Hyogo Framework for Action 2005-2015: Building the Resilience of Nations and Communities to Disasters**” came into light at the World Conference for Disaster Reduction held in Kobe, Hyogo, Japan, in 2005. It is the first global plan to explain, describe and detail the work that is required from all different sectors and actors to reduce disaster losses giving attention to the gaps and challenges identified in the “Yokohama Strategy”, which was adopted in 1994. Gaps and challenges identified in “Yokohama Strategy” were in different areas especially in governance, systematically addressing, assessing and monitoring the disaster risk and in effective disaster preparedness and recovery. The Hyogo Framework adopted three strategic goals (integration of disaster risk reduction into sustainable development policies and planning, developing and strengthening of mechanisms, institutions, and capacities to build resilience to hazards at community level, and the systematic incorporation of risk reduction approaches into the implementation of emergency preparedness, response and recovery programs) to attain its expected outcome. For achieving disaster resilience, and taking action it also sketched five priorities (e.g. ensuring disaster risk reduction is a national and a local priority with a strong institutional basis for implementation,

disaster risk identifying, assessing and monitoring and enhancing early warning as well, for building cultural safety and resilience at all level use of knowledge, innovation and education, reducing underlying risk factors and strengthen disaster preparedness for effective response at all levels) and a number of codes under those. The ultimate goal of this framework is a substantial reduction of disaster losses by 2015 by building the resilience of nations and communities to disasters, which means it aims to reduce the loss of lives and social, economic, and environmental assets when disaster strikes. To achieve this, states and other organisations both from regional and international and other actors should implement the activities that are listed under the priorities according to their own capacities (UNISRD, 2005).

Sendai Framework: “The Sendai Framework for Disaster Risk Reduction (2015-2030)” was approved at the Third United Nations World Conference on Disaster Risk Reduction in 2015, held in Sendai, Japan. This accord built on the learning and gaps of the Hyogo Framework for Action (2005-2015), by raising awareness both public and institutional, generating political commitment and catalyzing actions by a wide range of stakeholders at all levels. Though the Hyogo Framework for Action contributed to achieving the MDGs by giving critical guidance, a number of weaknesses were identified while addressing the underlying disaster risk factors. It was found for over ten years, the wellbeing and safety of people as well as communities and countries has been affected, which was a potential threat to achieving the sustainable development goals. Starting from this background and to reduce disaster risk; the need for a new treaty was felt among the national and international development practitioners. The Sendai Framework aims to reduce and manage all types of disaster irrespective of size, frequencies, patterns, places and sectors. Four specific priorities for action have been decided in this framework: Understanding disaster risk; strengthening disaster risk governance to manage disaster risk; Investing in disaster risk reduction for resilience; Enhancing disaster preparedness for effective response and to “Build Back Better” in recovery, rehabilitation and reconstruction. To support the assessment of global progress in achieving the outcomes and goals of the Sendai Framework, seven global targets have been agreed: Substantially reduce global disaster mortality by 2030, aiming to lower average per 100,000 global mortality between 2020-2030 compared to 2005-2015; Substantially reduce the number of affected people globally by 2030, aiming to lower the average global figure per 100,000 between 2020-2030 compared to 2005-2015; Reduce direct disaster economic loss in relation to global gross domestic product by 2030; Substantially reduce disaster damage to critical infrastructure and disruption of basic services, among them health and educational facilities, including through developing their resilience by 2030; Substantially increase the number of countries with national and local disaster risk reduction strategies by 2020; Substantially enhance international cooperation to developing countries through adequate and sustainable support to complement their national actions for implementation of the framework by 2030; Substantially increase the availability of and access to multi-hazard early warning systems and disaster risk information and assessments to the people by 2030 (UNISDR, 2015).

Urban Risk Assessment an Approach for Understanding Disaster and Climate Risk in Cities (World Bank 2011):

Rapid urbanisation often results in the unplanned expansion of cities which increases disaster risk and affects climate change. To reduce and manage disaster risk city governments often become overburdened and face challenges. This study discussed a framework which can offer planning,

management process and service delivery during disaster and climate change and can assess the risks related to disaster. When location and risks are known to the cities then more effective plans can be taken to fight against disaster. For managing disaster risk and adopting climate change processes risk assessment is essential. This study described a structure of urban risk assessment and its process. It stands upon three principle assessment pillars (institutional, hazard impact, and socioeconomic) with each associated with three levels of assessment complexity (primary, secondary, and tertiary). Risk assessment of a city can be adopted based on need, resources available, capacity. For risk assessment at primary level; it requires minimal resources and can help cities identify high risk areas and basic climate change challenges, and plan for disaster preparedness and response. At secondary level, the assessment relies on more advanced techniques including financial and technical resources for developing disaster response capacities to plan and implement non-structural measures. At the tertiary level, the assessment will require greater resources to undertake detailed disaster and climate change modelling to help cities develop superior disaster and climate risk management protocols including structural and non-structural tools. The next tier is urban risk assessment, which provides a foundation for building long-term sustainable risk reduction plans that can address a city's vulnerabilities to natural hazards. These assessments are structured to improve the knowledge base and increase the capacity to deal with short and long term hazards that any given urban environment may face (Dickson et al., 2010).

1.4 GENERAL CONCEPTUAL FRAMEWORK

The identification of vulnerable communities and the factors contributing to vulnerability are crucial for effective disaster risk management and significant advances have been made in the study of community vulnerability over the past two decades. However, we still know little about the local spatial and temporal factors influencing the risks to natural disasters and also to vulnerability and how these can be reduced or mitigated.

While understanding vulnerability is a core concept in many disaster management measures in many parts of the world, vulnerability is rarely well defined (Zhou et al., 2014). Similarly, risk itself remains more a derived concept, often confused with vulnerability. The classical pressure and release (PAR) model explained the risk as a direct relation between R (risk) = H (Hazard/disaster) x V (Vulnerability), which was derived from the interaction of society and disaster and its consequences. We feel the relation is not as linear as depicted, particularly when we consider natural disaster, and most of our reviewers feel that it is difficult to model something so complex and capture all of its characteristics. Risks are constructs that we use to calculate potential harm, impact or consequences of future disasters. Hazards are real world phenomena that exist but that could possibly interact with social structures, processes and the built environment to produce future disasters. Not all human societies are equally exposed to different types of hazards even if they have similar vulnerabilities arising out of, say, urbanisation.

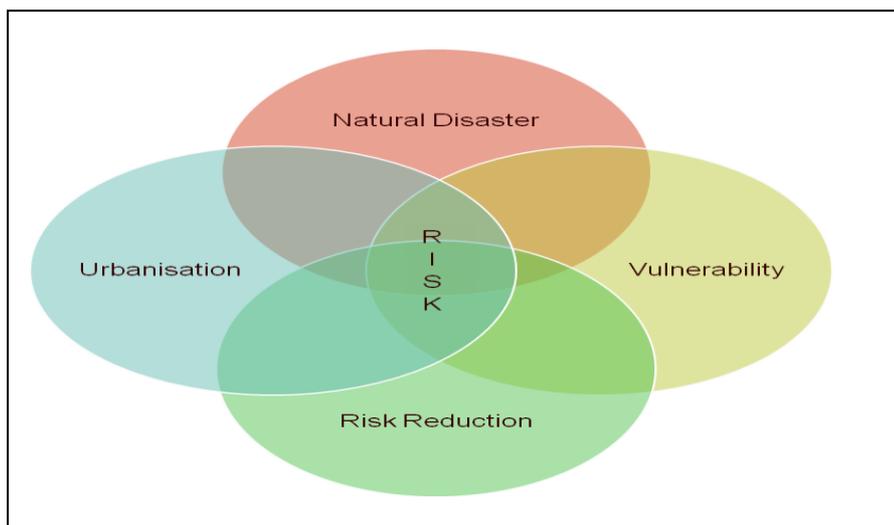
There are many unclear areas in understating how urbanisation increases the risk of natural disaster. Does urbanisation directly influence the occurrence of natural disasters or does it operate through particular mediators or modifiers? Do urban characteristics such as the pace of growth and

subsequent changes drive the risks of, and vulnerability to, natural disasters or directly induce some of the natural events? Urbanisation influences the risk of exposure of populations to certain kinds of hazards and, potentially, to certain kinds of disaster, however, there are also mitigating factors arising out of urbanisation such as the potential for preparedness and engagement with communities in understanding vulnerabilities and addressing them earlier on.

To understand this complex relation this review adopted the framework proposed by Mehrotra et al. (2009) and subsequently developed a theory of change based on the findings from scoping report. While Mehrotra and others (2009), defined risk from a capacity-based approach and the influence of external conditions, we modified the domains by including a risk reduction dimension (e.g. increased resilience) (see Figure 1). Here the assumption is that risk arises out of the interface of the four domains of urbanisation, natural disaster, vulnerability and risk reduction. Approaches that attempt to modify or mitigate the exposure of urban populations to disaster risk will vary across all four domains.

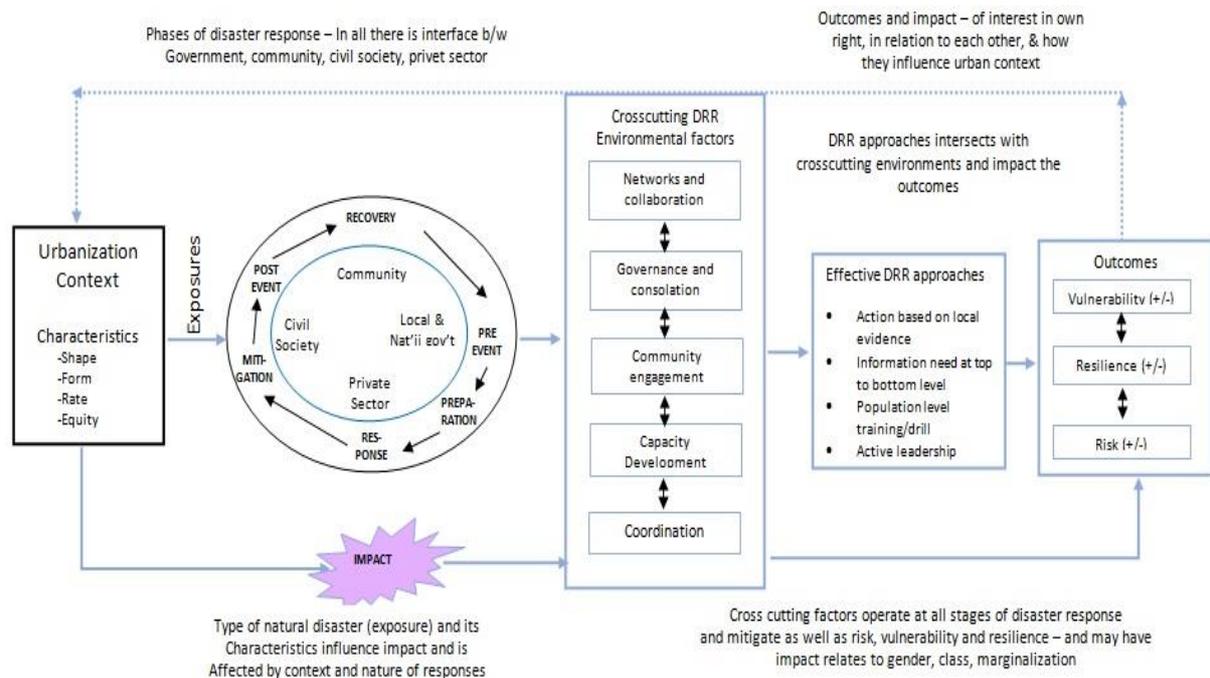
This framework helped to capture the intersecting complexities of the domains under review as well as to guide the search in the capture of relevant publications for the review.

Figure 2: Conceptual Framework



The theory of change (Figure 3) was developed based on the earlier described conceptual framework and the findings from the scoping review (Appendix 17). The scoping review identified the extent and breadth of literature on urbanisation and natural disaster, and reported the scope and limitations of the available information. Many studies described post disaster impact and resilience measures, while some discussed on planning, policies, resolutions, participations, challenges and barriers in the pathway of risk reduction (scoping report, Appendix 17).

Figure 3: Proposed Theory of Change



The Disaster Management (DM) cycle adapted from Alexander, 2002: 6; Coppola, 2007 and Eriksson, 2006

Based on the available literature and outcomes of the scoping review, a theory of change (ToC) was proposed to understand and guide the synthesis stage (Stage 2):

- i. A pathway of change that shows the connections between long term, intermediate and early outcomes
- ii. The ToC helps explain how an intervention fits within the pathway of change

Keeping these understandings in consideration, we have drawn this theory of change in which we tried to explain that:

1. Risk is the interface of four vectors; urbanisation, natural disaster, vulnerability and resilience and/or risk reduction (see Figure 2: Conceptual Framework).
2. The pathway to risk and resilience (the pathway to change) is affected largely by the context in which these vectors occur or interplay (see Figure 3: Theory of Change)
3. The types of factors related to the nature of three vectors such as urbanisation, natural disaster and vulnerability determine the risk. However, the shape of the pathway to risk and resilience is influenced by DRM interventions (pre, during and post disaster periods) and by complex interactions with other cross cutting themes that support governance, policy and programmes or initiatives. These initiatives are undertaken by the communities themselves and/or together with other DRR interventions (See Figure 3: Theory of Change).
4. DRR approaches can function effectively depending on the context and any associated cross-cutting themes, influencing the outcome of interventions (See Figure 3: Theory of Change).

2. METHODS

2.1 RESEARCH QUESTIONS AND OBJECTIVES

- i. What is the impact of urbanisation on risk of, and vulnerability to, natural disasters?
- ii. What are the effective approaches for reducing exposure of urban population to disaster risks?

The review was based on the outputs of the scoping exercise (Stage 1) and synthesized evidence of the relationships between variables of interest, including the analysis of outcomes and impact of interventions (Stage 2). The review tried to capture the range of risk mitigation interventions that were evaluated or reported and also to document the lessons concerning their applicability to different contexts, especially those in South Asia.

The second stage also focused on the reported interventions that addressed risk reduction and vulnerability. Inclusion criteria were fine-tuned after the scoping study (Stage 1) to focus on particular types of disasters, interventions and approaches or contexts of particular interest and to ensure the review could be feasible and meaningful to the policy community.

Emphasis had been given to include interventions focused on managing the disaster impact of urbanisation for further analysis for example, improved land use and watershed management, preparedness programs including those entailing extensive community engagement and participation, urban planning, policy change and urban risk assessments.

The review focused on all disaster types in South and East Asian LMIC countries, as long as the studies met the inclusion criteria at the synthesis stage (Stage 2) - disaster, urbanisation, intervention or impact or outcome evaluation assessment, but not limited to either particular disciplinary or methodological approaches, nor to particular types of disasters (see inclusion criteria in section 2.2). Relevant literature was drawn from the social and allied sciences, public administration and urban planning where these focused on South and South Asia.

2.2 INCLUSION CRITERIA

This review used a predefined and agreed upon PICO (Population-Intervention-Comparisons-Outcomes) framework to organise inclusion / exclusion criteria as follows (See Appendix 11):

POPULATION

This review included studies that investigated all urban and peri-urban populations living in low and middle income countries (LMIC- as per World Bank 2016 definition, last access on March 01, 2016)¹ of

¹ <https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups>

South and East Asia. Analysis included studies investigating particular demographic groups (age, gender, ethnicity, etc.) and/or socio-economic status (poor, middle class, wealthy). Studies included in the review also addressed population categories such as marginalized groups, slum-dwellers, displaced populations, migrants and other at-risk groups. In addition, studies investigating local and national governments and relevant government agencies, departments and ministries were included. Given that the context of urbanisation itself varied a great deal between these different studies, information was also gathered on urbanisation context: pace and rate of urbanisation; location of urban centres investigated; the characteristics of urbanisation in given contexts; the economy; social patterns and geophysical vulnerabilities, if any. The patterning of populations and urbanisation contexts was carefully examined and compared across the breadth of the literature reviewed.

Disaster: Natural disasters included all disaster types: flood, earthquake, tsunami, avalanche, fire, landslide, tidal wave, volcano, large scale catastrophe, cyclone, hurricane, typhoon, coastal hazard, lahars, blizzard, hailstorm, storm, tropical storm, heat wave, tornado, wildfire, mudflow, extreme weather events, and climate related hazards. The search strategy was as inclusive as possible in order to ensure the review captured as many studies as possible that could contribute to an improved understanding of disaster risk, resilience, and vulnerability in relationship to urbanisation in low and middle income countries in South and East Asia.

INTERVENTION

The focus of the review was to analyse the interplay of urbanisation with natural disasters in the context of risk, vulnerability and resilience. The review was informed by models and frameworks identified through the initial scoping exercise (Stage 1). The review sought to identify programmes and interventions implemented by governments, NGOs and community-based organisations, international organisations or donor agencies to reduce risk and vulnerabilities to disasters and their effects, and to boost resilience in the context of urbanisation and disaster. Interventions operating along the continuum - pre-disaster, disaster response, mitigation, and post-disaster - were included with an emphasis on identifying studies that linked urbanisation with risk and vulnerability to disasters (and their effects), and where undertaken, associated interventions. Specific forms of intervention that were incorporated into the theory of change – such as community engagement or establishment of cooperative networks – were also explored in relation to the interventions identified.

COMPARISONS

The review focus was on natural disasters and their interface with human settlements, urbanisation, disaster risk management programmes and related programme outcomes. With natural disaster it was anticipated that few experimental studies would be available but that insights would be derived through comparisons reported for people offered, exposed or affected by a particular intervention. It was anticipated that this would most likely be comparisons between baseline and end line, pre-test

and post-test circumstances, and would reflect presence or absence of interventions, or differences arising from intervention intensity. However, the scoping review (Stage 1) did not identify any such literature; the Stage 2 analysis therefore included a range of study types that could inform the development of interventions, reported the context in which impacts may have been modified by interventions, and insights regarding changes in processes and outcomes.

OUTCOME(S)

“Risk of” and “vulnerability to” are the major outcomes in the pathway of interaction between urbanisation and natural disaster. The search and this review tried to identify whether other related and important outcomes on this pathway were reported in the literature, importantly, any potential area to resolve implementation challenges. The review considered the outcomes such as “resilience”, “preparedness”, “disaster planning”, risk assessment, slum avoidance, and enforcement of safer land use, and building codes (See appendix 7 for details of search strategy) etc. More in-depth analysis was expected to reveal more detailed information about other outcomes (e.g. reduced hazard exposure, changed health or care seeking behaviour, improved disaster preparedness, improved responsiveness, improved quality of life etc.) and variables relevant to reducing disaster risk and vulnerability in urban areas.

STUDY DESIGN

All forms of impact, outcome evaluation or intervention assessment studies related to urbanisation and disaster were included. No particular designs of studies were excluded. All methods of data collection including quantitative, qualitative and mixed method approaches and hence study designs were considered. Observational studies such as surveys, cohort studies, case-controlled studies and case studies (with or without economic or equity analyses) assessing harm or causation were also considered potentially suitable for assessing reach, implementation and convergence of disaster and interventions.

We were especially concerned with identifying empirical data related to these interventions and their evaluation, as well as their interactions with the key concepts of risk, resilience and vulnerability. We anticipated drawing on but not systematically reviewing those studies that would help contribute understanding of context and mechanisms that help explain how and why given interventions might work.

LANGUAGE OF THE REVIEW AND DATE OF PUBLICATION

Only English-language publications were examined. The review was limited to literature published from 1980 to the end of 2015.

2.3 LITERATURE SEARCH

A systematic approach was adopted to search and identify relevant literature for the initial scoping review (Stage 1). The relevant studies were searched in specific and related databases using a variety of search terms including key words, relevant text word, index terms and entry terms. We searched Global Health, Pubmed, PsychINFO, PAIS, Scopus, ASSIA, British Humanities Index (BHI), Sociological Abstracts, Informit Humanities and Social Sciences and Health Collection, GEOBASE, CAB Abstracts, OARE, Collaboration for Environmental Science, Econlit, International Bibliography of the Social Sciences, IPSA (International Political Science Abstract). We also searched relevant websites including donor organisation website (DFID, USAID etc), and UN websites (UNISDR, WHO etc).

This was supplemented by searching grey literature using the same key words (see appendix 7 for search strategy). The search was managed using EndNote (version 5) software, which was used to create a library of all search results. All duplicate records were identified and deleted. The records in the Endnote library were then imported into EPPI-Centre's online review software, EPPI-Reviewer 4. EPPI-Reviewer was used to manage the screening, review, structure and record all processes, including those concerned with analysis. In Stage 2 review, a subset of relevant literature was drawn from the literature identified in the mapping stage for in-depth analysis. EPPI-Reviewer 4 was used to manage the search results.

The search outcome was screened using inclusion and exclusion (appendix 11) criteria relevant for the review. The synthesis stage (Stage 2) focused on LMIC countries of South and East Asia, and included urban populations and available interventions or approaches that examined or reported interactions among the three main domains under review, urbanisation, natural disaster and vulnerability. The identification of potential studies followed a systematic approach which included both the electronic databases, web sources, major and relevant organisation websites, key journals and grey literatures (Appendix 8). All searches were carried out by an expert search librarian.

2.4 SCREENING STUDIES: APPLYING INCLUSION AND EXCLUSION CRITERIA

The titles and abstracts were reviewed by two team members from UNSW (KS and NS) and two members from icddr,b (RM and IN), according to the inclusion and exclusion (Appendix 11) criteria. Quality assurance was maintained by rechecking 20% of the title and abstracts by SH, KS and LH. After selection, full-text was obtained and uploaded in the EPPI-Reviewer software for further applying exclusion criteria. Application of inclusion and exclusion after viewing full text was done by three team members (KS, NS and RM). It was recognised that this kind of evaluation based only on the review of a study's abstract was not always possible and, in these cases, a more detailed review of the full document was undertaken. If the study met the inclusion criteria, the study was retained for the next stage of the review. SH and KS undertook 10% of the full text rechecking to ensure quality application of the inclusion criteria. All aspects of the study processes have been documented to ensure rigour and transparency. The research team worked together to review articles that were contentious with the team leader making a decision where unresolved. Those articles not meeting the criteria were excluded.

Coding and data abstracting were applied using EPPI-Reviewer 4 software. A set of codes were set up in EPPI-Reviewer 4 for use by the review team (See Appendix 7). Included full text articles were reviewed one by one by four reviewers (SH, KS, RM, NLH) and multiple coding was applied as appropriate to each article. In addition, all studies were categorised and data recorded concerning key features of each study, including the presence of outcome data for assessment in the next stage of the review. Instances of disagreement or uncertainty were resolved via discussions among the whole team.

2.5 DESCRIPTION OF STUDIES AND QUALITY ASSESSMENT

All literature that met the inclusion criteria were included with quality judgements being made in respect of relevance to the aims and research questions of the review. The validity of insights derived from different aspects of the study was then considered in relation to the study's description of data collection and analysis methods. A careful assessment of the quality of each study contributing to the systematic review of interventions and impact was done. The quality of the included studies was assessed using Hawker *et al.*'s tool, which covers the following domains: abstract and title; introduction and aims; methods and data; sampling; data analysis; ethics and bias; results; transferability or generalizability; implications and usefulness. We have adopted the tool from Appendix 5 of Lorenc, T *et al.* This tool contains nine questions, each of which can be answered in "good", "fair", "poor" and "very poor". Having applied the tool to the studies, we converted it into a numerical score by assigning the answers from 1 (very poor) to 4 (good) points. This produced a score for each study of a minimum of 9 and a maximum of 36 points. To create the overall quality grades, we used the following definitions: high quality (A), 30-36 points; medium quality (B), 24-29 points; low quality (C), 9-24 points. We have modified scoring regards "low quality"; we set the points <24 instead of "9-24 points" (see appendix 4).

2.6 DATA SYNTHESIS

The review team used both Microsoft Excel and EPPI-Reviewer 4 software (Thomas *et al.*, 2010) to manage and analyse data. Analysis at the synthesis stage involved more in-depth and line by line coding for data abstraction.

In the absence of any experimental trials or other quantitative methods of comparison studies, neither meta-analysis nor regression analysis was possible. Framework analysis was undertaken to describe in more detail the thematic and sub-thematic issues of interest. Framework analysis is a data analysis technique adapted for use in research syntheses (Dixon-Woods, 2011; Oliver *et al.*, 2008). A framework approach enables reviewers to structure and organise information based on conceptual and thematic frameworks identified and refined during analysis (Dixon-Woods, 2011; Smith and Firth, 2011; Ward *et al.*, 2013). Carroll *et al.* (2011), for example, used framework approach as a tool in a systematic review of attitudes towards taking dietary supplements that can aid in the prevention of colorectal cancer. Another research team undertook a systematic review using framework analysis

that synthesised studies investigating patient perspectives on prevention programs for cardiovascular disease and diabetes (Surjan and Shaw, 2009).

The review used a set of predefined themes as ‘sensitizing concepts’ (Charmaz, 2006) to guide the development of the review search strategy, the research questions and the data extraction tools used in stages one and two (see Appendices 9 & 10). However, as coding proceeded, concepts emerged during analysis, which were then integrated into the evolving analysis. The codes were grouped and organised according to thematic categories which were then used to answer the two research questions of this review. The findings of the thematic coding were then analysed in relation to one another, exploring the resonance between the issues raised by the studies.

To determine which approaches are effective and appropriate in limiting the devastating outcome of natural disaster, the review assessed the impact of approaches by comparing and combining themes emerging from studies captured using a narrative synthesis of included studies (Arai et al., 2007; Popay et al., 2006; Rodgers et al., 2009). Emergent themes and concepts were organised in accordance with the two research questions. The thematic coding for the first research question included concepts related to the extent of risk and vulnerability to estimate the relative impact of different types of natural disasters in different LMICs. Due to the paucity of rigorous studies detailing explicit outcomes and specific program interventions, it was often difficult to find strong connections between the impact of urbanisation (question 1) and effective approaches to reducing the exposure of urban populations to natural disasters (question 2). Wherever possible, however, included studies were closely examined to see if they included examples of effective approaches and interventions that reduced affected populations’ exposure to natural disasters in urban settings.

The studies were also analysed and categorised according to a range of contextual factors reported in studies including:

- Lack or presence of collaborative initiative taken by the government or non-governmental organisation or joint collaborative effort between government and non-governmental organisations and presence of community participation in any of these initiatives.
- Studies were coded according to country and specific natural disaster type;
- Reported success or failure of approaches was drawn out of each study’s results and findings;
- Potential for approaches to be applied to other countries with similar settings.

The team also evaluated the quality of studies (see section 2.8 above); the range of outcomes and impacts and what influenced them; the strength of evidence; as well as the similarity or dissimilarity of outcomes in relation to context. We drew out key implications and findings, especially those of likely relevance to policymakers and future implementation, and considered these in relation to the context analysis.

3. FINDINGS OF THE REVIEW

This chapter describes the findings of the review. In this review each of the included studies addresses review questions:

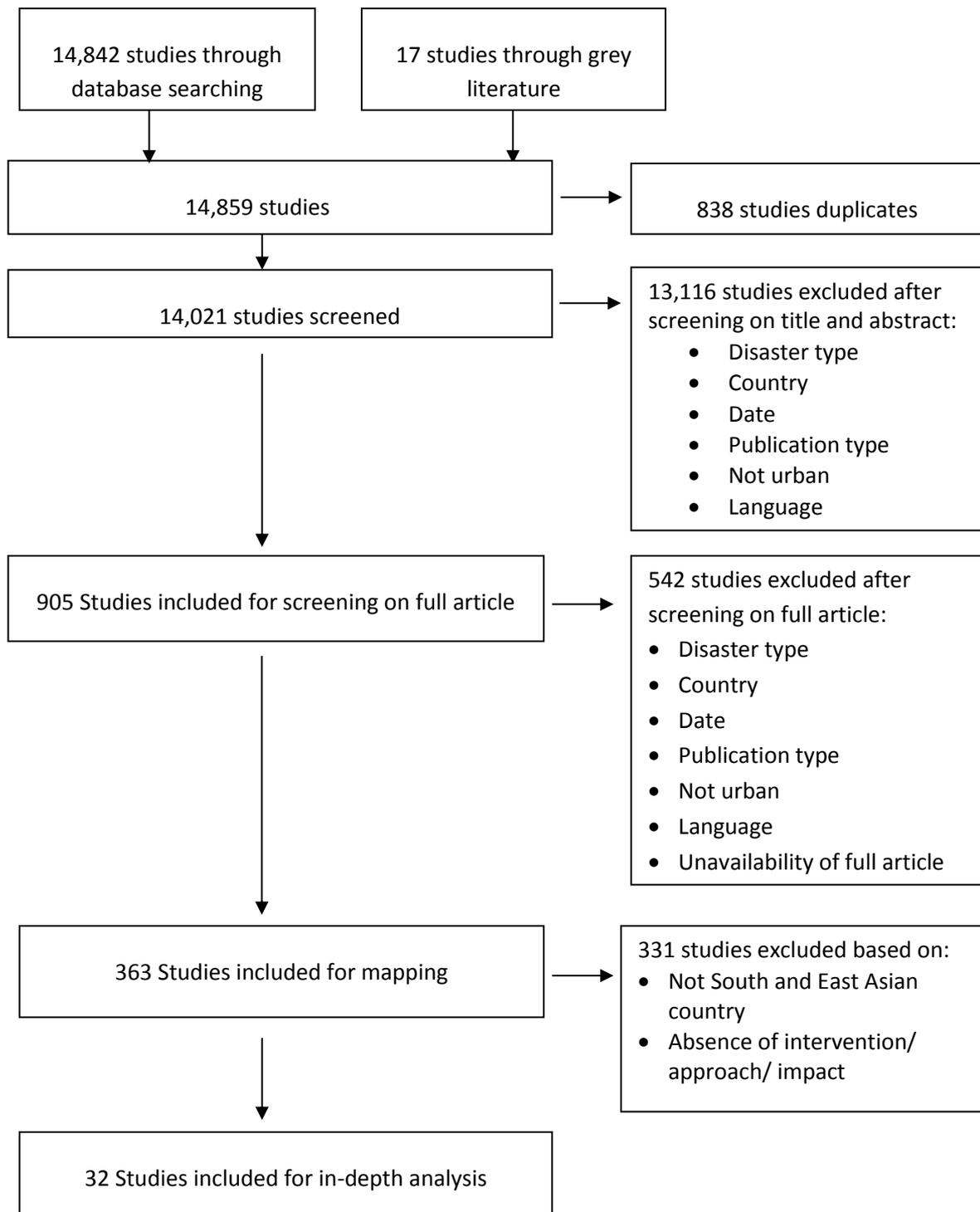
1. What is the impact of urbanisation on risk of, and vulnerability to, natural disasters?
2. What are the effective approaches for reducing exposure of urban population to disaster risks?

3.1 STUDIES INCLUDED FROM SEARCHING AND SCREENING

The in-depth review included a total of 32 studies. The initial search resulted in 14,859 citations from various sources. The sources included 17 databases and websites including institutional and organisational websites. A search of grey literature was done but none of the retrieved studies were found suitable to include in the review process. After duplicate checking, 14,021 citations were uploaded to the software EPPI-Reviewer 4 for screening process and further review. The scoping review included 363 studies.

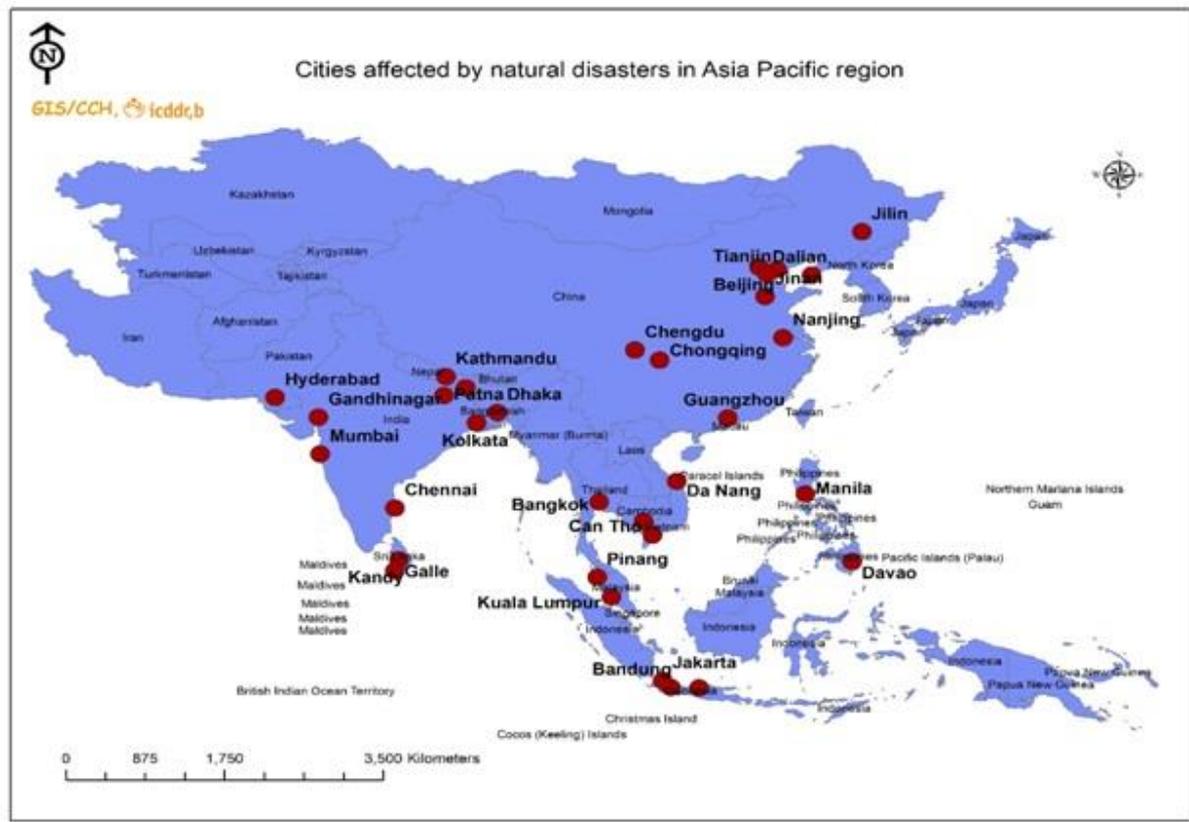
We have included all studies from the scoping review which are on Nepal and Bangladesh for inclusion in the **contextualisation** section.

Figure 4: Flow chart of study selection process



A total of 32 studies were reviewed, which were based on LMIC countries (Bangladesh, India, Indonesia, Nepal, China, Cambodia, Sri Lanka, Vietnam, Thailand, Malaysia and Philippines). Among these studies, 13 discussed only floods, nine discussed only earthquakes and one discussed tsunamis. The rest of the literature discussed other natural disasters (landslide, flash flood, typhoon, cyclone etc.) besides floods and earthquakes. All included studies were reviewed to answer research question 1 and 21 were reviewed for research question 2.

Figure 5: Distribution of included literature on natural disasters sites in South and East Asia



3.2 IMPACT OF URBANISATION ON RISK, VULNERABILITY TO NATURAL DISASTER

Research Question 1: What is the impact of urbanisation on risk of, and vulnerability to, natural disasters?

Findings in response to this review question have been arranged in two parts. The first section describes the evidence related to the physical, social and economic impacts of major disasters and the second part addresses those impacts related to urbanisation and existing vulnerabilities. The discussion attempts to describe the review findings using the conceptual framework and proposed theory of change.

PHYSICAL, SOCIAL AND ECONOMIC IMPACT

Flood, earthquake, tsunami, typhoon, cyclone, landslide are very common natural disasters that are often faced by LMICs in South and East Asia. Physical, social and economic impacts of major disasters are discussed in the subsequent passages.

IMPACT OF FLOODS

Floods impacted largely on physical, economic and social sectors. Almost every study found that economically marginalized people are at greater risk of being affected by natural disasters. Slum populations, poor and migrant people living in the hazard prone areas (e.g. river bank, low level plain land, coastal area etc.) are more vulnerable to disaster. In addition, children and women are another group of vulnerable people who are highly affected during disaster (Ahmed et al., 2015; Rumbach, 2014; Ramachandraiah, 2011; Sharma and Priya, 2001; Sudmeier-Rieux et al., 2015; Dewan et al., 2012; Surjan and Shaw, 2009). These authors reported in their studies that during floods, slum populations dispersed throughout the city, along hill slopes, railway lines, pavements and within industrial zones, and in low lying informal settlements were particularly vulnerable to floods. One study from Nepal found that ethnic groups were also very vulnerable to flood (Sudmeier-Rieux et al., 2012).

INFRASTRUCTURE LOSS AND MORTALITY AND MORBIDITY

During floods, communication and transportation systems are often damaged or even destroyed as telecommunications, roads and highways go under water. Floods also have a significant impact in terms of injury and the loss of life in cities in South and East Asia. In countries like Bangladesh, for example, floods create problems in drainage systems as they are pushed beyond their normal capacity. The drainage systems are often in poor condition in informal settlements especially, making it impossible to live in slum residences during floods (Ahmed et al., 2015; Dewan et al., 2012). In the 1955 flood, 80% of Dhaka, the capital city of Bangladesh and 35% of Bangladesh was submerged. Flood in 1974 inundated approximately 37% of Bangladesh and 25% of Dhaka. The 1988 flood submerged two-thirds of Bangladesh for two months. In the entire country, 50 million people were affected and 1600 died. In Dhaka alone, 50 percent of the area was inundated and 1.9 million people were affected. Due to the 1998 flood 52 districts were inundated for 65 days and 30 million people were affected across the whole of Bangladesh. The flood of 2007 submerged 32,000 square km and resulted in 649 deaths. Almost 85 thousand houses were destroyed and one million were damaged (Ahmed et al., 2015). Statistics showed that the 1988 flood engulfed 1,484 hectares of urban land; which increased to 2,991 hectares in the 1998 flood (Dewan et al., 2012). It was also found that in Kurnul, Andhra Pradesh, the total submerged area was calculated to be 11.56 km², or about 30% of the total city with the percentage of badly affected population equalling 42% (~195,000 people) (Ramachandraiah, 2011). In 2004, a flood in Surat affected nearly 400,000 people. In the 2006 flood, 75% of the city was submerged. Official number of deaths were estimated around 150 whereas, unofficial estimates of death counted more than 500 (Bhat et al., 2013). In Mumbai, the 2005 flood took the lives of more than 1000 people (Surjan and Shaw, 2009).

Abdullah et al., (2015) evaluated the policy aftermath of the massive flood events in three megacities (Bangkok, Kualalampur and Manila) where they described the impacts of disasters that caused between 700-1200 fatalities. Due to the 2011 flood in Bangkok, Thailand, 65 of the 76 provinces, 684 districts and 43,636 villages were affected. 13,595,192 people from 4,086,138 households were affected, with 693 persons confirmed dead and 3 missing. The educational system, including academic institutions such as schools and universities, was also affected by this flood with an unprecedented 3,088 schools disrupted and approximately 700,000 students affected (Abdullah et al., 2015).

In Salt Lake, Kolkata, a city in India, during monsoons slum dwellers encountered a lot of problems caused by poor housing and sanitation systems that led to health hazards (Rumbach, 2014). In the 2002 flood of Jakarta, Indonesia; approximately 330 km² was inundated with 22 deaths reported. The floods of February 2007 are regarded as the worst in the history of the Indonesian capital, with approximately 70 per cent of the urban area affected. Floodwaters directly impacted 400,000 people, resulted in 79 deaths, and destroyed a hundred houses in informal settlements (Mulyani Sunarharum et al., 2014). Vietnam, which is a densely populated coastline country, is at extremely high risk of natural disasters, especially flood. The 1999 flood claimed 595 lives (Razafindrabe, et al., 2014). Another studies described the flood in Jakarta in 2013, which displaced 14,300 people. In Indonesia in November 2007, flood damaged 6,368 homes in Indonesia, and another 6,368 homes were damaged in 2008 (Taylor, 2015).

ECONOMIC LOSS

Floods were found to not only affect infrastructure and cause the loss of lives, they also directly caused significant economic losses for countries in South and East Asia. Four major flood events were reported in 1988, 1998, 2004 and 2007 in Dhaka. The intensity of damage in Dhaka was reported to be more in the latter flood events. The structural and agricultural damage amounted to ²6-12 million USD in 1988 and 3 billion USD in 1998, which indicated the increase of loss. However, the economic loss (US\$2.2 billion) reduced during the 2004 flood from 1998. The loss might be reduced because of different flood mitigation approaches taken by Government and other organisations. Though many approaches are taken by Government, still the flood of 2007 caused huge agricultural damage estimated at over 1 billion USD (Ahmed et al., 2015). During the flood, households lost their valuables and savings, and people were unable to go to their place of work because of submerging of roads and workplaces, which therefore leads to economic hardship for the day labourer. Inflation happens after disaster because of crop destruction, disruptions in transportation networks, and hoarding by households and merchants. Exposure to contaminated water and a bad sanitation condition spreads waterborne diseases. With a lack of supplies and due to economic hardship people are unable to use their emergency supplies (Bhat et al., 2013; Braun and Aßheuer, 2011; Khan, 2008; Ramachandraiah, 2011; Rumbach, 2014; Surjan and Shaw, 2009). Due to flood in Surat, India, dams, flood embankments, electricity and telephone lines were destroyed and industrial losses amounted to around US\$ 3.5

² All monetary estimates are in US\$ as quoted in the studies. If otherwise reported are converted into US\$ as present day conversion rate using <http://epi.ioe.ac.uk/costconversion/default.aspx>

billion. Loss of public infrastructure totalled US\$ 544 million (Bhat et al., 2013). By using a qualitative method, Taylor (2015) reported a loss of approximately US\$ 1 billion due to flood in Jakarta, Indonesia. Emergency services for the flood in 2007 were estimated at more than US\$ 27 million (Taylor, 2015). In Manila, total damage was estimated at US\$1.04 billion, which is also a proof of great economic loss (Abdullah et al., 2015). In addition to that, Chinnarasri and Porkaew (2015) also described the flood of 2011, which greatly impacted on all sectors of the Thai economy, as costing approximately \$40 billion (Chinnarasri and Porkaew, 2015).

SOCIAL IMPACT

Several studies reported that during floods, earthquake and other natural disaster people encounter different social problems (Bhat et al., 2013; Ramachandraiah, 2011). Slum dwellers, low income populations residing in riverine areas, and new migrants faced greater difficulties due to disruptions to their earnings caused by disaster. New migrants have a particular kind of vulnerability due to a lack of social networks in their new locations. People were unable to maintain social networks post-disaster due to the fact they had to evacuate their homes without any preparation. In one interesting study, people from middle socioeconomic groups reported feeling disadvantaged as they were uncomfortable joining in relief queues and having to shove and push past people to get access to aid. Reportedly, the relief system set up in this case was unable to deal with the number of people, with people from non-affected areas unfairly joining relief queues, thereby increasing the crush and crowds in the relief distribution places. This increased the number of people seeking food aid and large numbers of affected people were unable to gain access to relief aid. A woman representative of the middle socioeconomic group in Budhavarpet said that,

“We could not get into that crowd and jostle for the relief. Both physically and psychologically it was difficult. We are not used to that. It was like begging, even worse than that.”

(Ramachandraiah, 2011).

IMPACT OF EARTHQUAKE

Many South Asian countries lie on or near to the convergence of the Indian and Eurasian plates of the earth's crust. Additionally, many cities from South and East Asia region are located on the edge of mountains making these cities vulnerable to earthquake (e.g. Kathmandu in Nepal, Bhuj, Ahmedabad in India, Lushan, Wenchuan in China, Vietnam etc). In the reviewed literature there were 10 studies which discussed the impact of earthquakes. Most of these studies were based in India, Nepal, Vietnam and China (Carpenter and Grünwald, 2015; Parvej, 2013; Peleg, 2015; Sudmeier-Rieux. et al. 2015; Tafti and Tomlinson, 2013; Teets, 2009; Theckethil, 2012; Thiruppugazh, 2008; Yang et al., 2014; You et al., 2009).

INFRASTRUCTURAL LOSS, MORTALITY AND MORBIDITY

Different studies discussed infrastructure damage, injuries and fatalities resulting from earthquakes. India, for example, was very prominent in the research addressing earthquake impact and loss. In 2001 an earthquake measuring 7.7 on the Richter scale in Bhuj city of Gujarat, India caused approximately

7000 deaths. Nearly 50% of the city was destroyed; approximately 11,036 houses were completely and 27,617 houses were partially destroyed. In addition, around 4000 households were destroyed in the old urban settlements and tenants' areas (Tafti and Tomlinson, 2013). It was reported in another study that due to the Bhuj earthquake on 26th January, 2001 nearly 14,000 people lost their lives, with another 167,000 suffering injuries. Further, 150,000 homes and many historical sites were damaged (Theckethil, 2012).

During the earthquake at Ahmedabad in 2001, 70% of multi-storey buildings collapsed and substantial buildings made of stone, brick, concrete or timber were razed to the ground. This was one of the most devastating earthquakes to hit the Indian subcontinent. 14 municipal towns of Ahmedabad city were affected. The official death figure was estimated at 13,805. Numbers of fully collapsed and partially collapsed houses were respectively 215,000 and 928,000 (Thiruppugazh, 2008).

China was also shown to be highly affected by earthquakes with some of the most devastating disasters worldwide. In 2008, an earthquake of 7.7 magnitude hit the Sichuan Province of West China impacting on the entire county along with the neighbouring provinces of Sichuan, Gansu, and Shanxi. Official data recorded the deaths of 15,645 people, 1,023 missing people, 26,916 injured with more than 142,000 made homeless (You et al., 2009). The 2008 earthquakes in Wenchuan area in Sichuan province demolished 7,967,000 buildings completely and damaged another 24,543,000. This earthquake resulted in 69,227 deaths, 374,643 injuries and 17,923 missing people. Some countries in Sichuan Province, such as Beichuan Qiang Autonomous County, were completely buried due to slope failure (Yang et al., 2014). In another study, Teets (2009) reported on the devastating earthquake that took place in 2008 in China. Due to this earthquake 7,000 classrooms were destroyed. Another earthquake hit Lushan area in 2013 causing 196 fatalities, 13,000 injuries, and 21 missing people. 724,000 buildings were completely destroyed and 1,173,300 were damaged due to this earthquake (Yang et al., 2014).

Nepal is another country at significant risk from earthquakes although this review only found one study addressing the latest one in 2015. This earthquake was devastating for Nepal with 8,800 people dying (Carpenter and Grünewald, 2015).

ECONOMIC LOSS

Economic losses were usually calculated in the studies based on secondary data from government statistics, news media or other sources. Total economic losses caused by the Sichuan earthquake of 2008 were estimated to be US\$2655.88 hundred million. However, direct economic losses reached US\$2174.77 hundred million. Five years after the 2008 Wenchuan Earthquake, another earthquake struck at Lushan area in 2013 with a total economic loss estimated to be approximately US\$267.66 hundred million (Yang et al., 2014).

IMPACT OF TSUNAMI

Tsunamis are another dangerous disaster initiated from the ocean that have far reaching consequences with tidal surges flooding entire cities and a devastating impact on living beings. Only one study from the review described the impact and consequences of the 2004 Indian Ocean tsunami on a city (Birkmann and Fernando, 2008).

A case study on Sri Lanka (Birkmann and Fernando, 2008) analysed the number of deaths due to tsunami in two different time periods. In 2011 tsunami at least 57 people were killed, around 193,700 were affected and at least 35 per cent of rice crops were destroyed. The 2004 tsunami proved to be a high impact event that caused the death of 35,000 people and displacement of 500,000 people. The estimation of economic loss totalled US\$900 million worth of assets and infrastructure. This case study in Sri Lanka surveyed households about the cause of deaths and missing people by gender and age group caused by the tsunami in the coastal communities of Sri Lanka in 2006. The estimated fatality rate was significantly higher in females than males, elderly people (61 years and older) and young people (0-10 years). This result demonstrated that females failed to climb to the roofs shortly after the devastating wave happened. They noticed the event too late because of their engagement in household chores. Some of the men interviewed in Batticaloa reported that,

“they [men] climbed on to the roof of their house, but their wives or daughters were less able to do so in the short time available after noticing the devastating wave.”

(Birkmann and Fernando, 2008).

IMPACT OF OTHER DISASTER (TYPHOON, FLASH FLOOD, CYCLONE, LANDSLIDE)

No studies were found where typhoon, flash flood, cyclone, landslide, storm were discussed alone. Among thirty-two studies, six described this disaster alongside other large disasters such as floods or earthquakes. Most of the time, these disasters were actually the consequence of other disasters such as flood, earthquake or tsunami or took place at the same time. It is often said the “disasters never occur in isolation usually never happen alone”. They bring other damage along with them and are frequently devastating depending on the context (Carpenter and Grünewald, 2015).

LANDSLIDE

The Philippines lies in a high disaster prone area as it is located within the Circum-Pacific belt (Pacific Ring of Fire) and the typhoon belt of the North Pacific basin. Volcanic eruptions, lava, mudflows, and landslides are common disastrous events in this country. In 2000, because of the Payatas trash slide which was triggered by heavy rains, 288 people died, hundreds of homes were buried and close to 1,000 waste pickers were displaced. Again in 2006, a landslide in Guinsaugon in Leyte province and a mudflow in Bicol region took the lives of 362 people. More than a thousand people were recorded missing as a result of these disasters (Carcellar et al., 2011).

TYPHOON, FLASH FLOOD AND CYCLONE

In 2008, the Philippines was hit by a Typhoon as it is located on the typhoon belt of the North Pacific basin. This typhoon brought 354 millimetres of rain within a 24-hour period which resulted in flooding in 180 villages in the city of Iloilo; with up to 500 people killed and 261,335 affected. Again in 2009, 464 people died, 529 were injured and hundreds of thousands left homeless by the widespread flash floods caused by Typhoon Ketsana in Metro Manila and neighbouring provinces. Total damages was counted at US\$ 852 million (Carcellar et al., 2011). Due to Typhoon Bopha in December 2012 at the southern island of Mindanao thousands of people became homeless. It caused 1,146 fatalities, with

another 834 missing. In November 2013, Typhoon Haiyan hit Philippines and 6300 people died. Haiyan also brought storm surges which wiped out most infrastructure, health facilities, schools, basic public services, homes and commercial buildings in several coastal towns/barangays in the islands of Samar and Leyte. 16 million people were affected. The terminal buildings of Tacloban Airport were destroyed (Abdullah et al., 2015; Thomas, 2015). Bopha caused damages totalling US\$1.04 billion and Super Typhoon Haiyan resulted in US\$9.7 billion losses and damage. Storm surges that were triggered by Typhoon Haiyan caused further damage equivalent to US\$9.7 billion (Abdullah et al., 2015).

VULNERABILITY

Studies showed that the poor suffer most from the impact of natural disasters such as typhoon and cyclones that have impacted on the Philippines. Limited financial access, insecure land and house tenure, high risk locations and a lack of organisation make these people more vulnerable to disasters (Carcellar et al., 2011). People living in huts and other forms of non-permanent housing adjacent to the sea (or in some cases, on stilts over it) were obliterated by the typhoon's winds and storm surge (Thomas, 2015).

RELATION OF DISASTER IMPACTS WITH URBANISATION AND VULNERABILITY/RESILIENCE

Research Question 1: What is the impact of urbanisation on risk of, and vulnerability to, natural disasters?

This discussion is mostly based on the findings from the high-medium quality studies (Birkmann and Fernando, 2008; Malalgoda et al., 2013; Razafindrabe et al., 2014; Tafti and Tomlinson, 2013; Taylor, 2015; You et al., 2009) addressing the first research question: *What is the impact of urbanisation on risk of, and vulnerability to, natural disasters?* However, when relevant evidence from included low-quality studies on the first research question was available, observations from these studies were included in the analysis.³ The main themes emerging in terms of the impact of urbanisation include:

1. Physical vulnerability: Geographic and climatic exposure to natural disaster
2. Collective vulnerability: Rapid, unplanned urban growth
3. Social vulnerability: High risk, vulnerable populations

All of these factors strongly intersect with each other. Rapid, unplanned urban growth and its associated population movements link up strongly with geographic location and increased vulnerability for high risk populations. Modern, urban spaces have grown rapidly and chaotically, not being subjected to systematic urban planning and governance processes that could potentially reduce and mitigate risk and vulnerability to the impact of natural disasters. The studies demonstrate that this is especially the case for disadvantaged and at risk populations who are moving into high risk urban areas such as riverbanks, coastal zones and hillsides. These population movements reflect

³ Please note that some studies investigated more than one type of vulnerability, event or population group. Consequently, numbers of studies vary and do not always equal the total of 22 studies included in this round of the review.

disadvantage, marginalisation and discrimination as the groups migrating to these marginalised urban spaces are from socially vulnerable groups. These areas attract low income and marginalised peoples because they have cheaper housing and land as well as enabling access to livelihoods and employment opportunities. Social, political and economic forms of vulnerability are also exacerbated by the physical geographies of cities: located in low elevation areas such as along coastlines, riverbanks or in seismically active areas, populations settling in low cost areas are often more exposed to risk of natural disasters such as floods, cyclones, earthquakes or tsunamis.

PHYSICAL VULNERABILITY: GEOGRAPHIC LOCATIONS AND CLIMATIC EXPOSURE

Cities were found to have variable exposure to different natural hazards depending on their geographic positioning and location in certain climactic zones. The physical spaces of urban geographies were strongly represented in the literature analysed in this round of analysis including all six (Birkmann and Fernando, 2008; Malalgoda et al., 2013; Razafindrabe et al., 2014; Tafti and Tomlinson, 2013; Taylor, 2015; You et al., 2009) of one high and five medium quality studies, fourteen studies investigated cities located on riverbanks and floodplains; eight studies urban development in coastal areas; another five looked at climactic exposure to monsoons and cyclones and four studies addressed cities in seismic risk areas.

Obviously, the physical location of cities cannot be easily changed, as it would be impossible to move entire urban populations completely into areas free of risk of natural disasters. Cities have grown up in these locations due to long historical processes based on population movements into spaces central to the social, economic and political lives of these cities for many centuries. The solution to vulnerability emerging out of physical location is to develop planning, policies and strategies to reduce as much as possible urban populations' exposure, risk and vulnerability to natural disasters. This highlights the need for robust governance processes at local level that can effectively manage and mitigate risk for urban populations, which will be discussed in more detail in the subsequent section of the report on approaches for reducing exposure to disaster risk.

RIVERBANKS AND LOWLAND PLAINS

Fourteen studies investigated vulnerability and risk of disasters in cities located in low-elevation areas such as river banks, river deltas or lowland plains (Abdullah et al., 2015; Ahmed et al., 2015; Birkmann and Fernando, 2008; Braun and Aßheuer, 2011; Chinnarasri and Porkaew, 2015; Dewan et al., 2012; Joerin et al., 2014; Ramachandriah 2011; Rumbach, 2014; Sharma and Priya, 2001; Sudmeier-Rieux et al., 2015; Mulyani Sunarharum et al., 2014; Taylor, 2015; Zope et al., 2015). All of these studies found that cities have rapidly expanded into low-elevation areas that placed them in localities that were physically vulnerable to the impact of floods, cyclones or tsunamis. Migration into these marginalised urban spaces reflects underlying social differentiation as socially, politically and economically disadvantaged groups move into these high risk areas.

Abdullah et al., (2015), for example, found that Bangkok (Thailand), Kuala Lumpur (Malaysia) and Manila (Philippines) experienced increased risk of disaster due to their expansion onto riverbanks and lowland plains. Disaster risk increased as urbanisation led to increased water discharge from built-up

areas combined with a reduction in natural water drainage and absorption as open spaces and agricultural areas were integrated into the urban sprawl (Abdullah et al., 2015). Dhaka city is another good example of this phenomena with three studies finding similar processes at work: the city's low income populations have settled in slums close to riverbanks exposing them to increased risk of flooding exacerbated by overtaxed and poorly planned water drainage systems, increased runoff from paved areas and reduced natural drainage (Ahmed et al., 2015; Braun and Aßheuer, 2011; Dewan et al., 2012). Informal settlements that grew up in low lying areas surrounding Salt Lake, a satellite city of Kolkata in India, were also found to lack effective drainage and waste management systems resulting in frequent flooding contamination by solid waste (Rumbach, 2014). Physical vulnerability to hydrological events emerging out of urban expansion into high risk areas with low elevation, combined with poorly planned urban development processes, can be seen in other studies investigating disaster vulnerability in the cities of Chennai, Kurnul, Mumbai and Patna in India (Joerin et al., 2014; Ramachandriah, 2011; Sharma and Priya, 2001; Zope et al., 2015) as well as studies on Dehran in Nepal (Sudmeier-Rieux et al., 2015), Jakarta, the capital of Indonesia (Mulyani Sunarharum et al., 2014) as well as Solo and Surabaya cities in Central Java (Taylor, 2015).

COASTAL AREAS

Seven studies discussed physical vulnerability for cities located in coastal areas (Abdullah et al., 2015; Bhat et al., 2013; Birkman and Fernando, 2008; Joerin et al., 2014; Malalgoda et al., 2013; Razafindrabe et al., 2014; Zope et al., 2015). The cities of Batticaloa and Galle in Sri Lanka are rapidly growing cities in Sri Lanka which are located close to the sea and are particularly vulnerable to flooding from rising sea levels, coastal erosion and tsunamis (Birkmann and Fernando, 2008; Malalgoda et al., 2013). In these two studies, local government was shown to have not successfully established planning or governance strategies to address the consequences of these hazards and these cities suffer from solid waste pollution, salt water intrusion into paddy fields; failures of water drainage system leading to localised flooding and polluted lagoons (Birkmann and Fernando 2008; Malalgoda et al., 2013). Similarly, as Danang city in central Vietnam has expanded into coastal areas, the city has become more vulnerable as urban development has increased vulnerability and exposure to hydrological events such as heavy rainfall, flooding and tidal surges (Razafindrabe et al., 2014). The cities of Surat and Chennai in India also demonstrate the ways in which location combined with unplanned, rapid urban development can increase risk and vulnerability to natural disasters like floods (Bhat et al., 2013; Joerin et al., 2014). Both cities have long histories and experience of dealing with regular flooding events, however, there has been a rapid growth of urban slums in coastal zones with the majority being located on marginal land along tidal creeks, rivers and the sea (Bhat et al., 2013; Joerin et al., 2014). Cities as diverse as Bangkok, Kuala Lumpur, Manila and Mumbai also highlight the potential problems that arise when urban areas expand into low lying coastal areas without effective disaster risk reduction policies, strategies and practices (Abdullah et al., 2015; Zope et al., 2015).

CLIMATIC ZONES: MONSOONS AND CYCLONES

Nine studies investigated the intersection of urban processes with cities located within the climatic belt affected by monsoon rainfall patterns and cyclones (Abdullah et al., 2015; Birkmann and

Fernandez 2007; Chinnarasri and Porkaew, 2015; Dewan et al., 2012; Ramachandriah, 2011; Razafindre et al., 2014; Sharma and Priya, 2001; Surjan and Shaw, 2009; Taylor, 2015). All of these cities have expanded into high risk low elevation areas such as coastal zones, floodplains or riverbanks without consideration of the unintended consequences of allowing populations to live in these high-risk areas. This rapid, unplanned urban growth into areas such as coastal zones and riversides expose these cities to seasonal and occasionally extreme weather events such as monsoons and cyclones that make these cities vulnerable. As with the previous categories, these studies highlight the ways in which social vulnerability (discrimination and disadvantage) intersects with physical vulnerability (geographic location) and collective vulnerability emerging out of rapid, unplanned and ill-considered urban governance practices. For the most socially vulnerable, these three factors intersect increasing risk and vulnerability to disasters.

HIGH SEISMIC RISK AREAS

Some areas within South and East Asia are more prone to seismic hazards such as earthquakes. Fifty-six percent of the Indian subcontinent, for example, is prone to different levels of seismic hazard with nearly 28% of the area falling within the high hazard zones. The vulnerability of cities located in these areas has increased considerably as urban areas have rapidly sprawled across the region (Parvez, 2013).

In China, increased risk of disaster impact was shown to occur when earthquake resistance technology and building designs are not used in rapidly growing urban spaces in Sichuan province (You et al., 2009). The city of Kathmandu, Nepal is one of the fastest growing cities in South Asia with 2.5 million people residing over a major seismic fault line. Urbanisation in Kathmandu is characterized by the rapid growth of urban populations; the conversion of rural space into urban spaces; the acceleration of rural to urban migration and inconsistent application of urban building codes. Rural people are drawn to the city, particularly for employment and educational opportunities, which resulted in the growth of informal settlements in vulnerable areas (Carpenter and Grünwald, 2015). The city of Ahmedabad in India is an industrial area experiencing high rates of migration as people come into the city in search of employment. With a high population density of 18,420 people for every square kilometre, most of these new migrants are forced to live in high risk areas such as slums (Thiruppugazh, 2008).

COLLECTIVE VULNERABILITY: RAPID, UNPLANNED URBAN GROWTH

Rapid, unplanned urban growth with associated movement of marginalised and disadvantaged populations into high risk areas was found to be a common process that has driven disaster vulnerability and risk in cities. This theme was found in nine studies (Abdullah et al., 2015; Ahmed et al., 2015; Birkmann and Fernando 2008; Braun and Aßheuer 2011; Malalgoda et al., 2013; Rumbach, 2014; Mulyani Sunarharum et al., 2014; Taylor, 2015; Jue et al., 2005). The studies covered a wide geographic area encompassing seven countries in total: Thailand (Abdullah et al., 2015); Bangladesh (Ahmed et al., 2015; Braun and Aßheuer 2011) Sri Lanka (Malalgoda et al., 2013); India (Bhat et al., 2013; Rumbach, 2014); Indonesia (Mulyani Sunarharuma et al., 2014; Taylor, 2015); Nepal (Sudmeier-Riieux et al., 2015) and Vietnam (Razafindrabe et al., 2014).

This theme intersects with the theme on the geographic location of urban settlements in areas with high physical vulnerability. Due to the rapid pace of urban growth, migrating and low income populations such as rural migrants, Internally Displaced Persons (IDPs) and other vulnerable groups have migrated into urban spaces that give them access to livelihood opportunities, employment opportunities (industries and factories) and low cost, affordable housing and land (see any of the above cited studies for more detail). In the cities investigated in the studies, however, these urban spaces were found to be predominantly located in high risk areas such as river banks, coastal areas and garbage dumps that place particular social groups at an especially high risk of cyclones, tsunami, floods and landslides. During the rapid growth of urban centres low income populations and rural migrants have moved into high risk areas (riverbanks, hillsides, coastal areas) to find cheap housing, be close to livelihood and employment opportunities such as fishing or working as boatmen in cities as diverse as Surat in India, Danang in Vietnam and Batticaloa and Galle in Sri Lanka (Bhat et al., 2013; Birkmann and Fernando 2008; Razafindrabe et al., 2014) and Salt Lake in Kolkata (Rumbach, 2014).

SOCIAL VULNERABILITY: HIGH RISK POPULATIONS

Exposure and vulnerability to certain types of natural disaster depended on the physical location of settlements intersecting with socio-economic factors. Sixteen studies (One high, two-medium and nine low quality) found that high risk populations such as slum dwellers, low income groups, women, children, the elderly and migrants were more vulnerable to natural disasters (Ahmed et al., 2015; Bhat et al., 2013; Birkmann and Fernando, 2008; Carpenter and Grünwald, 2015; Dewan et al., 2012; Malalgoda et al., 2013; Peleg, 2015; Ramachandraiah, 2011; Rumbach, 2014; Sharma and Priya, 2001; Sudmeier-Rieux et al., 2015; Surjan and Shaw, 2009; Taylor, 2015; Teets, 2009; Theckethil, 2012; Thiruppugazh, 2008). These studies highlighted the variable risk and vulnerability that has emerged from inequitable and unplanned urbanisation processes, which have impacted differentially on socially, economically and politically marginalised and disadvantaged groups. In terms of disaster studies, studies investigating the direct impact of urbanisation on the vulnerability of some specific social groups were not found in these studies, most notably, people with disabilities.

Slum dwellers were investigated in nine of the studies (Ahmed et al., 2015; Birkmann and Fernando, 2008; Carpenter and Grünwald, 2015; Malalgoda et al., 2013; Ramachandraiah, 2011; Rumbach, 2014; Sharma and Priya, 2001; Surjan and Shaw, 2009; Taylor, 2015). Residents of these informal settlements tended to be socially and economically disadvantaged people, including low income labourers, rural migrants, ethnic and religious minority households. Slums and informal settlements are located on what are considered marginal areas in urban spaces such as hillsides, river banks, lowland plains and coastal areas. Although these urban spaces allow low income slum dwellers to access livelihoods, employment and affordable housing they also expose them to risk of natural disasters such as floods, cyclones and tsunamis.

Bhat et al. (2013) discussed the challenges encountered by slum dwellers and low income populations residing in riverine areas in Surat, India and highlighted the fact that new migrants faced greater difficulties due to disruptions to their earnings caused by disaster. Thiruppugazh (2008) showed in his study that unplanned urbanisation, development within high risk zones, lack of adherence to building codes, poor management, and inappropriate construction practices were the main reason for

vulnerability to earthquakes in Ahmedabad. Natural disasters such as earthquakes cannot be completely avoided, however, the study found that if regulations had been implemented correctly and bureaucracy minimized, the impact of the disaster could have been mitigated.

Studies showed that slum dwellers suffer most from the impact of natural disasters such as cyclones. In the Philippines, low income residents of informal settlements in Manila who had limited financial capacity, insecure land and housing tenure and resided in high risk locations experienced higher levels of vulnerability to and risk of natural disasters (Carcellar et al., 2011). In Tacloban city in the Philippines, people living in huts and other forms of non-permanent housing adjacent to the sea (or in some cases, on stilts over it) were obliterated by winds and storm surge generated by typhoons such as Haiyan (Thomas, 2015).

Children, renters and the elderly were other groups found to be more affected by disasters in urban spaces in eight studies (Ahmed et al., 2015; Carpenter and Grünewald, 2015; Dewan et al., 2012; Ramachandraiah, 2011; Rumbach, 2014; Sharma and Priya, 2001; Sudmeier-Rieux et al., 2015; Surjan and Shaw, 2009). In Sichuan province, China, a large number of school children (approximately 10,000) were died due to a massive earthquake which took place in May 12, 2008 (Teets, 2009) and similar findings were reported in a study from Nepal (Carpenter and Grünewald, 2015). This was in part due to residing in areas of high seismic risk but also because of failures in urban governance. Hospitals, schools and rental properties were found to have not followed existing building codes and used inadequate building materials. This made these locations more vulnerable to natural disasters such as earthquakes (Carpenter and Grünewald, 2015; Peleg, 2015). It also meant that social groups such as children, the elderly and rental tenants who resided in or worked in these areas were exposed to more risk. Following the Bhuj earthquake, for example, tenants did not have alternate places to live unlike building and land owners who had alternate properties and resources that gave them the capacity to recover faster (Theckethil, 2012). It was also found that elderly people (61 years and older) and young people (0–10 years) were more likely to die during natural disasters such as tsunamis. In Galle, Sri Lanka, more elderly and young people died or were injured during the 2004 tsunami (Birkmann and Fernando, 2008).

Though males and females are both vulnerable due to Tsunami, studies showed that gender played a significant role in the likelihood of death during the 2004 tsunami (Birkmann and Fernando, 2008). Birkmann and Fernando (2008) reported that, in Batticaloa in Sri Lanka, males accounted for 44 percent of the dead and missing, whereas females made up 56 per cent. The situation was even more striking in Galle where 35 percent of the dead and missing were male compared with 65 percent who were female. Some of the men interviewed in Batticaloa reported that, *“they (the men) climbed on to the roof of their houses, but their wives or daughters were less able to do so in the short time available after noticing the devastating wave.”* (Birkmann and Fernando, 2008).

3.3 APPROACHES FOR REDUCING RISK AND VULNERABILITIES DUE TO NATURAL DISASTER

This section describes the approaches identified in response to the research question no 2:

“What are the effective approaches for reducing exposure of urban populations to disaster risks?”

The discussion is based on mainly one high (You et al., 2009) and five medium quality (Birkmann and Fernando, 2008; Malalgoda et al., 2013; Razafindrabe et al., 2014; Taylor, 2015; Tafti and Tomlinson, 2013) studies. However, this is supplemented with relevant evidence when available from other included studies⁴.

The review identified nine major thematic areas of approaches described in the included studies which are applicable across all types of disasters:

1. Addressing the information need
2. Regulate and manage urban space and development
3. Approaches for immediate response
4. Monitoring and responding to cumulative or unfolding of disaster
5. Coordination among all levels
6. Active engagement with community and civil society
7. Population level education and training / drill
8. Supportive and proactive leadership
9. Addressing access and inequities

It is to be noted that the impacts due to natural disaster may vary in magnitude according to the variation in the context and process of urbanisation; the outcomes (vulnerability, risk, and resilience) also varied accordingly. The relation and impact between urbanisation and natural disaster is a complex, multifaceted interlinked issue and needs multi-sectoral approaches to address this. Therefore, all the identified thematic areas are interrelated and overlap in terms of context, cross-cutting areas of interventions and the involvement of implementers from different sectors. The identified themes are composed of several other sub themes with common components grouped together under one major action oriented theme or area of activity.

ADDRESSING THE INFORMATION NEEDS

Information needs are substantial and must be addressed prior to, during and after disasters. The speed and agility with which the information is obtained, processed and communicated can mitigate the disaster risk and vulnerability to a large extent before, during and after any disaster. This theme is reported by several studies (Peleg, 2015; Bhat et al., 2013; Carpenter and Grünewald, 2015), including

⁴ (Khan, 2008; Thiruppugazh, 2008; Surjan and Shaw, 2009; Braun and Abheuer, 2011; Carcellar et al., 2011; Ramachandraiah, 2011; Dewan et al., 2012; Sudmeier-Rieux et al., 2012; Theckethil, 2012; Bhat et al., 2013; Parvez, 2013; Barnes et al., 2014; Joerin et al., 2014; Rumbach, 2014; Yang et al., 2014;; Carpenter and Grünewald, 2015; Chinnarasri and Porkaew, 2015; Peleg, 2015, Sudmeier-Rieux et al., 2013; Thomas, 2015;).

one medium quality study (Birkmann and Fernando, 2008). The context in which the disaster happens and its impact plays an important role in the disaster management cycle, which in turn interacts with other thematic areas. In general, it was found that when *immediate and accurate local level information was available* on the risk and vulnerability of the population, the impact of disaster can be reduced. In Surat, India for example (Bhat et al., 2013), short-term, mid-term and long-term strategies were taken for flood management. The short term strategies included developing an end-to-end *early warning system and improved information and data management*. To mitigate flood risks during monsoon municipality took steps for clearing the drainage and sewer systems and commenced preparedness for emergency evacuation, including regular evacuation drills. LED hoardings in Surat displayed the water levels of the reservoir behind the Ukai dam in order to warn people. Advance warnings were provided by megaphones and through the short messaging system (SMS) for mobile phones. On the other hand, during the 2006 flood, not everyone received alerts from the early warning system, irrespective of income or socioeconomic class, due to lower phone connectivity. Though phone coverage is now high, 40 per cent of the slum population, 35 per cent of the lower-income and 21 per cent of the mixed- and middle income groups still have no cell phone, so *alternative warning systems are still required* (television and loud speaker etc.). Based on this experience, the municipal corporation is now planning to set up a GIS-assisted two-way information system, which includes geo-tagging of all residential buildings, pre-monsoon updates of people requiring special medical care during emergencies (elderly, infirm, babies, pregnant women) and also a volunteer and mobile SMS-based two-way information system. Rapid communication using internet was reported from Nepal showing that for disseminating news of earthquakes, the internet can be a useful source beside television, as over million of people from Nepal have Facebook accounts and other internet access (Peleg, 2015).

Providing appropriate information has an important impact. Any simple information can trigger rumours that create panic among the people in urban areas after disaster. A clear and understandable communication strategy is essential to control the information flow. In Nepal, a post-earthquake communication plan has been developed by BBC Media Action which included messages on managing expectations, medical and psychological issues, search and rescue and social rehabilitation. Moreover, strong and effective coordination with media actors is essential to minimise disaster related panic (Carpenter and Grünewald, 2015).

Action taken on the basis of local evidence can contribute to reducing disaster risk and vulnerability. It was apparent from damage analysis in Sri Lanka that removing the built environment from the inundation area was nearly impossible, since this would necessitate relocation of the bulk of coastal cities. Based on a local damage analysis, the promotion of a 100 metre “buffer zone” was identified as a reasonable and effective intervention tool in Sri Lanka as a preventive measure of tsunami. With regards to the aspect of exposure, the analysis focused among other things on damage “inside” and “outside” the 100 metre “buffer-zone” (Birkmann and Fernando, 2008). A significantly higher amount of intensive damage was reported in Galle and Batticaloa inside the “100 metre buffer zone” and the extent of damage was identified as greater in Batticaloa. Its main cause was that a significant proportion of squatters in Galle living within the 100-metre buffer zone before the tsunami agreed to move to a safer place (75.4 percent), compared with 67 per cent of households that own their land. Beside the endeavour of protecting lives and valuables, squatters wanted to acquire a legally

accepted, permanent residence. In coastal and flood-prone areas, familiarisation with *past tsunami and education about tsunami* and other coastal hazards were identified as an important element in increasing awareness of threats to human life in order to minimise possible losses due to the negative impacts of future tsunami events (Birkmann and Fernando, 2008). The study recommended that vulnerable groups and areas be identified on a priority basis when designing interventions like early warning systems or financial aid. This can be used as a policy advocacy tool to motivate politicians, provide directions to the universities and international and governmental agencies to take coordinated action for practical actions (Birkmann and Fernando, 2008).

REGULATE AND MANAGE URBAN SPACE AND DEVELOPMENT

The Asian cities are growing at an unprecedented rate and mostly without following any proper plan. This theme has been reported in all six high and medium quality studies (Birkmann and Fernando, 2008; Malalgoda et al., 2013; You et al., 2009; Razafindrabe et al., 2014; Taylor, 2015; Tafti and Tomlinson, 2013) and also supplemented by other low quality studies. The vulnerability increased not only by the population rush but also pattern of growth into areas and spaces mostly identified as risk zone like low elevation areas, along the coast lines, seismically risky areas at the foot of hilltops, and within the city in any empty spaces like over the embankment, railroad, market places, garbage dumps and slum areas. The marginalised like the migrants, the poor, and the minority population usually move to these risky spaces. The already existing vulnerability is further aggravated by the absence of infrastructure support, basic services and absence any policy support. This growth pattern of increased density of population, also impacts DRR approaches during and after disaster. Fragile constructions (without building code), narrow roads, crowded living space with poor drainage and resources created barriers to immediate rescue and recovery operations and after rehabilitation approaches, increasing the damage substantially during the disaster (Abdullah et al., 2015; Ahmed et al., 2015; Birkmann and Fernando, 2008; Braun and Aßheuer, 2011; Dewan et al., 2012; Parvez, 2013; Rumbach, 2014; Taylor, 2015; You et al., 2009).

Regulated city plans following an effective DRR policy framework on the other hand contributed to reducing disaster risk like seasonal flood, climatic catastrophes and protecting people's lives and properties. In Salt Lake, Kolkata, India, people living in planned city areas experienced no water logging and flood whereas people living in the unplanned outskirts squatter settlements suffered from flood and water-logging (Rumbach, 2014). The 100-metre buffer zone resulted in less casualties during Tsunami incident in Sri Lanka in 2004 (Birkmann and Fernando, 2008) and when building codes were followed no damage occurred to any public constructions during 2001 earthquake in Ahmedabad (Thiruppugazh, 2008) despite being one of the fastest growing cities in India and situated over seismic zone III. In this way, Kathmandu was worst affected during the 2015 earthquake where no building code was reportedly followed (Carpenter and Grünwald, 2015).

Relocation of the affected population to a safe zone worked in Galle and Batticaloa as this was backed by strong policy support, which was again based on local level evidence and with the participation of local community (Birkmann and Fernando, 2008).

APPROACHES FOR IMMEDIATE RESPONSE

Immediate response is at the heart of disaster risk reduction. Immediate measures like rescue and recovery, first aid, assuring people of any further risks, organising relief, and safe shelters for vulnerable persons (elderly, children, injured) should be taken just after the disaster happens before the conventional approach (public sector response) comes into act. *Immediate response is enhanced when appropriate systems are working and available.* Again this theme intersected with other themes including information need, coordination, governance and community participation. This theme was discussed in one high (You et al., 2009), two medium (Birkmann and Fernando, 2008; Taylor, 2015) and two low quality studies (Carpenter and Grünewald 2015; Peleg, 2015). The role of context, the preparedness, previous experience and all the components of Disaster Management (DM) cycle influence these approaches.

After the 2008 Sichuan earthquake in China, preventive medical teams dispatched by the Chinese Centre for Disease Control and Prevention, hospital medical teams, and army field hospitals from within and outside Sichuan Province arrived and contributed to the rescue effort in Beichuan County. The first medical team arrived two hours after the earthquake from Mianyang City. On the other hand, the first external medical team arrived from Mianyang City (supervisor of Beichuan County) in Sichuan 10 hours after the earthquake. Lacking a good understanding of the local needs, some institutions dispatched highly specialized surgeons, physicians, cardiovascular experts, ophthalmic experts, or urological experts to offer help. Many of these experts could not function effectively in the field, either because local people had no such needs or they lacked access to the specialized equipment they needed for their work. Drugs and materials that were donated were found to be inappropriate and failed to meet the needs of local people (You et al., 2015).

Informal networks can start working quicker than any other formal organisation. It was evident in Sri Lanka primarily neighbours (55 per cent), friends (10 per cent) and other family members and relatives (18 per cent) started to assist the affected people before the authorities could provide aid and rescue support. When formal organisations got involved, only six percent received financial assistance from local organisations. However, this endeavour of local people was very much context specific and the government was reluctant to provide such support with the anticipation that this would promote further encroachment and illegal settlement in the future (Birkmann and Fernando, 2008). Given the rapidly changing scenario during and after disaster in urban areas, setting a constant indicator to find the appropriate target person is difficult, and complicated. Additionally, it was more complicated to decide whether this support was appropriate, and whether it helped affected people to generate their own resources to overcome the negative impacts of a natural hazard. In some cases, the household members did not continue to work, since they received monthly compensation for their loss of income. Therefore, some forms of aid can be counterproductive (Birkmann and Fernando, 2008).

Again after disaster people become so vulnerable that it could be impossible for some survivors to reach the shelter centres. Thus the support process should start immediately alongside “rescue and recovery” efforts and be accounted for. In Nepal helping people to leave the affected area, supporting them on their journey, and supplying assistance to them worked well (Carpenter and Grünewald, 2015; Peleg, 2015). Immediate response worked well when the existing knowledge and information was available on, for example, mapping the disaster zone, vulnerability mapping and geo technical

facilities. In Surat, mid-term strategies identified mapping of flood-risk areas and the regulation of construction in floodplains (Bhat et al., 2013). In Strenkali, Surabaya the local government stipulated that the community members move their homes back from the water's edge, install sanitation infrastructure and septic tanks for each home, and replant along the riverbanks to prevent further erosion (Taylor, 2015).

It was evident that the local government can also play a vital role in healthcare during the immediate post disaster period. The local government of Sichuan, China was the key player in organizing the evacuation of the population, food, clothes and blankets, repairing roads and supply of water, electricity, and gas (You et al., 2009). All of these processes started early after disaster happened and before the central level assistance arrived.

MONITORING AND RESPONDING TO CUMULATIVE AND UNFOLDING IMPACT OF DISASTERS

A mix of high and low quality studies indicated that monitoring and responding to unfolding impacts of disasters is an important theme for urbanisation and disaster interaction (Carcellar et al., 2011; Carpenter and Grünewald, 2015; Peleg, 2015; Yang et al., 2014; You et al., 2009). This intersects with other themes and contributes to both immediate and continued efforts of disaster risk reduction.

Disaster doesn't happen alone and it brings a chain of effect. For example, it was observed that in Kathmandu, housing is densely located so it increases the risk of spreading fires. Again after disaster it becomes impossible for vulnerable people to immediately find and reach safe shelter, food and other requirements. In Nepal the civil military coordination mechanism worked effectively, helping people to leave the affected area, supporting them on their journey, and supplying assistance to them. For preparedness measures, ensuring the ownership of any response and relief efforts by the Government of Nepal should be ensured (Carpenter and Grünewald, 2015; Peleg, 2015). After earthquakes, people not only need rescue but also require medical help. After the Wenchuan earthquake, for example, the government focused on getting more aid and support from medical and rescue professionals (You et al., 2009; Yang et al., 2014). Adequate emergency drugs and equipment were stored at the emergency disaster control headquarters for rapid transport, which was used immediately after Lushan earthquake. Development and training of emergency professional medical rescue teams were provided by the central government. The Ministry of Health began to organise medical rescue teams specializing in disaster medicine called National Emergency Medical Rescue Teams. Emergency rescue teams also have been created by local governments using Chinese medical institutions and fire fighting forces (Yang et al., 2014). In Philippines, after the Payatas trash slide in the year 2000, people become homeless, which increased their vulnerabilities. An alliance was then built between the Homeless People's Federation Philippines, Inc. (HPFPI) and Philippine Action for Community-led Shelter Initiatives, Inc. (PACSII) with the mission of organising, building capacities, mobilizing and networking with low-income communities in high risk areas with the aim of building community-driven approaches to securing tenure, housing, and disaster/climate change impact risk reduction and management (Carcellar et al., 2011). The Alliance facilitated community based initiatives such as immediate, mid-term and long term data gathering, management and financial programme to render the affected population self-reliant and capable (Carcellar et al., 2011).

COORDINATION AMONG ALL LEVELS

Five high to medium studies (Birkmann and Fernando, 2008; Malalgoda et al., 2013; Razafindrabe et al., 2014; Taylor, 2015; You et al., 2009) reflected on the need for coordinated efforts to disaster risk reduction approaches. Coordination should be operating not only among the teams and organisations active during and after disaster at ground level, it should extend beyond the local to district to central level stakeholders. Any approach to address the complicated situation as urbanisation and disaster should be comprehensive, integrating all stakeholders at all levels.

One study indicated that in the view of one township director, failures in coordination and communication resulted in potentially avoidable deaths (Taylor, 2015). In the Surabaya case, the conflict between the provincial government's willingness to be flexible and the city government's rigidity and inflexibility resulted in protests, sometimes with violent results. Government inflexibility can lead to community inflexibility too (Taylor, 2015).

It is also evident from the studies that decentralization is an important factor in creating opportunities for improved governance and resilience, but it is not without its shortcomings (Mulyani Sunarharum et al., 2014; Taylor, 2015). In Indonesia, local government capacity and innovative policies stem from decentralization laws that localize decision-making. The community groups were empowered by the cash grants to seek and negotiate land on their own. The Mayor of Solo convinced the national government for a comprehensive policy to cover the informal riverbank dwellers and migrants to have access to the social welfare programs. In Surabaya, the community undertook a pivotal role for raising money and providing their own services along with the local government initiatives. In the Solo and Surabaya cases, creative solutions were observed but relocation made the people vulnerable to the breakdown of social networks (Taylor, 2015). It was also observed that decentralization was not evenly applied throughout the country. Given the local political conditions, this innovation could not provide clear illustration about its replicability to different local contexts (Taylor, 2015). The reason could be that Indonesian governance incorporated a top-down model which intended to implement national-level policies and plans trumping all others at lower levels, and cascading down subsequent levels of governance. Good coordination amongst governments was recommended as necessary (Mulyani Sunarharum et al., 2014). However, to facilitate effective planning for disaster management, a city needs to have a central governance system where leaders are aware of hazards and prepared for risks (Malalgoda et al., 2013).

Poor coordination with central government and external organisations resulted in the decreased effectiveness of initiatives to reduce the risk due to natural disaster taken by both formal and informal institutions. In central Vietnam, during the 2009 flood, internal coordination was poor among different stakeholders. Moreover, poor networking with neighbouring countries was reported. By observing its demerits, the city officials decided to improve the level of coordination among different stakeholders along with government (Razafindrabe et al., 2014). Lack of coordination between different levels of government and with the community resulted in inappropriate responses and loss of resources and time (Razafindrabe et al., 2014). In the Sichuan earthquake highly qualified medical experts could not contribute and some donated drugs and materials where inappropriate to the needs of the local people (You et al., 2009). In Sri Lanka, overlapping of responsibilities was observed among a number of governmental organisations engaged in initiatives to build the environmental measures within the

Batticaloa municipal area. Lack of coordination between institutions and non-adherence to the hazard maps and disaster resilient planning and construction guidelines were reported in this sub-standard DRR intervention. In order to reduce tsunami vulnerability coordinated action among universities and international and governmental agencies was also recommended. It is important for the different committees to work holistically to ensure education on tsunami vulnerability and thus to make Batticaloa a disaster resilient city (Birkmann and Fernando, 2008).

Study findings highlighted that in Thailand, several working groups at the national board level have overlapping authority and lack modern management and approaches in terms of policy, planning, the alarm system, operation, establishment of rules and regulations, and budgeting (Chinnarasri and Porkaew, 2015). For a large part of the allocated budget for flood management, the contracting and disbursement process was unclear and lacked transparency. Moreover, core agencies serving in water and flood management were set up temporarily under the Office of the Prime Minister's Regulation, the level of which is lower than that of the act released by Parliament. Due to these unclear proposals for such projects, the draft legislature for provision of lending funds could not be passed. *Important conditions such as the principles of good governance, including transparency of actions, accountability and equity, need to be considered* (Chinnarasri and Porkaew, 2015). Most committee members are government officials, who are often reticent to express their viewpoints to their managers and to the public due to Thai cultural norms. Therefore, a lack of diversity in ideas and opinions was found among government officials. Only a small number of committee members came from various private sectors. The acceptance and encouragement of a modern organisational culture and change is, therefore, hard to establish (Chinnarasri and Porkaew, 2015).

Public private partnership is another important approach that was found to have worked well when integrated into the disaster risk management cycle. For example, in Nepal, the **Nepal Risk Reduction Consortium (NRRC)** was formed with the Government of Nepal, aid agencies, donors, and international financial institutions for working in the field of school and hospital safety; emergency preparedness and response; flood management in the Koshi River Basin; community-based DRM; and policy and institutional support for DRM (Peleg, 2015).

It was reported that in the aftermath of the 2015 Nepal earthquake many international urban search and rescue (USAR) teams came to help. India, for instance, deployed USAR teams within six hours of the event, whereas 74 international USAR and 158 foreign medical teams were dispatched within the first week of the response. It was an emergency requirement that a centralised coordination mechanism should be in place to effectively direct all these stakeholders and organise their activities. A guideline for civil-military coordination was developed as a preparedness measure ensuring ownership by the Government of Nepal. The study found that immediate local, post-disaster efforts like light search and first aid interventions, warning people of the risk of aftershocks, directions on how to receive relief, and movement of the wounded to health centres was an effective way to assist survivors before the arrival of international SAR teams (Peleg, 2015).

ACTIVE ENGAGEMENT WITH CIVIL SOCIETY AND COMMUNITY

The active participation of community residents in Disaster Risk Reduction (DRR) initiatives, as well as implementing DRR guideline and activities, is an important aspect for accomplishing sustainable DRR

initiatives. Two medium quality (Tafti and Tomlinson, 2013; Taylor, 2015) and some low quality studies (Braun and Aßheuer, 2011; Carcellar et al., 2011; Peleg, 2015; Ramachandraiah, 2011; Sudmeier-Rieux et al., 2015) discussed this theme. Again this theme also interacts with other themes in its approaches.

Community engagement was very evident in Indonesia where riverbank dwellers in Solo were reluctant to move to new areas after the announcement of the resettlement policy. Civil society or community working groups played an important role in negotiating with the Government and received the Government's assurance regarding ensuring transportation, electricity, education, health and other necessary facilities at the resettlement areas. However, in those communities where the working group or *Kelompok kerja* were not active resettled groups sometimes ended up without electricity (Taylor, 2015). In both Solo and Surabaya regions the mayors involved community groups and discussed the policy. The study showed that when city governments involved citizens through making information publicly available, engaged communities in the planning process and when civil society or community groups were simultaneously active in negotiation and proactive in the exchange of views and needs, the initiatives were more successful in relation to resilience outcomes (Taylor, 2015).

Moreover, government cannot solve issues acting alone. Solo, an Indonesian case, showed that NGOs can play a vital role in both processes to help in mobilizing the community to participate in a DRR program and also raise awareness among the community, including helping community people to build houses in relocated areas (Tafti and Tomlinson, 2013). Other studies showed that community residents participated in some self-initiated activities, including building a barrier at the entry of the house with sandbags, positioning one's personal belongings on stilts of bricks or hanging them under the roof (Braun and Aßheuer, 2011). Due to the absence of formal shelters or relief camps, community people made use of available public buildings or spaces including schools, railway stations and mosques (Ramachandraiah, 2011). Community people take initiative to build gabion walls but the study showed that it was not entirely effective (Sudmeier-Rieux et al., 2015). It was reported that relief and shelter are more often provided by governments during disasters with public schools providing the only flood shelter in slum areas. If they are well organised and structurally sound, public schools offer a dry place and a certain level of protection against theft and unfavourable weather conditions (Braun and Aßheuer, 2011). To make local people's initiatives more effective, the media can also play an important role: not only traditional media such as television but also new media such as the internet can be very useful sources where internet access is high (Peleg, 2015).

All these are self-initiated activities and played an important role to reduce the impact of natural disaster. One experience from the Philippines showed that an alliance of community based organisations was able to develop a community driven DRR intervention which was able to undertake initial data gathering, trust and contact building, money savings programme implementation, organisational formation and registration, and intervention identification (immediate, mid-term or long term). In fact, these initiatives involving the community were proven to be very effective in mobilizing communities to act on their disaster rehabilitation agenda (Carcellar et al., 2011).

Active community participation in DRR related activities including rescue training will ensure faster rescue and first aid treatment after earthquake (Peleg, 2015). In 2015 a devastating earthquake in Kathmandu involving immediate search and rescue by professional Urban Search and Rescue teams

was delayed due to unavoidable administrative reasons. The study showed that if community members could be trained in basic rescue techniques for disaster prone areas, they could start search and rescue without waiting for external help. This could decrease the number of casualties and assist the injured (Peleg, 2015). In the city of Batticaloa and Galle in Sri Lanka, community engagement was found along with the different committees focusing on training and awareness programmes to community and school children (Birkmann and Fernando, 2008).

In Mumbai, motivated citizens started ALM (Advanced Locality Management), which was a community-government partnership. This was an informal voluntary body with participants from diverse groups in the population, which played a key role in sensitizing residents in civic consciousness by educating the majority of people and ensuring their co-operation with the municipal administration during disaster and in daily activities (Surjan and Shaw, 2009). However, the effectiveness of this approach was not documented adequately.

In Bangladesh, government and NGOs implemented different initiatives to engage the community to develop disaster preparedness and awareness, including an education programme; the collection of local knowledge such as the coping strategies of local people, and the development of appropriate sanitation technology in coastal and flood-prone areas (Khan, 2008). Familiarisation with past tsunami and education about tsunamis and other coastal hazards were identified as an important element in increasing awareness of threats to human life in order to minimise possible losses due to the negative impacts of future tsunamis in Sri Lanka (Birkmann and Fernando, 2008).

Multi-purpose cyclone shelters were started in the coastal areas with the help of donor funds after a major cyclone in 1985 in Bangladesh. These shelters subsequently serve a dual purpose, as schools, health centers and community centres under normal conditions and shelters for people during and after cyclones. Programmes have been implemented that aim to protect coastal areas from high tides, to build coastal-embankments and start coastal reforestation. Coastal embankments were constructed for protection against high tide and salinity intrusion into surrounding agricultural land. This support was effective to some extent against low-intensity storm surges as well. These measures were expensive, however, and sometimes caused drainage congestion and obstruction to local water drainage systems. Coastal forests were identified as a key resource and source of livelihoods for local people (Khan, 2008).

In other instances, local measures were taken to cope with flood. In many flood prone areas, people raised the height of plinths, ground floors were used as parking spaces and houses are now built with small attics or lofts for storing valuable items. Slum dwellers stored their valuables in plastic pouches and moved to shelters during disaster. Sometimes male members stayed in the house to guard their valuables. It is interesting to note that these coping mechanisms were more prevalent among lower income groups than wealthier groups (Bhat et al., 2013).

POPULATION LEVEL EDUCATION, TRAINING AND DRILL

This is an important theme that was discussed in one high (You et al., 2009) and five medium quality (Birkmann and Fernando, 2008; Malalgoda et al., 2013; Razafindrabe et al., 2014; Tafti and Tomlinson, 2013; Taylor, 2015) studies. The high quality study showed that there was a lack of understanding and planning in disaster management in China (You et al., 2009). China experienced its most devastating

earthquake in May 2008. It was found that in affected areas there was no earthquake management policy prior to this high magnitude earthquake (You et al., 2009). It was also found that health facilities personnel were not adequately trained in disaster emergency care and management at local level which made the situation more difficult (You et al., 2009). Furthermore, local community people were not aware and experienced in minimizing injuries resulting from earthquakes, which increased casualties due to inappropriate rescue and evacuation (You et al., 2009). This experience helped local authorities to commence preparation programmes that aimed to reduce the impact of future disaster including population level mass drills on search and rescue, emergency medical services etc. The Chinese government has taken many initiatives including population level training after the earthquakes happened in Sichuan Wenchuan earthquake in China in 2008. It was found that the numbers of deaths were 353 times less and the economic loss was 10 times less when the second earthquake happened in Sichuan Lushan in 2013 than the 2008 earthquake (Yang et al., 2014).

In Surat, an Indian municipality undertook steps to manage monsoon floods by improving drainage and sewerage systems. In addition, the municipal authority conducted regular emergency drills as a part of emergency preparedness (Bhat et al., 2013).

LEADERSHIP PLAYS KEY ROLE

Active leadership plays an important role in pro-actively reducing risks and vulnerabilities and strengthening resilience. This phenomenon has been reported by one medium quality included study. This theme is interrelated with coordination, community engagement and local government engagement. Already described under these themes is the role played by the Mayor of Solo city, in Indonesia. The mayor took a proactive role in engaging with a tsunami affected population, utilised their feedback, coordinated among communities and implemented a successful relocation programme (Taylor, 2015). In addition, the mayor was instrumental in getting further financial allocation from the parliament to target the poor, riverbank dwellers and migrants' entry into the city's social welfare program, which helped them to gain access to basic services (Taylor, 2015).

ADDRESSING ACCESS AND INEQUITIES

This is another important theme and is more crosscutting with all themes in the approaches described. Two studies (Taylor, 2015; Tafti and Tomlinson, 2013) among six high and medium quality studies discussed inequality and vulnerability after disaster or during implementing DRR initiatives. Study findings showed that the relocation policy made undocumented migrants and marginalized people more vulnerable due to their limited access to available services including health, education and other public services (Tafti and Tomlinson, 2013; Taylor, 2015).

After the devastating earthquake in Bhuj, India in 2001, under the legal entity of the Gujarat State government, ten NGOs built 2497 housing units. Half of the NGOs built the housing units in the new relocated sites and the rest of the NGOs built the houses in other areas outside the old city. However, this policy did not provide a housing recovery option for the people who failed to prove their pre-earthquake tenure status (Tafti and Tomlinson, 2013). This group of tenants squatted inside the old city with inadequate public transportation system as well as low quality health and education services (Tafti and Tomlinson, 2013). Poor tenants among this group became more vulnerable as they were

unable to pay high rents for more desirable and better located accommodation and were forced to live in either the old city or temporary housing (Tafti and Tomlinson, 2013).

Another study discussed relocation in Solo and Surabaya in Indonesia (Taylor, 2015). In Solo, the riverbank dwellers were unwilling to move to the new sites as those places were far away from their work places and sources of livelihoods. Additionally, the implementation of the relocation policy became more challenging as there were many migrant riverbank dwellers that were not Solo residents and did not have official identity cards. However, the city Mayor implemented initiatives that aimed to bring poor riverbank dwellers and migrants into the city's welfare program (Taylor, 2015). On the other hand, in Surabaya, the riverbank dwellers who lived in rented housing were not eligible for the relocation compensation payments (Taylor, 2015). Additionally, in Surabaya, most of the riverbank population lived there without legal land tenure and few options had been proposed by the local government. It was challenging to make sustainable policy in terms of relocation as an estimated 30 per cent of Jakarta's populations were migrants and most of them were reluctant to take up legal residential status with many migrating to find temporary work. Thus, government programs excluded many people due to their lack of legal status (Taylor, 2015).

Few low quality studies also discussed the vulnerabilities of poor, marginalized and migrant people living in urban areas in both post disaster situation and in the phase of DRR implementation. Rumbach (2014) discussed poor residents of Salt Lake, Kolkata, India. In the outskirts of the new town of Salt Lake, where the vast majority of low-income workers live, disaster risk is elevated because of higher exposure to natural hazards, poor or non-existent infrastructure, low-quality housing materials, and poor service delivery (85% of the respondents used shared sources of piped water as drinking water, less than 10% of survey households had access to private toilet and only 38.6% reported having a drain outside their homes). In order to avoid problems encountered by this intervention, long-term environmental risks must not be overlooked when constructing new towns on peripheral land (Rumbach, 2014).

Another study (Bhat et al., 2013) discussed slum dwellers and low income populations in Surat residing in riverine areas who were most vulnerable to floods. Unskilled workers are often more vulnerable to floods because they are paid on a daily basis and do not have a secured income source. New migrants faced greater difficulties with income insecurity as the industries they worked in take time to resume production after flooding. Migrants may also face particular difficulties because of their lack of social contacts and there were a high proportion of migrants from distant states among the Surat population living in slums. In addition to that, many higher-income households were also at risk of flooding when living on the ground or first floors of housing (Bhat et al., 2013). Floods are a common feature in Dhaka's slums where mainly the poor and migrant workforces live (Braun and Aßheuer, 2011). On average a major flood hits Dhaka every four years and water-borne diseases were very common. In addition, working areas were flooded and workers were unable to reach their workplaces due to inundated roads. This in turn led to a significant loss of income for most households in slum areas (Braun and Aßheuer, 2011).

POLICIES TO REDUCE/MITIGATE RISK AND VULNERABILITIES: URBAN PLANNING AND DISASTER MANAGEMENT

This section discusses different policies raised in the included studies which provide an understanding about the context in which different approaches should be implemented. The most important actor is the government in the disaster risk management (DRM) cycle. Government plays a key role in reducing and managing risk and vulnerabilities caused by natural disasters. An enabling environment needs to be created where policy support, funding guarantees, capacity building, and local government involvement are prioritised.

As a preventive response, a “planned city” will be more resilient to natural disasters. As a satellite city, Salt Lake is situated on the outskirts of Kolkata, India and located on a lowland plain. Normally, economically well-established people live here. However, a satellite town has been established near Salt Lake with low income people. During the rainy season this area is often flooded by stagnant water making the slum dwellers very vulnerable to flooding as this area lacks proper drainage and waste management systems even though Salt Lake itself doesn’t face any problems during heavy rain (Rumbach, 2014). *So, this is the gap identified in this initiative: there is a need for balanced urban planning that takes into account the needs of the whole population.* Therefore, governments need to enforce building codes as well as improving drainage systems for all parts of the city. Lack of enforcement of building codes and development plans was also identified as the cause of damaged buildings caused by the Bhuj earthquake in Gujarat (Theckethil, 2012).

Several policies for flood risk mitigation were identified in the reviewed literatures. In Bangladesh, a Flood Action Plan (FAP) was undertaken to minimize the flood problem (Khan, 2008). This action plan considered potential flood damage, improved agro-ecological conditions, communication, public health, commerce and industry. In addition to that, the construction of embankments, improved gravity drainage, built pumped drainage and developed effective flood forecasting system were integrated into the plan. The FAP also included the collection of local knowledge such as the coping strategies of local people and development of appropriate sanitation technology in the coastal and flood prone areas (Khan, 2008). However, because of a lack of public participation and extensive flood prone areas, the FAP was controversial during the implementation stage.

During 2012–2013, the Thai government spent a significant proportion of the public budget on restoring the flood damage that occurred in 2011, prepared extensive flood protection for the future and reassured the public regarding the flood protection system. An action plan for the implementation of national water and flood management was established with several units (NWFPC, SCWRM, WFMC etc.) whose main endeavour was to prepare appropriate action plan/s for the implementation of national sustainable water and flood management programme for short and long term goals (Chinnarasri and Porkaew, 2015). Unfortunately, the policy didn’t work very well because a large part of this budget lacked transparency with the contracting and disbursement process being unclear (Chinnarasri and Porkaew, 2015).

In Jakarta, a master plan with long term vision was outlined consisting of water drainage and improvement of retention ponds, coastal defences and road protection. This master plan highlighted three key principles, including: focusing on urban growth management, metropolitan area functional-based planning (including Jakarta, Bogor, Depok, Tangerang, Bekasi, Puncak and Cianjur) and a

paradigm shift to “stakeholders” becoming “shareholders”. In the coastal areas of the cities of Galle and Batticaloa a buffer zone policy of 100 metres was adopted. The existing data found the safety of the zone and a majority of squatter settlers agreed to relocate outside the zone. However, they demanded legal land ownership and status in the new permanent settlement (Birkmann and Fernando, 2008).

The Philippines initiated a shift towards disaster risk reduction and management (DRRM) in combination with climate change mitigation and adaptation. This shift manifests itself in the adoption of various policy and implementation protocols such as the Medium-term Development Plan for 2004–2010, the Strategic National Action Plan on DRR (2009–2018) and laws such as Republic Act No 9729 (Climate Change Act of 2009) and Republic Act No 10121 (Philippine Disaster Risk Reduction and Management Act of 2010) (Carcellar et al., 2011).

For scaling up, the community-driven Disaster Risk Reduction (DRR) effort involves the establishment of four pillars. These are: i. strong urban poor community networks; ii. an alternative finance facility that supports DRR upgrading and housing; iii. a technical professionals network that supports community processes; and iv. a community-managed information system (Carcellar et al., 2011).

CDRI (Climate Disaster Resilience Index) is a disaster index which was adopted in Chennai, India by local authorities to see whether Chennai is a resilience city or not. It was observed through five dimensions (physical, social, economic, institutional and natural). The CDRI attempted to improve the resilience of the city, which is important to disaster risk reduction. As noted, various risk drivers, such as aspects of urbanisation, the decline of eco-systems, urban poverty, and unplanned growth, characterize many cities in developing countries. Although the CDRI may be similar in some ways to vulnerability studies, such as the hot-spot assessments of the World Bank or the World Wildlife Fund, it attempts to understand, through adoption of the concept of resilience, a city’s ability to reduce the probability of shocks and its capacity to respond to potential climate-related disasters. The lack of available quantitative resilience assessments or indicators that quantitatively represent resilience in a community located in an urban area, underpins the need for the CDRI (Joerin et al., 2014).

A limitation of the CDRI is its aim to understand all aspects of community resilience, when some variables are better evaluated at the household level. However, it may contribute to a discussion on how to measure a city’s resilience to climate related disasters. In the future, the results of the CDRI need to be linked to community/ neighbourhood action planning and analysis. Understanding the different resilience levels of a city may facilitate planning of sector-specific DRR solutions (Joerin et al., 2014).

In 2010, the Province Planning Agency (BAPPEDA), in coordination with Province Department of Public Works (DPU), initiated a master plan for flood mitigation in DKI Jakarta (Mulyani Sunarharum et al., 2014). This master plan consists of several structural measures, including: drainage improvement, river improvement, improvement of retention ponds, coastal defence and road protection (Mulyani Sunarharum et al., 2014). Flood risk management in Jakarta requires coordination amongst governments of Jakarta Metropolitan Region (JMR), particularly West Java. However, the collaboration between governments across different provinces has been challenged and complicated by fragmentation of authority based on administrative boundaries (Mulyani Sunarharum et al., 2014).

An initiative undertaken in Nepal to reduce risk due to floods and landslides included land-use planning, watershed management, zoning and providing safer places for marginalized populations (Sudmeier-Rieux, et al., 2012). The project established a watershed management program in the upper watershed of Dharan (Sudmeier-Rieux et al., 2015).

3.4 CASE STUDIES

FLOOD:

Dhaka, Bangladesh (Ahmed et al., 2015; Braun and Aßheuer, 2011; Dewan et al., 2012; Khan, 2008)

Dhaka, a 300-year-old city, now known as a megacity, is the capital of Bangladesh and surrounded by the three large rivers of Buringanga, Balu and Turag. The city is so densely populated that the UN stated that it will become one of the 20 most populous countries in the world by 2050. The pattern and pace of urbanisation in Dhaka is alarming as open ground, agricultural land, water bodies and wetlands are rapidly being converted into built-up areas (Ahmed et al., 2015). Urban built-up areas occupied only 11.1% in 1960; which more than doubled (26.1%) in 1988; in 2005 these areas occupied half of the city. A significant amount of the wetlands and low-lying areas, which previously served as retention ponds during the wet season, is now being converted to residential areas without consideration of the potential consequences of recurrent flooding (Dewan et al., 2012). Though different approaches were taken by the Government for flood mitigation, still the flood in 1988 caused massive impact in Dhaka due to lack of infiltration of ground water. The subsequent flood events took place in 1998, 2004 and 2007 in Dhaka. There was a reduction of permeable lands across the years and generation of more surface runoff due to reduced infiltration and natural drainage, resulting in frequent flood events which are further augmented due to heavy rainfall and monsoon depression. Despite this, the first urban development plan of Dhaka in 1959 did not take into consideration flood protection strategies but prioritised rapid unsustainable urbanisation that led to increased vulnerability to natural disasters such as floods. Construction of water levies and embankments has led to saturated urban spaces, water drainage failures and environmental problems (Ahmed et al., 2015). On the other hand, due to lack of housing space people from low income groups are being forced to settle in areas susceptible to natural hazards, e.g. in unprotected wetlands or river banks. More than one-third of Greater Dhaka's population live in marginal settlements, which are extremely flood prone areas. Adaptation Tipping Points (ATPs) is an action plan to approach disaster vulnerability that was adopted after the extensive damage to crops and settlements during 1955 flood but mostly targeting flood control, drainage and irrigation. A water Master Plan was also established in 1964. Despite the different strategies set up to manage floods, the 1974 flood still caused huge amounts of damage as requisite monitoring and assessment of urban development projects and planned development of water resources were not implemented comprehensively. After the major floods of 1987 and 1988; flood action plans (FAP) were taken to integrate flood management measures. The National Water Policy and National Water Management Plan () were established after the 1998 flood as the FAP was not implemented due to a lack of funds and public consultation. At drainage a masterplan was developed in 2006 as uncontrolled urban growth was found to be one of the main reasons for severe flooding. National Adaptation Programme of Action (NAPA) 2005, Bangladesh Climate Change Strategy and Action Plan (BCCSAP) 2009 and Detail Area Plan (DAP) 2010 were taken to mitigate flood impacts (Ahmed et al., 2015). Along with Government of Bangladesh different Non-

Governmental Organizations (NGOs) like BRAC, Proshika, Gono Shahajjyo Shongstha (GSS), Dhaka Ahsania Mission, Disaster Management Forum also work to reduce vulnerabilities during natural disaster (Khan, 2008).

Surat, India (Bhat et al., 2013):

Surat, situated in South Gujarat, India stands on the banks of the Tapi River. The frequency of floods occurred once every four years between 1949 and 1979. Since 1979, there have been five major floods in South Gujarat (1979, 1990, 1994, 1998 and 2006).

Surat became a big city early in the 20th century and continued to grow with a rapid influx of population, shift of industries, and development of commercial centres. As a result, the city's population has grown since 1951 more than ten-fold to reach 4.5 million inhabitants. To accommodate this large number of people the municipality area has expanded from 8.2 square kilometres in 1951 to 327 square kilometres till 2013 with exponential growth of slums and informal settlements (100 such settlements per year). The expansion of the city boundaries to include the Dumas coastal area has made Surat a coastal city acquiring the risk associated with coastal areas. The majority of the slums are located on tidal creeks, along the river and water drainage channels. High population density, combined with informal settlements close to the sea shore, makes the people vulnerable to dual risk, flood and tidal calamities.

Urbanisation processes that have contributed to increased risk of flooding include: increasing the size of the built-up area; construction on the floodplains; filling in of the riverbed and floodplains and the construction of embankments' new bridges and the Singapore weir. Establishment of weirs and dams also have added in problems by blocking the natural water flow patterns, resulting in increased risk of flooding. The floods of 1998, 2004 and 2006, for example, in part resulted from emergency discharges from the Ukai dam. Large-scale industrial development at the mouth of the river has also caused a rise in the water level immediately upstream. Due to these poorly planned urbanisation policies, Surat's climate change risk profile was further worsen with rising sea levels, water scarcities and temperature rises.

The Surat City resilience strategy included a comprehensive early warning system, an improved information and data management system, the mapping of flood-risk areas, regulating construction in floodplains, the diversion of floodwaters from the Tapi River and the construction of a balloon barrage. In order to reduce the consequences of floods, other steps included increasing the height of building plinths; ensuring parking places were above flood levels and building small attics or lofts in house for storing valuables. The municipality also instigated procedures to clear drainage and sewer systems as well as develop preparedness processes for emergency evacuation, including regular evacuation drills during the monsoon season. In order to warn people LED hoardings were placed to display the water levels of the reservoir behind the Ukai dam. Advanced warnings were also provided by megaphones and through the short messaging system (SMS) for mobile phones. However, during the 2006 flood, some sections of the urban population did not receive messages from the early warning system because 40% of the slum population, 35% of the lower-income and 21% of the mixed- and middle income groups had no access to cell phones. That is why the municipality has planned to set up a GIS-assisted two-way information system, which included geo-tagging of all residential buildings, and pre-monsoon updates for people requiring special medical care during emergencies (the elderly, infirm, babies, pregnant women). This also included volunteer and mobile SMS-based two-way information system. As a part of the early warning mechanism, Asian Cities Climate Change Resilience Network (ACCCRN) helped to establish an Urban Health and Climate Resilience Centre at

Surat that will work with local authorities to study the impacts of climate change on health, with a particular focus on poor and vulnerable city residents (Bhat et al., 2013).

EARTHQUAKE

What does earthquake preparedness look like? Case studies from China, Nepal and India

The impact of earthquake is devastating and quite impossible to stop as it mostly depends on natural hazard factors (base rock motion, soil amplification, liquefaction potential, slope failure potential). Despite this, the damage can be minimized with effective disaster planning, robust building regulations, and successful emergency rescue. Of the 32 studies, 10 studies discussed earthquake and the experience and lessons learnt can be well demonstrated with the case studies from China and Nepal.

Experience from China (Yang et al., 2014):

Two major earthquakes took place in Wenchuan (12 May, 2008) and Lushan (20 April, 2013) over a period of five years. These two areas are 87 km apart from each other. After posing the similar social structure of the residents, buildings, and communities the devastation in terms of casualties, building damage and economic loss caused by the two earthquakes had extreme differences although there was only a 1-2 magnitude difference in intensity between them. Lack of disaster preparedness, planning and management caused high disaster losses in Wenchuan Earthquake of 2008. No emergency drugs and equipment, emergency response system, awareness among people were available to combat against earthquake. People jumped from windows or from high-rise buildings as they were unaware of what steps to take during earthquake. However, five years later, organisations used what they had learnt during the Lushan earthquake, and steps were taken from every sphere including Government, NGOs, professionals and the community, which reduced the vulnerabilities of earthquake.

After the Wenchuan earthquake, the Government focused on getting more aid and support from medical and rescue professionals. Adequate emergency drugs and equipment were stored at the emergency disaster control headquarters for rapid transport which were used immediately after Lushan earthquake. Development and training of emergency professional medical rescue teams were given by Central Government. The Ministry of Health began to organise medical rescue teams specializing in disaster medicine called National Emergency Medical Rescue Teams. Emergency rescue teams were created by local governments using Chinese medical and fire-fighting institutions' forces. Local medical rescue teams played a major part in the 2013 Lushan Earthquake and accounted for more than 75% in all medical rescue teams. A large number of people in Sichuan Province had taken part in an earthquake drill to raise awareness of how to respond to a large disaster. Local rescue teams and volunteers were more active and undertook most of the duties and coordinated well with military forces. The Chinese people's ability to help themselves and offer aid to others helped to avert deaths and injuries from the Lushan Earthquake. Structures were stronger, since many people had rebuilt or reinforced their houses to make them safer in the event of earthquake (Yang et al., 2014).

Experience from Nepal (Carpenter and Grünewald, 2015):

The city of Kathmandu, Nepal is one of the fastest growing cities in South Asia. The Kathmandu Valley has 2.5 million people living in it even though it is situated on a major seismic fault line and has significant seismic risk. The devastation of an earthquake is so great in Nepal that 8800 people died because of an earthquake in 2015. Urbanisation in Kathmandu is characterized by the growth of population density in urban areas, the conversion of rural space into urban spaces, the acceleration of rural to urban migration and inconsistent application of urban building codes. People are drawn to the city, particularly for employment and educational opportunities, which resulted in the growth of informal settlements in vulnerable areas such as riverbanks, rubbish dumps, or temples, with housing patterns in these areas mostly irregular and substandard. In addition to this, three or four storey buildings have been constructed on agricultural and open land to accommodate this burgeoning population. Again, in Kathmandu the National Building Code of 1994 is rarely enforced during construction and high levels of corruption in the construction sector are also prevalent.

Managing the risk of earthquakes in a complex urban system like Kathmandu is multifaceted and hence difficult and complicated. The Ministry of Physical Planning and Works has implemented a system of voluntary land pooling. Under the scheme, landowners looking to establish new developments sacrifice a portion of their private land for use as proper roads and other infrastructure, including public open space, with the return of an increase in the value of the remaining. Public safety is enhanced through improved access for emergency vehicles, while the earthquake-related hazard of falling buildings is reduced through wider streets and more open space for evacuation. In community-based disaster risk management, beside television the internet was shown to be a useful information source with more than one million people in Nepal having a Facebook account and internet access. The Kathmandu Valley NCELL, the mobile network provider with the largest share of market users in Nepal, has a designated disaster planning focal point.

The Nepal Risk Reduction Consortium (NRRC) works in the areas of school and hospital safety; emergency preparedness and response; community-based DRM; and policy and institutional support for DRM. In the aftermath of the 2015 earthquake many foreign urban search and rescue (USAR) teams were deployed to Nepal. However, a civil military coordination worked effectively for preparedness measure ensuring ownership of any response and relief efforts by the Government of Nepal and others (Carpenter and Grünewald, 2015).

Experience of Gujarat earthquake (Thiruppugazh, 2008):

More than 57 percent of the land in India is earthquake prone with more than 500,000 people living in the seismic zones. Gujarat, a state of Ahmedabad province is almost entirely prone to seismic hazard and vulnerable to earthquakes. Gujarat experienced eight high magnitude earth quakes of 6 and higher on the Richter scale.

Five other states of Ahmedabad are situated in seismic zones. Ahmedabad is of 1300 square kilometres in size with more than 5 million people. It is an industrial centre and thus people tend to migrate to this city. The population density is 18,420 people per square kilometre and approximately 440,000 people living in slums. Unplanned urbanisation, development within high risk zones, a lack of

adherence to building codes, deficient urban management practices and inappropriate construction practices increase the city's vulnerability to earthquake. Ageing building stock, lack of training and education in earthquake design and construction and not having a professional engineering association also increase earthquake risk. In 2001 earthquake, while many private buildings collapsed, a single government building was not found to collapse in Ahmadabad because of following the appropriate building codes, approval protocols and procurement procedures by the government buildings.

In Gujrat, good urban governance has imputed as one of the key factor of disaster mitigation and management. A holistic approach was taken which included solutions for legal, political and socioeconomic problems. After the earthquake, the syllabus of the civil engineering curriculum was revised to include earthquake engineering. Training was undertaken for teachers in engineering colleges, engineers working in government and municipal organisations and stonemasons. Following the earthquake, legal processes were also instigated to file criminal cases against the builders and professionals responsible for illegal or under regulation building design and construction. The Federation of Real Estate Developers Association of Gujarat, for example, voluntarily adopted a code of conduct to ensure building safety and quality. The Gujarat Professional Civil Engineers Act 2006 was passed to set up an engineering council to test the competency of engineers and issue licenses. The engineering council of Gujarat also ensured the safety, accountability and encouraged high standards of engineering. In addition to that, donors are also now paying more attention to pre-disaster mitigation than post disaster relief work, funding the retrofitting of unsafe structures, information campaigns, and promotion of safe construction practices through civil society involvement (Thiruppugazh, 2008).

4. POLICY AND PRACTICE IMPLICATIONS

Unplanned urbanisation has been emerging as a major concern in South Asia. Most of the governments in the region have adopted policies for achieving the Hyogo and more recently the Sendai Framework and have started working towards implementing the UN-SDG goals. However, most of these work plans are focused in general on “warning-relief-rescue” type of approaches, with the issue of urbanisation not firmly established on their agendas. One of the gaps is most probably the lack of a strong evidence base and action related outcomes from low and middle income countries of Asia, particularly from the south (From scoping report). This review can serve as a starting point for policymakers to identify the existing lessons and approaches, gaps in information, future needs and to develop policies.

This review indicated that the process of urbanisation and its association with natural disasters is complex, multifaceted and as yet unfolding. The impacts of disaster are often devastating and highly contextualised. Similarly, the success of any initiative or approach to DRR always depends on the magnitude of the disaster, preparedness and participation of the community and coordination among the stakeholders and implementers. Policies should therefore keep focus on these highly contextualised factors before development and implementation. This requires legal frameworks and policy support, centralized coordination and clear-cut and proactive guidance. Disaster risk management should be integrated into longer-term national policies so that a regular allocation of funding is ensured and resources identified.

Existing policies should be strongly implemented and monitored and innovative policies developed to address emerging issues including:

- Enabling environment needs to be created for policy support, ensuring funds, capacity building emphasizing local government, environmental protection and eco-resilient climate change adaptation and supportive activities or regulations.
- Regulate and manage the spacing and pattern of urban settlements to avoid high risk locations (safe areas, buffer zones etc.) with attention to marginalized populations and focusing on construction regulations, and effective water drainage.
- Systems in place to collect and utilize accurate information from all levels. It is necessary to establish appropriate communication and information mechanisms by creating links with all types of media, by exploring innovative technologies (use of mobile phone / GIS / electronic systems, etc.)
- Create an environment to engage all stakeholders, including vulnerable populations. A national platform where academics, institutions and policy relevant public / private representatives from commercial and private sector stakeholders can participate in urban DRR processes.

Urbanisation and natural disaster is a multi-sectoral and multifaceted problem. Risk and vulnerability in urban areas is changing, particularly in cities of South East Asia that are rapidly passing through the phases of urbanisation, economic growth and profound societal changes. It is necessary to better understand these dynamics, to monitor the changes and act accordingly.

Governments should ensure evidence based policy making, use of knowledge and innovation, intervening when necessary to create safe, resilient and risk sensitive practices for the cities. To this end, successful lessons from home and abroad should be piloted and scaled up if proven to be effective. The long term goal should be reducing risk factors associated with urbanisation, preventing of disasters before they occur and strengthening response capacity.

RESEARCH

This review uncovered a huge gap in the information and knowledge required to fully understand the dynamics of urbanisation and natural hazards. The review is solely based on qualitative studies and demonstrates the absence of studies with robust methodologies, explicitly stated interventions and outcomes or implementation research or causal studies. The way in which urbanisation and natural hazard intersect is emerging is complex and multifaceted, however, the extant knowledge base has significant gaps and weaknesses pointing to the need for more robust, high quality research in order to more deeply investigate the issues and consequently provide evidence to better support policy and practice.

Research should investigate and meet the information needs required for all aspects of Disaster Risk Reduction. The information should include the rate and pace of urbanisation and its key characteristics; changes in the air quality; land and water use and abuse and collate existing impact and vulnerability assessments and potential socio-economic effects. In addition, monitoring mechanisms should continue to collect observations of geophysical, climatological and meteorological changes to provide early warnings for flood, earthquake or other natural hazards.

Research should also cover the political, social and economic aspects of urbanisation and hazards. Researchers need to engage more with the issues and be prepared to argue for the rigorous collection of information in a comprehensive way to support robust policy and practice. Some issues that need more evidence to support them include the kinds of technology best suited to the different phases of emergencies, including early warning, pre- and post-disaster. Some questions unanswered in the studies reviewed include how to better incorporate the private sector in urbanisation initiatives, and which policy instruments are needed to undertake changes, legislation, regulations, and incentives.

To address existing gaps, it is necessary to undertake more action research to evaluate the best applicable strategy to prevent, eliminate and reduce natural hazard risk in equitable way, how well to target the most vulnerable and marginalized populations and ultimately how viable these interventions will be from a financial point of view.

Finally, more research is needed into the important role communities play in disaster risk reduction. Community is inclusive of all survivors of natural hazards. It is of utmost importance not only to understand how communities cope with an ever changing pattern of risk and vulnerability but also to evaluate how effectively communities can participate in transforming that risk and contribute to develop safe and resilient urban habitats.

5. DISCUSSION AND RECOMMENDATION

This impact assessment and approaches to risk reduction is based on 32 included studies. However, a further synthesis was undertaken on six selected medium to high quality studies, with most of the recommendations and conclusions based on that synthesis. This six high to medium quality studies on urbanisation and natural disaster highlighted the fact that injury, death and economy loss were substantial from flood, tsunami and earthquake. Five out of these six studies described used qualitative methods to collect data to show the outcomes of post disaster management intervention and narrate the specific issues for the achievement or failure of an intervention. One study discussed existing vulnerability and resilience in relation to risk of disaster. Additional information and support came from some of the low quality studies. The studies examined the geographical location and associated physical vulnerabilities as well as social vulnerabilities emerging out of the rapid pace of urbanisation, and the lack of resilience of south Asian cities. These studies' expositions of each city's exposure to particular hazards, combined with increasing social and physical vulnerabilities due to the processes of urbanisation, assists us in better understanding the intersecting complexities related to urbanisation processes and disaster vulnerability in urban spaces in south Asia. Despite limited evidence in terms of numbers of high and medium quality studies conducted and types of evidence available following recommendations can be made. The inclusion of low quality study evidence will not change the evidence.

IMPACT OF URBANISATION AND NATURAL DISASTER

The main themes emerging in relation to urbanisation and natural disaster can be grouped into i. Physical vulnerability: Geographic and climatic exposure to natural disaster, ii. Collective vulnerability: Rapid, unplanned urban growth; iii. Social vulnerability: High risk, vulnerable populations. Rapid and unplanned urban growth and its associated changes, particularly in cities in south Asia when located by the riverside, at sea cost or over the seismic zone bear the additional risk of natural disaster. It is indicated that the risk and vulnerability further increased with slum and poor populations. Rapid, unplanned urban growth and movement of marginalized and disadvantaged populations into high risk areas was found to be a common process that has driven disaster vulnerability and risk in cities. Occasionally risk was reported with people at extremes of ages (children and elders) and with women.

URBANISATION, RISK AND VULNERABILITY TO NATURAL DISASTER

While risk is a difficult concept to measure and capture most of the studies used surrogate measures in reporting risk. In many studies both risk and vulnerabilities were used synonymously or together with one representing the other. Risk was defined in most studies as the potential losses an individual or community might face in terms of physical, social and economic loss due to disaster. Vulnerability was often seen in terms of the characteristics of the population affected by disaster; the location of the population, as well as the preparedness, capacity, skill and existing context of the city and government implementers.

The location of urban areas as well as the rapid pace of urbanisation in low and middle income countries was shown to greatly increase risk and vulnerability to natural disasters. Urban centres in

Asia were found to be exposed to and at risk of impact from two key categories of disaster resulting from hydro-meteorological and geologic events. The effects of changes to the environment are caused by rapid concentration urbanisation either at river side or coastal zone or seismic risk areas as explained by the reviewed studies (Birkmann and Fernando, 2008; Taylor, 2015; Carcellar et al., 2011; Malalgoda et al., 2013; Razafindrabe et al., 2014; Tafti and Tomlinson, 2013; Taylor, 2015; You et al., 2009).

The studies also demonstrated that economically marginalized groups are at greater risk of being negatively affected by natural disaster. Populations studied included slum dwellers; poor and migrant people living in hazard prone areas (Sudmeier-Rieux et al., 2012). Much of this growth was unplanned (Sudmeier-Rieux et al., 2012), and even when urban development was planned, the development process was found to have been influenced by the agendas and interests of different stakeholder groups to the detriment of the planning processes. Climate change was also found to have a role with rising sea levels impacting on cities located in coastal areas. This led to an increased risk of storm surges, typhoons and eventually an overall increase in flood risk.

RESILIENCE/RISK REDUCTION

Urbanisation has also created opportunities to build resilience. It has led to improved economic opportunities, education, communication facilities and transportation systems for the urban population of a country. However, it is important not to think only about urbanisation but also think about how municipal governments and other actors can more effectively plan and manage urbanisation processes. The findings of the review also highlighted the important role of governance and policy support. Governance played a key role in risk mitigation and vulnerability reduction leading and mobilizing responses to disaster, ensuring post disaster security, medical assistance, waste management, as well as ensuring safe water supply and food (You et al., 2009, Carpenter and Grünewald 2015). On the other hand, results showed that most of the time there was a big gap between policy and practice. In most countries the implementation system is linear with a top down approach (Mulyani Sunarharum et al., 2014; Taylor, 2015). Poor governmental management of urbanisation and population growth has exacerbated disaster risk in Bangladesh and unplanned growth in Chinese delta cities and in Vietnam has led to sustained and higher exposure to disaster (Bayes, 2015); Razafindrabe et al., 2014; You et al., 2009). Neglecting the needs of the marginalized populations increased disaster impact in cities such as in Manila and Kathmandu (Carcellar et al., 2011; Carpenter and Grünewald, 2015) whereas poor and incapacitated disaster risk management resulted in a loss of lives and property in Bangladesh (Ahmed et al., 2015). The studies showed that not all the drivers of urbanisation were addressed in a consistent, systematic manner by different authorities. A central coordination mechanism was absent in many cities and countries covered by the evidence. The government in many situations was inadequately prepared to respond, lacked capacity or appropriate approaches required to act (Carcellar et al., 2011; Carpenter and Grünewald, 2015; Taylor, 2015; You et al., 2009). In summary the role of government and good governance is the most important factor necessary for effective risk reduction and risk management of natural disasters. However, the studies showed that not all the drivers of urbanisation were addressed in a consistent, systematic manner by different authorities.

DRR INTERVENTIONS AND OUTCOMES

Based on the review results on the impact and approaches to reducing the effects of disaster it is evident that the risk varied according to the context. Differing impacts are associated with the location of cities; the nature and characteristics of urban growth and development and different levels of resilience across the different population groups (women, ethnic minorities, low-income, children and older persons). Vulnerability also depends on the physical, economic and social characteristics of the population. The synthesis indicated that risk and vulnerability are intricately interlinked and disaster risk reduction in the context of urbanisation is complex and multifaceted. Therefore, risk reduction approaches also need to be flexible enough to address these issues and should be as inclusive, adoptive, context specific and multi-sectoral as possible. Obviously it is not possible to shift in built infrastructure in a day, most of the DRR approaches therefore were focused on modifying existing risk and preventing further decorations.

Only a few medium quality studies assessed approaches to disaster risk reduction (Birkmann and Fernando, 2008; Malalgoda et al., 2013; Tafti and Tomlinson, 2013; Taylor, 2015; You et al., 2009). Vulnerability reduction and resilience development were discussed mostly in the form of long term policy support, related urban planning, governance and community involvement (Carcellar et al., 2011; Dewan et al., 2012; Rumbach, 2014; Sudmeier-Rieux et al., 2015; Tafti and Tomlinson, 2013; Theckethil, 2012). For example, in the cases where disaster risk management was not comprehensive; communities did not participate and top-down policies were implemented, the disaster risk and the benefits of rehabilitation efforts shifted from public to private, from poor to the rich and from disadvantaged to more advantaged groups (Sudmeier-Rieux et al., 2015).

In much of the literature community involvement and community based disaster management emerged as an important theme. Community involvement was discussed in relation to risk identification, risk management and in risk reduction through resilience development. Sharing and communicating local knowledge and customs can be important tools in risk identification and risk reduction. The approaches discussed included immediate response and information management, community based approaches with involvement of local level governance and civil society, coordination among stakeholders, role of leadership and addressing vulnerabilities by population groups.

Studies reported that bottom up approaches to disaster policy could be helpful in vulnerability reduction and resilience development (Birkmann and Fernando, 2008). Community based initiatives in awareness building, organizing shelter, community policing, and networking between public sector implementers, disaster affected and unaffected population were found to be effective (Bhat et al., 2013; Birkmann and Fernando, 2008; Carcellar et al., 2011; Peleg, 2015). Some of the community based initiatives created during or after disaster survived and continued to function post-disaster, extending their activities in affected areas and organizing loans and financial support to affected people, and engaging in long term rehabilitation and even reconstruction of housing and shelters (Birkmann and Fernando, 2008; Carcellar et al., 2011; Tafti and Tomlinson, 2013). Community backed approaches when implemented by the government or NGOs had better potentialities. Community based and NGO backed organizations effectively supported immediate post disaster data collection

on the severity and scope of destruction; engaged in trust and contact building initiatives and savings programme implementation (Birkmann and Fernando, 2008; Taylor, 2015; Razafindrabe et al., 2014).

COORDINATION, COMMUNICATION AND INFORMATION

Another important theme noted was communication and information. It was noted that timely communication saved lives and helped to develop response activities (Bhat et al., 2013; Birkmann and Fernando, 2008; Carpenter and Grünewald, 2015). Warnings disseminated during tsunamis helped save many lives in Indonesia and a GIS based remote sensing early warning system was proposed as one part of the solution by a study in Bangladesh (Ahmed et al., 2015). However, in both the cases the systems were not well developed and described and studies recommended that such systems should be part of a broader or holistic approach of DRR. Studies showed that when information systems incorporated local knowledge and customs this assisted in the rapid dissemination of information, trust building and capacity building efforts (Bhat et al., 2013, You et al., 2009).

5.1 RECOMMENDATIONS

Recommendation 1: *Information needs are substantial and must be addressed prior to, during and after disasters.*

- *Immediate and accurate local level information can reduce disaster risk and impacts:* Collection of data helps target interventions and to estimate what is needed at emergency and afterwards (Birkmann and Fernando, 2008; Bhat et al., 2013; Carpenter and Grünewald, 2015; Peleg, 2015). Evidence suggests that much depends on data quality and accuracy, particularly information should be locally collected and based on local need. Decisions made centrally may turn out to useless and unnecessary (You et al., 2009). On the other hand, decisions based on local assessment can improve the situation (Birkmann and Fernando, 2008).
- *Particular value in forecasting and warning systems:* Early warning and forecasting can reduce the disaster impact (Bhat et al., 2013; Peleg, 2015). However, information should be targeted, should reach out to all irrespective of socioeconomic status and should be early enough that people at risk can take appropriate measures beforehand (Carpenter and Grünewald, 2015).
- *Action taken on the basis of local evidence can contribute to reducing risks and vulnerability and/or enhancing resilience:* When measures are taken based on local evidence, it is helpful to undertake appropriate measures, to create safe zones in risk areas, and to target vulnerable population. This action could be more useful when prior detailed information about local vulnerabilities is available (Birkmann and Fernando, 2008).

Recommendation 2: *Regulate and manage the spacing and pattern of urban settlements to avoid high risk locations and address vulnerabilities.*

- *Design and establish effective DRR policy frameworks and monitor their progress and implementation:* Despite the natural risk to disaster by geographical location, the vulnerability to environmental hazard might often be a function of appropriate land use, water management and

protection of natural ecosystems by the residents and their community. One of the common recommendations was to reduce physical exposure to disaster by effective urban planning. As with other examples of physical vulnerability, expansion into high risk areas can be mitigated through careful and effective governance and planning approaches that ensure that high risk urban populations do not experience increased vulnerability to, and risk of, natural disasters such as earthquakes. It was proposed that urban planning should adopt a risk sensitive approach and which should not be based on a **standalone disaster management plan, but be an integrated part of urban development**. Suggestions for improvement were diverse and very much dependent on the urban context. Recommendations were made to strictly enforce and maintain building codes during approval and construction which should subsequently be adequately monitored (Thiruppugazh, 2008; Yang et al., 2014) and schools should be built high with a second storey to serve as future emergency shelter (Sharma and Priya, 2001). Studies that examined the physical conditions of the cities and their expansion suggested that future city plans should take a more holistic approach. Urban planners, for example, need to focus on developing satellite towns away from the main cities that have adequate communication and drainage systems and should restrict any unplanned and illegal establishment of industries near riverbanks.

- *Ensure relocation strategies for disaster affected populations:* Integrate affected populations' needs regarding livelihood opportunities, social networks and access to welfare and health services. The reviewed six studies revealed that mass tsunami, earthquake and flood led to huge destruction of property, which caused displacement of the affected population due to reconstruction of residence as a part of DRR interventions in different locations. These relocations impacted on people's social networks; this new housing in new locations placed people in unfamiliar surroundings, with a detachment to standard schooling and health services because of the long distance from the main area of the city and scarcity in the establishment of transport system. Moreover, migrant people who already had lost their social ties during their migration from rural to urban areas, lacked the ability to recover and return to normalcy after a disaster. Therefore, this became a vital issue for implementing initiatives for relocation of the affected people after disaster by the government.

Recommendation 3: Immediate response is enhanced when appropriate systems are working and available:

- *Response and recovery (R&R) systems:* Immediate response is at the heart of disaster risk reduction and the process should start immediately and continue for as long as necessary. The R&R should include first medical aids, assuring people of any further risks, organise relief, and safe shelters to vulnerable persons (elderly, children, wounded) should be taken just after the disaster happens and before the conventional approach comes into act. Unless there is ground level preparation, organising this kind of operation is difficult and takes a long time and much effort (You et al., 2009). People become seriously vulnerable after disaster and need not only rescue but also safe shelter and passage to shelter. All these require development and mainlining safe areas, logistic supplies and security measure. Incentives when given including cash should be well targeted and transparent in systems. Otherwise such initiatives often become counter effective (Birkmann and Fernando, 2008).

- *Mapping of disaster zone and affected populations:* Studies highlighted the need for accurate information on disaster impact and risk, especially in terms of understanding who is most at risk and the nature of their vulnerability. Collecting information on vulnerability and risk will help with planning and organizing rescue efforts, and post-disaster rehabilitation and reconstruction activities. The alliance between Homeless People's Federation Philippines and Philippine Action for Community-led Shelter Initiatives provides a good example. This alliance helped local government collect accurate information needed to assess the severity and scope of disaster impact and survivor needs immediately after landslides, flash floods and mud flows took place in Manila. This assisted the local government authorities to organise recovery, reconstruction and rehabilitation activities in a targeted manner (Carcellar et al., 2011).
- *Systematically analyse disaster risk, social and physical vulnerabilities and potential impact to produce evidence based decisions:* Each and every type of disaster should be critically analysed in terms of risk, resilience and impact by wide-ranging geography characteristics. This is anticipated to support knowledge-based decisions by using the evidence on the causes of natural disaster (Birkmann and Fernando, 2008; Razafindrabe et al., 2014). The review of limited number of scientific rigorous studies suggested an application of scientific and systematic methods to investigate the impact of DRR on quality life. There is a need for comprehensive assessment, rather than assessing risk and vulnerability of affected people only and also equally importantly to understand the relationship of culture in addressing and responding to disasters.
- *Explore innovative technology for effective communication use of mobile phone / GIS / electronic systems:* Providing appropriate information has important impact and outcomes. For an effective coordination, providing warning in emergency and for preparatory exercises effective communication systems plays a pivotal role. During, after and even before any disaster the speed and access to information has a vital role (Birkmann and Fernando, 2008; Peleg, 2015; Bhat et al., 2013; Carpenter and Grünewald, 2015). Electronic media can reach out to the mass population quicker than any conventional way and can disseminate information faster. With the rapid advent and access to internet through mobile phones the ability to reach the general population is increasing and expanding and these new innovative approaches should be availed (Carpenter and Grünewald, 2015).

Recommendation 4: *Monitoring and responding to cumulative and unfolding/emerging effects/impact of disasters on people and systems "is crucial"*

- *Assurances, information, minimize panic:* Disaster does not happen alone and it starts a chain of events which cascade effect. Monitoring during and after the event is vital to reduce risk and vulnerability to disaster. In addition to natural and physical after effects like fire, road block, water logging, disease and infirmity, disaster produces insecurity, crime and uncertainty (Carpenter and Grünewald, 2015; Peleg, 2015; Tafti and Tomlinson, 2013). It is essential to monitor the unfolding situation; provide accurate information and security to minimize these effects.

- *Solution to legal, political and socioeconomic problems:* It is indicated that during and after disaster several legal, political or socioeconomic problems may surface and create barriers to DRR efforts (Tafti and Tomlinson, 2013; Carcellar et al., 2011). Good policing, vigilant volunteers and support from local authorities helped avoid such situations and reportedly could even result in increased community resilience and protection (Theckethyl, 2012; Tafti and Tomlinson, 2013). It was also proposed that governments need to provide sufficient security in the evacuated areas to convince people to leave their homes and move to relief camps.

Recommendation 5: *Coordination among all stakeholders is essential*

- *Engage all stakeholders of urban and disaster related and relevant fields (One Approach):* Urbanisation and natural disaster produce a multifaceted problem. Studies described how poor governance and weak public policy support increased the impact before, during and after a disaster. Resources (time, personnel, and service) are ineffectively used in the presence of poor coordination. Constraints to local level decision-making and resource allocation compromise responses and non-coordination between local government and other government institutions undermined effective implementation. The major barriers identified were multiple authorities acting separately without coordination; lack of capacity and knowledge to respond and slow and inappropriate policy responses. The role and influence of vested interest groups and commercial stakeholders also hindered effective risk reduction efforts (Tafti and Tomlinson, 2013). The studies emphasized the need for a better understanding of the power dynamics, leadership, and decision-making processes that take place when business, civil society, and the state mechanisms cooperate on DRR interventions. These actors are important players and understanding how they function can assist tremendously in improving urban risk management programmes (Carpenter and Grünewald, 2015). Systematically establishing and maintaining coordination and consultation mechanisms are indicated to integrate the perspectives of all levels of government, local communities, civil society and the private sector into DRR strategies and plans.
- *As a critical player in urban DRR, invest in local government:* The role of local governments was found to be an important institution for DRR intervention, and studies decentralized the DRR intervention through the local governments (Taylor, 2015; Razafindrabe et al., 2014; Birkmann and Fernando, 2008; Carcellar et al., 2011). Non coordination between the local government and other government institutions were also described as factors having an effect on the DRR intervention. It is indicated that during and after disaster to institute good coordination among health service providers, search and rescue teams, one single authority should be in charge of and coordinate disaster management activities (You et al., 2009) so that the requisite legislative and governance authority, and financial and human resource capacity needed to effectively mitigate against disasters can be mobilized rapidly and effectively (Malalgoda et al., 2013).

Recommendation 6: *Active engagement with civil society and communities brings a wide range of benefits*

- *Facilitating communication with communities:* Among these six studies, how the community engagement helped to improve government relief and recovery efforts was described in three studies (Carcellar et al., 2011; Tafti and Tomlinson, 2013; Taylor, 2015). This engagement was seen

as an illustrative shift from response and recovery to risk management through proactive community participation. High awareness about the consequences of natural disaster was evident in two studies, however it was not associated with the disaster preparedness, relief effort and post disaster management initiatives. Other studies reported that lack of awareness about the natural disaster, its consequences and management attributed to the less effectiveness of DRR initiatives. Nevertheless, it is suggestive that awareness of natural disaster and its implications is important to prevent as well as to control the loss due to natural disaster. In addition, a disaster-resilient city needs integration of local government and community to anticipate and limit the risk by avoiding risky land-use activities.

- *Identifying and avoiding risky areas/land use and promoting safer and lawful construction activities:* Studies indicated that active engagement with community can enhance implementation of DRR guidelines and activities through awareness campaigns, planning, information dissemination, and recognition of community concerns. This may lead to application and following up building codes, safe construction practices, and avoiding use of risk zones.
- *Can strengthen in facilitating agency of vulnerable populations:* Community engagement not only helps identify the vulnerable population, it can also guide implementing safety measures. Community driven DRR activities included involvement in data gathering, money gathering and initiating long term rehabilitation programmes (Carcellar et al., 2011).

Recommendation 7: *Population-level education training and drills on disaster preparedness and response can be effective in reducing the impacts of disasters*

- *Should be undertaken as preparedness for reducing disaster impact.* It was evident from at least two studies that this kind of population level education and training can reduce the risk and impact of natural disaster to a great extent. A range of communication strategies can be undertaken. The role of electronic media, GIS warning systems, automated SMS information and advice or population level drill has been demonstrated to reduce both loss of human lives and properties (Bhat et al., 2013; Yang et al., 2014; You et al., 2009).

Recommendation 8: *Leadership is the key for change*

- Active leadership plays an important part in taking initiatives to reduce risks and vulnerabilities, and strengthen resilience, particularly when the leadership comes from the local community or a local population representative. A leader is the key connection between the population and the administration. A leader can set into motion the existing policy, allocate fund, secure incentives, implement regulations and address local needs immediately and as required. Studies indicated that while a local leader can be instrumental in programming welfare initiations, a central level leader can mobilize policy level support and wide scale coordination and communication.

Recommendation 9: *DRR agenda should be inclusive to ensure increased access by marginalized and vulnerable population*

- Vulnerability and risk to natural disaster depend and vary with the urbanisation characteristics and people's existing status. Studies reported that marginalised population like migrants, slum dwellers, low income groups, women, children and the elderly were more at risk than others (Birkmann and Fernando, 2008; Carpenter and Grünewald, 2015; Malalgoda et al., 2013; Rumbach, 2014; Sudmeier-Rieux et al., 2015; Taylor, 2015; Theckethil, 2012). These studies indicated that risk to disaster emerged from inequitable and unplanned urbanisation processes and the results were different for the marginalized and disadvantaged population. Moreover, the political, governance and planning failures of urban programming, policies and practices increased the risk and vulnerability of socially disadvantaged groups who move into urban spaces that increase their exposure to natural disasters (Bhat et al., 2013; Rumbach, 2014; Tafti and Tomlinson, 2013; Taylor, 2015).
- In Kathmandu, Nepal, in Ahmedabad, India and other cities, rapid urbanisation forced vulnerable people to move to more risk prone areas such as slums, garbage dumping, low lands zones. City development plans failed to include them in their expansion programmes (Carpenter and Grünewald, 2015; Thiruppugazh, 2008). After Bhuj earthquake housing and shelter policy was drawn in favour of the house and land owner, and the tenants became the victims of both disaster and urbanisation process (Theckethil, 2012). In absence of preparedness it was noted that children, female and the elderly were more likely to die during Tsunami in Sri Lanka (Birkmann and Fernando, 2008). Any DRR agenda should therefore be carefully drawn addressing the needs of the vulnerable population, considering physical, social and economic vulnerability. This approach should be synchronized with the development and growth of the cities and was strongly advocated in the Sendai framework as well as the recently adopted Sustainable Development Goals (SDG) of UNDP. Unfortunately, there is a huge dearth of such approach in most of the review studies.

5.2 METHODOLOGICAL IMPLICATIONS

This review identified a large volume of literature focused on disasters and urban setting, including that which focused on South and South East Asia. The review, however, also uncovered a significant gap in literature linking the dynamics of urbanisation with hazards and disasters. Their intersection is complex and multifaceted, with an absence of robust evidence upon which to base policy and practice.

Our research was undertaken in a number of phases leading into a more rigorous analysis of a small number of medium to high quality studies with a focus on approaches with some bearing on urbanisation processes, disasters, and insights related to reducing risks and vulnerabilities and/or enhancing resilience. Our efforts led to insights regarding approaches that appear to be effective and are based upon evidence from South Asia. These have been clearly specified along with the evidence upon which they are based. This has been further complemented by consideration of policy and practice implications which have in turn sought to incorporate understanding of the

context of disasters in Nepal and Bangladesh in particular. A number of questions requiring further research have been identified and reported.

6. STRENGTHS AND LIMITATIONS OF THE REVIEW

This review adopted robust methods in an attempt to minimize error and bias.

6.1 STRENGTHS

The review's strengths include:

1. Standardised, transparent and comprehensive methods – allowing replication at later date or different setting.
2. Adoption of standard quality assessment protocol (Hawker et al., 2002 and Lorenc et al., 2016) to determine quality of primary studies; quality influenced description of results, conclusions, and recommendations.
3. Comprehensive literature search encompassing both electronic and digital databases, organisational and other web sources, grey literature and hand searches.
4. Focus on most frequent and worst affected urban areas of South and South East Asia - these are among the most rapidly growing urban areas, allowing comprehensive purview of available evidence linking urbanisation and natural disasters in low and middle income countries.
5. Fruitful collaboration between the health systems research hub of icddr,b of Bangladesh and the Health, Rights and Development group at University of New South Wales (HEARD@UNSW) was forged. Moreover, the review's progress was assessed by a Quality Assessment Team from EPPI-Centre, based in the Department of Social Science at the UCL Institute of Education in the United Kingdom.
6. The review is further strengthened by a contextualization exercise carried by the UNSW team, in collaboration with the Nepal South Asia Institute of Advanced Studies (SIAS) group, focusing on Bangladesh and Nepal.

6.2 LIMITATIONS

The review also had several limitations and encountered a number of challenges that potentially influenced the outcome of the review:

1. Disparate insights - results were based on multiple qualitative studies covering a wide range of contexts and issues. Strong clusters of studies with common conceptual or thematic outcomes or that had a strong country or regional focus were not identified; this posed difficulties in drawing conclusions that were applicable across contexts and remained robust.
2. Most included studies either lacked standardized data collection methods or did not explicitly state how they measured the impact of the interventions and approaches investigated. Most frequently, studies simply reviewed secondary data based on observational descriptions and used convenience population samples. In many instances, studies were largely descriptive evaluations or opinion pieces based on author perspectives.
3. Most of the studies lacked methodological rigor, had design flaws and even unclear statements on outcome variables. In this review, no study used comparison or even a pre- and post-survey design, which could have provided information about changes over time in the aftermath of natural disasters.

4. A high degree of heterogeneity was present across the studies and none of the studies presented statistical data. The limited quality of the studies identified was challenging thus constraining generalizability of insights regarding interventions and outcomes. Generalization to the broader policy implications for urban disaster risk reduction in low and middle income countries highlighting the assertion that “Two cities are never alike”. Heterogeneity in terms of disaster type and duration, pre-disaster conditions, population sub-groups and forms of governance varied substantially. Findings were highly contextual posing difficulties in transferring lessons to other settings.
5. Urbanisation is a multi-sectoral and multi-dimensional issue. Its link with natural disaster is equally complex. Therefore, there are inherent complexities to capturing or addressing these in a classical systematic review approach. Included studies lacked a holistic approach to this complex subject and were highly heterogeneous in their objectives and outcomes.
6. This review was limited to studies published in the English language. The review team believes that there could be rich experiences and important evidence published in other languages.
7. The types of studies that will more fully answer the questions posed for this review have yet to be rigorously undertaken and reported.

7. CONCLUSIONS

The review demonstrates the need for more robust research into the intersection of urbanisation and disaster vulnerability in low and middle income countries. Consequently, these conclusions are made with the caveat that they are based on a small subset of studies that cannot represent the complexity of issues encountered in disaster affected urban centres in low and middle income countries. Despite this, the review did find several robust studies that examined urbanisation contexts' solutions to issues related to disaster vulnerability in the context of urbanisation in low and middle income countries.

Studies demonstrated the need for strong *governance and coordination* that enabled and supported the empowerment of local communities and their active participation in disaster risk reduction and management interventions. Interventions were usually successful in those instances where local, provincial and national governments had strong, adaptive governance regimes that were open and flexible enough to integrate the expressed, real world needs of urban populations, especially the urban poor. In a related issue, the studies show that, in order to have effective DRR/DRM programming, all levels of government need to develop effective strategies to strongly engage with *local communities, civil society and community institutions*. If governments did engage effectively with local communities on interventions to reduce risk and vulnerability such as relocation and secure housing tenure and if residents actively participated in the process, then this led to successful outcomes that reduced risk and vulnerability. However, studies also found that many *government agencies needed further capacity development* across several domains: financial, human resources, appropriate expertise and disaster knowledge.

Studies indicated that a strong communication process is at the heart of the DRR approach. Reaching people at risk in an effective manner is essential to early recovery, providing warning, reduce risk and addressing vulnerability. In this connection innovative approaches involving electronic medias, mobile phones or internet were found to encourage effective response and recovery efforts. More practical demonstration of these approaches is required. Similarly, approaches involving people's participation in *disaster preparedness training, demonstration drills* and *addressing immediate responses* to unfolding events after disaster were found effective in certain instances. However, the approaches were usually multi-sectoral, complex and very contextual. Capacity building of public sector implementers, engagement with private sector and civil society, role of local level leaders and initiatives that target and address the needs of vulnerable groups of the population are among other initiatives reported in the included studies. All these approaches need further research required to comprehensively meet the information needs of the stakeholders, should be inclusive to address the needs of the poor, should be multi-sectoral and should be methodologically of high quality.

The review recommends that effective urban planning; improved governance and enabling policy support; increased public engagement and community participation and suitable communication and information systems, including appropriate operative technology when implemented in concert, would significantly reduce disaster risk and vulnerability in the rapidly growing urban cities in low and middle countries of South and South East Asia.

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9. APPENDICES

APPENDIX 1: AUTHORS AND CONTRIBUTORS

The review was undertaken by members of the icddr,b in Dhaka, Bangladesh {Dr. Shahed Hossain (SH), Nafisa Lira Huq (NLH), Rubana Islam (RI), Razib Mamun (RM), Iffat Nowrin (IN), Saraban Ether (SE) and Dr. Alayne Adams (AA)} and {Professor Anthony Zwi (AZ); Dr Kim Spurway (KS); Jacqui Bonnitcho (JB); Nahid Sultana (NS)} by University NSW, Australia. The team have experience in undertaking systematic review on different issues in collaboration with Cochrane and EPPI-Centre as well conducting research on various issues ranging from public health (SH, NLH, AA), societal issues (AA, RM, SH), urban issues (AA, RI, SH, RM), humanitarian and disaster-related issues (AZ, KS, JB), global health initiatives in low and middle income settings (AZ, KS), and on equity and the social determinants of health (AZ, AA, SH). The team members also have experiences in undertaking systematic reviews, realist reviews (AZ, KS, JB) and conducting research on the research to policy and practice interface (AZ, KS). Additional help came from Nahid Sultana (NS) from UNSW and Iffat Nowrin (IN), Saraban Ether (SE) and Al Mamun (AM) from icddr,b during checking, screening and retrieving articles for the review.

The review was commissioned under the DFID Systematic Review Programme for South Asia, which was coordinated and managed by PricewaterhouseCoopers (PwC India). The review sought to synthesize and analyse evidence so as to inform the concern country authorities associated with disaster management and DFID country offices.

The review was registered with EPPI-Centre, a UK-based Centre which supports the conduct of systematic reviews, including those focused on low and middle-income countries. The team drew on advice from these sources, along with policy and practice insights from a Reference Group established to assist the Review.

The Reference Group comprised:

1. Dr. Mustaq Raja Chowdhury, Vice Chairperson, BRAC
2. Ms. Moira Reddick, Coordinator, Nepal Risk Reduction Consortium
3. Dr. Peter Kim Streatfield, Emeritus Scientist, Climate Change and Health Department, icddr,b
4. Dr. Md. Khalequzzaman, Assistant Professor, BSSMU
5. Mr. Mofizur Rahman, Research Investigator, icddr,b

APPENDIX 2: LIST OF INCLUDED STUDIES

Abdullah, K., Anukularmphai, A., Kawasaki, T., & Nepomuceno, D. (2015). A tale of three cities: water disaster policy responses in Bangkok, Kuala Lumpur and Metro Manila. *Water Policy*, 17(S1), 89-113.

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APPENDIX 3: TYPES OF INCLUDED STUDIES

SI No.	Reference No.			Location		Study Design	Method of data Collection	Study Participant/ Target Group
	Author	Year	Title	City	Country			
1	Abdullah et al., 2015,	2015,	Water disaster policy responses in Bangkok, Kuala Lumpur and Metro Manila	Bangkok, Thailand; Kuala Lumpur, Malaysia; Manila, Philippines		Descriptive	Secondary data review	All population
2	Ahmed et al., 2015,	2015,	Case study of flood risk management in Dhaka, Bangladesh	Dhaka, Bangladesh, Plain land, River bank		Document review	Literature review	All population
3	Bhat et al., 2013,	2013,	Addressing flooding in the city of Surat	Surat, India		Descriptive	Secondary (reports and literature review)	Slum dwellers and low-income populations residing in riverine areas
4	Birkmann and Fernando, 2008,	2008,	Measuring vulnerabilities of coastal communities to tsunami in Sri Lanka	Galle and Batticaloa, Sri Lanka, Coastal area		Descriptive	Secondary data (tsunami census data)	All population
5	Braun and Aßheuer, 2011,	2011,	Floods in megacity in Dhaka/Bangladesh	Dhaka, Bangladesh, Plain land, River bank		Descriptive	Survey and Qualitative interview	625 interviewed among 2000 household
6	Carcellar et al., 2011,	2011,	Addressing DRR through community-rooted interventions in the Philippines	Philippines, Coastal and volcano region		Document review and Qualitative	Secondary (reports and literature review; Community surveys began since 2000 for needs assessment, review of secondary data)	All population
7	Carpenter and Grünewald, 2015	2015	Disaster preparedness in a complex urban system	Kathmandu Valley, Nepal		Qualitative, Document review	Interview, Secondary (literature review)	All population
8	Chinnarasri, 2015,	2015,	An organisation for improving flood resilience in Thailand	Thailand		Descriptive	Document reviews, KII	All population
9	Dewan et al., 2012,	2012,	Urbanisation and environmental degradation in Dhaka, Bangladesh	Dhaka, Bangladesh, Plain land, River bank		Descriptive	Secondary data, Literature review	Poor population
10	Joerin et al., 2014,	2014,	The adoption of a Climate Disaster Resilience Index	Chennai, India, Coastal area and low land		Qualitative,	Observation, KII, Quantitative assessment with CDRI tool	All population
11	Jue et al., 2005,	2005,	Flood Risk Assessment and Emergency Management in China	9 Metropolises in Yangtze River Delta, Pearl River Delta, Mid-South of Liaoning Peninsula, Jilin-Helongjian, Central China, Chengdu-Chongqin		Descriptive	Secondary (reports and literature review)	All population

		and Mid-Yangtze River, 9 Metropolises in Yangtze River Delta, Pearl River Delta, Mid-South of Liaoning Peninsula, Jilin-Helongjian, Central China, Chengdu-Chongqin and Mid-Yangtze River			
12	Khan, 2008, Disaster preparedness for sustainable development in Bangladesh	Coastal and flood prone areas	Descriptive	Secondary data	All population
13	Malagoda, 2013, Disaster resilient built environment in urban cities of Sri Lanka	Batticaloa, Sri Lanka, Coastal area	Descriptive	Secondary data (literature review and a case study)	All population
14	Mulyani Sunarharum et al., 2014, Increasing flood resilience in Jakarta	Jakarta, Indonesia	Descriptive	GIS, Secondary (literature review)	All population
15	Parvej, 2012, New approaches for seismic hazard studies in the Indian subcontinent	Indian subcontinent	Descriptive	Secondary (literature review)	All population
16	Peleg, 2015, Is There a Better Way to Provide Search and Rescue?	Nepal	Descriptive	Secondary (reports and literature review)	All population
17	Razafindrabe et al., 2012, Flood risk and related impacts in central Vietnam	Ngu Hanh Son and Cam Le districts in Danang, Vietnam, Coastal area	Descriptive	Interviews, questionnaire surveys, FGD, stakeholder analysis, Direct observation using the transect method, and secondary data (literature review)	All population
18	Rumbach, 2014, Do new towns increase disaster risk, Kolkata, India?	Salt Lake, Kolkata, India, Plain land	Descriptive	Secondary data (reports and literature review), case study & survey data	All population
19	Ramachandraiah, 2011, Coping with Kurnool floods, India	Krunool, Andhra Pradesh, India, Coastal (by the side of the river Tungabhadra- a tributary to Krishna river)	Descriptive	Case study, FGD, Secondary data (reports and literature review)	All population

20	Sharma, 2001, Development strategies for flood prone areas, Patna, India	Patna, Bihar, India	Descriptive	(secondary data)	Slum population
21	Surjan and Shaw, 2009, Enhancing disaster resilience in Mumbai, India	Mumbai, India, Coastal area	Qualitative	Archive review and Informal discussion	All population
22	Sudmeier-Rieux et al., 2015, Opportunities, incentives and challenges to risk sensitive land use planning	Ho Chi Minh City, Can Tho of Vietnam; Dharan Municipality of Nepal; Ferrol of Spain, River bank, Mountainous	Qualitative and Document review	KII and Survey, Secondary data	All population
23	Sudmeier-Rieux et al., 2012. Floods, landslides, and adapting to climate change in Nepal:	Dharan, Nepal	Descriptive	Geological assessments, remote sensing, flood modeling, and a GIS database	Marginalized population
24	Teets, 2009, Post-Earthquake Relief and Reconstruction Efforts	Sichuan province , China	Qualitative, Document review	KII, Secondary (literature review)	All population
25	Tafti and Tomlinson, 2013, Post-disaster public policy responses in housing recovery	Bhuj, India, Costal, Seismic zone Bam, Iran, Mountainous, Seismic zone	Qualitative	Archive review, IDI, observations and survey	Tenants
26	Taylor, 2015, Comparing alternative approaches to reducing the vulnerability of riverbank communities	Solo, Strenkali, Indonesia	Qualitative	IDI, FGD, Literature review	River bank population
27	Theckethil, 2012, Earthquake rehabilitation and vulnerability reduction in Indian town	Bhuj, Gujarat state, India, Coastal and low land, high seismic zone V	Descriptive	Case study, IDI, Secondary data (reports and literature review)	All population
28	Thiruppugazh, 2008, Urban vulnerability reduction	Ahmedabad, India, Seismic zone	Qualitative	Case study (secondary data)	All population
29	Thomas, 2015, Post-disaster resettlement in Philippines	Tacloban, Philippines	Descriptive	Secondary data	All population
30	Yang et al., 2014, Comparison of two large earthquakes in China	Lushan and Wenchuan, China	Descriptive	Secondary data (report and literature review)	All population
31	You et al., 2009, How China responded to the May 2008 earthquake	Beichuan, China	Qualitative	Interviews and Secondary data (reports and literature review)	All population
32	Zope et al., 2015, Impacts of urbanisation on flooding of a coastal urban catchment	Mumbai, India, Coastal area	Descriptive	Secondary data (reports and literature review)	All population

APPENDIX 4: QUALITY ASSESSMENT OF STUDIES

The quality of the included studies was assessed using Hawker *et al.*'s tool, which covers the following domains: abstract and title; introduction and aims; methods and data; sampling; data analysis; ethics and bias; results; transferability or generalisability; implications and usefulness. We have adopted the tool from Appendix 5 of Lorenc, T *et al.* This tool contains nine questions, each of which can be answered in "good", "fair", "poor" and "very poor". Having applied the tool to the studies, we converted it into a numerical score by assigning the answers from 1 (very poor) to 4 (good) points. This produced a score for each study of a minimum of 9 and a maximum of 36 points. To create the overall quality grades we used the following definitions: high quality (A), 30-36 points; medium quality (B), 24-29 points; low quality (C), 9-24 points. We have modified scoring regards "low quality"; we set the points <24 instead of "9-24 points". The nine questions in the tool are as follows:

1. Abstract and title. Did they provide a clear description of the study?

Good: structured abstract with full information and clear title.

Fair: abstract with most of the information.

Poor: inadequate abstract.

Very poor: no abstract.

2. Introduction and aims. Was there a good background section and clear statement of the aims of the research?

Good: full but concise background to discuss/study containing up-to-date literature review and highlighting gaps in knowledge; clear statement of aim AND objectives including research questions.

Fair: some background and literature review; research questions outlined.

Poor: some background but no aim/objectives/questions OR aims/objectives but inadequate background.

Very poor: no mention of aims/objectives; no background or literature review.

3. Method and data. Is the method appropriate and clearly explained?

Good: method is appropriate and described clearly (e.g. questionnaires included); clear details of the data collection and recording.

Fair: method appropriate, description could be better; data described.

Poor: questionable whether method is appropriate; method described inadequately; little description of data.

Very poor: no mention of method AND/OR method inappropriate AND/OR no details of data.

4. Sampling. Was the sampling strategy appropriate to address the aims?
Good: details (age/gender/race/context) of who was studied and how they were recruited and why this group was targeted; the sample size was justified for the study; response rates shown and explained.
Fair: sample size justified; most information given but some missing.
Poor: sampling mentioned but few descriptive details.
Very poor: no details of sample.
5. Data analysis. Was the description of the data analysis sufficiently rigorous?
Good: clear description of how analysis was carried out; description of how themes derived/respondent validation or triangulation.
Fair: descriptive discussion of analysis.
Poor: minimal details about analysis.
Very poor: no discussion of analysis.
6. Ethics and bias. Have ethical issues been addressed and has necessary ethical approval been gained?
Has the relationship between researchers and participants been adequately considered?
Good: ethics: when necessary, issues of confidentiality, sensitivity and consent were addressed; bias: researcher was reflexive and/or aware of own bias.
Fair: lip service was paid to above (i.e. these issues were acknowledged).
Poor: brief mention of issues.
Very poor: no mention of issues.
7. Results. Is there a clear statement of the findings?
Good: findings explicit, easy to understand and in logical progression; tables, if present, are explained in text; results relate directly to aims; sufficient data are presented to support findings.
Fair: findings mentioned but more explanation could be given; data presented relate directly to results.
Poor: findings presented haphazardly, not explained and do not progress logically from results.
Very poor: findings not mentioned or do not relate to aims.
8. Transferability or generalisability. Are the findings of this study transferable (generalisable) to a wider population?
Good: context and setting of the study are described sufficiently to allow comparison with other contexts and settings, plus high score in Q4 (sampling).
Fair: some context and setting described but more needed to replicate or compare the study with others, plus fair score or higher in Q4.
Poor: minimal description of context/setting.
Very poor: no description of context/setting.

9. Implications and usefulness. How important are these findings to policy and practice?
- Good: contributes something new and/or different in terms of understanding/insight or perspective; suggests ideas for further research; suggests implications for policy and/or practice.
 - Fair: two of the above.
 - Poor: only one of the above.
 - Very poor: none of the above.

Quality Assessment of Studies: [Questions are answered as Met Criterion (Denoted by 1), Did Not Met Criterion (Denoted by 2) and Not Clear (Denoted 3)]

A.

Result of the quality assessment for the qualitative studies (n=35) (1=very poor, 2=Poor, 3=Fair, 4=Good) High quality=A (30-36), Medium quality =B (24-29), Low quality=C (<24)											
Study	abstract/ Title	Introduction/ aims	Method/ data collection	Sampling	Data analysis	Ethics/bias	Results	Generalisability	Implication	Total	Grade
Abdullah et al., 2015	2	2	2	1	2	1	4	3	3	20	Low quality
Ahmed et al., 2015	2	4	3	1	1	1	2	3	4	21	Low quality
Braun, B. and Aßheuer, T., 2011	3	3	2	2	1	1	4	3	3	22	Low quality
Bhat et al., 2013	2	2	1	1	1	1	2	3	3	16	Low quality
Birkmann and Fernando, 2008	3	3	3	4	2	1	4	3	3	26	Medium quality
Carcellar et al., 2011	2	2	1	1	1	1	1	3	2	14	Low quality
Carpenter, S. and Grünewald, F., 2015	3	3	3	1	1	1	4	3	3	22	Low quality
Chinnarasri, C. and Porkaew, K., 2015	3	3	2	1	2	1	2	2	3	19	Low quality
Dewan et al., 2012	2	4	1	1	1	1	3	3	3	19	Low quality
Joerin et al., 2014	3	4	4	1	3	1	3	2	2	23	Low quality
Jue et al., 2005	3	4	3	1	1	1	3	3	2	21	Low quality
Khan, 2008	3	3	1	1	1	1	4	3	2	19	Low quality
Malalgoda et al., 2013	4	4	3	1	1	4	4	2	3	26	Medium quality
Mulyani Sunarharum et al., 2014	4	2	2	1	1	1	3	2	2	18	Low quality

Parvez, 2013	2	3	3	3	3	1	3	1	2	21	Low quality
Peleg, 2015	1	1	1	1	1	1	1	2	3	12	Low quality
Ramachandraiah, 2011	3	1	2	1	1	1	4	3	3	19	Low quality
Razafindrabe et al., 2014	2	3	3	2	3	1	4	3	3	24	Medium quality
Rumbach, 2014	3	4	2	2	1	1	4	3	3	23	Low quality
Sharma and Priya, 2001	2	2	2	1	1	1	3	3	3	18	Low quality
Sudmeier-Rieux et al., 2012	3	3	4	1	1	1	3	2	2	20	Low quality
Sudmeier-Rieux et al., 2015	1	3	3	1	1	1	4	3	4	21	Low quality
Surjan and Shaw, 2009	3	2	2	1	1	1	2	3	2	17	Low quality
Tafti and Tomlinson, 2013	2	4	4	3	1	1	4	3	3	25	Medium quality
Taylor, 2015	3	4	3	3	1	1	3	3	3	24	Medium quality
Teets, 2009	2	2	2	1	1	1	3	2	2	16	Low quality
Theckethil, 2012	1	4	4	4	1	1	2	2	2	21	Low quality
Thiruppugazh, 2008	2	3	1	1	1	1	3	3	3	18	Low quality
Thomas, 2015	1	2	1	1	1	1	1	2	2	12	Low quality
Yang et al., 2014	3	2	1	1	1	1	3	4	3	19	Low quality
You et al., 2009	4	1	4	4	4	1	4	4	4	30	High Quality
Zope et al., 2015	2	4	3	1	1	1	3	3	3	21	Low quality

APPENDIX 5: LIST OF STUDIES FOR ADDRESSING RESEARCH QUESTION 2

Sl. No	Reference No.			Location		Disaster Type	Approaches
	Author	Year	Title	City	Country		
1.	Braun, B., & Aßheuer, T.	2011,	Floods in megacity in Dhaka/Bangladesh	Dhaka, Bangladesh, Plain land, River bank		Flood	<ul style="list-style-type: none"> • Community participation • Government initiative • NGO participation
2.	Birkmann and Fernando,	2008,	Measuring vulnerabilities of coastal communities to tsunami in Sri Lanka	Galle and Batticaloa, Sri Lanka, Coastal area		Tsunami	<ul style="list-style-type: none"> • Community participation • Government initiative to create “buffer zone” • Immediate response
3.	Carcellar et al.,	2011,	Addressing DRR through community-rooted interventions in the Philippines	Philippines, Coastal and volcano region		Landslide, Mudflow, Flood, Typhoon	<ul style="list-style-type: none"> • Community based intervention • Policy implementation
4.	Carpenter and Grünewald,	2015	Disaster preparedness in a complex urban system	Kathmandu Valley, Nepal		Earthquake	<ul style="list-style-type: none"> • Information needs
5.	Chinnarasri,	2015,	An organisation for improving flood resilience in Thailand	Thailand		Flood	<ul style="list-style-type: none"> • Policy implementation • Coordination among all level
6.	Dewan et al.,	2012,	Urbanisation and environmental degradation in Dhaka, Bangladesh	Dhaka, Bangladesh, Plain land, River bank		Flood	<ul style="list-style-type: none"> • Urban space development
7.	Joerin et al.,	2014,	The adoption of a Climate Disaster Resilience Index	Chennai, India, Coastal area and low land		Flood, Cyclone	<ul style="list-style-type: none"> • Policy implementation
8.	Khan,	2008,	Disaster preparedness for sustainable development in Bangladesh	Coastal and flood prone areas		Flood	<ul style="list-style-type: none"> • Community participation • Policy implementation
9.	Malagoda,	2013,	Disaster resilient built environment in urban cities of Sri Lanka	Batticaloa, Sri Lanka, Coastal area		Flood, Tsunami	<ul style="list-style-type: none"> • Urban space development • Coordination among all level
10.	Mulyani Sunarharum et al.,	2014,	Increasing flood resilience in Jakarta	Jakarta, Indonesia		Flood	<ul style="list-style-type: none"> • Policy implementation • Coordination among all level
11.	Peleg,	2015,	Is There a Better Way to Provide Search and Rescue?	Nepal		Earthquake	<ul style="list-style-type: none"> • Coordination among all level • Community training
12.	Ramachandraiah,	2011,	Coping with Kurnool floods, India	Krunool, Andhra Pradesh, India, Coastal (by the side of the river)		Flood	<ul style="list-style-type: none"> • Active engagement of civil society

		Tungabhadra-a tributary to Krishna river)		
13.	Rumbach, 2014, Do new towns increase disaster risk, Kolkata, India?	Salt Lake, Kolkata, India, Plain land	Flood	<ul style="list-style-type: none"> • Urban space development • Addressing inequity
14.	Sudmeier-Rieux et al., 2012, Floods, landslides, and adapting to climate change in Nepal:	Dharan, Nepal	Flood, Landslide	<ul style="list-style-type: none"> • Policy implementation
15.	Sudmeier-Rieux et al., 2015, Opportunities, incentives and challenges to risk sensitive land use planning	Ho Chi Minh City, Can Tho of Vietnam; Dharan Municipality of Nepal; Ferrol of Spain, River bank, Mountainous	Flood, Landslide, Earthquake	<ul style="list-style-type: none"> • Policy implementation • Active engagement of civil society
16.	Surjan and Shaw, 2009, Enhancing disaster resilience in Mumbai, India	Mumbai, India, Coastal area	Flood	<ul style="list-style-type: none"> • Policy implementation • Active engagement of civil society
17.	Tafti and Tomlinson, 2013, Post-disaster public policy responses in housing recovery	Bhuj, India, Coastal, Seismic zone Bam, Iran, Mountainous, Seismic zone	Earthquake	<ul style="list-style-type: none"> • Active engagement of civil society • Urban space development • Addressing inequity
18.	Taylor, 2015, Comparing alternative approaches to reducing the vulnerability of riverbank communities	Solo, Strenkali, Indonesia	Flood	<ul style="list-style-type: none"> • Active engagement of civil society • Addressing inequity • Policy implication
19.	Theckethil, 2012, Earthquake rehabilitation and vulnerability reduction in Indian town	Bhuj, Gujarat state, India, Coastal and low land, high seismic zone V	Earthquake	<ul style="list-style-type: none"> • Policy implication
20.	Yang et al., 2014, Comparison of two large earthquakes in China	Lushan and Wenchuan, China	Earthquake	<ul style="list-style-type: none"> • Policy implication • Immediate response • Coordination among all level
21.	You et al., 2009, How China responded to the May 2008 earthquake	Beichuan, China	Earthquake	<ul style="list-style-type: none"> • Coordination among all level • Policy implication • Community training

APPENDIX 6: SUMMARY OF HIGH AND MEDIUM QUALITY STUDIES

Study	Research Question or focus	Limitations identified by author
<p>Birkman n and Fernando , 2008</p> <p>Study funding</p> <p>United Nations Inter-Agency Secretariat of the International Strategy for Disaster Reduction/Platform for the Promotion of Early Warning (UN/ISDR -PPEW).</p> <p>Quality Rating</p> <p>Medium</p> <p>Location</p> <p>Batticaloa & Galle, Sri Lanka</p>	<p><i>This study was aimed to describe the revealed and emergent vulnerabilities of two tsunami affected coastal communities.</i></p> <p>Theoretical approach</p> <p>To understand the broad term “vulnerability”, a different conceptual framework has been developed to conceptualize and structure vulnerability.</p> <p>Sampling methods</p> <p>It was assessed that most indicator and assessment approaches failed to forecast the devastating 2004 tsunami and the vulnerability of coastal communities. Therefore, to measure the vulnerability, two affected coastal areas were selected purposively. Moreover, the selected two areas were bearing the major damages due to tsunami.</p> <p>Recruitment methods</p> <p>Areas were selected as they have similar characteristics such as both of them are tsunami affected and coastal areas.</p> <p>Sample demographics</p> <p>Batticaloa city was situated in Eastern Sri Lanka. Galle, the south-west city, was coastal area but not in the direct line of the tsunami.</p> <p>Data collection methods</p> <p>Primary data were collected through structured questionnaire. The questionnaire contained 73 questions with 610 possible answering criteria. Besides this survey, focus group discussion took place as well as in-depth interviews with 20 selected families.</p> <p>Analysis methods</p> <p>The data were analysed using Statistical package for Social Science (SPSS).</p> <p>Intervention/ measure approach</p> <ul style="list-style-type: none"> • <i>Action taken on the basis of local evidence can contribute to reducing disaster risk and vulnerability.</i> It was apparent based on damage analysis promotion of a 100 metre “buffer zone”. • <i>An effective early warning system in Galle made these differences.</i> In coastal and flood-prone areas, familiarisation with <i>past tsunami and education about tsunami</i> and other coastal hazards were identified as an important element in increasing awareness of threats to human life in order to minimise possible losses. <p>Study Findings</p> <p>Impact of Tsunami: A case study on Sri Lanka (Birkmann and Fernando, 2008), analysed the number of deaths due to tsunami in two different time periods. In 2011 tsunami at least 57 people were killed, around 193,700 were affected and at least 35 per cent of rice crops were destroyed. The 2004 tsunami showed to be a high impact event that caused the death of 35,000 people and displacement of 500,000 people. The estimation of economic loss was counted at US\$900 million worth of assets and infrastructure. This case study in Sri Lanka reported through household survey about the cause of deaths and missing by gender and age group due to tsunami in the coastal communities of Sri Lanka in 2006. The estimated fatality was significantly higher in female than male and elderly people (61 years and older) and young people (0-10 years) suffered the most fatalities. This result demonstrated that females failed to climb to the roofs shortly after the devastating wave happened.</p>	<p>The most vulnerable groups didn't get priority during early warning and evacuation.</p> <p>Limitation identified by reviewer</p> <p>During providing cash incentive for housing, households should be listed as priority basis based on basic income of the household head; that was not done in Galle and Batticaloa.</p>

<p>Study Malalgoda et al., 2013</p> <p>Study funding Not mentioned</p> <p>Quality Rating Medium</p> <p>Location Batticaloa Sri Lanka</p>	<p>Research Question or focus The purpose of this study was to find out the role of the Sri Lankan government and the challenges that the government faced in creating a disaster resilient built environment within Sri Lankan cities.</p> <p>Theoretical approach Not mentioned.</p> <p>Sampling methods To address the role and challenges of local government in Sri Lanka in terms of creating resilient built environment towards natural disaster, evidence was collected through literature review and a case study conducted in the Batticaloa city of Sri Lanka. Moreover, interviews were conducted among local and other government officials, policymakers, practitioners and academics who are engaged in disaster management and urban planning within the country to support the evidence gathered from reviewed literatures and case study.</p> <p>Disaster addressed Earthquake, flood, hurricane, tsunami</p> <p>Recruitment methods People involving with disaster management and planning were selected from different sectors of government and private as they have a significant role to play in disaster management.</p> <p>Sample demographics For the interview, selected participants were from various sectors and disciplines of governance (such as national, provincial and local), private sector, civil society, NGOs, community based organisations, research institutions and institutions of higher studies. Case studies have been selected as most appropriate strategy that enabled the researcher to understand the context.</p> <p>Data collection methods Research used both primary and secondary data. The data was provided by local and other government officials, policymakers, practitioners and academics who are engaged in disaster management and urban planning within the country. Moreover, data was collected through literature review and from a case study. Synthesis of the collected will develop knowledge on existing barriers that would help to explore good practice in the field of disaster management.</p> <p>Analysis methods Not mentioned</p> <p>Intervention/ measure approach Challenges should be considered in a holistic manner in order to make a disaster resilient city. Different committees and sub committees at different levels have been formed with the participation of the local community. Some of the initiatives included the formation of district, divisional and village level disaster management plans and committees, training and awareness programmes to community and school children. As per previous plan, a number of governmental organisations are in place for design, development and maintenance of the built environment within the Batticaloa municipal area. Hazard maps and disaster resilient planning and construction guidelines were available to ensure built assets and other support systems to continue functioning at times of extreme hazard events. The new</p>	<p>Limitations identified by author Lack of coordination, lack of defined specific responsibilities, overlapping of responsibilities, lack of monitoring</p> <p>Limitation identified by reviewer No policies were recommended to overcome the lacking of local government.</p>
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	<p>constructions were recommended to be away from high risk zone and are resilient to tsunamis, floods, cyclones and other hazards and would be able to withstand these conditions at a time of a hazard.</p> <p>Study Findings</p> <ul style="list-style-type: none"> • Urbanisation leads to environmental degradation because overconsumption of natural resources and over-exploitation of natural services leads to deforestation. • Inadequate plans and practices was responsible for severe destruction after Hurricane Katrina. <p>The role of local or municipal level government identified in the study:</p> <ul style="list-style-type: none"> • In building disaster resilient city, local government has a significant role to play in order to limit or reduce the adverse impacts of disasters. • Local knowledge and measures are required to cope with local hazards and vulnerabilities. • As the national disaster management authorities in most of the developing countries are centrally organised, they are unable to provide emergency support to rural population. • To enhance the resilience of disaster prone community, local people should be more aware about the vulnerability and risk management. <p>Challenges faced by the local government:</p> <ul style="list-style-type: none"> • The efforts of local government may fail due to having inadequate knowledge and capabilities in managing disasters. • The ability of disaster management can often be limited due to financial and human resource constraint. • Inadequate urban planning and lack of monitoring identified as the challenge of local government. • Proactive decision making process and preparedness related to disaster risk mitigation often being limited due to proper allocation of limited resources by the local government. 	
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<p>Study Razafindrabe et al., 2014</p> <p>Study funding Global COE (Centre of Excellence) Program “Global Eco-Risk Management from Asian Viewpoints” at Yokohama National University.</p> <p>Quality Rating Medium</p> <p>Location Danang city Vietnam</p>	<p>Research Question or focus This study aimed to enhance the resilience and adaptive capacity of a community towards the threat of flood by understanding the flood risks and their impact on the respective community.</p> <p>Theoretical approach A conventional risk management process was employed which considered social, physical, economic and institutional dimensions of resilience in order to grasp the extent of risks. This risk management process was based on the “Risk management framework”.</p> <p>Sampling methods Two districts and four wards (two wards in each district) were selected. Stratified random sampling was chosen which was based on topography (coastal and inland) and also on economic status.</p> <p>Recruitment methods Areas were selected as they were situated in coastal or inland area. Areas belonged to different economic status.</p> <p>Sample demographics Areas from different economic status were situated in coastal bank and inland.</p> <p>Data collection methods This study looked at flood risks from a different perspective based on secondary data analysis coupled with questionnaire survey and focus group discussions. Data collection method also included stakeholder analysis, direct observation using transect method and a literature review.</p> <p>Analysis methods Qualitative and quantitative data analysis was conducted using textual analysis and Statistical Package for Social Science (SPSS), respectively.</p> <p>Study Findings</p> <ul style="list-style-type: none"> • Typhoon and flood were very common in Vietnam due to tropical monsoon. • The study findings showed a significant relationship between perception of flood risks and education level of the household heads; there was found no significant difference in terms of this issue. • Greater resilience of built environment and infrastructure was found in Cam Le district. • Access to electricity as well as electric supply was found better in Cam Le district. Moreover, in the same area, highest score was found in terms of water supply, housing, land use and sanitation. • Existing policy geared towards integrated coastal zone management which aim was to developing Danang city, Vietnam. • Government was continuing with their efforts like raising awareness on disaster risk reduction, incorporating risk reduction into development planning or zoning schemes and establishment of flood control. <p>Discussion</p> <ul style="list-style-type: none"> • A long-term sustainable solution to recurrent flood disasters needs to be implemented. • To cope with flood disasters, assurance of sustainable livelihoods or maintaining income is one of the most important guarantees. 	<p>Limitations identified by author No assessment or mapping was done in terms of flood hazards owing to the lack of resources and scarcity of historical data.</p> <p>Limitation identified by reviewer Didn't specify the integrated management process of risk reduction.</p>
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<p>Study Tafti and Tomlinson, 2013</p> <p>Study funding University of Melbourne</p> <p>Quality Rating Medium</p> <p>Location Bhuj India</p>	<p>Research Question or focus This study aimed to examine the responses of affected tenants (by earthquake) towards the policies for housing recovery implied during post-earthquake period in the cities – Bhuj, India and Bam, Iran.</p> <p>Theoretical approach Examined the policies for housing recovery implemented by the government.</p> <p>Sampling methods To fulfil the research objective, people were selected to answer semi-structured questionnaire. Key informants from government officials were selected according to the similarities in the context, urban population, the nature of disaster and the role of public sector.</p> <p>Recruitment methods Participants were selected on the basis of similarity including the context, urban population, nature of disaster and the role of public sector.</p> <p>Sample demographics All participants were residing in urban areas in same location, experienced same kind of vulnerabilities due to earthquake.</p> <p>Data collection methods Research used both primary and secondary data. Data collection method included archival data from literature review, in-depth interviews, observation, onsite mapping and small-scale surveys. More than 95 semi-structured interviews were done with people- among which 60 interviews were in Bhuj, India. More than twenty interviews with key informants included policymakers, chief urban planners, city officials and real estate brokers.</p> <p>Analysis methods Not mentioned</p> <p>Intervention/ measure approach</p> <ul style="list-style-type: none"> • After the Bhuj earthquake in 2001, the government established a legal entity for quick decision making and policy formulation for reconstructing the affected areas. • For reconstruction of permanent houses, the previous house owners were provided financial and technical support to rebuild their houses. • NGOs were contracted out by the government to take part in building new houses for the tenants. Five NGOs built housing projects in other areas outside the old city, ten NGOs built 2497 housing units, both for tenants and homeowners, in a turn-key manner with no or partial financial contribution of their beneficiaries. • Caste-based and religious-based affiliations facilitated accessing the contribution of some of the operating NGOs. This policy offered a window of opportunity for tenants with higher financial or social assets to shift their tenure status to ownership. Three years after the earthquake, and under the pressure of local elites, the site has been officially declared as the fourth relocation site and a budget was dedicated for its development. <p>Study Findings</p> <ul style="list-style-type: none"> • Due to an earthquake (measuring 7.7 in Richter scale) in January 2001, a city with a population of around 130,000, approximately 7000 people, mostly inhabitants of the historic part of the city, died. • The government initiated to address the gap in knowledge about post disaster housing recovery of tenants. • Seven years after the earthquake, a new policy was formulated to address the housing recovery of those who could not prove their tenure status. The new policy adopted a more relaxed regulation for recognizing pre-earthquake tenants. These households were eligible to buy a plot of 50m2 and to receive Rs.1.4 lakhs (US\$ 3780) assistance for housing construction on the GIDC site. 	<p>Limitations identified by author Access to livelihood, infrastructure, quality health and education services and moreover, inadequacy of public transportation system was not considered while planning for new location for housing recovery. The policy did not provide housing recovery option for tenants with lower income.</p> <p>Limitation identified by reviewer The data analysis method was not mentioned in the study. Level of income of the tenants was not specified for receiving housing benefits. The policy for ownership of the recovered houses was not clearly mentioned.</p>
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<p>Study Taylor, 2015</p> <p>Study funding Not mentioned</p> <p>Quality Rating Medium</p> <p>Location Solo and Surabaya, Indonesia</p>	<p>Research Question or focus This study focused on the resettlement offer made by the local authority and other issues related with the resettlement.</p> <p>Sampling methods Two riverbank cities (Solo and Surabaya) were selected purposively where riverbank residents offered resettlement by the local government.</p> <p>Recruitment methods Government officials, community residents' civil society leaders and non-government organisation representatives were purposively selected for interview.</p> <p>Sample demographics Selected participants were from various sectors involved in resettlement process including riverbank residents.</p> <p>Data collection methods Interview or Focus Group Discussion (FGD) was conducted. Government documents, local regulations and newspaper articles were also considered for desk review.</p> <p>Intervention/ measure approach Resettlement of riverbank residents.</p> <p>Study Findings</p> <ul style="list-style-type: none"> • Resettlement initiative has been taken for riverbank residents to prevent further erosion; also to ensure the safety of residents. • Riverbank residents were reluctant regarding resettlement. Many of them were migrants and did not have a legal permit which made them more vulnerable. However, local government has taken initiative to include these migrants under a special program to ensure services for them as well. • In Solo, local government organised 24 separate meetings with community representatives to motivate them for resettlement. Both sides showed respect to each other and heard respective concerns. This community engagement approach strengthened local institutional networks. • In Solo, local government offered cash incentives and compensation to other necessary social services. • Riverbank tenants in Solo were not eligible for cash incentive. However, they received disaster aid. • Local Mayor in Solo was dynamic and took community engagement approach to ensure the resettlement plan. • Local community representative/ community group played important role to negotiate with the local government. • NGOs played key role to ensure resettlement process. <p>Discussion</p> <ul style="list-style-type: none"> • Leadership is important. Motivated and dynamic leader can handle the situation more effectively. • Community engagement plays important role to accomplish any plan. • Need to engage community representatives in disaster management to ensure proper implementation. • Need to think about poor and migrant people while initiating any policy. 	<p>Limitations identified by author Not mentioned</p> <p>Limitation identified by reviewer Analysis method of collected data was not described clearly.</p>
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<p>Study You et al., 2009</p> <p>Study funding Not mentioned</p> <p>Quality Rating High</p> <p>Location Sichuan province, China</p>	<p>Research Question or focus This research focused to describe the damage due to May 2008 earthquake in Sichuan province in China and also response and gap.</p> <p>Theoretical approach Evaluated response and gap to inform responses to similar disaster in future.</p> <p>Sampling methods Four towns were selected. The two most severely affected towns in terms of death and building damage were selected. Additionally, least affected area and another town were selected.</p> <p>Areas were selected as per the intensity of loss defined by the local government.</p> <p>Recruitment methods People involved with disaster management in county and town level from various organisation were selected.</p> <p>Sample demographics Selected participants were from various sectors involved in post earthquake management.</p> <p>Data collection methods Authors used survey, semi-structured questioner for data collection.</p> <p>Analysis methods 2 researchers independently grouped all similar responses from respondents under each broad theme. Consensus among 2 researchers about responses under each theme were made, any asked help from senior researcher and even went back to respective respondent as well.</p> <p>Intervention/ measure approach Three months “Emergency response and rescue period” declared by the Chinese government.</p> <p>Study Findings</p> <ul style="list-style-type: none"> • Respective personnel’s various government bodies were not well aware and trained on earthquake management. • Lack of coordination among different implementing bodies. • County government initiated search and rescue after earthquake and organised emergency free medical facilities as well as taken initiatives to ensure food. • Local medical personnel were not adequately trained in disaster emergency care. <p>Discussion</p> <ul style="list-style-type: none"> • Separate plan for earthquake management is necessary. • All related departments should formulate emergency plans and their staff, as well as general people, should be trained to minimize disaster risk. • Local government should be empowered and trained to take immediate action. • Effective multi-sectoral coordination is must. • Psychological/ moral support is necessary and counselling should take place for victims. Emergency workers should be trained to understand the psychological impact of disaster on individual and to give moral support to the victims. 	<p>Limitations identified by author Not mentioned</p> <p>Limitation identified by reviewer Sampling method for respondents was not clear and the total number of respondents was not mentioned.</p>
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Search strategy:

The search strategy targeted the major domains under conceptual framework. The domains included:

- i. Urbanisation
- ii. Natural disaster
- iii. Risk and risk reduction
- iv. Vulnerability

Searches constituted a mixture of keywords and index terms as appropriate with targeted databases. Searches were adopted based on this search strategy covering the domains of the review. Searches included the following fields: title, abstract, other abstract, MeSH, other index terms, but **NOT** place of publication. Searches were combined using Boolean operators whenever possible depending on the yields of the search and the functionality of each database.

1 Search: Population terms:

urbanicity OR urbanisation [tiab] OR urbanization [tw] OR "Urban Population/classification"[Majr] OR "Urban Population/organization and administration"[Majr] OR "Urban Population/statistics and numerical data"[Majr] OR "Urban Population/trends"[Majr] OR "Urbanisation [Mesh] OR urban* OR metropol* OR city OR town* OR "(local AND government) OR "local authority" OR "Vulnerable Populations/classification"[Mesh] OR "Vulnerable Populations/epidemiology"[Mesh] OR "Vulnerable Populations/statistics and numerical data"[Mesh]

AND

2 Search: Disaster or disaster related terms:

Search #: "natural disaster*" OR "environmental emergenc*" OR "natural hazard" OR avalanche* OR earthquake* OR fire* OR flood* OR landslide* OR tsunami* OR volcan* OR catastroph* OR cyclon*OR "tidal wave*" OR tsunami* OR "coastal hazard*" OR lahar OR blizzard OR hailstorm OR hail OR storm OR "heat wave" OR heatwave OR landslide OR hurricane OR typhoon OR tornado* OR wildfire OR "wild fire" OR "wildland fire" OR "bush fire" OR bushfire OR "extreme weather event" OR "Disasters/economics"[Majr] OR "Disasters/epidemiology"[Majr] OR "Disasters/mortality"[Majr] OR "Disasters/organization and administration"[Majr] OR "Disasters/prevention and control"[Majr] OR "Disasters/statistics and numerical data"[Majr] OR "Disasters/supply and distribution"[Majr] OR "Disasters/utilization"[Majr]

NOT ('toxic combustion' OR 'toxic incident' OR 'chemical incident' OR 'chemical fire' OR 'simulated disaster' OR 'chemical release' OR 'chemical spill' OR 'hazardous incident' OR 'environmental contamination' OR 'environmental disasters')

AND

Search 3 Vulnerability and impact related

Search: vulnerabilit* OR Injur* OR displace* OR refuge*OR homeless OR wounded OR wound* OR death* OR mortalit* OR casualit* OR killed OR died OR fatalit* OR poverty* OR “poverty reduction” OR microinsurance OR “micro-insurance” OR “safety net*” OR microfinance OR externalities OR “multiplier effect*” OR “opportunity cost” OR “cost benefit analysis” OR livelihood OR resilien* OR vulnerabl*

AND

4 Risks and risk reduction related:

Search: “disaster risk reduction” OR “risk reduction” OR “disaster risk management” OR “disaster preparedness” OR “disaster recovery”OR “disaster relief” OR “disaster mitigation” OR “disaster management” OR “disaster prevention” OR “disaster preparedness” OR “disaster planning” OR “disaster response” OR "Environmental Restoration and Remediation/adverse effects"[Majr] OR "Environmental Restoration and Remediation/classification"[Majr] OR "Environmental Restoration and Remediation/organization and administration"[Majr] OR "Environmental Restoration and Remediation/statistics and numerical data"[Majr]) OR “Hyogo Framework for Action” OR resilien* OR “risk planning” OR “risk analysis” OR “risk assessment” OR “risk management” OR “disaster resilience” OR “disaster loss*” OR “economic aspect*” OR “social risk management” OR “social vulnerability” OR capacity OR “coping capacity” OR “capacity development” OR “capacity building” OR “social protection” OR “indigenous coping” OR “traditional coping strateg*” OR “social capital” OR “indigenous knowledge” OR “local knowledge” OR “traditional knowledge” OR empowerment OR “public participation” OR “community planning” OR “local government” OR “local authority” OR “local leader*” OR municipalit* OR “village leader*” OR “local council” OR “town* council” OR “district council” OR “community-based disaster risk management” OR “community based disaster risk management” OR “community based disaster risk reduction” OR “community-based disaster risk reduction” OR "Risk Reduction Behavior/statistics and numerical data"[Majr]

We limited the search to only low and middle income countries as defined by World Bank recent list of 2016 of LMIC. We used the Cochrane/EPOC LMIC PubMed Filter and modified it accordingly. (Available at <http://epoc.cochrane.org/lmic-filters>, accessed on December 23, 2015).

APPENDIX 8: SEARCH SOURCES

BIBLIOGRAPHIC DATABASES

Health: Global Health, Medline, PsychINFO

Political/Sociological: PAIS, Scopus, ASSIA, British Humanities Index (BHI), Sociological Abstracts, Informit Humanities and Social Sciences and Health Collection

Environment: GEOBASE, CAB Abstracts, OARE, Collaboration for Environmental Science

Economics: Econlit

Disaster/ Development: IBSS: International Bibliography of the Social Sciences, IPSA (International Political Science Abstract),

QUAKELINE Database: <http://mceer.buffalo.edu/utilities/quakeline.asp>

SYSTEMATIC REVIEW DATABASES

3ie database of systematic reviews

Campbell Collaboration database

Collaboration for environmental evidence

EBM Reviews: Cochrane Database of Systematic Reviews

EPPI-Centre systematic reviews database

Johanna Briggs systematic reviews

KEY JOURNALS

African Journals Online: <http://www.ajol.info/>

Asia Journals Online: <http://www.asiajol.info/>

Health in Disasters and Natural Disasters, PLoS Disasters

Int. Journal of Disaster Risk Reduction, Disasters, Public

Journal of Disaster Risk Studies (South Africa)

Latin American Journals online: <http://www.lamjol.info/>

World Bank Economic Review

INTERNATIONAL ORGANISATION WEBSITES

African Development Bank

Asian Development Bank

British Library for Development Studies

Eldis

HRH Global Resource Center Secretariat of the Pacific Community

Inter-American Development Bank

International Committee of the Red Cross

International Federation of Red Cross and Red Crescent

Prevention Web (lists documents from a wide range of DRR/DRM, organisations)

World Bank (incl. GFDRR, Poverty Impact Evaluations Database)

CLEARING HOUSES & NETWORKS

Active Learning Network for Accountability and Performance in Humanitarian Action (ALNAP)

Asian Disaster Preparedness Center (ADPC)

Centre for Global Development (<http://www.cgdev.org/page/list-impact-evaluation-databases>)

Evidence and Lessons from Latin America (<http://ella.practicalaction.org/>)

EU

Institute of Development Studies

International Development Research Centre

(<http://publicwebsite.idrc.ca/EN/Pages/default.aspx>)

IRIN

OECD

Overseas Development Institute

Pacific Disaster Net

ProVention Consortium

Public Policy Pointers (<http://www.policypointers.org/>)

Relief Web

SOPAC

Bilateral Aid Agencies:

DFAT (formerly AusAID), DFID, USAID, JICA, SIDA, DANIDA, NORAD, CIDA, GIZ (previously GTZ)

United Nations:

WHO, UNEP, UNCRD, UNDP, UNFPA, UNISDR, UNICEF, UNESCAP, UNHABITAT, UNU, FAO, OCHA, IOM, IFAD, WMO

INGOs:

OXFAM, Plan, World Vision, Action Aid, Save the Children, Care, Caritas, IFRC, Concern Worldwide, Practical Action, HelpAge International, Cordaid, MercyCorps, Islamic Relief, Tearfund, International Alert

Other organisations:

Bangladesh Directorate of Disaster management (<http://www.ddm.gov.bd/>)

ACCRA – African Climate Change Resilience Alliance

CENESTA – Centre for Sustainable Development, Iran

CECI - Centre for International Studies and Cooperation

ICIMOD - The International Centre for Integrated Mountain Development

ICHARM – The International Centre for Water Hazard and Risk Management

IIED - The International Institute for Environment and Development

ISET - Institute for Social and Environmental Transition

IUCN - International Union for Conservation of Nature

APPENDIX 9: DATA EXTRACTION SHEETS FOR STAGE 1

Sl.	Categories	Sub-categories/Description
	Type of document (select one)	<ul style="list-style-type: none"> - Journal article - NGO report - World Bank report - Donor report - Independent research report - Master or doctoral thesis - Other [describe briefly]
	Region (select one)	Africa; East Asia & Pacific; Europe & Central Asia; Latin America & Caribbean; Middle East & North Africa; South Asia
	Country (select one or more)	Name or LMIC
	Discipline	Environmental Sciences, Health Sciences, Social Sciences, Economics, Natural Sciences, Urban Planning, Public Administration, Development Studies, other [describe briefly]
	Study type (select one)	<ul style="list-style-type: none"> -Theoretical/conceptual overviews (no outcomes). -Systematic reviews and general secondary data analysis -Descriptive studies -Theory-practice studies (e.g. a case study used to illustrate concepts) -Primary data collection which may include interviews, surveys, case studies, content analyses, that examine participants' behaviour, beliefs, perceptions, cognitive or affective processes concerning the program/intervention/practices studied) -Outcome evaluations (or Effectiveness Study or Intervention Study) (explicit outcomes) -Other/None of the above [describe briefly]
	Research design(select one)	<ul style="list-style-type: none"> - Qualitative - Quantitative - Mixed - Other - n/a
	Type of disaster addressed (select one or more)	Avalanche, earthquake, fire, flood, landslide, tsunami, volcanic eruption, typhoon, cyclone, tidal wave, tsunami, coastal hazard, lahar, blizzard, hailstorm, storm, heat wave, hurricane, tornado, wildfire/bushfire, mudflow, extreme weather event, natural disaster,

		environmental emergency, natural hazard, catastrophe, climate related hazard, various/multiple or other.
	Relation between urbanisation and disaster (select one or more)	<ul style="list-style-type: none"> - Intermediate processes - risk - vulnerability
	Specific urban population group (select one or more)	<ul style="list-style-type: none"> - Socioeconomic classes (Focused on poor/marginalised; All Groups of people with low socio-economic status) - Children (Young people under the age of 18 years of age) - Elderly (Older people over the age of 60 years of age) - Female - Male - Migrants - Slum Dwellers - Disabled People - Other (specify) (Please describe briefly in text box)

APPENDIX 10: DATA EXTRACTION SHEETS FOR STAGE 2

Study Identifiers			Urbanisation, disaster, risk of disaster			
Author	Year Published	Country	Type of urban development	Disaster type	Location	Participant characteristics
Name Author(s)	Year	LMIC name	Population growth, rural urban migration, water drainage, scope of earning, building code, slum population	e.g. Earthquake, Storms, floods (magnitude, frequency)	e.g. hilly, valley, low land, forest	e.g. ; socio-economic status (upper, middle, poor); female/male, ethnicity, disability, children/adults/elderly, stakeholders

Disaster risk management						
Intervention type	Policy type	Implementation year(s)	Intervention Aims	Type of approach	Outcomes	NOTES
e.g. community-based government, NGO, private sector, etc.	e.g. people centred, participatory, community based, multi-sectoral	e.g. 1980-1991	e.g. Reduce vulnerability, improve access to resources	e.g. training, awareness, advocacy, rehabilitation, health services, reconstruction	Disaster preparedness, health behaviour change, reduced hazard exposure, improved QOL	Category descriptors

APPENDIX 11: EXCLUSION CRITERIA FOR STAGE 1 AND STAGE 2

	EXCLUDE IF....	FOR STAGE 1: SCOPING REVIEW	FOR STAGE 2: INDEPTH REVIEW
Exclude on country	Not LMIC.	Exclude if not on World Bank List of low and middle-income countries. World Bank recent list of LMIC will be adopted.	Exclude if NOT LMICS in South & East Asia
Exclude on language	Language is not English.	Exclude if study titles and abstracts are not in English. However, hand searches of local journals in Bangla and Nepalese will be performed at least in Bangladesh and Nepal.	No change
Exclude on publication type	News article, editorial, comment, periodical, update, speech, book review, fiction, film, symposia, write	Exclude if study is news article, editorial, comment, periodical, update, speech, book review, fiction, film, symposia, write up of workshops.	No change
Exclude on publication date	Publication before 1 st January 1980.	Exclude all studies published prior to 1 st January 1980.	No change
Exclude on disaster type	Not natural disaster.	Exclude if any condition is not related to a natural disaster as identified by the author/s in title & abstract. Natural disasters include natural hazards, environmental emergencies, avalanche, earthquake, fire, flood, landslide, tsunami, tidal wave, volcano, catastrophe, cyclone, hurricane, typhoon, coastal hazard, lahar, blizzard, hailstorm, storm, tropical storm, heat wave, tornado, wildfire or bushfire. Rapid onset climate change hazards (like epidemic, medical conditions) and slow onset hazards (like famine, draught etc.) will be excluded .	No change
Exclude on study design type	No restrictions on study type.	No restrictions on study type	Exclude if studies reporting theoretical concept, technological /engineering /mathematical and concept modelling. (But information obtained from them can be utilized to

APPENDIX 12: DEFINITIONAL AND CONCEPTUAL ISSUES

Urbanisation: Urbanisation is the process by which large numbers of people become permanently concentrated in relatively small areas, forming cities (Gencer EA 2013, Klimeš and Escobar 2010). An urban area can be defined by one or more of the following: administrative criteria or political boundaries (e.g., area within the jurisdiction of a municipality or town committee), a threshold population size (where the minimum for an urban settlement is typically in the region of 2,000 people, although this varies globally between 200 and 50,000), population density, economic function (e.g., where a significant majority of the population is not primarily engaged in agriculture, or where there is surplus employment) or the presence of urban characteristics (e.g., paved streets, electric lighting, sewerage).

Hazard: A dangerous phenomenon, substance, human activity or condition that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage (UNISDR 2009).

Disaster: A serious disruption of the functioning of a community or a society involving widespread human, material, economic or environmental losses and impacts, which exceeds the ability of the affected community or society to cope using its own resources. Disasters are often described as a result of the combination of: the exposure to a hazard; the conditions of vulnerability that are present; and insufficient capacity or measures to reduce or cope with the potential negative consequences (UNISDR 2009).

Natural disaster: A natural disaster is a major adverse event resulting from natural processes of the Earth; examples include floods, volcanic eruptions, earthquakes, tsunamis, and other geologic processes. A natural disaster can cause loss of life or property damage, and typically leaves some economic damage in its wake, the severity of which depends on the affected population's resilience, or ability to recover. An adverse event will not rise to the level of a disaster if it occurs in an area without vulnerable population (UNISDR 2009).

Disaster risk: Disaster risk is the 'potential disaster losses, in lives, health status, livelihoods, assets and services, which could occur to a particular community or a society over some specified future time period' (UNISDR 2009).

Disaster risk management: Disaster risk management aims to avoid, lessen or transfer the adverse effects of hazards through activities and measures for prevention, mitigation and preparedness (UNISDR 2009). This is a systematic process of using administrative directives, organisations and operational skills and capacities to implement strategies and policies (UNISDR 2009).

Disaster risk reduction: The concept and practice of reducing disaster risks are systematic efforts to analyse and manage the causal factors of disasters. The efforts include accumulating the proper management of land with improved environment and develop preparedness for managing adverse events, due to disaster. Hence, lessening the vulnerability of people to the exposure of disaster (UNISDR 2009).

Exposure: People, property, systems, or other elements present in hazard zones that are thereby subject to potential losses. Measures of exposure can include the number of people or types of assets in an area (UNISDR 2009).

Preparedness: The knowledge and capacities developed by governments, professional response and recovery organisations, communities and individuals for anticipation of a hazard event and response to the event, thus achieving the recovery from the impacts of hazard event (UNISDR 2009).

Resilience: 'The ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions' (UNISDR 2009).

Risk assessment: Risk assessment is defined as a methodology to determine the nature and extent of risk by analysing potential hazards and evaluating existing conditions of vulnerability that together could potentially harm exposed people, property, services, livelihoods and the environment (UNISDR 2009).

Socio-natural hazard: The phenomenon of increased occurrence of certain geophysical and hydro meteorological hazard events, such as landslides, flooding, land subsidence, chemical pollution, extreme heat and cold, drought etc. These hazards are consequences of human activity that goes beyond their natural probabilities.

Building code: A set of ordinances or regulations and associated standards intended to control aspects of the design, construction, materials, alteration and occupancy of structures that are necessary to ensure human safety and welfare, including resistance to collapse and damage (UNISDR 2009).

Vulnerability: Vulnerability to disaster depends on the level and nature of individual and societal resources, capacity and coping mechanisms. Vulnerability differentiates between one group and another, such as age, gender, ethnicity and mobility. The extent of vulnerability also depends on the frequency and intensity of natural hazards.

APPENDIX 13: NATURAL DISASTERS AND SEQUEL OF EVENTS

Primary Hazard	Secondary Hazards
Severe storms	Floods, tornadoes, landslides
Extreme summer weather	Wildfires
Tornadoes	Toxic chemical or radiological materials releases
Hurricane wind	Toxic chemical or radiological materials releases
Wild fires	Landslides (on hillsides in later rains)
Floods	Toxic chemical or radiological materials releases
Storm surges	Toxic chemical or radiological materials releases
Tsunamis	Toxic chemical or radiological materials releases
Volcanic eruptions	Floods, wildfires, tsunamis, hazardous materials release
Earthquakes	Fires, floods (dam failures), tsunami, landslides, toxic chemical or radiological materials releases
Landslides	Tsunami

APPENDIX 14: SUMMARY KEY THEMES – NEPAL (CONTEXTUALIZATION)

Education – 8 out of 10 articles

Aryal – Disaster vulnerability in Nepal (training/education of locals in preparing for disasters)

Bhakta et al. – Urban ritual events and coping with disaster risk (understanding of rituals and local knowledge and the role they can play in disaster management by policymakers)

Chaulagain et al. – Seismic risk assessment and hazard mapping in Nepal (adequate education and understanding of seismic risk in order to use appropriate building materials in construction)

Dewan – Societal impacts and vulnerability to floods in Bangladesh & Nepal (understanding/education of local knowledge in policy making in order to be adequately prepared for floods)

Jones et al. – Local level governance of risk and resilience in Nepal (role of education in individual participation in RRC groups)

Peleg – Notes from Nepal – Is there a better way to provide SAR (need to train locals, especially in rural areas) in first aid skills and search and rescue as it is not feasible to rely on USAR)?

Sudmeier et al. – Floods landslides & adaptation to climate change in Nepal (greater efforts need to be made to educate locals on climate change and disaster knowledge)

Thakur & Saito – Post earthquake quick damage inspection of buildings in Nepal (the need for a widespread and uniform method of assessing the structural integrity of buildings in urban areas in the wake of natural disasters (focusing on a government funded education of specific individuals to carry out this job).

Preparedness – 7 out of 10 articles

Aryal – Disaster vulnerability in Nepal (case studies used to reflect the detrimental effect of a lack of preparedness for disasters)

Aryal – The history of disaster incidents and impacts in Nepal 1900 – 2005 (understanding history and impacts of disasters in Nepal to better prepare for future disasters)

Carpenter & Grunewald – Disaster preparedness in a complex urban system (factors specific to Nepal's urban settings that would contribute to a preparedness to disasters)

Chaulagain et al – Seismic risk assessment and hazard mapping in Nepal (the need to adequately understand seismic risk in specific regions in regards to choice of building materials and subsequent structural integrity)

Dewan – Societal impacts and vulnerability to floods in Bangladesh and Nepal (integration of local knowledge and outside support to heighten preparedness for floods in Nepal and Bangladesh)

Peleg – Notes from Nepal – Is there a better way to provide SAR (the need to train locals in SAR, allow communities to have adequate training to help in the aftermath of a disaster)?

Thakur & Saito – Post earthquake quick damage inspection of buildings in Nepal (training and framework to adequately assess the integrity of buildings prior and post-earthquakes)

Governance – 5 out of 10 articles

Aryal – Disaster vulnerability in Nepal (lack of government support in relieving vulnerability)

Carpenter & Grunewald – Disaster preparedness in a complex urban system (looks at how urban development is driving risk, and what governments and agencies should be doing to address the issue)

Dewan – Societal impacts and vulnerability to floods in Bangladesh & Nepal (the need for heightened support from the government to relieve vulnerability)

Jones et al. – Local level governance of risk and resilience in Nepal (community based disaster risk reduction methods need to be embedded in local government structures to be effective)

Peleg – Notes from Nepal – Is there a better way to provide SAR (need for the government to fund the training of locals (especially in rural areas) in first aid skills and search and rescue)?

Community – 4 out of 10 articles

Aryal – Disaster vulnerability in Nepal (increased sense of community amongst displaced communities to facilitate local knowledge sharing)

Bhakta et al. – Urban ritual events and coping with disaster risk (role of ritual/religion in building community and subsequent resilience)

Jones et al. – Local level governance of risk and resilience in Nepal (the need for bottom-up disaster policies and increased community involvement)

Peleg – Notes from Nepal – Is there a better way to provide SAR (SAR provided by community members)?

Local knowledge – 3 out of 10 articles

Aryal – Disaster vulnerability in Nepal (the importance of local knowledge being passed to displaced individuals to reduce vulnerability)

Bhakta et al. – Urban ritual events and coping with disaster risk (local knowledge gained from rituals and religious events in heightening individual resilience and lowering vulnerability through access to support and resources)

Dewan – Societal impacts and vulnerability to floods in Bangladesh & Nepal (importance of local knowledge integrated with outside support in coping effectively during floods)

APPENDIX 15: NEPAL FRAMEWORK ANALYSIS – STUDY TYPE, DESIGN, DISCIPLINE & DRR-URBANISATION

Author/Title	Type of document	Discipline	Study type	Research design	Type of disaster addressed	Relation between urbanisation and disaster	Specific urban population group
Aryal – Disaster vulnerability in Nepal	Journal article	Development studies	Primary data collection (case studies)	Qualitative	Floods, landslides	Vulnerability (of those young/elderly /poor left in rural areas)	Socioeconomic classes
Aryal – The history of disaster incidents and impacts in Nepal 1900 – 2005	Journal article	Development studies	General secondary data analysis	Mixed	Storms, floods, landslides, fires	Risk	Residents of mountain, Hill and Terai
Bhakta et al. – Urban ritual events and coping with disaster risk	Independent research report	Sociology	Primary data collection (interviews) and conceptual overviews	Qualitative	Earthquake	Vulnerability	Residents of Lalitpur City
Carpenter & Grunewald – Disaster preparedness in a complex urban system	Journal article	Development studies	General secondary data analysis and primary data collection (interviews)	Qualitative	Earthquake	Risk	Residents of the Kathmandu Valley
Chaulagain et al. – Seismic risk assessment and hazard mapping in Nepal	Journal article	Environmental sciences	General secondary data analysis and exploratory quantitative analysis	Quantitative	Earthquake	Risk	Residents of Nepal
Dewan – Societal impacts and vulnerability to floods in Bangladesh & Nepal	Journal article	Development studies	General secondary data analysis	Qualitative	Floods	Vulnerability	Residents of Nepal and Bangladesh
Jones et al. – Local level governance of risk and resilience in Nepal	Independent research report	Development studies	Primary data collection (interviews)	Qualitative	Disasters in general	Risk	Residents of Dhankuta and Panchkhal
Peleg – Notes from Nepal – Is there a better way to provide SAR	Journal article	Health sciences	Conceptual overview	Qualitative	Earthquakes	Vulnerability	Nepal residents
Sudmeier et al. – Floods landslides & adaptation to climate change in Nepal	Book chapter	Environmental studies/humanities	Primary data collection (case study) and conceptual overview	Qualitative	Droughts, floods, landslides	Risk	Nepal residents
Thakur & Saito – Post earthquake quick damage inspection of buildings in Nepal	Independent research report	Urban planning/development studies	Procedural proposal	Mixed	Earthquake	Risk	Nepal residents

APPENDIX 16 NEPAL FRAMEWORK ANALYSIS – KEY EMERGING THEMES

AUTHOR/TITLE	EDUCATION	LOCAL KNOWLEDGE	GOVERNMENT	COMMUNITY	PREPAREDNESS
Aryal – Disaster vulnerability in Nepal	Training/education of locals in preparing for disasters	The importance of local knowledge being passed to displaced individuals to reduce vulnerability	Lack of government support in relieving vulnerability	Increased sense of community amongst displaced communities to facilitate local knowledge sharing	Case studies used to reflect the detrimental effect of a lack of preparedness for disasters
Aryal – The history of disaster incidents and impacts in Nepal 1900 – 2005					Understanding history and impacts of disasters in Nepal to better prepare for future disasters
Bhakta et al. – Urban ritual events and coping with disaster risk	Understanding of rituals and local knowledge and the role they can play in disaster management by policymakers	Local knowledge gained from rituals and religious events in heightening individual resilience and lowering vulnerability through access to support and resources		Role of ritual/religion in building community and subsequent resilience	
Carpenter & Grunewald – Disaster preparedness in a complex urban system			Looks at how urban development is driving risk, and what governments and agencies should be doing to address the issue		Factors specific to Nepal’s urban settings that would contribute to a preparedness to disasters
Chaulagain et al. – Seismic risk assessment and hazard mapping in Nepal	Adequate education and understanding of seismic risk in order to use appropriate building materials in construction				The need to adequately understand seismic risk in specific regions in regards to choice of building materials and subsequent structural integrity
Dewan – Societal impacts and vulnerability to floods in Bangladesh & Nepal	Understanding/education of local knowledge in policy making in order to be adequately prepared for floods	Importance of local knowledge integrated with outside support in coping effectively during floods	The need for heightened support from the government to relieve vulnerability		Integration of local knowledge and outside support to heighten preparedness for floods in Nepal and Bangladesh
Jones et al. – Local level governance of risk and resilience in Nepal	Role of education in individual participation in RRC groups		Community based disaster risk reduction methods need to be embedded in local government structures to be effective	The need for bottom-up disaster policies and increased community involvement	

Peleg – Notes from Nepal – Is there a better way to provide SAR	Need to train locals (especially in rural areas) in first aid skills and search and rescue as it is not feasible to rely on USAR		Need for the government to fund the training of locals (especially in rural areas) in first aid skills and search and rescue	SAR provided by community members	The need to train locals in SAR, allow communities to have adequate training to help in the aftermath of a disaster
Sudmeier et al – Floods landslides & adaptation to climate change in Nepal	Greater efforts need to be made to educate locals on climate change and disaster knowledge				
Thakur & Saito – Post earthquake quick damage inspection of buildings in Nepal	The need for a widespread and uniform method of assessing the structural integrity of buildings in urban areas in the wake of natural disasters (focusing on a government funded education of specific individuals to carry out this job)				Training and framework to adequately assess the integrity of buildings prior and post earthquakes

APPENDIX 17: EXECUTIVE SUMMARY OF SCOPING REVIEW

In recent decades the rate and extent of urbanisation has increased and these changes have been strongly reflected in low and middle income countries, particularly from South and East Asia. Most of the time this growth remains unplanned and has made the urban population vulnerable to natural disasters. In addition, vulnerability is aggravated by other risk factors among poor urban populations that include poverty, inadequate nutrition, illiteracy, and poor water and sanitation.

This review aimed to answer the questions:

- i. What is the impact of urbanisation on risk of, and vulnerability to, natural disasters?
- ii. What are the effective approaches for reducing exposure of urban population to disaster risks?

The aim was to better understand unanswered questions about the complex relationship between urbanisation, natural disaster, risk and vulnerability. The project approach was founded on the concept that risk arises out of the interface of the four intersecting domains of urbanisation, natural disaster, vulnerability and risk reduction. Approaches that attempt to modify or mitigate the exposure of urban populations to disaster risk will vary across all four domains (see conceptual frame work and theory of change in page no 15 and 44 respectively).

This was a 2 stage review: stage 1 mapped out the extent and dispersion of literature on these issues and based on these findings stage 2 review is planned to look more in depth and analyse the interrelation of the urbanisation and natural disaster and the interventions / approaches that influence changes.

In stage 1 scoping review the target **population** was the urban and peri-urban population from low and middle income countries, **all types of natural disaster** were considered, any programme and **intervention** implemented by governments, NGOs, international organisations or donor agencies were included. The review included any type of **comparison** reported and the major outcomes considered were “Risk of” and “vulnerability to” natural disasters. However, the search included many other attributes of them like “resilience”, “preparedness”, “disaster planning”, risk assessment, etc.

The stage 1 review showed that the number and extent of literature was from LMICs in **South and East Asia**. Certainly the impact of large scale natural disasters will have a high impact on populations living in such cities where both population growth and densities are higher than other similar cities in other parts of the world as also supported from this scoping review. There was also abundant literature on **risk and vulnerability to disasters** describing the wide range of variables that determine the risk and vulnerability within specific urban settings. Most studies covered the **population** as a whole, with only a few studies investigating particular social group such as women, children or elderly populations. About 67% of the publications were about three major natural hazards: **flood, earthquake and tsunami** in these regions. Apart from population growth, climate change was studied in relationship to exacerbating natural disasters in LMICs. These studies describe the magnitude of flood and thermal extremes as a result of shifts in climatic conditions. The LMICs of the South Asian and

East Asian coastal regions have recorded unprecedented growth both in population and economies. It is predicted that the number of people living in the low-elevation coastal zones as well as the number of people exposed to flooding from 1-in-100 year storm surge events, is highest in Asian countries such as China, India, Bangladesh, Indonesia and Vietnam.

The Stage 2 review will be based on the outputs of Stage 1 (scoping review) and will synthesize evidence of the relationships between variables of interest (risk and vulnerability), including the analysis of outcomes and impact of interventions. This will assist in documenting the range of risk mitigation interventions that have been evaluated or described and will contribute to deriving lessons concerning their applicability to different contexts, especially those in South Asia and East Asia. The PICO approach will not change from the stage 1, and **in stage 2 we will focus on all disaster types in South and East Asia LMIC countries. The review** will not exclude any **particular disciplinary or methodological approaches**. We intend to examine in detail all studies with clear intervention, outcome and impact data. The stage 2 review will draw on the literature identified in the mapping stage but will examine a subset of relevant materials in more depth. Therefore, the stage 2 review will aim to assess the depth of disaster impact and its relation to urbanisation and related risk, vulnerability and resilience among these identified intervention, approach and policy related studies.

Framework analysis will initially be undertaken to describe in more detail the thematic and sub-thematic issues of interest. Analysis will be data driven, interrogating the type and strength of association between disasters, urbanisation and the outcomes of interest. We will also evaluate the quality of studies, the range of outcomes and impacts and what influences them; the strength of evidence; similarity or dissimilarity of outcomes in relation to context. In addition, the stage 2 review will be aim to effectively disseminate the review findings in keeping with current best practices. We will consider a range of questions, in relation to contextualizing of the findings of the review on the drafted theory of change over time, and will focus more attention on identifying the key contextual factors of interest, with particular emphasis on Nepal and Bangladesh. We will draw out key implications and findings, especially those of likely relevance to policymakers and future implementation, and will also consider these in relation to a context analysis.

FINDINGS FROM THE SCOPING EXERCISE

The scoping review found a rich body of literature with a strong East and South Asian focus. The literature has a substantive set of studies covering the environmental sciences as well as the social and natural sciences. The studies used a variety of methods and were primarily empirical in nature. The literature also investigated the consequences of disasters of importance to the field of disaster risk management and reduction such as resilience, risk, coping capacity and vulnerabilities.

There is a substantial body of literature focusing on the regions of East Asia (n=105) and South Asia (n=87), followed by the Caribbean and Latin America. The East Asian body of literature is composed predominantly of Chinese studies (n=53). South Asian literature is rich with documentation from India (n=40) and Bangladesh (n=23).

The literature demonstrated a broad interdisciplinary approach to understanding and investigating urbanisation and disasters. There are a wide range of studies covering environmental science and related subjects (n=157), followed by the social sciences (n=117), urban planning (n=41) and the natural sciences (n=38).

The studies that have been reviewed used a wide variety of methodologies including quantitative, qualitative and mixed methods. Among the design of studies, quantitative methods (n=166) were used to a much greater extent than qualitative (n=59) or mixed methods approaches (n=57). A sizeable proportion of the studies collected primary data (n=124).

The review found a large body of literature focused on risk (n=208) and vulnerability to disasters (n=178) describing the wide range of variables in specific urban settings that influence these outcomes (risk and vulnerability). Descriptions of resilience referenced coping capacities in terms of social, institutional and informational resources (Brecht et al., 2013).

In terms of vulnerability mapping, the review found a set of articles using GIS based mapping and modelling (Apa et al., 2012; Armaş, 2012; Aryal, 2012; Aryal, 2014; Yong et al., 2001), mathematical modelling (Brata et al., 2014; Chardon, 1999) and occasionally demographic modelling specifically in relation to elderly people (Ardalan et al., 2010; Ardalan et al., 2011; Chan and Griffiths, 2009). Social vulnerability was also modelled in some studies in terms of economic loss and areas of habitation (Apa et al., 2012; Chardon, 1999; Zhang and You, 2014; Zhou et al., 2014a; Zhou et al., 2014b).

The literature also included a set of studies on seismic risk assessments (Chaulagain et al., 2015; Parvez, 2013; Yousefi and Taghikhany, 2014; Zobin and Ventura-Ramírez, 2004) and studies that tested the use of other tools such as the Urban Risk Assessment tool (URA) or mathematical models (Brody et al., 2013; Brody et al., 2015; Browning and Thomas, 2016; Budiyo et al., 2015). Another observation was that the literature tended to group around one specific extreme event (ASIA Tsunami 2007-08), geographic location (e.g. Pearl River floods in China) or urban area (e.g. Shanghai or Kathmandu) (Chan et al., 2012; Chan et al., 2013a; Chan et al., 2013b).

The impact of disasters in urban areas was assessed mostly in terms of economic loss (Bibbee et al., 2000; Zoleta-Nantes, 2003), physical damage (Bono and Gutierrez, 2011; Bulut et al., 2005; Chen and Yang, 2014; Shi and Cui, 2012; Yilmaz, 2004) or health hazards (Cerdá et al., 2013; Cheng et al., 2013; Chinnarasri and Porkaew, 2015).

There were several resilience-related studies that described how urban communities coped with disaster (Braun and Aßheuer, 2011; Carlin et al., 2014; Schaer, 2015). studies with a resilience focus also presented theoretical case studies and modelling including the use of DRM guidelines (Caddis et al., 2012), locating cities on floodplains (Chang et al., 2007; Chatterjee, 2010) and community based approaches (Shakib et al., 2011; Siebeneck et al., 2015; Zaré and Nazmazar, 2013; Zhang, 2012).

In our search we did not find any experimental or quasi experimental designs among the studies. We identified very few interventions that explicitly set out to assess impact and

outcomes of DRM programmes or initiatives. When impact was assessed, it was based on surveys or secondary data to compare conditions before and after the disaster. Intervention studies looked at the feasibility and applicability of early warning systems in specific types of disaster (Stankiewicz et al., 2013; Ye et al., 2012; Yin et al., 2010), used mathematical modelling and its application as a case study (Cheng et al., 2012) or further analysed the effectiveness of the political regime and public-private partnerships (Shankland and Chambote, 2011).

The literature was comprised mostly of peer reviewed journal articles with limited reach to a broader audience in particular policymakers or practitioners. However, it is evident that the impact of natural disasters on urban populations has been studied across a diverse set of disciplines and approaches. Even so, urbanisation's impact and relationship with disaster is still an emerging field and worthy of more in-depth investigation.

APPROACH FOR SCOPING EXERCISE AND STAGE 2 PROTOCOL

The purpose of this review was to explore and understand the complex relationships between three main domains: urbanisation, natural disasters and vulnerability. The review adopted a mixed systematic review process and was conducted in two stages. Stage 1 was composed of a scoping review which mapped the nature and extent of the available literature and evidence addressing the research questions. The review's search strategy targeted a wide range of literatures from diverse disciplinary perspectives as well as grey literature from key agency websites. The review systematically searched for and identified relevant literature using a set of key search terms. Search outputs were managed using EndNote (version 5) software. All duplicate records were identified and excluded. Endnote libraries were then imported into EPPI-Centre's online review software, EPPI-Reviewer 4.0 (Thomas et al., 2010). EPPI-Reviewer was used to organise and manage the screening and review, using agreed checklists and templates, and to structure and record all review processes and analyses. The initial scoping review has identified important clusters of literature that warrant deeper analysis within the proposed Stage 2 review. This in-depth analysis will explore further the relationships and interactions among the four domains of urbanisation, natural disaster, vulnerability and resilience. The focus of Stage 2 will be a purposively selected subset of literature identified in Stage 1 that potentially can provide information on best practices and effective approaches for disaster risk reduction in urban areas, particularly in the context of Bangladesh and Nepal.

APPENDIX 18: RISK AND VULNERABILITIES TO NATURAL DISASTER

Author, Year and Country	Type of disaster	Risk and vulnerabilities to Natural disaster			
		Infrastructural hampers (Death/ loss of Properties/ livestock/ land/ houses)	Economic	Social	Health (Physical and mental)
Abdullah et al., 2015 Bangkok, Thailand; Manila, Philippines, Kualalumpur, Malaysia	Flood, storm and flash flood, typhoon	Bangkok: Confirmed death 693 and missing 3. 4,086,138 households, 12.61 million hectares of farm land and 9,859 manufacturing plants affected. Manila: Death 1,146 with 834 missing. 170,000+ people moved to evacuation centres. Kuala Lumpur: N/A	Bangkok: 1.4 trillion baht. Manila: US\$ 1.04 billion.	N/A	N/A
Ahmed et al., 2015 Dhaka, Bangladesh	Flood	Roads destroyed and communication system hampered. Death of domestic animals, submerging of cultivable lands. About 50 million people affected and 1,600 died in 1988 flood. Whole country remained under water for 65 days in 1998 flood. Flood 2004 affected 36 million people and caused 800 deaths. In 2007, 649 deaths, destruction of 85,000+ houses took place.	Increase poverty and food insecurity.	Communication gaps increased between relatives and neighbours.	Outbreak of waterborne diseases. People suffered from Post disaster trauma.
Braun and Aßheuer, 2011 Dhaka, Bangladesh	Flood	Houses go under water and people leave their houses for safer shelter. 70% households lost their valuables during flood. Roads submerged with water and communication and transportation system disrupts. Height of the water level causes flooding of the water supply (tube wells or water pipes) that results in contaminations of drinking water.	Because of waterborne disease, submerging of working place and inability to reach at working place hinders income generating activities for people and results economic hardship. People couldn't buy food and medicine as they didn't have savings or food storage.	N/A	Waterborne disease was common but people have limited scope to access medicine and health service. At least one family

			74% households lost their all savings.		member among 57% of households got severely sick during flood. Nutrition cutback was common as 90% household forced to eat less than normal time.
Bhat et al., 2013 Surat, India	Flood, coastal storms, cyclones	In 2006, around 150 people were officially estimated as dead, unofficial estimates suggest death toll was more than 500. Industrial losses, loss to the dam, flood embankments, electricity and telephone lines destroyed.	Industrial losses totalled 160 billion rupees (around US\$ 3.5 billion), loss to the dam, flood embankments, electricity and telephone lines damage totalled 25 billion rupees (US\$ 544 million). Slum dwellers and low income populations residing in riverine areas, new migrants faced greater difficulties due to disruption to their earnings.	N/A	N/A
Carcellar et al., 2011 Philippines	Landslide mudflow, Flash flood, fire and typhoon	Roads and communication disruptions. 362 deaths and thousands missing in 2006 and 2007 disasters in Lyete and Bicol region. 500 deaths and 261,335 morbidities in Iloilo city and 529 morbidities and hundreds homeless in 2009 in Metro Manila	38 billion Php (US \$ 38 million) in total damage	N/A	N/A

Carpenter and Grünewald, 2015 Kathmandu Valley, Nepal	Earthquake	8,850 lives lost Housing / lives / infrastructure/ communication hampered.	N/A	N/A	Death
Chinnarasri and Porkaew, 2015 Thailand	Flood	N/A	Broad, negative impact on all sectors of Thailand's economy, including the agricultural and industrial sectors, and on property and public life, costing about \$40 billion.	N/A	N/A
Dewan et al., 2012 Dhaka, Bangladesh	Flood	Housing, Communication, Health hampered. 40% - 50% city areas covered with flood, loss of vegetation 38%, agricultural land 55%, wetlands 47%, water bodies 29% Water sanitation problem, solid waste disposal are major problems for slum dwellers during flood.	N/A	N/A	Outbreak of waterborne diseases
Huong and Pathirana, 2013 Can Tho city, Vietnam	Flood	Cantho stands beside Mekong river delta and the rapid increase of population/densities, poor living conditions and poor quality of infrastructure cause the city's vulnerability to floods. In 2008, out of 81 main roads in the centre of the city, 21 were flooded with more than 30 cm water level due to high tide, and 10 due to heavy rainfall and again in 2009 heavy rainfall caused inundation to the city.	N/A	N/A	N/A
Joerin et al., 2014 Chennai, India	Flood, cyclone	N/A	N/A	N/A	N/A

Jue et al., 2005 China	Flood	N/A	N/A	N/A	N/A
Khan, 2008 Bangladesh	Flood, cyclone	Loss of properties like crop land, damage of crops. Flood 2004 affected 54 districts out of 64 and about 33.6 million people affected due to this.	N/A	N/A	Death of a lot of people and waterborne disease.
Malalgoda et al., 2013 Batticaloa, Sri Lanka	Flood, tsunami	Flood 2011 affected Sri Lanka severely e.g. lives of many people were disrupted (57 people were killed, around 193,700 were affected) and numerous rice crops (35%) destroyed. The Indian Ocean tsunami of December 2004 caused the death of 35,000 people. In addition, nearly one million people (234,000 families) were affected in 13 districts.	Tsunami 2004 destroyed US\$900 million worth of assets and infrastructure in Sri Lanka.	N/A	N/A
Mulyani Sunarharum et al., 2014 Jakarta, Indonesia	Flood	N/A	N/A	N/A	N/A
Parvez, 2013 India, Mountain belt	Earthquake	Most of the houses are destroyed due to earthquake when structure is weak.	N/A	N/A	N/A
Peleg, 2015 Nepal	Earthquake	Heavy mass casualties, building collapsed	N/A	N/A	N/A

Ramachandraiah, 2011 Andhra Pradesh, India	Flood, 1-3 October 2009	Roads were blocked with waste. Lack of drinking water supply. The total submerged area 271 to 284 metre contours measured 11.56 KM or about 30% of the town areas affecting 42% of the population (~195000 people) and in all 56.1% or 260000 people were somehow affected badly. Exposure to bad water and sanitation conditions.	Loss of asset, housing materials. Physical injuries, homelessness, deprive of supplies.	People had to evacuate homes without any preparation. No formal relief camps. Middle class could not join the relief queue.	Outbreak of waterborne diseases
Razafindrabe et al., 2014 Danang City, Vietnam	Flood	1999 flood took 595 lives. Flood in 2006, snatched 105 lives. Death of 163 people and missing of 11 people happened during typhoon Ketsana in September, 2009. Poor infrastructures of drainage and sanitation system increase the vulnerabilities of population during flood.	Economic loss was measured more than 3,773 billion VND (approx. US \$194 million after 1999 flood). Flood 2006 resulted in an economic loss of 5314.80 billion VND. Economic loss evaluated at US \$785 million during typhoon Ketsana, 2009. Households suffered a significant decrease in income during and after flood events (28% and 19%) respectively	N/A	Health disruptions due to poor sanitation system.
Rumbach, 2014 Kolkata, India	Flood	Heavy rainfall causes flood and housing, drainage and roads in the slum settlements affect due to this. The planned township areas were saved from flood. Only people living around the city were affected by flood frequently during rainy seasons.	Wage loss. Price increases occur after disaster events because of crop destruction, disruptions in transportation networks and people suffer a lot because of this.	N/A	Inadequate drainage and sanitation system often results diseases not only on children but also on adults.
Sharma and Priya, 2001 Patna, India	Flood	N/A	N/A	N/A	N/A

Sudmeier-Rieux et al., 2012 Dharan, Nepal	Flood, landslides	1988 earthquake killed 138 people and injured 2,117. damage to 2,500 buildings	N/A	N/A	N/A
Sudmeier-Rieux et al., 2015 Nepal, Vietnam	Flood, landslides, earthquake	The Dharan city of Nepal was severely damaged by the 1988 earthquake (6.8 on Richter scale), which killed 138 people, injured 2,117 people and damaged 2,500 buildings. September 2009, a school collapsed because of flooding along Khahare Khola River, Nepal.	N/A	N/A	N/A
Surjan and Shaw, 2009 Mumbai, India	Flood 2005	Flood, cyclones, landslides, waterlogging causing collapse households, loss of lives > 1000 people. Loss of property.	Loss of working days.	N/A	Breakout of waterborne diseases.
Tafti and Tomlinson, 2013 Ahmedabad, India	Bhuj earthquake January 26, 2001	Bhuj, a city with a population of around 130,000, approximately 7000 people, mostly inhabitants of the historic part of the city, died. Nearly 50% of the historic part of the city was destroyed. Approximately 11,036 houses completely, and 27,617 houses partially, collapsed in the city.	Rental units accounted for 40% of the housing loss in the old urban fabric and tenants who lost their houses in Bhuj were around 4000 households.	N/A	N/A
Taylor, 2015 Solo & Strenkali, Indonesia	Flood	In 2007; 6,368 homes damaged in Solo.	Economic loss was around US\$ 27,000,000 due to flood, 2007 in Solo.	N/A	N/A
Teets, 2009 Sichuan province, China	Earthquake	Death toll approximately 70,000. 7,000 classrooms collapsed, approximately.	N/A	N/A	N/A
Theckethil, 2012 Bhuj Township Gujrat, India	Earthquake, January 26, 2001	150,000 homes damaged. 14,000 people died and 167,000 suffered injuries.	Net economic cost estimated to be US \$ 5 billion.	Social relation ruined.	People were terribly shocked after the earthquake. Excess number of deaths and injuries.

Thiruppugazh, 2008 Ahmedabad, India	Earthquake, January 26, 2001	Over 7000 villages, Ahmedabad city and 14 municipal towns were affected. In the urban areas affected by the earthquake 26726 houses fully collapsed and 213,158 houses were partially damaged. 70 multistoried buildings collapsed, 752 people died.	N/A	N/A	N/A
Thomas, 2015 Philippines	Typhoon	Houses like huts destroyed those were adjacent to the sea.	N/A	Displaced 4 million people (loss of family members and neighbours).	N/A
Yang et al., 2014 China	Earthquake	In 2008, 7,967,000 buildings damaged. In 1st earthquake, 69227 died and in second earthquake 196 died.	Direct economic losses reached US\$2174.77 hundred million hundred million.	Social relations ruined.	Terribly shocked during the 1st earthquake. Beside this, excess number of deaths and injuries took place during 1st earthquake.
You et al., 2009 China	Earthquake	This study investigated damages in four towns. 95% of its buildings collapsed in Qushan. 14 214 buildings in Leigu, 1306 buildings in Tongkou and 460 buildings in Xiangquan collapsed. About 15 000 people in Qushan, 607 in Leigu, 73 in Tongkou, 44 in Xiangquan died. More than 142 000 people were made homeless.	The direct economic loss has been estimated at 5.27 billion euros.	N/A	People were terribly shocked. 26 916 people were injured.
Zope et al., 2015 Mumbai, India	Flood	N/A	N/A	N/A	N/A

<p>Birkmann and Fernando, 2008</p> <p>Galle and Batticaloa, Sri Lanka</p>	<p>Tsunami</p>	<p>30,000 deaths and 500,000 missing were measured. Women were more vulnerable during disaster. In Batticaloa, males accounted for 44 per cent of the dead and missing, whereas females constituted 56 percent and in Galle: 35 per cent of the dead and missing were male, whereas 65 per cent were female.</p> <p>Houses that were within 100 metres from the sea were damaged significantly.</p>	<p>N/A</p>	<p>N/A</p>	<p>Death</p>
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APPENDIX 19: EFFECTIVE APPROACHES FOR REDUCING EXPOSURE OF URBAN POPULATION TO DISASTER RISK

Author, Year and Country	Type of disaster (e.g. flood, tsunami, earthquake etc.)	Effective approaches for reducing exposure of urban population to disaster risk				
		Intervention Approaches			Aim	Outcome
		Community participation (Community itself, Govt.,NGO,mixed) at least a community component	Only government initiatives (relief, policy making)	External Mixed approach(Govt.,NGO,mixed) no part of community		
Birkmann, 2008 Galle and Batticaloa, Sri Lanka	Tsunami	Community participation -gathering knowledge about natural hazards to protect their lives from coastal hazards and to address the vulnerable situation of chronic poverty by acquiring a legally accepted, permanent residence.	Govt initiative -to clearly identify the "buffer zone" for reconstructing houses (including restrictions on reconstruction, resettlement, early warning, and the different compensation and financial support mechanisms).	External aid	To make sustainable reconstruction by assessing revealed and emerging vulnerability	Got a baseline need for recovery of the two cities. The most vulnerable groups have been identified which will also be helpful to choose intervention tools in future.
Braun and Aßheuer, 2011 Dhaka, Bangladesh	Flood	Five basic livelihood assets (physical, financial, human, social and natural capital) were discussed for survival strategy. Physical: technical infrastructure and structural protection devices (raised plinth or elevated door entries) against flood could be used. People use coping measures such as blocking the entry of the house with sandbags, positioning one's personal belongings on stilts of bricks or hanging them under the roof. Financial: Though they have limited income that can be used as savings they can access their home at their birth places. It was found some people take loans from local money lenders with high interest whereas the majority of them take from neighbours and	Relief and shelter house.	Government and NGO often provide relief (food and medicine) at shelter centre during flood.	N/A	Levels of social capital are the secret of slum dwellers to cope with disaster. Social capital comprises an important asset that increases resilience and improves the coping capacities of slum households and their ability to respond to external shocks.

		<p>relatives to buy food and medicines.</p> <p>Human: Human capital should increase through education as they can play role during disaster with different ideas of survival.</p> <p>Social capital: good relations with neighbours and relatives can often help during disaster as people's relation with those nearest is good in slum area.</p> <p>Natural: it's not possible to use natural capital (water bodies and land) in slum area as ponds are contaminated.</p>				
<p>Carcellar et al., 2011</p> <p>Philippines</p>	<p>Landslide mudflow, Flash flood, fire, and typhoon</p>	<p>From post disaster management to disaster risk reduction (DRR) approach, NGO mediated community driven initiatives in disaster response and risk reduction like 1. Immediate house material loan 2. Mid- term transit housing 3. Long term -a land acquisition initiative</p>	<p>Policy support, evaluation of national policy e.g., Republic Act 9729 (Climate change act of 2009), and Republic act 10121 (Philippine Disaster Risk reduction and Management act of 2010)</p>	<p>Alliance community based DRR implementation (Homeless People's federation Philippines, Inc or HPFPI, and The Philippine Action for Community-led Shelter Initiative or PACSII and with relief and support from local Govt.</p>	<p>To fulfil its mission to organise, build capacities, mobilize and network low income communities in high risk towards community driven approaches to securing tenure, upgrading, housing, and disaster/climate change impact risk reduction and management</p>	<p>Scaling up from post disaster vulnerability management to pre disaster risk reduction (DRR) 1. Partnership with local government, 2. networking with international organisations, 3. partnerships with local technical bodies, e.g. engineering college, 5. organised urban poor under unified network 6. use of indigenous knowledge, tools and practices, 7. Internal financial resources</p>
<p>Carpenter, 2015</p> <p>Kathmandu Valley, Nepal</p>	<p>Earthquake</p>	<p>N/A</p>	<p>N/A</p>	<p>N/A</p>	<p>This study examines the analytical utility of recent research on complex urban systems in</p>	<p>N/A</p>

					strengthening scholarly understanding of urban disaster risk management, and outlines its operational relevance to disaster preparedness.	
Chinnarasri and Porkaew, 2015 Thailand	Flood	N/A	Thailand government agencies team initiated a master plan and water resource management strategy. Many government agencies collect rainfall and weather data from their own stations. Web base data collection by institution.	N/A	Water resource management in crisis conditions.	Sustainable national disaster management plan focusing on water resource management strategy. Obtain the right model for integrated water resource management
Dewan et al., 2012 Dhaka, Bangladesh	Flood	N/A	Not clear	Not clear	The goal of this study is to document the environmental problems that result from the physical development of DMA.	N/A
Joerin et al., 2014 Chennai, India	Flood, cyclone	N/A	CDRI is a disaster index which was adopted in Chennai by local authorities to see whether Chennai is disaster resilience city or not. Through five dimensions (physical, social, economic, institutional, natural) it is observed whether Chennai is disaster resilient country or not. In Chennai economic resilience is lower	N/A	N/A	For making a disaster resilient zone specific training of local authorities is needed who deal with planning and public works issues.

			<p>because of the high percentage of urban poor and high unemployment rates. Northern area also has potential shocks.</p> <p>Northern areas have lower resilience as compared to other areas of the city because of their economic, natural, and social disadvantages (lower resilience). The northern areas have lower natural resilience as here heavy industries are situated. It is also the site of waste collection coal-fired power plant.</p>			
Khan, 2008 Bangladesh	Flood, cyclone	Engaged community to build up disaster preparedness and awareness; include extraction of local knowledge such as coping strategies of local people, and development of appropriate sanitation technology in the coastal and flood-prone areas.	Formal education about disaster preparedness.	NGOs contributed in preparedness program by providing non-formal education.	to: safeguard lives and livelihoods, minimize potential flood damage, improve agro-ecological conditions for enhanced crop production, meet the needs of fisheries, navigation, communications and public health, promote commerce and industry, and create flood-free land for a better living environment. The FAP also provides guidelines for	Government and NGOs provide formal and non-formal education in disaster preparedness and management with a view to promoting a resilient and sustainable society. The formal education programs are conducted at the primary school and postgraduate levels. NGOs have a relatively strong program in non-formal education.

					people's participation and environmental assessment.	
Mulyani Sunarharum et al., 2014 Jakarta, Indonesia	Flood	N/A	N/A	Initiated a master plan for flood mitigation that consists of drainage & improvement of retention of ponds, coastal defence and road protection.	Master planning and intergovernmental coordination to implement flood risk management strategies.	Reframe planning decision-making to address risks of flood to increase community resilience.
Parvez, 2013 India, Mountain belt	Earthquake	N/A	N/A	Different institutions and individuals have carried out some basic work, particularly with regard to selection of appropriate scales of maps and development to identify seismic zone and microzone.	N/A	It can mitigate the earthquake result as Delhi, Bangalore and other big and megacities are already lies upon seismic zone.

Ramachandraiah , 2011 Andhra Pradesh, India	Flood, 1-3 October 2009	Increased solidarity among sufferers and those living in the temporary relief camps.	Local government and municipality, Local health camp, water purification tablets, emergency ambulance services, relief services.	Relief services, water supplies by NGO and a political party.	To report cause of flooding, the extent of damage and measure taken with recommendations.	Recommendations based on the reporting: 1. Crucial to disseminate prior information and warnings 2. Provide security arrangements 3. Public address systems 4. Effective communication (e.g. mobile phone) 5. Basic provision of supplies 6. Involving media and civil society 7. Well coordination among providers with health, relief or administrative issues 8. All treatment should be with fairness, equity and empathy.
Rumbach, 2014 Kolkata, India	Flood	Building materials and construction codes (in city well to do persons maintained, outskirts poor people could not)	City planning, building construction, infrastructure development	N/A	To report urban disaster risks in new town like Salt Lake and its nearby informal settlements.	Recommendations: Planned township, underground drainage, sewerage system and elevated pumping stations. High income and high education.

Sharma and Priya, 2001 Patna, India	Flood	N/A	Policy regulations advocated to be implemented	N/A	A brief case study highlighted strategies required to mitigate natural disaster e.g. flood linked with urban planning	No outcome mentioned. But, Strategies mentioned: 1. Residential density control 2. Increasing capacity of drainage 3. Zone wise flood plan approach. 4. Management and development of streets, 5. Building codes, 6. Government acquisitions, 7. Non structural measures, 8. Utilizing existing schemes
Surjan and Shaw, 2009 Mumbai, India	Flood 2005	ALM (The Advanced Locality Management) started since 1996, a community based approach for effective management of civic services at the grass root level. Informal voluntary bodies with participants from wide ranges of population. 783 ALM groups are functioning.	Mumbai Disaster Management Plan (MDMP)	The Municipal Corporation of Greater Mumbai (MCGM) in partnership with ALM started "Good urban governance campaign" (e.g. solid waste management department)	Effective management of civic services as grass root level. ALM committee plays a key role in sensitizing the citizens to inculcate the spirit of civic consciousness, and ensure their co-operation to the municipal administration, to implement various projects and programmes (CDP, 2006).	This is a system which encourages the citizen to take active role in monitoring the civic administration at every ward level. At the same time, the efforts made by collective action of citizens locally have resulted in environmental risk reduction, particularly in the community based waste management.

Sudmeier-Rieux, et al., 2012 Dharan, Nepal	Flood, landslides	N/A	Risk reduction through land-use planning, watershed management, zoning, and providing safer places for marginalized populations. Develop a FLOW-R software to model debris flows, to be also used to model floods	N/A	Reduce the negative impacts of climate change.	Produce several scenarios of flooding that can be useful for local flood planning, as well as developing risk maps
Sudmeier-Rieux, et al., 2015 Nepal, Vietnam	Flood, landslides, earthquake	Risk sensitive land use planning, e.g. i. The Guided Land Development ii. Land Pooling Acts are two public initiatives iii. The 1997 Town Development Fund	Payment for ecosystem service (PES) management of upstream watershed and relocation of housing, other regulations	Insurance policies	Disaster risk reduction and prevention	Resilience building, capacity building, risk shifting (to those who create risk)
Tafti and Tomlinson, 2013 Ahmedabad, India	Bhuj earthquake January 26, 2001	N/A	Government initiatives	N/A	This study examined post-disaster public policy responses for addressing housing recovery of tenants in two earthquake-affected cities of Bhuj and Bam.	Higher income tenants got the benefits of the policies but lower-income tenants faced problems including long periods of living in temporary housing or displacement.
Taylor, 2015 Solo & Strenkali, Indonesia	Flood	In Strenkali, Surabaya the local government stipulated that the community members move their homes back from the water's edge, install sanitation infrastructure and	1. In Solo, households that owned houses in the riverbank areas would be given cash grants to buy new land (equivalent to US\$ 1,200), build new	N/A	Decrease the vulnerability of the population living in the river bank	N/A

		septic tanks for each home, and replant on the riverbanks to prevent further erosion.	houses (US\$ 800) and contribute to building public infrastructure (US\$ 150). Nearly 1,000 houses have been relocated to a safer place. 2. In Strenkali, Surabaya local government initiated the process for river dredge and other river maintenance measures.			
Theckethil, 2012 Bhuj Township Gujrat, India	Earthquake, January 26, 2001	Partial, Not clear, state defined participation through town planning meetings, consultant meetings, NGO forums, individual approaches	Multi-sectoral long term disaster management through regulatory mechanisms; Development Plan (DP); Town Planning Schemes (TPS); building codes	Network and collaboration, Governance and consultation, Community engagement, Coordination, Multi sectoral (central government backed with state government) negotiated with international donors, NGOs and private sectors. Approximately 200 NGOs participated in the reconstruction and rehabilitation works.	Provide effective management of disaster, mitigation of effects of disaster, administer, facilitate, coordinate and monitor emergency relief during and after occurrence of disasters, and implement monitor and coordinate measures for reconstruction and rehabilitation in the aftermath of disaster in the state of Gujarat (Gujarat State Disaster Management Authority 2003 a)	Relocated households, Quake proof households, Policy support, Compensation, community engagement, Improved QOL (Construction of houses); Improved livelihood (Health Education, handicrafts, legal aids)

Yang et al., 2014 China	Earthquake	Local residents and medical staff have been well trained	Set up a national and local emergency response planning system, stored adequate emergency drugs and equipment at the emergency disaster control headquarters for rapid transport. Regular training for emergency professional medical rescue teams.	The China International Search and Rescue Team (CISAR), the Chinese Red Cross, the Chinese Medical Association, the Chinese PLA, and many other organisations also organised emergency rescue teams. Local emergency rescue teams also have been created by local governments using Chinese medical and firefighting institutions forces.	To reduce the damage and improve emergency response services	The number of deaths in second earthquake was 353 times lesser and the economic loss was nearly 10 times lesser than 1st earthquake
You et al., 2009 China	Earthquake	Policy implication Free medical service after earthquake	Community engagement	External Support	Decrease the vulnerability of the population	In Qushan, 15 000 people died (75 per cent of its population) and 95 per cent of its buildings collapsed. In Leigu, 607 people died and 14 214 buildings Collapsed. In Tongkou, 73 people died and 1306 buildings collapsed. In Xiangquan 44 people died and 460 buildings collapsed.