A GUIDE TO MEASURING URBAN RISK RESILIENCE

Principles, Tools and Practice of Urban Indicators

First Edition

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With applications from
Istanbul, Turkey
Mumbai, India
Quezon City, Philippines
Medellin, Colombia
Bogotá, Colombia
Manizales, Colombia

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KIT Karlsruhe Institute of Technology
EMI Earthquakes and Megacities Initiative
CAPRA
CIMNE
GEM GLOBAL EARTHQUAKE MODEL working together to assess risk

A Guide to Measuring Urban Risk Resilience: Principles, Tools and Practice of Urban Indicators

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Earthquakes and Megacities Initiative - EMI

Mr. Jerome Zayas has been involved as a project manager for EMI and contributed to the technical editing of the Guidebook. Mr. Joel Abelinde, Ms, Ishtar Padao, Ms. Ayhen Dalena and Ms. Joanne Constantino also contributed to the technical editing. Mr. Allaine Aaron Corpuz contributed to the overall design and layout.

Center for Disaster Management and Risk Reduction Technology – CEDIM

Prof. Friedemann Wenzel organized and initiated the contributions of the Karlsruhe Institute of Technology to urban DRM indicators starting with the project in Istanbul and has supported the development of urban risk and resilience indicators in many cities presented in this Guidebook.

International Center for Numerical Methods in Engineering - CIMNE

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Istanbul Metropolitan Municipality

Mr. Mahmut Bas and Osman Kilic, as the Director and Deputy Director in Directorate of Earthquake and Ground Research at the Istanbul Metropolitan Municipality together with Mr. Emin Mentese and Ms. Betul Konukcu have actively contributed and implemented the urban indicators of risk and resilience in Istanbul. Furthermore, Prof. Mustafa Erdik and Ms. Bilgen Sungay from the Bogazici University Kandilli Observatory and Earthquake Research Institute (KOERI) have been instrumental in the development of this work.

GETTING STARTED

HOW TO USE THIS GUIDEBOOK

THE GUIDEBOOK DESCRIBES THE PRINCIPLES, TOOLS AND PRACTICES FOR DEVELOPING AND IMPLEMENTING URBAN DISASTER RISK AND RESILIENCE INDICATORS BASED ON STAKEHOLDER CONSULTATIONS IN CITIES.

WHAT IS THE OBJECTIVE OF THE GUIDEBOOK?

This Guidebook describes the principles, tools and practice of three urban disaster risk and resilience indicator systems based on our collective experience in implementing them in various urban settings in the last decade with local authorities. The objective of the Guidebook and the case studies presented here is to describe the methodology and participatory processes for developing, customizing and implementing these indicator systems with the aim of supporting urban professionals in their DRM decision-making.

FOR WHOM IS THE GUIDEBOOK INTENDED?

Public officials and authorities in local, regional and national government agencies are the primary target audience for this Guidebook. The Guidebook would also be useful for a various type of professionals dealing with urban disaster risk management; development planning and policy reform in the realm of disaster risk reduction; and for practitioners working in risk reduction, emergency and recovery planning.

HOW TO USE THE GUIDEBOOK?

The Guidebook serves as a toolkit - a collection of useful methods, tools and cases relevant for dealing with the challenge of operationalizing indicators in urban disaster risk management. The Guidebook is designed specifically for urban DRM professionals to plan and implement a participatory process for assessing a city's risk and resilience from an integrated perspective. The Guidebook walks the users through the indicator design process and supports them in activities and exercises for selecting and weighting appropriate indicators. The case studies demonstrate how indicators can be used as an innovative risk communication tool to engage stakeholders in understanding their risk and for taking ownership of the risk factors in their city. The Guidebook draws from the experience in implementing this process in various urban settings throughout the world, including Bogota, Istanbul, Manizales, Medelin, Quezon City and Mumbai.

THE GUIDEBOOK IN A NUTSHELL

The Guidebook focuses on the principles, methods and practices for the application of three indicator systems of urban risk and resilience where the authors have over a decade of experience in the participatory implementation of these tools for risk communication and disaster risk management.

CHAPTER

01 General notions of urban risk and resilience

02 Urban Disaster Risk Index (UDRi)

A risk communication tool which provides a holistic view of disaster risk by capturing through indices, both the direct physical damages of buildings and infrastructure. It also condsiders social vulnerability and lack of resilience that can aggravate the physical effects.

03 Risk Management Index (RMI)

A risk management tool which measures a city's risk management performance, reflecting organizational, development, capacity and institutional actions taken to reduce risk, to prepare for crisis and to recover efficiently from disasters.

04 Disaster Resilience Index (DRI)

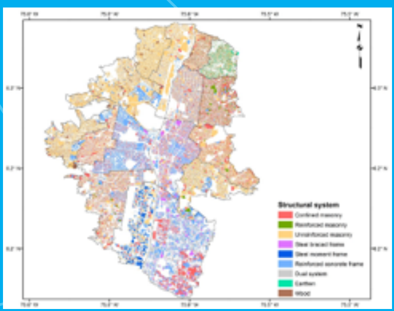
A monitoring and evaluation tool for benchmarking and measuring progress or lack thereof, along a city's key development policies and processes for mainstreaming risk reduction and increasing resilience.

Bogotá, Colombia

The system of indicators have been applied two times. First, in the framework of the Program of Indicators of Disaster Risk and Risk Management of the Inter-American Development Bank. Second, by the City Administration itself with the participation of all city's institutions to evaluate the evolution of DRM and to update the Integrated Disaster Risk Management Plan.

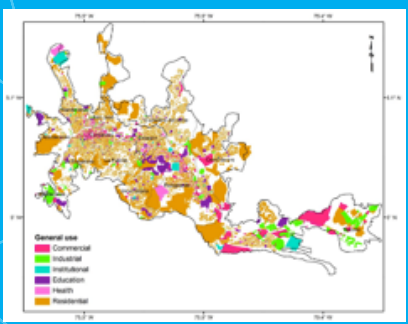
Medellin, Colombia

As result of the interest of the Development Planning Secretary of the City Administration, a collective evaluation of risk management was implemented with the participation of many agencies of the city. In addition, a comprehensive risk assessment was conducted to define the actions of the Integrated Disaster Risk Management Plan of the city.



Manizales, Colombia

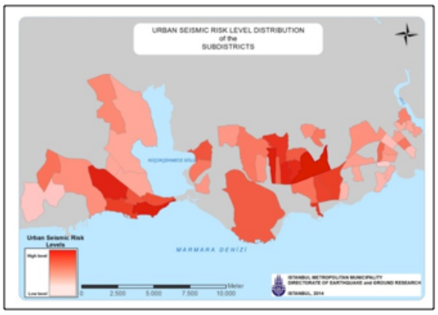
The evaluations in Manizales have been made two times in the last decade. The first one was conducted by the National University (IDEA) as result of the request of the Municipality and the second was promoted in the framework of the Disaster Risk Management Program of Manizales with the support of the Environment Authority of the Region. The results have been key information for the public investment, the land-use plan and the Participative Disaster Risk Management Plan 2013-2026.



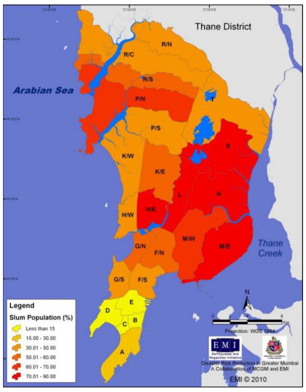
05 Case Studies

Istanbul, Turkey

The system of indicators has been applied in several stages from 2007 till present time. Starting with collaborations between the municipality in Istanbul, EMI and KIT the indicator systems and initial framework were established. The City of Istanbul then undertook a wide-scale customization and implementation of the indicator systems which included a specially developed social survey for developing the UDRi.

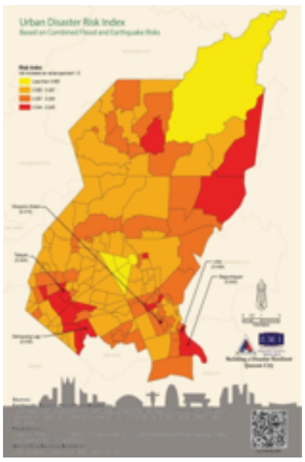


Mumbai, India



The UDRi and the DRI were customized and applied in Mumbai in a collaboration between EMI and the Municipal Corporation of Greater Mumbai (MCGM) with over 130 stakeholders as a risk communication and planning tool for measuring progress (or lack of progress) on the mainstreaming of risk reduction approaches in the city's development policies and processes.

Quezon City, Philippines



The UDRi was applied in Quezon City through a collaborative effort between EMI and the Quezon City Government. The implementation outlines a participatory process for the development of social fragility and lack of resilience indicators and their respective weights.

EXECUTIVE SUMMARY

PRINCIPLES AND THEORIES

Local governments and city stakeholders need to have a clear understanding of the urban risk and resilience conditions and trends. It will enhance their ability manage available risk reduction and risk management options. A successful implementation of Disaster Risk Reduction (DRR) options demands appropriate mechanisms to communicate and transfer the overall knowledge on risk. In the age of multiple data layers, indicators turn data into relevant information for decision-makers and public officials. They simplify a complex array of information about natural hazard risk and resilience. Indicators contribute to improved disaster risk management and policy development.

The Guidebook describes three urban risk indicator systems developed as complementary tools to communicate risk and promote discussion around appropriate local level risk and resilience strategies: Urban Disaster Risk Index (UDRi), Risk Management Index (RMi), and Disaster Resilience Index (DRI). In the last decade, these urban indicator systems were implemented and tested in 16 cities worldwide. Some were applied in Asia by EMI and the Karlsruhe Institute of Technology (KIT) (Mattingly et al., 2006; Khazai et al., 2008, Khazai et al., 2009; Khazai and Bendimerad, 2011; EMI, 2012; Bendimerad et al., 2013; EMI, 2014; and Khazai et al., 2015). In the Americas and Europe the indicator system was applied by the National University of Colombia (UNC/IDEA) at Manizales (IDEA, 2005; Cardona 2006, Suárez and Cardona 2007, Suárez 2008) and by the International Center for Numerical Methods in Engineering (CIMNE) of the Technical University of Catalonia in Barcelona (Marulanda et al., 2013; Salgado-Gálvez et al., 2014a; Cardona et al., 2014; Carreño et al., 2014b). The authors present their collective experience and findings in the application of the indicator systems in these applications in this Guidebook. Overall, the objective of the indicator systems and the way that they were applied is to help enhance ownership within city stakeholders with the aim to assist in disaster risk management policy development, decision-making, and monitoring effectiveness of specific DRR options adopted.

Figure 0.1 locations of case study implementations of the three indicator systems

In this Guidebook, the authors present their collective experiences and findings in these applications. Furthermore, they present the theory, development, and application of the urban risk and resilience indicator systems.

This Guidebook is structured in three sections. Section one (1) provides brief overview of the theories and principles of the three urban indicator systems. Section two (2) presents a step-by-step guide to the application of the indicator methods along with an overview of the softwares developed by Global Earthquake Model (GEM) and the Comprehensive Approach to Probabilistic Risk Assessment (CAPRA) initiatives for implementing the indicator systems. Lastly, section three (3) deals with the practices in the collaborative development and application of the indicator systems in six (6) case studies carried out between 2004-2014.

THREE URBAN RISK AND RESILIENCE INDICATOR SYSTEMS

URBAN DISASTER RISK INDEX (UDRI)

The quantitatively derived Urban Disaster Risk Index (UDRi) provides a holistic view of disaster risk by capturing through indices both the direct physical damages of buildings and infrastructure, as well as considering social fragility and lack of resilience issues (risk drivers) that can aggravate the physical effects. The models and methodology referred to here as the Urban Disaster

[1] City applications by EMI/KIT: Istanbul (2007-2009), Amman (2008-2009), Kathmandu, Metro Manila (2006), Quezon City (2011-2012), Pasig (2010-2011), Dhaka (2013), Mumbai (2008-2010); City applications by UNC/IDEA and CIMNE: Manizales (2006 and 2014), Medellín (2010 and 2014), Bogotá

Risk Index (UDRi) was developed by Carreño (2006), Carreño et al. (2007a) and is based on Cardona's model (Cardona, 2001; Cardona and Hurtado, 2002; Barbat and Cardona, 2003; IDEA, 2005) using a holistic approach for evaluating disaster risk by means of indices. The main objective of this indicator system is to measure disaster risk from an integrated perspective and to guide decision-making, not only by considering the potential direct impacts of disasters but also by identifying multiple socio-economic and capacity/resilience factors. Input data on disaster loss scenarios and vulnerability conditions at the urban level are necessary to apply the method. This technique covers different areas of the risk problem, taking into account issues such as: potential damages and losses resulting from extreme events; recurrent disasters or losses; social and environmental conditions that make particular countries or regions more disaster prone; the capacity of the economy to recover; the operation of key services, among others. This approach contributes to communication of disaster risk and its efficient management, through the identification of risk drivers, weaknesses or "hot-spots" within the urban space. It is noteworthy that when seismic risk assessments are performed the UDRi has also been referred to in the literature as Urban Seismic Risk Index (USRi).

RISK MANAGEMENT INDEX (RMI)

The disaster Risk Management Index (RMI) brings together a group of indicators that measure a city or country's risk management performance and effectiveness. These indicators reflect the organizational, development, capacity and institutional actions taken to reduce vulnerability and losses, to prepare for crisis and to recover efficiently from disasters (Carreño et al. 2004, 2005b; 2007b; IDEA 2005; Cardona and Carreño, 2013). This index provides a quantitative measure using qualitative qualifications of management based on predefined targets or benchmarks that risk management efforts should aim to achieve. This approach of risk management evaluation was implemented taking into account four public policies, each of which has six topics to be evaluated using five levels of performance. The policies include the risk identification, risk reduction, disaster management, and governance and financial protection. Risk identification and knowledge comprise the individual perception, social representation and objective assessment. Risk reduction involves corrective and prospective prevention and mitigation interventions. Disaster management comprises response and recovery. And, governance and financial protection, related to institutionalization and risk transfer. The results obtained are very useful to define the next step to improve the existing level of achievement in each topic and public policy; therefore the RMI is very effective method to define a disaster risk management plan.

DISASTER RESILIENCE INDEX (DRI)

The Disaster Resilience Index (DRI) was developed as a monitoring and evaluation tool for benchmarking and measuring progress (or lack of progress) on the mainstreaming of risk reduction and resilience approaches in the city's development policies and processes (Khazai and Bendimerad, 2011a). The structure of the DRI is based on key thematic areas of resilience in cities and linked to EMI's analytical Disaster Risk Management Master Planning (DRMMP) model, which consists of strategies, policies, actions and processes for mainstreaming disaster risk reduction at the local level through a participatory planning process (Bendimerad et al., 2016). The DRI is a self-assessment tool which aims to establish an initial benchmark and obtain consistent and objective evaluations around 10 indicators grouped along five thematic areas: 1) legal and institutional processes; 2) Awareness and capacity building; 3) Critical services and infrastructure resiliency; 4) Emergency preparedness, response and recovery planning; and 5) Developmental planning, regulation and risk mitigation. The DRI was initially developed and applied in Mumbai (Khazai and Bendimerad 2011a, Khazai et al., 2011), in Aqaba (Jordan) and different provinces and municipalities in the Philippines (EMI, 2014).

The application of the indicator systems described in this Guidebook in cities prove their value, to the extent they have been helpful as a tool in a cities DRM practices and other planning processes that impact DRM in the city. The 6 Case Studies described here demonstrate how the indicators systems are localized and customized to a cities own needs and have evolved in successive implementations depending on needs of the city stakeholders. These Case Studies will also show how the indicator systems can be set up in a participatory way so that they can reflect a city's DRM plan and be relevant for its resilience strategy. Informed by lessons learned in the practice of implementing the indicator systems in various cities, the Guidebook also provides recommendations in the participatory planning, implementation and evaluation of the indicators encompassing the following three broad areas:

- To develop the system of indicators in close collaboration with a "Core Group" of local professionals, to engage them in the development of the data, the understanding of the framework and methodology; and to ensure ownership over the indicator system and its periodic updating and upgrading.

- To work closely within a broader and targeted "Focus Group" in evaluating and validating the indicators, such that they are: relevant to the organizational, functional and cultural processes of a city; represent the conditions and reality of socio-economic vulnerability in city; and reflect the insight, view and past studies when they are available (e.g., earthquake risk assessment, transportation study, housing and shelter, land use planning, construction codes and standards, water supply and water treatment analysis, etc.)

- To implement and disseminate the system of indicators through a process of engaging a broad group of stakeholders in the city, such that they are used: as an effective risk communication tool that inherently relates to the city-level DRM practices; as a planning tool that aids in correcting, reviewing and deciding on where to invest resources; and as Disaster Risk Management benchmarks which assist in policy decision making and monitoring of different risk reduction practices implemented at the local level.

LIST OF ACRONYMS

CAPRA
Comprehensive Approach to Probabilistic Risk Assessment

CIMNE
International Center for Numerical Methods in Engineering of UPC

DRI
Disaster Resilience Index

EMI
Earthquake and Megacities Initiative

GEM
Global Earthquake Model

ICSU
International Council for Science

IDEA
Institute of Environment Studies of UNC (Instituto de Estudios Ambientales)

MOVE
Methods for the Improvement of Vulnerability Assessment in Europe

IRDR
Integrated Research of Disaster Risk

RMI
Risk Management Index

UDRI
Urban Disaster Risk Index

UNC
National University of Colombia (Universidad Nacional de Colombia)

UPC
Technical University of Catalonia (Universidad Politécnica de Cataluña)

USRI
Urban Seismic Risk Index

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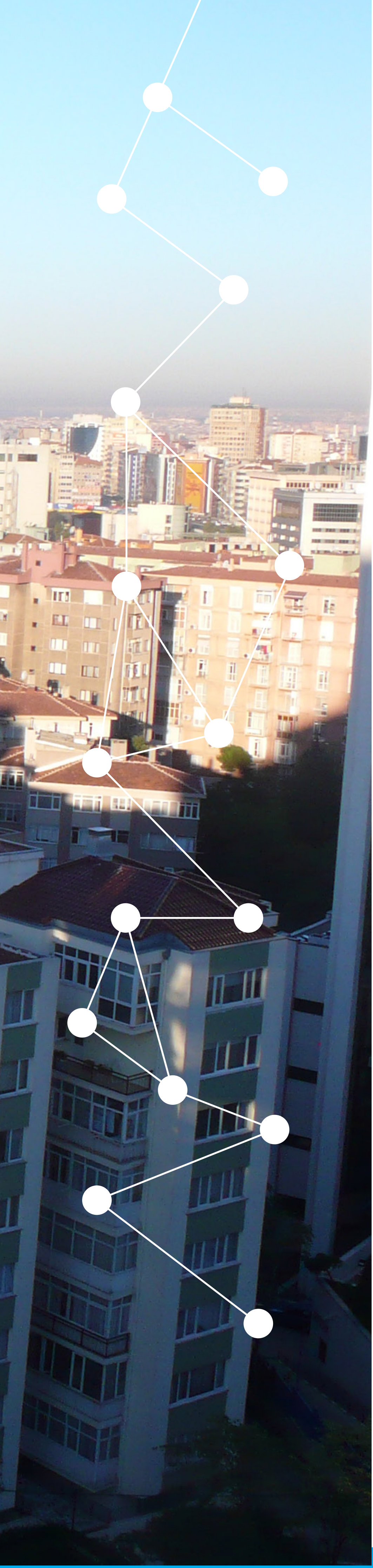
CHAPTER 01

GENERAL NOTION FOR URBAN RISK RESILIENCE



CHAPTER 1

Disaster risk is defined as the probability of future damages and losses associated to the occurrence of environmental hazards, where levels and types of loss are determined by the levels of exposure and vulnerability of society (UNDRO, 1980; Cardona, 1990; UNISDR, 2009; Birkmann, 2006).

Risk is the result of the interactions, in time and space, of probable physical events with exposed vulnerable assets of the social and environmental systems (Cuny, 1984; Davis and Wall, 1992). On those interactions, physical events are transformed into hazards with the real potential for contributing to future loss and damage. It is in the latency of risk that the opportunity for risk prevention, mitigation and transfer exists, employing diverse adaptation or disaster risk management principles, strategies and instruments (Lavell, 1996; 1999). Disaster risk management should be defined as a social process that aims to reduce, predict and control disaster risk drivers in a development framework, by means of the design and implementation of appropriate policies, strategies, instruments and mechanisms (Cardona and Barbat, 2000).

Disaster, on the other hand, is a social condition whereby the normal functioning of society is severely interrupted by the levels of loss, damage and impact suffered (Cardona, 1990; Alexander, 1993; 2000; Birkmann, 2006). Those damages and losses may reach levels and consequences that can be defined as large-scale or small-and-medium-scale “disasters” or “catastrophes” (Marulanda et al., 2008; 2010; United Nations, 2009). All disasters are product of a complex relationship between the physical world, the natural and built environmen; and society, its behaviour, functions, organization and development (Quarantelli, 1998). Moreover, the existence of disaster conditions leads to new social processes and new or transformed risk conditions. Disasters associated with environmental hazards reflect and signify unmanaged risk and may also be seen as representing unresolved development problems (Westgate and O’Keefe, 1976; Wijkman and Timberlake, 1984). In other words, disaster may be seen as the actualization or materialization of existing disaster risk. Latent risk conditions are transformed into real damage and loss when an extreme or triggering physical event occurs (Maskrey, 1993). The existence of risk is a sine qua non a prerequisite for future disaster. Risk is a continuum, and disaster is one of its many “moments” or “materializations” (ICSU-LAC, 2009).

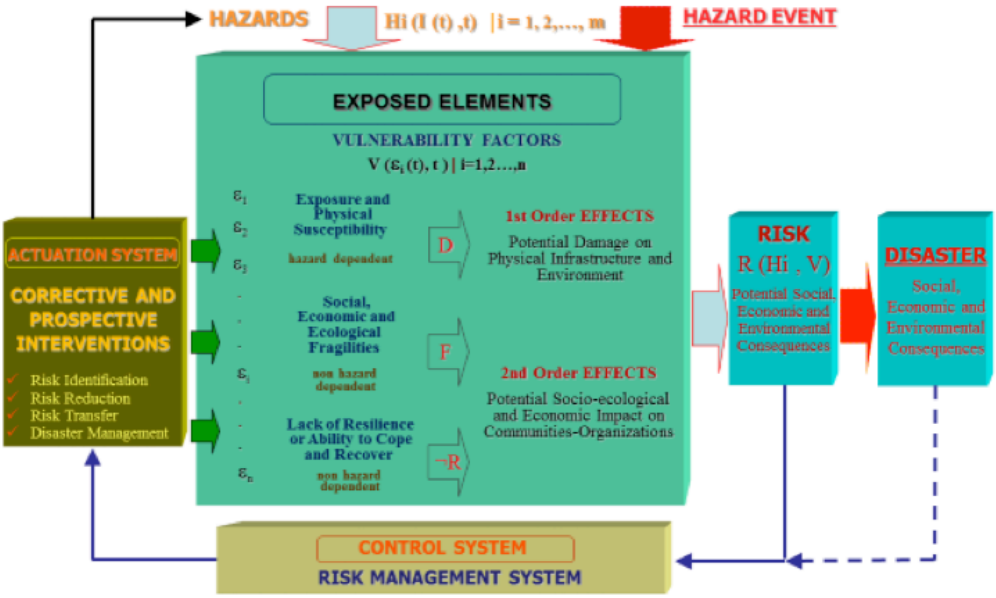


Figure 1.1 Theoretical framework for a holistic approach to disaster risk assessment and management. (Cardona and Hurtado, 2000; Cardona and Barbat, 2000; Barbat and Cardona, 2003; IDEA, 2005; Carreño et al., 2007a; 2007b; 2012; Cardona, 2009)

Figure 1.1 shows the conceptual framework of the holistic approach for risk evaluation. From this comprehensive perspective, it can be seen that risk is a function of the physical vulnerability –or the potential physical damage– and a set of vulnerability factors that configure the vulnerability conditions. The physical vulnerability is obtained from the susceptibility of the exposed elements to hazards considering the potential intensities of the hazardous events in a period of time. The vulnerability depends on the social fragilities and issues related to lack in resilience of the disaster prone socio-technical system. Using the meta-concepts of the theory of control and complex system dynamics to reduce risk, it is necessary to intervene through corrective and prospective actions. Furthermore, risk management requires an institutional structure (control system) and public policies and actions (an actuation system) to implement the changes needed on the exposed elements to reduce risk. This framework provides a summary of the causal and intervention aspects associated with this holistic vision of risk and vulnerability (Cardona and Hurtado, 2000; Cardona and Barbat, 2000; Barbat and Cardona, 2003; IDEA, 2005; Carreño, 2006; Carreño et al., 2007a; 2007b; 2012; Cardona, 2009). This diagram is based on different but common risk approaches in which the main focus is the vulnerability understanding and intervention to emphasize the association of risk assessment with decision-making (Turner et al., 2003; IDEA, 2005; Birkmann, 2006; Carreño et al., 2007a,b).

This conceptual framework recognizes natural or socio-natural hazards and the exposed elements and their associated vulnerability factors. Both elements, hazards and exposed assets, coexist and have constant interactions among each other.

Hazards can be the result of the physical impacts on natural environment of extreme events. Subsequently, these hazards may have impacts on natural (ecosystems) and human systems (socio-economic). When the intensity or recurrence of hazard events is related to processes of environmental degradation and human intervention in natural ecosystems, the origin of hazard can be considered as socio-natural. They are created where human activity intersects with natural ecosystems. Changes in the environment and new hazards associated with climate change will probably comprise the most notable example of socio-natural phenomenon (Lavell, 1996; 1999; 2000).

The exposure is the social and material context represented by people, resources, infrastructure, production, goods, services and ecosystems that may be affected by a hazard event. It is the inventory of components of society and environment that are exposed to the hazard from spatial and temporal point of view.

The objective of land use and territorial planning is to reduce to a minimum unnecessary exposure and vulnerability to damaging events. Where exposure to events is impossible to avoid, land-use planning and location decisions must be accompanied by other structural or non-structural methods to prevent and mitigate risks. Land use plans must be based on location and vulnerability reduction strategies and methods (UNISDR, 2009). Migration, development models, regional trade, economic dependency, global trends and transitions, among others, are also key issues related to exposure and physical susceptibility at local level. Understanding this diversity of contexts and decisions is an intrinsic challenge for social science research.

Vulnerability essentially refers to the propensity of exposed elements, such as human beings and their livelihoods, to suffer damage and loss when impacted by single or diverse hazard events (UNDRO, 1980; Timmerman, 1981; Cardona, 1990; Liverman, 1990; Cannon, 1994; 2006; UNISDR, 2009; Birkmann, 2006; Blaikie et al., 1996; Thywissen, 2006; IPCC, 2007).

Although there are intrinsic or innate levels of vulnerability associated with life in general, as far as risk and disaster studies are concerned, vulnerability, its facets, factors and levels should be seen as a result of defined social processes. That is to say, vulnerability is the most palpable manifestation of the social construction of risk (Aysan, 1993; Blaikie et al., 1996; Wisner et al., 2004). As such, it is a social construction and the physical world and the potential for hazard it presents are given real social dimension and significance by differential forms of human behaviour and their results in terms of the organisation, structuring and functioning of society and its support elements (Wilches-Chaux, 1989; Wisner et al., 2004). Such social construction may be expressed or understood in various ways. These include (ICSU-LAC, 2009):

CHAPTER 1

- how human actions influence the levels of exposure and vulnerability in the face of different physical events;
- how human interventions in the environment (degradation or transformation) lead to the creation of new hazards or an increase in the levels or damage potential of existing ones (socio-natural);
- how human perception, understanding and assimilation of the factors of risk influence their reactions, prioritization and decision making processes.

Vulnerability is the "state of reality" that underlies the concept of risk. It is the causal reality that determines the selective character of the severity of damage when a hazard event occurs. Vulnerability reflects susceptibility, the intrinsic predisposition to being affected; the conditions that favour or facilitate damage. The measurement of vulnerability is a challenge; it is related to the degree of exposure, susceptibility, fragility and lack of resilience of a socio-ecological system that favours adverse effects.

Many believe that it is not possible to assess vulnerability;however it is important to understand how vulnerability is generated, increased, and built up (Cardona, 2001; 2004; 2010). The evaluation and follow-up of vulnerability and risk is needed to make sure that all those who might be affected, as well as those responsible for risk management, are made aware of it and can identify its causes and roots. To this end, evaluation and follow-up must be undertaken using methods that facilitate an understanding of the problem and that can help guide the decision-making process.

Vulnerability of human settlements and ecosystems is intrinsically tied to different socio-cultural and environmental processes (Cutter, 1994; Kasperson et al., 1988; Cutter et al., 2008). In any case, it refers to susceptibilities or fragilities of the exposed elements; i.e. to the likelihood to be affected, but it is also related to the lack of resilience of the society and environment. Vulnerability is also closely tied to natural and built environmental degradation at the urban and rural levels and in some cases to the gradual climate change. Therefore, when seen from a social perspective, vulnerability signifies a lack or deficit of sustainability. In this regard, risk is socially constructed, even though it has a relationship to physical and natural space. In many places, increases in vulnerability are likely to be related to factors such as rapid and uncontrollable urban growth and environmental deterioration. These lead to losses in the quality of life, the destruction of natural resources and landscape, and loss of genetic and cultural diversity. In order to analyse vulnerability as part of wider societal patterns it is necessary to identify the deep rooted and underlying causes of vulnerability and the mechanisms and dynamic processes that transform these into insecure conditions. All this leads to the conclusion that the underlying causes of vulnerability are social, economic, environmental, and political processes that affect the distribution of resources among different groups, which in turn reflect the distribution of power in society.

In summary, vulnerability reflects the susceptibility or the intrinsic predisposition to being affected or the conditions that favour or facilitate damage. The measurement of vulnerability is a challenge; it is related to the degree of exposure, susceptibility, fragility and lack of resilience of a socio-ecological system that favours adverse effects (Cardona, 2001; 2004; 2006; 2010). Adhering to the hypothesis that the lack of sustainability and vulnerability are correlated and considering that the lack of capacity to anticipate, cope, and recover is also a factor of vulnerability, particularly taking into account the climate variability and change, then, it is possible to say that the causal factors of vulnerability are defined as follows:

- **Exposure** is the susceptibility of human settlements and environment to be affected by a dangerous phenomenon due to its location in the area of influence of the phenomenon and to a lack of physical resistance.
- **Susceptibility/Fragility** is the predisposition of society and ecosystems to suffer harm resulting from the levels of susceptibilities or fragilities of human settlements and disadvantageous conditions and relative weaknesses related to physical, ecological, social, economic, cultural, and institutional issues.
- **Lack of resilience** is the limitations in access to and mobilization of the resources of the human settlements and their institutions, and the incapacity to adapt and respond in absorbing the socio-ecological and economic impact. Resilience includes the capacity to anticipate, cope and recover.

Indicators or indices could be proposed to measure vulnerability from a comprehensive and multidisciplinary perspective. Their use intend to capture favourable conditions for direct physical impacts (exposure and susceptibility), as well as indirect and, at times, intangible impacts (socio-ecological fragilities and lack of resilience) of hazard events (IDEA, 2005; Carreño et al., 2007a). Therefore, according to this approach, exposure and physical susceptibility are necessarily "hard" conditions for the existence of physical risk, or first order effects, and these are hazard dependent. The propensity to suffer negative impacts as a result of the socio-ecological fragilities and not being able to adequately face disasters, are circumstances of the context that can be considered "soft" conditions, related to second order effects that aggravate the impact and usually are non-hazard dependent.

Whilst accepting this general principle as to the hazard specific nature of vulnerability, it is also clear that certain factors, such as poverty, the lack of social networks and social support mechanisms, will affect vulnerability levels irrespective of the type of hazard context — i.e. they are non-hazard dependent. Clearly this type of generic factor is different to the hazard specific factors and assumes a different position in the intervention equation and the nature of risk management processes (ICSU-LAC 2009). Vogel and O'Brien (2004) stress the fact that vulnerability is multi-dimensional and differential –i.e. varies across physical space and among and within social groups; scale-dependent with regard to time, space and units of analysis such as individual, household, region, system; and dynamic– characteristics and driving forces of vulnerability change over time. The society is exposed in the time and space to different hazards, and it can be vulnerable to them. The vulnerability of the society depends on several factors related to thematic dimensions.

Under this generic framework, it is possible to develop different approaches that capture the different thematic dimensions of vulnerability (Cardona and Wilches-Chaux, 2006). Overall, these dimensions provide the initial basis for a holistic and integrative perspective on vulnerability. A deconstructive approach helps us visualizing vulnerability from different angles and perspectives that involve also technological, anthropological, and psychological aspects. Some aspects have to be addressed with specific methods and modelling approaches. Physical and economic vulnerabilities must be addressed using probabilistic and deterministic approaches associated with damage scenarios and potential economic impacts; social and cultural issues of the vulnerability shall be assessed with reference to demographic, institutional and cultural aspects defined by indicators, population data, statistics and qualitative judgements. A holistic approach facilitates an understanding of vulnerability as a dynamic and changing circumstance or condition (Susman et al., 1983; Comfort et al., 1999; Renn, 1992; Vogel and O'Brien, 2004). Moreover, we can also see it as an accumulative process of permanent fragilities, deficiencies, and limitations that play a role in the existence of higher or lower levels of vulnerability.

Risk is defined as the potential occurrence of physical, social, economic, and environmental consequences or losses, in a given area and over a period of time, resulting from the vulnerability conditions of a socio-ecological system exposed to hazards (UNDRO, 1980; Cardona, 1990; UNISDR, 2009). In order to face the recognized risk, it is necessary to involve the risk governance which includes the totality of actors, rules, conventions, processes and mechanisms concerned with how relevant risk information is collected, analysed and communicated and management decisions are taken. These management decisions include tasks on risk reduction, prevention, mitigation and transfer which allow implementing measures for hazard intervention or vulnerability intervention that lead to exposure and susceptibility reduction and resilience improvement. Figure 1.2. presents a conceptual framework of risk and risk management based on the abovementioned holistic approach of risk. This conceptual model has been used to propose the framework of the EU project MOVE (Methods for the Improvement of Vulnerability Assessment in Europe) (Cardona 2010; Carreño et al. 2014a; Birkmann et al. 2013, 2014)

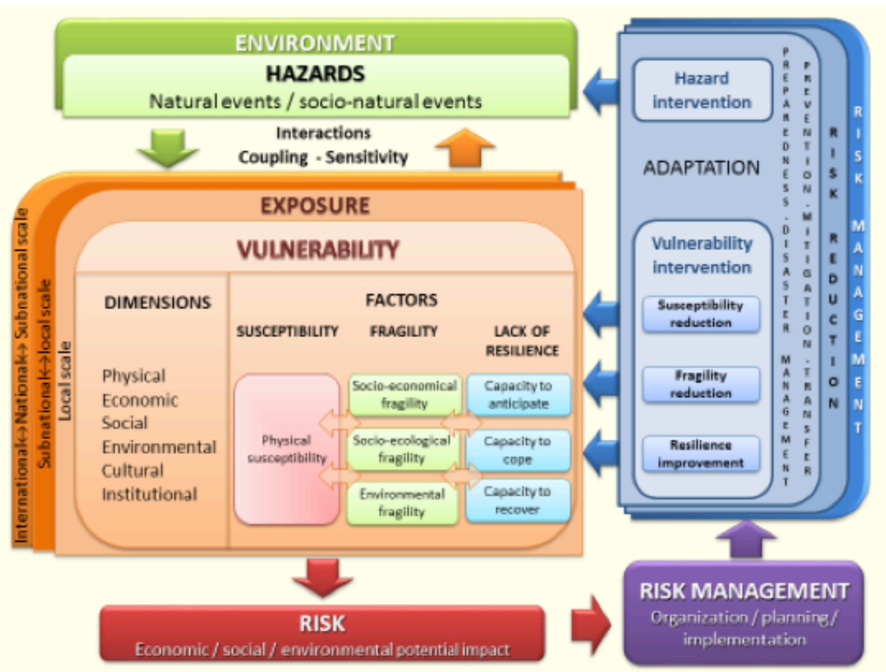


Figure 1.2 Components of the framework for integrated risk management. (Cardona 2010; Carreño et al. 2014a; Birkmann et al. 2013, 2014)

Risk management may be understood as a series of elements, measures and tools directed towards intervention in hazards and vulnerabilities with the objective of reducing existing or controlling future possible risks (IDEA, 2005; Carreño et al., 2007b). It involves preparedness, emergency response and reconstruction. Disaster risk management aims to articulate different types of actions, assigning a central role for prevention and mitigation, but without abandoning disaster response, in an attempt to develop preventive policies that significantly reduce the need for intervening in disasters once these occur (UNISDR, 2009). This type of management should not be seen as a purely government-led process, but a participatory exercise, involving governmental and non-governmental actors with the idea of dealing with risk and disaster. In this sense, good risk governance means disaster risk management based on, one hand, the involvement of the diverse social, institutional, public, and private forces and groups that exist, on a broad and inclusive territorial basis, and on the other hand, rules, conventions, processes and mechanisms concerned with how relevant risk information is collected, analysed and communicated and management decisions are taken. It follows, therefore, that risk management is a fundamental strategy for sustainable human development given that it attempts to establish an equilibrium between natural ecosystems and the societies which occupy and utilize them, guiding human actions and activities that affect the environment and vice versa.

The terms prevention and mitigation have been used to identify activities that attempt to intervene hazards and vulnerabilities, and thus avoid or reduce risk or future disasters and loss; they are related to the society's capacity to anticipate (Carreño et al., 2007b). In addition, preparedness activities provide better options for disaster management prior to and during disaster, and are put in place prior to the impact of dangerous physical events. Emergency or humanitarian response attempts to guarantee human security and welfare immediately following the impact of different physical phenomenon and is related to the coping capacity of the society (UNISDR, 2009). Rehabilitation and reconstruction activities, on the other hand, attempt to optimally restore, transform and improve the economic, social, infrastructure and life style conditions in the affected zone, granting higher future levels of security through the implementation of activities and actions that control future risk. In this sense, the notion of capacity to recover (rehabilitation and reconstruction) has been imbued with the idea of future disaster prevention and mitigation; i.e. the capacity to anticipate.

Central to the capacity to recover from natural hazard events is the concept of disaster resilience. In an urban environment, resilience emphasizes the processes and conditions within communities that enhance or reduce a population's ability to resist, adapt to, and recover from a shock or perturbation within the shortest possible time and with little or no outside assistance. Resilience, in this way, is synonymous with the notions of "bouncing back" or "jumping back" (Klein et al. 2003; Paton and Johnston 2006), and the term "resilience" has been used to describe great strength under adversity and the ability to withstand unfavorable circumstances (Burton 2015). Timmerman (1981) is probably the first to define resilience within natural hazards and disasters research where he described the concept as the measure of a system, or part of a system's, capacity to absorb or recover from a damaging event. This report adopts the UNISDR definition of resilience in which resilience is "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). How communities will be affected following an earthquake may be conceptualized in terms of their resilience, and numerous perspectives have been developed to advance the underpinnings of the concept. In general, resilient communities are those that take deliberate action to reduce hazard risks, prepare for, and accelerate recovery in the face of hazards and disasters.

From the perspective of vulnerability and risk reduction, it is important to make emphasis that corrective intervention are related to processes that attempts to reduce "existing" levels of risk in society or in a component of society, product of the historical patterns of territorial occupation, production, construction of infrastructure, amongst other things. It reacts to and compensates for risk that already exists in society. Examples of corrective risk management methods or instruments are the construction of dams and dykes to protect population already located in the flood plains of rivers, the retrofitting of buildings against earthquakes and hurricanes, changes in cropping patterns in order to adjust to adverse environmental conditions, reforestation of river basins in order to diminish existing processes of erosion, landslides and flooding. On the other hand, prospective intervention refers to the anticipation or prevision of risk that may be generated with "future" development projects and investments. It comprises measures taken to guarantee that new risk factors do not appear with new initiatives in construction, production, infrastructure, transport and commercialization. Prospective intervention must be seen as an integrated part of development and project planning, whether these are developed by government, private sector or civil society. The final objective of this type of intervention is to avoid new unnecessary risks guaranteeing adequate levels of sustainability for new investments and thus avoiding the need for more costly corrective intervention later (Lavell, 1999; 2000; UNISDR, 2009).

Disaster risk management concepts and experience have been developed in the light of historical and projected future contexts of hazard and vulnerability. When dealing with climate related aspects this can be seen in the light of hazards associated with what may be referred to as "normal climate variability". Adaptation to climate change, on the other hand, has been developed as a notion and sought practice through other professional and institutional modalities as if it were a separate and discrete area of knowledge, directed to future climate conditions influenced by human intervention, using scenarios which go up to 50 or 100 years ahead.

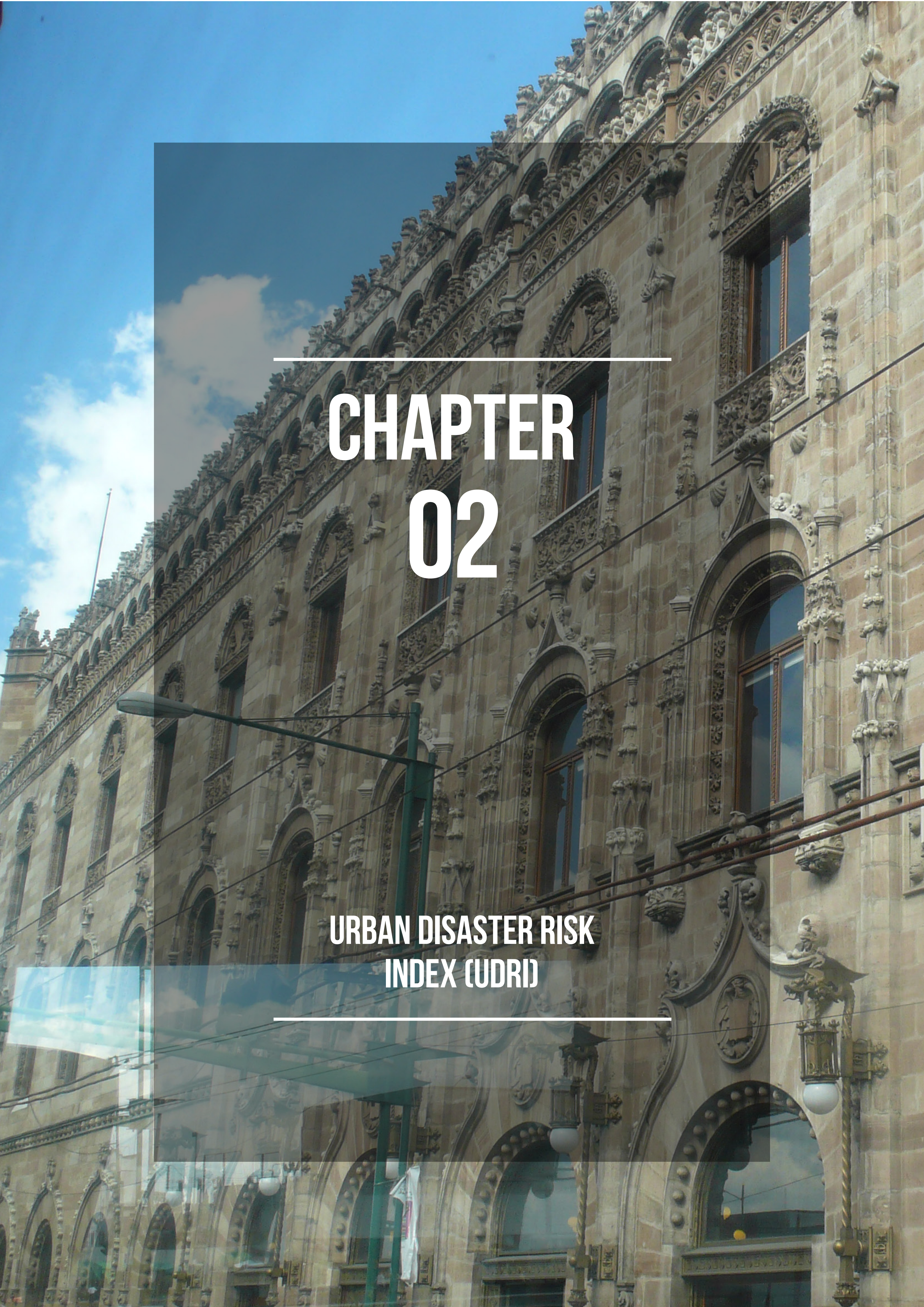
Adaptation means "adjustment" in natural or human systems to a new or changing condition; i.e. the ability of an individual or group to adjust to changes in the natural and built environment (IPCC, 2007; UNISDR, 2009). Overall, adaptation can be anticipatory or reactive, autonomous and planned. Adaptive capacity requires techniques and strategies to be devised that enable society to absorb and deflect the impact of hazards (Birkmann et al., 2013).

Disaster risk management and adaptation mean, therefore, not only the hazard and vulnerability intervention but also the resilience improvement (Lavell, 1999; 2000; IDEA, 2005; Cardona, 2004; 2010). Finding a common ground for understanding disaster resilience is difficult, and the relationship between vulnerability and resilience is not well articulated. The latter is partially because academic understandings of the concepts vary by context (Adger 2006; Eakin and Luers 2006; Cutter et al. 2008). There is some overlap in characteristics of communities that make them vulnerable and characteristics that make them resilient, however. The extent of overlap often depends on the definition and description of the vulnerability and resilience terms (Manyena 2006; Cutter et al. 2008). In general, two viewpoints have emerged in natural hazards and disasters research. The first viewpoint describes vulnerability as the degree or capacity of a system to cope with and recover from a damaging event. Within this context, vulnerability is described as a function of reduced resilience (see Timmerman 1981; Dow 1992; Bohle et al. 1994; Wisner et al. 2004). That is, a population or community that is highly vulnerable is not resilient, and vice versa. Conversely, if vulnerability is only viewed as a 'threat' or 'exposure' to a natural hazard, or as the degree for potential for loss, or the circumstances that put people at risk (see Mitchell 1989; Downing 1991; Alexander 1993; Cutter 1996; Cutter et al. 2003), then vulnerability and resilience may not be related at all.

In conclusion, the development of techniques that permit a permanent monitoring of territorial and social accumulation of vulnerability or the evolution of physical trigger processes is conducive to the application of realistic and dynamic planning techniques. This should be flexible enough to adjust to continuous or abrupt changes in the natural, economic, and social environment. This type of corrective and prospective approach is more appropriate than the uni-dimensional approaches, given the levels of uncertainty and instability that characterize existing processes of change and which render long term plans almost impossible to realize. In many places economic, social, and cultural factors are becoming increasingly relevant for the dynamics of growth and progress. In view of this, it is necessary to develop less rigid planning models that allow to, more adequately, incorporate uncertainty, instability and surprise, using diagnostic and follow-up techniques that permit the monitoring of the social and environmental context and possible perturbing agents.

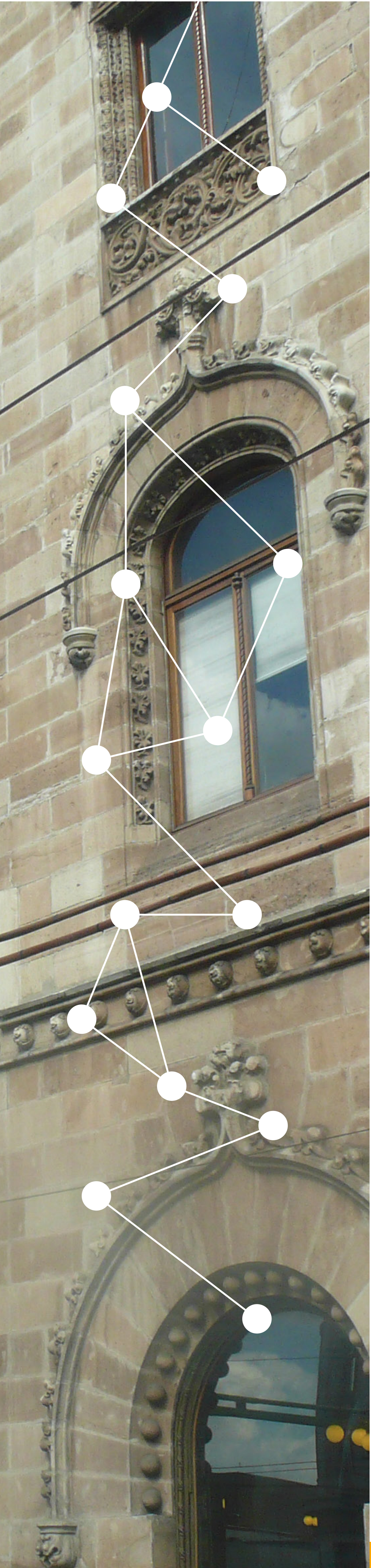
Some of those disaster risk indexes can be applied at urban level depending on the subject that is being measured and the objective of the assessment. On one hand, the Urban Disaster Risk Index (UDRi), also known in the literature as the Urban Seismic Risk Index (USRi) when the assessment is only related to earthquake allows quantifying risk from a holistic perspective, that is, by not only considering the direct physical impact but socioeconomic aspects related to the social fragility and the lack of resilience. UDRi is flexible in terms of resolution level and the definition of it depends on the disaggregation level of the required information which at urban level is usually at counties, localities and neighbourhoods. Because UDRi is a composite index that depends on several descriptors, the final result can be disaggregated to assess which are the descriptors that are contributing the most so they can be communicated to the decision-makers and stakeholders inviting to the action identifying the hard and soft weaknesses of the urban center. On the other hand, the Risk Management Index (RMI) aims to assess the management level and how it has evolved along to time. Both indices are complimentary and to show that, three case studies in

Colombia are presented for main cities where the indices have been estimated. In either case, the objective of the measurement is to identify key factors that can be intervened with the aim of improving, by decreasing the risk levels or by increasing the disaster risk management capacity. Also complimentary to the quantitative derivation of the UDRi is the Disaster Risk Index (DRI). The Mumbai case study presented here, shows how the DRI is applied based on a participatory assessment of resilience that allows the co-production of key indicators describing the key themes of resilience in a city as well as their evaluation through a self-assessment. The DRI framework pays particular attention to the diagnosis of potential deficiencies and opportunities along a city's key development policies and processes for mainstreaming of risk reduction and increasing resilience



CHAPTER 02

URBAN DISASTER RISK INDEX (UDRI)



CHAPTER 2

PRINCIPLES AND THEORY

A holistic evaluation of disaster impacts has to take into account not only potential losses or damages from natural hazards, but also economic, social, and institutional factors. In this sense, a holistic evaluation of risk must fully leverage results of urban loss and damage scenarios.

These outputs describe potential physical impacts of disasters, such as number of casualties, number of injured, percent of building damage or economic costs and are obtained through mathematical modeling of the underlying hazard and physical vulnerability of the built environment. This is sometimes referred to as the "hard approach".
In addition, a holistic evaluation of risk must also look through a multi-disciplinary lens and take into account the dynamic interplay between physical risk of the built environment as well as the human dimensions within a hazard zone that can aggravate the physical risk. This, so-called "soft approach"

must include both susceptibility or fragility factors – as pre-event, inherent characteristics or qualities of exposed systems that create the potential for harm- as well as lack of resilience factors that can account for the societal response to an event in terms of pre-event risk reduction, in-time coping and post-event response measures (Birkmann et al., 2013, 2014).

The Urban Disaster Risk Index is a composite indicator that measures risk from an integrated perspective and guides decision-making for identifying the main interdisciplinary factors of vulnerability to be reduced or intervened.

The quantitatively derived Urban Disaster Risk Index (UDRi) (also known in the literature as Urban Seismic Risk Index – USRi when seismic risk is assessed) provides a holistic view of disaster risk by capturing through indices both the direct physical damages of buildings and infrastructure, as well as considering social fragility or lack of resilience that can aggravate the physical effects. The models and methodology referred to here as the Urban Disaster Risk Indicators (UDRi) was developed by Carreño (2006) and Carreño et al. (2007a) which is based on Cardona's model (Cardona, 2001; Cardona and Hurtado, 2002; Barbat and Cardona, 2003; IDEA, 2005) using a holistic approach for evaluating disaster risk by means of indices. The main objective of this indicator system is to measure disaster risk from a holistic and integrated perspective to guide decision-making, not only by considering the potential direct impacts of disasters but also by identifying multiple factors contributing to social vulnerability and lack of resilience in a city. The rationale behind this methodology is that the development of preparedness strategies and allocation of resources must not only consider the direct physical risk to people and assets, but also the societal context present within a city that gives rise to risk. The Urban Disaster Risk Indicators allow decision makers to separately view the different dimensions of physical risk from disasters (e.g. losses of population, buildings, critical facilities) as well as obtain a holistic view and gain further insight when combining the additional impact from lack of resilience and social fragilities within a city with physical risk. The goal of the integrated risk analysis is to identify concentrations of the highest impact areas or "hot spot" areas within a limited geographic area to focus respective planning and decision-making. Hotspots can be defined in terms of the local administrative units that are relevant for emergency planning, preparedness and policy. Usually these constitute the smallest administrative areas for which building and population census data is available. Input data on disaster loss scenarios and vulnerability conditions at the sub-city district urban level are necessary to apply the method. This approach contributes to communication of disaster risk and its efficient management, through the identification of hotspot within the urban space.

The UDRi methodology was originally developed for the Inter-American Development Bank through the IDB-IDEA Indicators Program by the Institute of Environmental Studies (IDEA) of the National University of Colombia, Manizales (UNAL) (Cardona et al. 2005; Carreño, 2004; IDEA 2005). The UDRi approach outlined in the Guidebook remains essentially the same holistic, systematic, multi-step process, however, the stakeholder-validated implementation of the methodology presented in the Guidebook has been further refined through numerous applications and projects in cities across the world and updated with lessons learned from each of these case studies. Together with its partners at Manizales, the International Center for Numerical Methods in Engineering (CIMNE) of the Technical University of Catalonia (UPC), and local counterparts in the Philippines, the Earthquake and Megacities Initiative (EMI) undertook a preliminary application of the indicator approach to megacities in Metro Manila (Fernandez et al., 2007). Besides the implementation in Metro Manila, many other related applications of the model have been undertaken by the IDEA-CIMNE team and the methodology has been tested and evaluated in other cities and sub-national regions in Latin America and Europe. These applications include Bogotá D.C. (Carreño and Cardona, 2006; FOPAE, 2011), Manizales (Suárez 2007) and Medellín (Salgado-Gálvez et al., 2014a; 2014b) (Colombia), Quito (Ecuador), Managua (Nicaragua), San José (Costa Rica), Santo Domingo (Dominican Republic), Port of Spain (Trinidad and Tobago) (Carreño et al. 2013), Barcelona (Marulanda et al., 2013, Carreño et al. 2014a,b) (Spain) and Lombardy region (Italy). The Urban Disaster Risk Indicators have also been successfully implemented with stakeholders by EMI in Metro Manila (Fernandez et al., 2006); Istanbul (Khazai et al., 2008; Khazai et al., 2009; Kilic et al., 2012), Amman (EMI, 2009), Pasig (EMI, 2012), Quezon City (Bendimerad et al., 2013), Mumbai (Khazai et al., 2011a, 2011b) and Dhaka (EMI, 2014). In this Guidebook we present in detail the application of this method in Istanbul, Mumbai, Medellín, Bogotá D.C. and Manizales.

METHODOLOGY

The current UDRi methodology is based on Cardona's original model (Cardona, 2001; Cardona and Hurtado, 2002; Barbat and Cardona, 2003, IDEA 2005), accounting for a holistic approach and describing seismic risk by means of indices. Expected building damage and losses in the infrastructure, obtained from feasible future loss scenarios are basic information for the evaluation of physical risk in each unit of analysis and then, using these data, a physical damage index that accounts for the first order effects is obtained. The proposed method can be developed on a multi-hazard evaluation environment and, therefore, it is necessary to include physical damage estimations for all the considered hazards.
The holistic evaluation of risk by means of indices is achieved by affecting the physical risk with an aggravating coefficient, obtained by considering contextual conditions, such as the socioeconomic fragility and lack of resilience, that aggravate initial physical losses. Available data about these conditions at urban level are necessary to apply the methodology. The proposed holistic evaluation of risk is performed using a set of input variables, herein denominated descriptors. They reflect the physical risk and the aggravating conditions that contribute to the potential impact. Those descriptors, which will be discussed later, are obtained from the future loss scenarios and from socio-economic and coping capacity information of the exposed context (Carreño et al., 2005).

The model of holistic urban risk evaluation proposed by Carreño et al. (2007a) improves conceptual and methodological aspects of the first proposal of Cardona (2001), refining the applied numerical techniques and turning it into a more versatile tool; which has been possible because remarkable advances in the probabilistic estimation of losses associated to natural extreme events. The conceptual improvements provide a more solid theoretical and analytical support, eliminating unnecessary and assumed aspects of the previous method and providing more transparency and applicability in some cases. Cardona's original model allows the evaluation of the seismic risk in an urban center taking into account the characteristics of the physical risk, seismic hazard, physical exposure, socio-economical fragility and lack of resilience, that permits to identify those characteristics of the urban center that increase the level of risk and also the critical areas. This model studies different types of information by means of indicators and uses a normalization process of the results based on the mean and on the standard deviation which is applied to each indicator. As a consequence, the results obtained with Cardona's method allow a comparison of the holistic seismic risk among the different areas of an urban center in a relative way, but not a comparison in absolute terms with other urban areas.

The new method proposed by Carreño (2006) conserves the approach based on indicators, but it improves the procedure of normalization and calculates the final indices in an absolute (non-relative) manner. This feature facilitates the comparison of risk among urban centers. The exposure and the seismic hazard have been eliminated in the method proposed in this paper because they have been included into the physical risk variables calculation in a direct manner; also, the descriptor of population density, a component of the exposure in Cardona's model, is now included as a descriptor of social fragility. The new approach preserves the use of indicators and fuzzy sets or membership functions, proposed originally by Cardona, but in a different way. Other improvements of Carreño's model refer to the units of some of the descriptors; in certain cases it is more important to normalize the input values respecting the population than with respect of the area of the area under analysis. This is, for example, the case of the number of hospital beds existing in the studied urban area.
The socio-economic fragility and the lack of resilience are a set of factors (related to indirect or intangible effects) that aggravate the physical risk (potential direct effects). Thus, the total risk depends on the direct effect, or physical risk, and the indirect effects expressed as a factor of the direct effects. Therefore, the total risk can be expressed as follows:

$$UDRi = R_F\left(1+F\right) \qquad (2.1)$$

Expression known as the Moncho's Equation in the field of disaster risk indicators, where RT is the total risk index, RF is the physical risk index and F is the aggravating coefficient of the impact factor (1+F). The physical risk, RF, is evaluated in the same way, using the transformation functions like the one shown in the Figure 2.1.

$$R_F = \sum_{i=1}^{p} w_{RFi} \times F_{RFi} \qquad (2.2)$$

where p is the total number of descriptors of physical risk index, FRFi are the component factors and wRFi are their weights respectively. The factors of physical risk, FRFi, are calculated using the gross values of physical risk descriptors such as the number of deaths, injured or the destroyed area, and so on. It has to be mentioned that although important, the calculation of physical risk scenarios is not the main objective of a holistic risk assessment.

Coefficient, F, depends on the weighted sum of a set of aggravating factors related to the socio-economic fragility, FFSi, and the lack of resilience of the exposed context, FFRj

$$F = \sum_{i=1}^{m} w_{FSi} \times F_{FSi} + \sum_{j=1}^{n} w_{FRj} \times F_{FRj} \qquad (2.3)$$

where wFSi and wFRj are the weights or influences of each i and j factors and m and n are the total number of descriptors for social fragility and lack of resilience respectively. Each of the factors used in the calculation of the USRi captures different aspects and is quantified in different units. Because of that, certain scaling procedures are needed to standardize the values of each descriptor and convert them into commensurable factors. In this case we used the transformation functions as the one shown in Figure 2.1 that standardize the physical risk, social fragility and lack of resilience factors used in this study. Depending on the nature of the descriptor, the shape and characteristics of the functions vary and because of that, functions related to descriptors of the physical risk have an increasing shape while those related to the lack of resilience have a decreasing one; that is, the higher the value of the factors, the lower their aggravation.

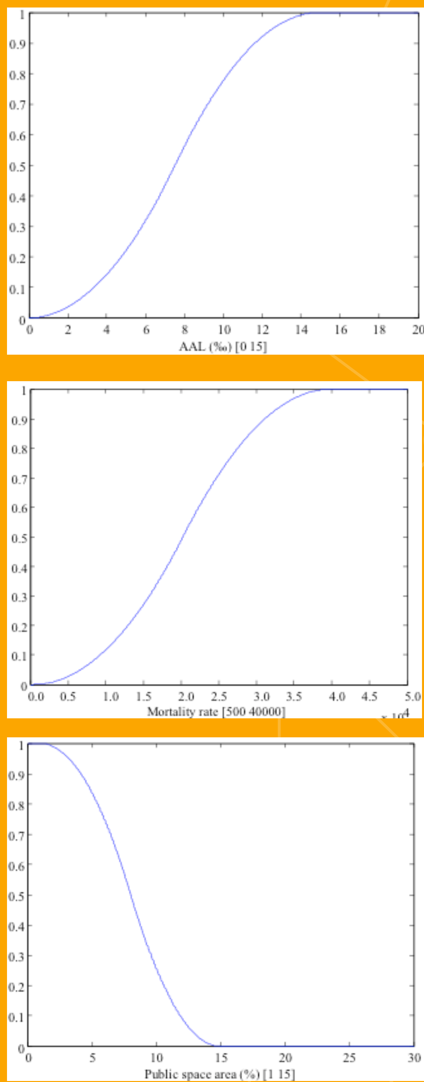


Figure 2.1 Example of transformation functions used to standardize physical risk, social fragility and lack of resilience factors (Carreño et al., 2007a)

The values on the abscissa of the transformation functions correspond to the values of the descriptors while the ordinate corresponds to the final value of each factor, either related to the physical risk or to the aggravating factor. In all cases, values of the factor lie between 0 and 1. Since the transformation functions are membership functions, for high risk and aggravating coefficient levels, 0 corresponds to non-membership while 1 means full membership. Limit values, denoted as XMIN and XMAX are defined by using expert opinions and information about previous disasters. Relative weights wFSi and wFRj that associate the importance of each of the factors on the index calculation are obtained by using an Analytic Hierarchy Process (AHP) that gives ratio scales from both discrete and continuous paired comparisons (Saaty and Vargas, 1991; Carreño, 2006; Carreño, et al. 2007a). This process has been performed starting from the experts opinions collected by means of the Delphi method. This is the most adequate way of judging the relative importance of variables having different nature and calculating their relative weights.

It is estimated that the indirect effects of hazard events, sized by the factor F in Equation 2.3, can be of the same order than the direct effects. According to the Economic Commission for Latin America and the Caribbean (Zapata, 2004), it is estimated that the indirect economic effects of a natural disaster depend on the type of phenomenon. The order of magnitude of the indirect economic effects for a ‘wet’ disaster (as one caused by a flood) could be of 0.50 to 0.75 of the direct effects. In the case of a ‘dry’ disaster (caused by an earthquake, for example), the indirect effects could be about the 0.75 to 1.00 of the direct effects, due to the kind of damage (destruction of livelihoods, infrastructure, housing, etc.). This means that the total risk, RT, could be between 1.5 and 2 times RF. In this method, the maximum value selected was the latter. For this reason, the impact factor, F, takes values between 0 and 1 in Equation 2.3.

Table 2.1 shows, as example, a list of suggested descriptors to be used in the estimation of the physical risk, social fragility and lack of resilience indexes; nevertheless, depending on the available information and its quality, they can be modified and even extended. At this stage it is important to note that the selection of the descriptors must ensure that the aspects that are being captured are not double-counted and that also, since all of them have an associated weight, its number should not be very large.

INDEX	DESCRIPTOR
PHYSICAL RISK	Average annual loss (by sector)
	Dead people
	Injured people
	Unemployed
	Homeless
SOCIAL FRAGILITY	Violent deaths rate
	Mortality rate
	Slums-squatter area
	Connection to public services
	Access to health care
	Population density
LACK OF RESILIENCE	Development level
	Emergency response level
	Human development index
	Distance to closest hospital
	Available public space

Table 2.1 Example of physical risk, social fragility and lack of resilience descriptors

The robustness of the composite indicator at urban level has been tested by means of Monte Carlo simulations (Marulanda et al., 2009) showing very good results.

UDRI PARTICIPATORY MODELLING PROCESS

The methodology for co-developing the UDRi with city stakeholders is presented here uses a practical "how to" approach. It is important to note that numerous scientific and technical references are available in the literature which presents various advancements to the methodology – for example, how to deal with missing and incomplete data - while preserving the conceptual framework shown here. The process of developing the Urban Disaster Risk Index through a stakeholder consultation model consists of eight main steps (Figure 2.2) which should be passed in an iterative manner. However, as shown in the Case Studies this can be tailored to fit stakeholder needs with additional or less steps as required.

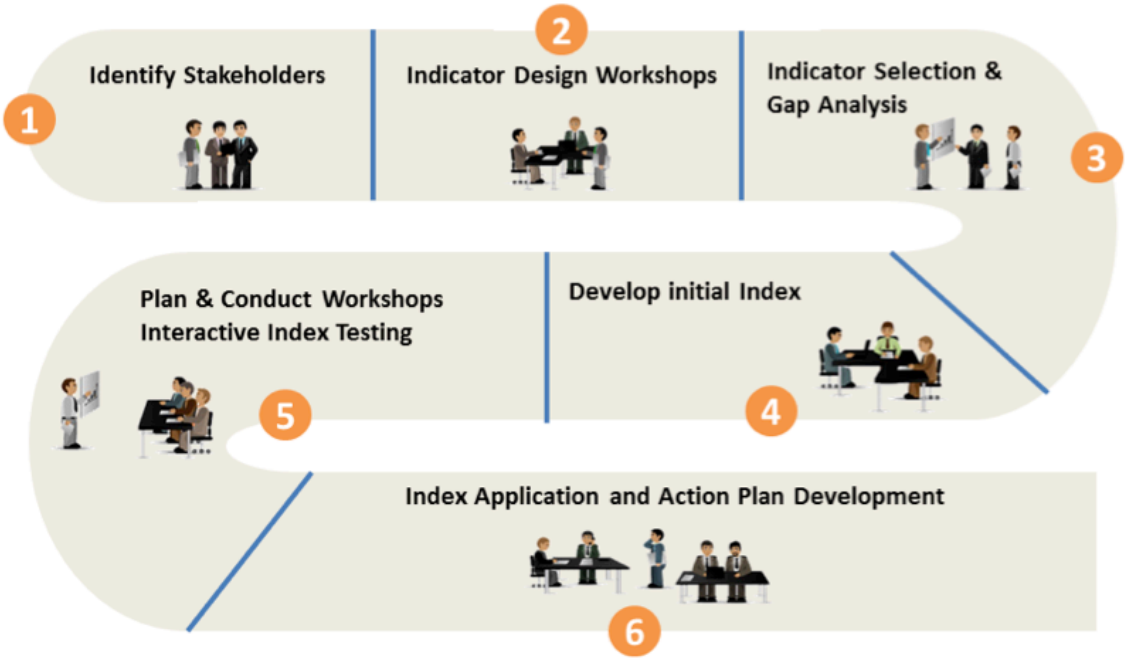


Figure 2.2 Multi-step indicator development process for the UDRi through a Stakeholder Consultation Model

STEP 1: IDENTIFY KEY STAKEHOLDERS

Identify and convene a broad representative range – "Focus Group" - of local government officials in a city (e.g. emergency management, land-use planning, critical infrastructure and services, legal and institutional, awareness and advocacy, etc.) to join in an initiative to test, monitor, and validate the results of the implementation of UDRi for their city. In addition the Focus Group can be representatives from academia, particularly experts in decision science and risk management, representatives of the private sector and business leaders, and representatives of other organized groups. Within this broad stakeholder group, invite a "Core Group" of individuals that have the most significant roles in using the urban indicator systems for managing DRM and assuring resilience in their city to be part of a work group to provide oversight and direction for the indicator systems and assume ownership of the entire process and outputs. The Core Group members should be composed of technical persons familiar with the application of the UDRi methodology and its key elements and/or may be supported by a technical project implementation team. The optimum number of members of the different Core Groups should be decided in each case. Experience from previous implementation has shown that the Core Group should be at least three members and a maximum of 10 so that the intensive collaborations are easier to handle.

STEP 2: INDICATOR DESIGN WORKSHOPS

Develop and conduct one to two workshops to allow the Core Group to explore significant issues and provide guidance and insights from key experts (e.g., local scientists, planners, etc.) on priority issues for incorporation into the indicator selection and design). This step contains the specification of the various dimensions to be covered for the Urban Disaster Risk Index, i.e.: (1) specification of the different types of hazards and respective loss scenarios to be covered; (2) specification of the different dimensions of the built environment to be covered; (3) and specification of different dimensions of vulnerability and resilience to be covered. The consultation approach with the Core Group including key experts to define the different dimensions of vulnerability and resilience for the city must ask two important questions: (1) What are the key factors describing groups that are especially vulnerable and the underlying conditions of vulnerability in a city; (2) What are key drivers contributing to the resiliency of a city in terms of pre-event risk reduction, in-time coping and post-event response. These factors should be viewed in light of the DRM concerns and associated policy objectives in the city. A list of indicators based on the literature and experience in other cities of different types of factors/drivers is presented in a facilitated meeting with the Core Group as a starting point in generating an initial candidate list of factors. The result of the first round of engagement is to establish a comprehensive "Wish-list" of factors contributing to physical risk, societal fragility and lack of resilience in the city.

STEP 3: INDICATOR SELECTION & GAP ANALYSIS

Once a "Wish list" of factors and indicators or proxies that can be used to measure them has been identified for the UDRi framework, conduct a baseline assessment (gap analysis) reviewing, assessing and debating the nominated factors in more broadly-based participative workshops of stakeholders and decision-makers. In order to guarantee the quality of the UDRi the gap analysis should validate the indicators nominated by the Core Group through objective or quality criteria, such as the SMART criteria (i.e. Specific, Measurable, Achievable/Accessible, Relevant/ Reproducible, Time-sensitive/Tangible). At this stage the nominated indicators for the UDRi framework can be prioritized by means of rankings and weights together with the stakeholders. This can be accomplished using Focus Group workshops, interviews or stakeholder surveys. This step will ensure that the selection process for the UDRi indicators have been through a vetting and validation process through a broad participatory process, however this can be a time and labor intensive process. In a more simple implementation, the gap analysis step with Focus Groups can be skipped and the broader stakeholder engagement in the interactive testing of the index outlined in Step 5 used to validate the indicators structure and their proposed weights.

STEP 4: INITIAL INDEX DEVELOPMENT AND DATA COLLECTION

The Core Group (or a supporting project implementation team in close coordination with the Core Group) will develop, from the information collected up to this point from the workshops, survey, interviews and other stakeholder interactions an initial set of indicators corresponding to the UDRi framework and collect the requisite data for these indicators. Initial weights of the selected indicators can be assigned based on the prioritization/ranking of nominated indicators in the Gap Analysis (Step 3). In case this step is skipped, borrowed weights (based one expert input) or equal weights can be assigned to the indicators. The final weights of the indicators can be changed through the interactive table top exercises (Step 5) or even at later stages.

The Core Group should be trained by the support team in the various steps of computing composite indices according to well-established methods for constructing composite indicators which include statistical multivariate analysis, imputation of missing data, normalization of data, weighting and aggregation, and sensitivity analysis (Nardo et al., 2005). The GEM and CAPRA indicator toolkits presented in the next section incorporate the various steps of composite index development and can be used interactively to arrive at an initial formulation of the UDRi by the Core Group. An extensive discussion of this step is beyond the scope of the Guidebook and the technical literature should be referred to for this (e.g. Nardo et al., 2005).

However, the following points should be considered in the development of the composite index:

- Normalization: Before aggregating the values of the indicators into an overall composite indicator value, the indicator values must be normalized. This is necessary because most of the indicators have different units and cannot be combined into the indicator framework in their original values. The transformation describes the intensity of risk for each one of the indicators. Here, 0 stands for low risk values and 1 for a high degree of risk. Different transformation functions (e.g. sigmoid, linear, etc.) used for normalizing the values of the indicators can result in differences in the final UDRi score for the different units of analysis and sensitivity of the output with respect to the transformation functions should be explored.

- Aggregation: The indicators are combined together as a weighted sum which results in the form of one single aggregated index value, UDRI, and several sub-levels: Physical Risk (RF) and Impact Factor (F) which is in turn composed of Social Fragility (Fs) and Lack of Resilience (FR). An especially important aspect for the quality of results of the integrated indicator system is marked by the assignment of weights for the individual indicators. The values of total urban disaster risk, UDRI, will differ depending on the weights assigned to each of the indicators. The effects of the weights on the final outcome can be explored in Step 5 through interactive table top exercises.

- Sensitivity Analysis: Due to the difficulty in operationalizing all dimensions of vulnerability (i.e., some dimensions cannot be measured), the results might be affected by different sources of uncertainty. This applies also to the uncertainties associated with the weighting process and the implementation of transformation functions, but also the variable qualities contained as a final step. Sensitivity of these different dimensions can be explored in great detail through various types of statistical analysis or kept simple. However, the sensitivity of the weights assigned to the indicators should be explored at a minimum to ensure the robustness of the final UDRi values.

STEP 5: INTERACTIVE INDEX WORKSHOP WITH STAKEHOLDERS

Plan and conduct an interactive tabletop exercise with a broad stakeholder group (e.g. Focus Groups) to demonstrate the UDRi rankings developed by the Core Group using initial borrowed weights based on expert input or equal weights. In particular, through this process the Core Group (in coordination with a support team) will attempt to demonstrate to the larger focus group of stakeholders how the UDRi can be used by stakeholders. Each of the indicators used in the UDRi will be discussed with the stakeholders. After an initial round of discussion to provide context for the methodology, the participants in this workshop will be asked to provide input on the importance of weights of each of the indicators working individually or in groups. This can be kept simple through a simple ranking of most to least important indicators by the participants or conducted using more rigorous methods such as the Analytical Hierarchy Process (AHP) to conduct a pairwise comparison of the indicators and assign the relative importance of one indicator with respect to the other.

Once a set of weights is proposed by the stakeholders, the GEM Integrated Risk Toolkit or the CAPRA indicator tool can be used interactively in the implementation of the UDRi with stakeholders. The tool will allow the stakeholders to display the indicators using various outputs and visualization formats. To facilitate the process of assigning weights, the tools will allow the stakeholders to manipulate the existing weights and interactively investigate the changes upon the total ranking outcome. The interactive design of the UDRi weights with stakeholders will enable them to understand the weighting methodology and to arrive at a final consensus weighting for the indicators. This should also provide a more comprehensive sense of the UDRi application, interpretation of the results and motivate them to use the UDRi as an instrument to discover key policy and action areas where performance needs improvements. The goal of this process is for the stakeholders to take ownership of the indicator model for effective DRM. Through such exercises the most relevant patterns and components of risk will be determined that would become the essential risk management tools for the city stakeholders. A key outcome of the workshop with the Focus Group will be to recommend action plans with short-term, mid-term and long-term goals for how and by whom the UDRi can be used in disaster risk reduction planning of the city.

STEP 6: UDRI ACTION PLAN DEVELOPMENT

The Core Group (with the project implementation team supporting the Core Group) will synthesize findings of the stakeholder workshop in Step 5 and conduct necessary interviews with key stakeholders on how to use UDRi in the DRM planning of their city. The preceding workshop and subsequent interviews should inform the development of the UDRi Action Plan and implementation strategy as a component of a city's resilience strategy and disaster risk management plan. The Action Plan should include: (1) Prioritized areas of risk reduction and resiliency strategy planning where UDRi can be used in periodic monitoring and evaluation of the city's risk; (2) Lead and participating organizations utilizing UDRi for each of these areas along with milestones and potential resource/funding requirements; and (3) A plan that proposes a periodic updating and review of the indicators and their weights and responsible groups for carrying this out.

TOOLS

Both the Global Earthquake Model (GEM) and the CAPRA (Probabilistic Risk Assessment) Program have developed interactive indicator software applications (toolkits) which are compatible with the UDRi methodology and provide a platform for the development of indicators and composite indices based on a holistic or integrated assessment of risk.

GEM INTEGRATED RISK MODELLING TOOLKIT FOR OPENQUAKE

While a myriad of approaches are used to better understand earthquake impacts including the delineation of physical vulnerability, social vulnerability, and risk, it is the dynamic interrelationships between these that are a focal point for researchers, policy-makers, and disaster risk reduction practitioners. To facilitate the holistic and integrated modelling of earthquake risk within GEM's open source software tools, the Integrated Risk Modelling Toolkit (Version 1.0) was released as part of the OpenQuake Platform in January 2015. The Integrated Risk Modeling Toolkit comprises of a series of geospatial-modelling tools that were developed to support the meaningful convolution of estimates of physical earthquake risk with socio-economic characteristics of populations (see Khazai et al. 2014). It should be noted that the Integrated Risk Modelling Toolkit will provide a final score of "integrated risk" based on Moncho's equation described earlier, once the variables and respective weights for physical risk index and the aggravating or impact factor are configured.

The GEM Integrated Risk Modelling Toolkit walks the user through the workflow for the development of indices from the selection of variables to the presentation and dissemination of the integrated risk assessment. Each step is extremely important, and coherence in the whole process is vital.

As focal point, the Integrated Risk Modelling Toolkit leverages a QGIS platform as a main component (https://plugins.qgis.org/plugins/svir/). The QGIS platform was chosen explicitly to utilize a geographic information system's ability to manipulate, analyse, manage, and present spatial information. QGIS was chosen due to its transparent and open-source philosophy in its development as well as to provide a graphical user interface for creating, editing, manipulating, and exploring socio-economic indicators and indices and to meaningfully combine these with estimates of physical earthquake risk using various methodologies. It is within this context that the Integrated Risk Modelling Toolkit allows a number of GEM's open-source tools to operate seamlessly through an intuitive workflow. The latter includes: 1) the OpenQuake Engine (https://github.com/gem/oq-engine/) that can export the results of physical risk calculations as csv files which can be loaded by the QGIS portion of the toolkit as GIS layers; and 2) the OpenQuake Platform (https://platform.openquake.org/) that can be used to upload statistically robust and comprehensive spatial data into the QGIS at the national level (for the globe) and at sub-national resolutions. Complete projects may also be uploaded to the OpenQuake Platform to facilitate project sharing and project visualization via the web using advanced exploratory data analysis tools such as the parallel coordinate plots demonstrated in Figure 2.3 for municipalities in Portugal.

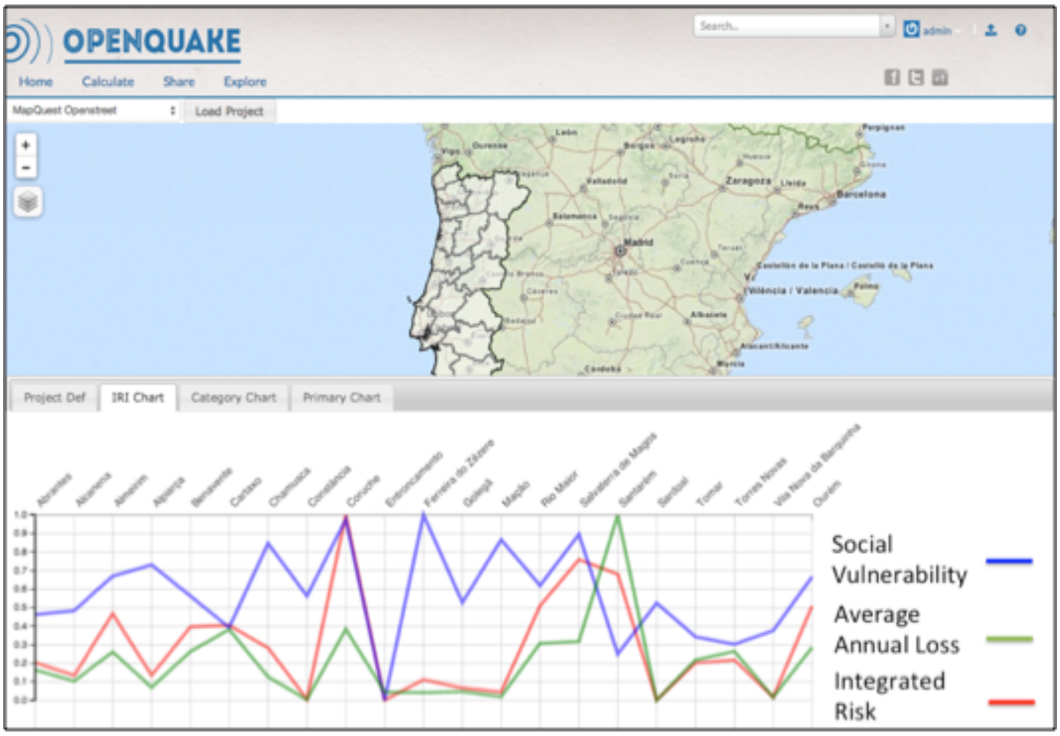


Figure 2.3 Visualization of integrated risk on the OpenQuake platform

The workflow for the development of indicators within the Integrated Risk Modelling Toolkit consists of an "ideal sequence" of steps, from the selection of variables to the presentation and dissemination of the final convoluted risk assessment. Choices made in one step of the process can have important implications for others. Therefore, the analyst has not only to make the most appropriate methodological choices in each step, but also to identify whether the choices fit together. The intent is for the toolkit to guide the user through this process via a workflow that facilitates:

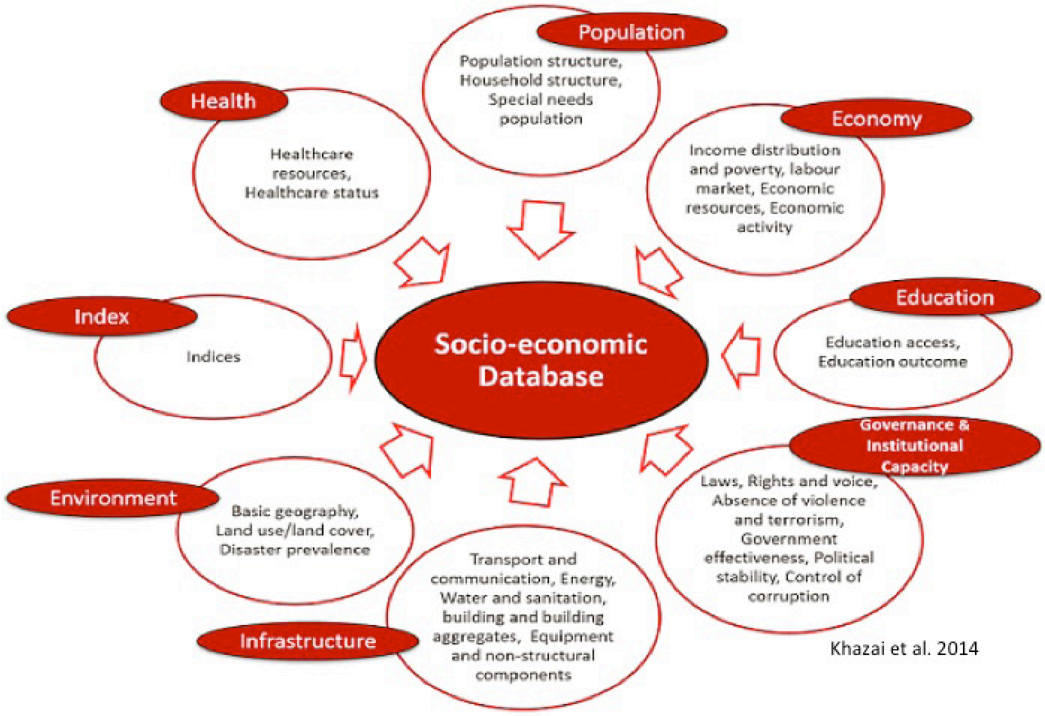


Figure 2.4 Taxonomy of categorizations and sub-categorizations for socio-economic vulnerability data available on the GEM OpenQuake Platform

VARIABLE SELECTION

The selection of variables often comprises the first step in the assessment of risk from an integrated and holistic perspective. During this step, the strengths and weaknesses of indicators are derived from the quality of the underlying variables selected for a given purpose. Variables should be selected based on a meaningful theoretical framework that has relevance to the phenomenon being measured, their analytical soundness, coverage, and accessibility. Since there is no definitive set of indicators for measuring social vulnerability and integrated risk, proxy variables are utilized within the toolkit. Upon initiation of the tool, users are given a direct link to the OpenQuake Platform which houses GEM socio-economic vulnerability databases that provide a set of proxy variables for measuring social vulnerability that have been stringently tested for representativeness, robustness, coverage and analytical soundness (see Khazai et al. 2014). This data was classified into a broad hierarchical system of categories and sub-categories used to make search and browse capabilities of socio-economic data functional for use in the QGIS software platform. The developed taxonomy of categorizations and sub-categorizations for data can be seen in Figure 2.4. This includes seven key themes: population, economy, health, education, environment, infrastructure and governance in an effort to improve the search capabilities of the database. Each categorization is composed of two or more sub-categorizations for the further refinement of the variable selection that may be queried within the QGIS interface using a number of filters (e.g. keyword and/or variable name) and dropdown menus (e.g. theme and/or sub-theme).

Within the interface, a menu is provided to give users the option to select a given study area (e.g. region, country, etc.). The selection initiates a spatial query of the relevant database to render the user relevant geometries and the data to create their mapped indices. Users also have the opportunity input their own data, as was the case for Portugal, in a shapefile (.shp) or comma-separated (.csv) format.

DATA TRANSFORMATION

Once data is selected, it should be standardized or normalized before being aggregated into a composite index and compared and convoluted with estimates of physical earthquake risk. This is because data are often compiled or delineated in a number of statistical units and with varied data distributions. It is within this context that variables are transformed to avoid problems inherent with mixing measurement units. The most common approach used in composite index development to transform data is normalization or conversion to z-scores. This approach converts all variables to a common scale by assuming a normal distribution with a mean of 0 and a standard deviation of 1. Scaling indicators via a standard deviation of 1 often implies that positive values represent an above average performance for a given indicator. Conversely, negative values often indicate a below average performance.

A number of methods for transforming indicators are provided within the Integrated Risk Modelling Toolkit. Functions within the toolkit for transforming data include: 1) data ranking which is the simplest transformation function; 2) normalization (or z-scores); 3) Min-Max rescaling which standardizes indicators by decomposing them into an identical range of values between 0 and 1 by subtracting the minimum value and dividing by the range of indicator values; 4) logarithmic transformations that are commonly used for positively skewed data 5) sigmoid transformations; and 6) a series of quadratic or U-shaped functions.

Future developments within this module will include the implementation of sensitivity tests to give users the ability to gauge the impact of the transformation of data on their index outputs and the ability to manually adjust minimum and maximum values for optimal curve fitting.

ASSESSMENT OF RELATIONSHIPS BETWEEN DATA

A multivariate analysis is a step that is often utilized for indicator development. Although not currently implemented at the time of this writing, it is envisioned that subsequent versions of the software will provide the means for users to conduct exploratory data analysis using multivariate statistical procedures to investigate the overall structure of the data.

WEIGHTING AND AGGREGATION

Central to the development of composite indices is the need to meaningfully combine different data dimensions where consideration is given to weighting. Most composite indices are equally weighted largely for simplicity or due to a lack of justification to weight one variable over another. Equal weighting, however, implies that all variables within an index are of equal importance, and weights are being increasingly assigned in participatory workshop settings for the development of indices such as the UDRi. As a result, the Integrated Risk Modelling Toolkit provides a mechanism for the weighting data based on participatory approaches or survey data that offers flexibility in the manner in which weights are assigned. Here, a Collapsible Tree chart (Figure 2.5) was embedded into a QGIS dialog to allow users to define their model type, to apply weights, and to aggregate their data in one module. The workflow supports both deductive and hierarchical model types that make use of linear aggregation or an aggregation structure defined by separate sub-components or categorizations. The development of a hierarchical model provides one example of the tool's workflow in which the user may construct the model within a project definition tree by first defining a primary node (or categorization) such as a "social vulnerability index" and then defining sub-categorizations such as a population index (node 1), an economy index (node 2), an education index (node 3), and etc. Via the interface, the user then dynamically selects relevant data from fields within the QGIS layer and dynamically applies the fields to populate a given node via dropdown menus, e.g. variables related to population are applied to the population node, variables related to the economy node are applied to economy, etc. Weights and aggregation methods are then applied to the categorized data using the interface. Here, weights will always add up to 1, and weights may be applied to individual indicators or to sub-indices via a simple right click on a given tree node which will pull up the appropriate dialog boxes to input weighted values. Nodes can then be combined for both deductive and hierarchal model types using aggregation methods that include geometric aggregation, simple summation, weighted summation, simple multiplication, and weighted multiplication. At each modification of the tree, the composite indices are automatically re-calculated and graphically displayed, styling the QGIS layer accordingly so the user can immediately note feedback the outcomes produced by changing the project definition tree.

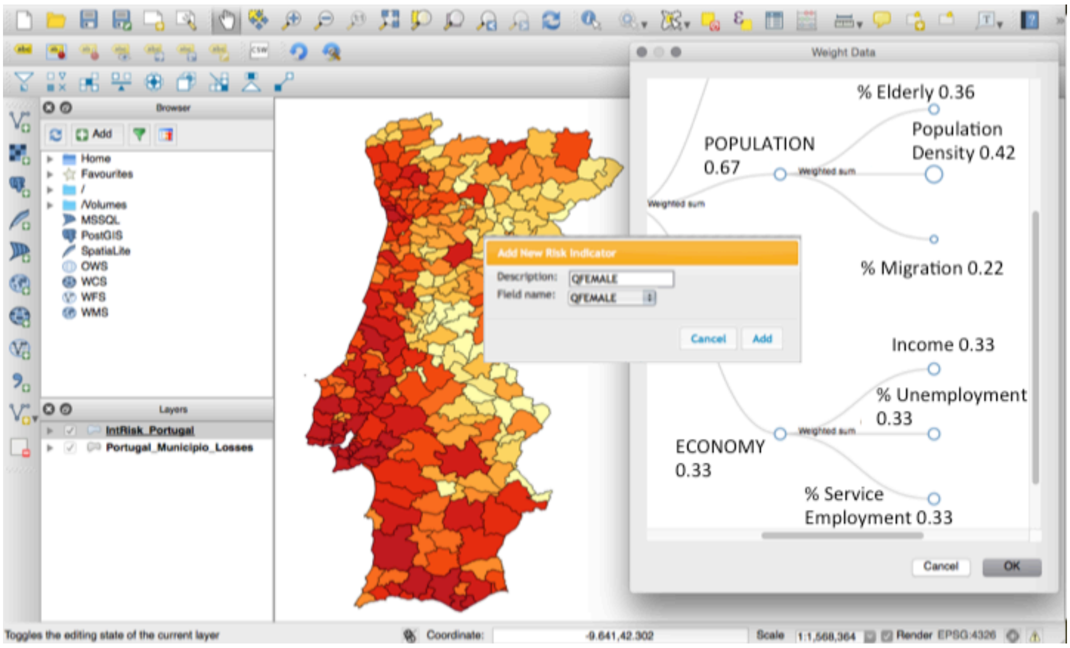


Figure 2.5 Collapsible tree chart embedded into the Toolkit QGIS dialog to allow users to define their model type, to apply weights, and to aggregate their data

RISK INTEGRATION

A number of techniques exist for the convolution of estimates of physical risk with social and economic indices, and these may be implemented within the tool. The method of aggregation for the UDRi based on Moncho's equation can be readily configured in the Integrated Risk Toolkit. The convolution of earthquake risk and aggravating or impact factor (i.e. social fragility and lack of resilience parameters) in this context can be accomplished by, first, importing risk assessments using the OpenQuake platform or using the toolkit's risk import tools for data not developed within OpenQuake to develop the physical risk index. Then the impact or aggravating factor can be estimated through selecting, transforming and weighting the indicators comprising the impact factor using the different functionalities of the Toolkit. Finally the physical risk index and impact factor are multiplied to obtain the UDRi rankings .

PRESENTATION AND DISSEMINATION OF RESULT

Composite indices and calculations of integrated risk may be visualized and presented in a number of different ways, which can influence their interpretation. When visualized in the form of a map, geographic variations in risk, social vulnerability, and integrated risk may become evident. Currently, the Integrated Risk Modelling Toolkit supports both mapping and graphing capabilities.

CAPRA HOLISTIC RISK ASSESSMENT POST-PROCESSING TOOL

As a new module of the CAPRA initiative, the CAPRA Holistic Risk Assessment Post-processing tool[2] (CIMNE-RAG, 2014) was first presented and released in June 2014 during the 2nd Integrated Research on Disaster Risk (IRDR) in Beijing, China. The module uses the output files of the CAPRA-GIS risk calculator engine (ERN-AL Consortium, 2011) containing risk results for damage and casualties as input data for a holistic risk evaluation as shown in Figure 2.6. The tool allows performing the holistic risk assessments at different resolution levels (e.g. urban and sub-national) and provides a user-friendly interface to select this at the beginning. The stages from the user perspective are presented next.

[2] Available at:
http://www.cimne.com/cvdata/cntr2/spc1151/dtos/img/mdia/Projects/EvHo/EvHo.zip

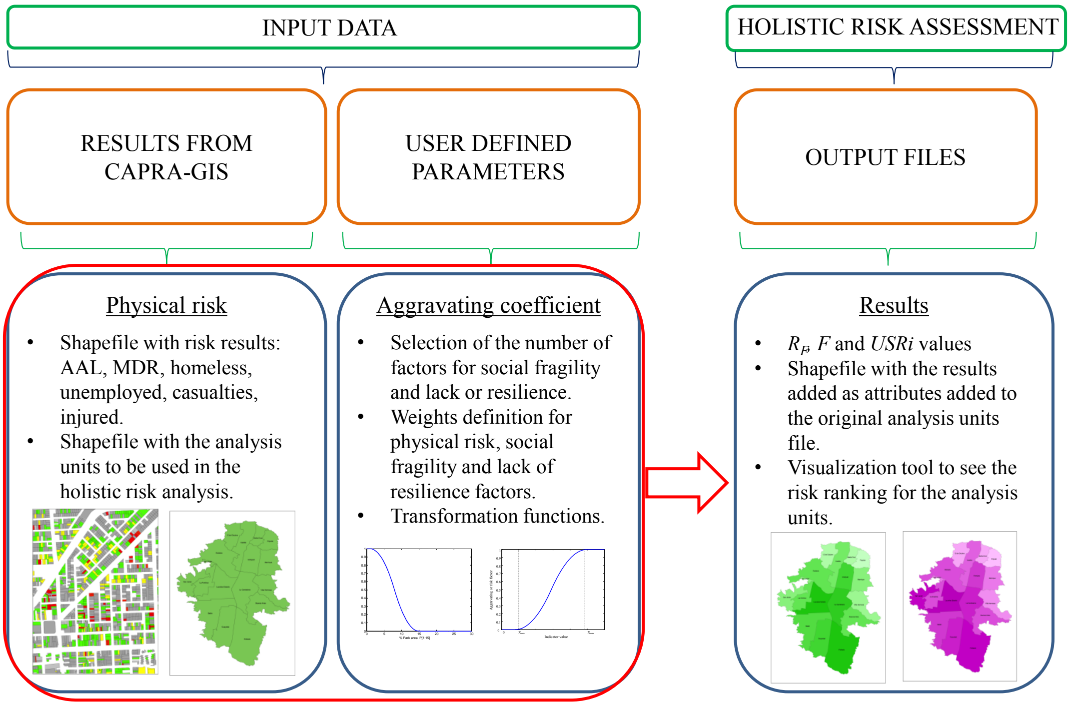


Figure 2.6 CAPRA Holistic Risk Assessment Post-processing tool flowchart (CIMNE-RAG, 2014)

SELECTION OF THE ANALYSIS UNIT

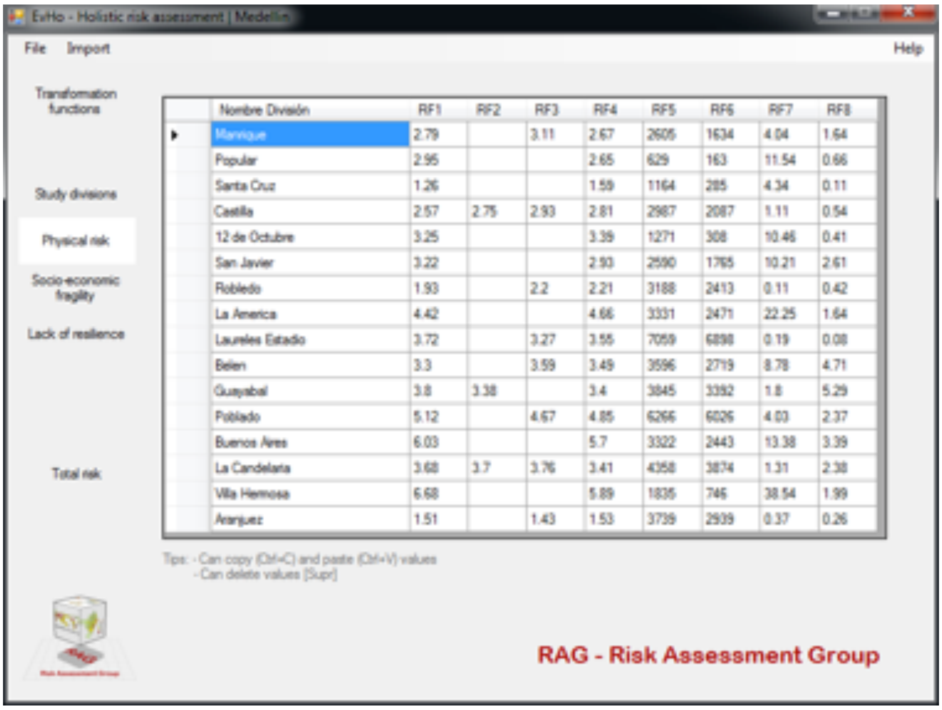
The user can define the analysis unit, an issue that can have great influence in urban holistic risk assessment. The analysis unit data can be directly incorporated in the module through shapefiles (*.shp). Since risk analysis can be performed at different resolution levels, the tool allows the selection of the desired level, and if the risk has been calculated on a more detailed scale, it groups the results into the desired analysis units based on a GIS-based platform.

SELECTION OF THE DESCRIPTORS

As explained before in this chapter, a set of descriptors associated to the estimation of the physical risk, social fragility and lack of resilience indexes are needed to be chosen. The user can select the number of descriptors to be used in the assessment for each of the indexes as well as specifying the units for each of them.

INPUT DATA FOR THE PHYSICAL RISK INDEX ESTIMATION

This tool reads the physical risk files if the risk estimation has been performed in the CAPRA Platform and calculates the different physical risk factors (FRFi), which can account for damage and casualties, while allowing the user to associate the results to the corresponding previously chosen descriptors (See Figure 2.7). Anyhow, since the tool is intended to be flexible, if the physical risk estimation has been performed in a different tool than CAPRA, results can be entered directly by the user.



Nombre División	RF1	RF2	RF3	RF4	RF5	RF6	RF7	RF8
Manrique	2.79		3.11	2.67	2605	1634	4.04	1.64
Popular	2.95			2.65	629	163	11.54	0.66
Santa Cruz	1.26			1.59	1164	285	4.34	0.11
Castilla	2.57	2.75	2.93	2.81	2987	2087	1.11	0.54
12 de Octubre	3.25			3.39	1271	308	10.46	0.41
San Javier	3.22			2.93	2590	1765	10.21	2.61
Robledo	1.93		2.2	2.21	3188	2413	0.11	0.42
La America	4.42			4.66	3331	2471	22.25	1.64
Laureles Estadio	3.72		3.27	3.55	7059	6898	0.19	0.08
Belen	3.3		3.59	3.49	3596	2719	8.78	4.71
Guayabal	3.8	3.38		3.4	3845	3392	1.8	5.29
Poblado	5.12		4.67	4.85	6266	6026	4.03	2.37
Buenos Aires	6.03			5.7	3322	2443	13.38	3.39
La Candelaria	3.68	3.7	3.76	3.41	4358	3874	1.31	2.38
Villa Hermosa	6.68			5.89	1835	746	38.54	1.99
Aranjuez	1.51		1.43	1.53	3739	2939	0.37	0.26

Figure 2.7 FRFi descriptors read from the CAPRA-GIS output files

INPUT DATA FOR THE AGGRAVATING COEFFICIENT ESTIMATION

Data related to social fragility and lack of resilience can be added to the project in tabular form or by importing it on a shapefile (*.shp) that has the values in the associated attribute table. Data must be added with the compatible units according to the selection made by the user.

NORMALIZATION OF THE DESCRIPTORS

As explained, whatever descriptors are chosen capture different aspects in terms of different units. Because of that, for the application of the methodology it is needed to normalize the results by means of transformation functions. The user needs to assign a unique transformation function as shown in Figure 2.8 to each of the descriptors that can be chosen from the set of built-in transformation functions available from the tool. In each case and according to the needs, the user needs to define the minimum and maximum values.

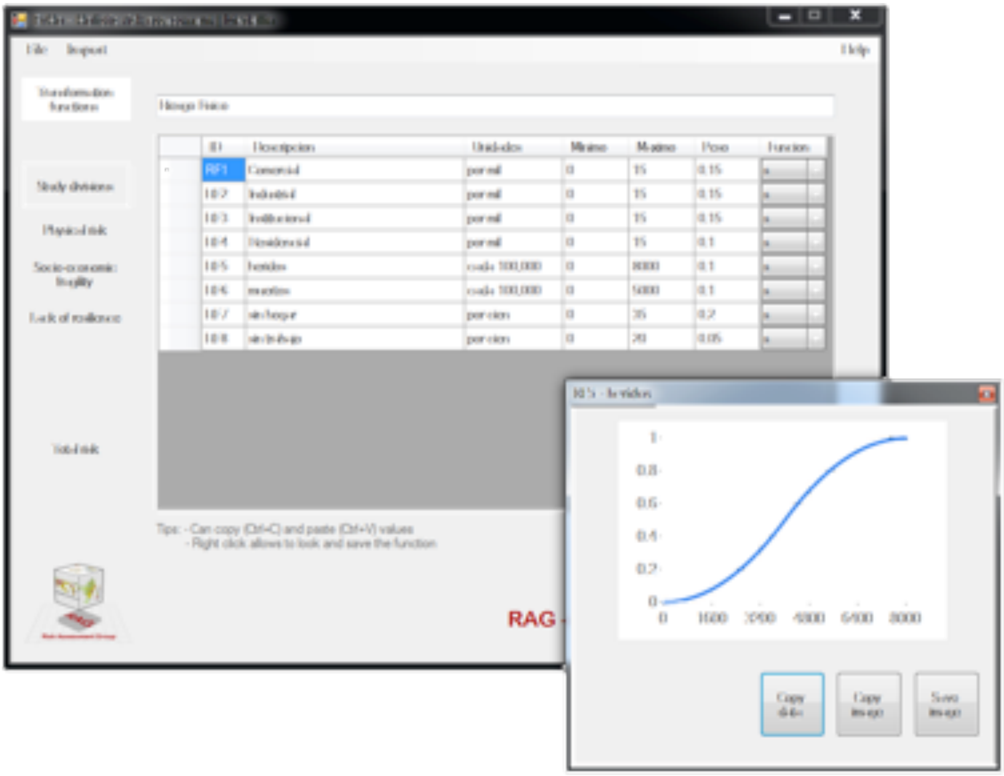


Figure 2.8 Definition and assignation of transformation functions to the selected descriptors

WEIGHTING OF THE DESCRIPTORS

Because UDRi is a composite index, the weighting process has a fundamental importance within the complete assessment process. The user has complete flexibility in the assignation of the weights for each of the descriptors and this is a value that must be defined previously to the use of the module. Because the definition of the weights associated to each of the descriptors is usually based on interdisciplinary workshops, surveys and/or interviews of stakeholders, it is not practical to include weighting methodologies (e.g. AHP) in the module. Anyhow, the module makes the verification that the weights associated to each index always sum 1.0.

UDRI ESTIMATION

The UDRi estimation is based on the methodology proposed by Carreño et al. (2007a) and the composite index is calculated for each analysis unit. The calculation process can be understood as the convolution between of the physical risk and the social vulnerability. The estimation is performed base on a GIS-platform which guarantees the spatial compatibility of the analyses and also allows the disaggregation of the results.

OUTPUT FILES

Results can be exported in Excel (*.xls) and shapefile (*.shp) format containing the overall results for each analysis unit. Allowing exporting the results in tabular and geo-referenced format gives flexibility to the user in order to incorporate and present the results in terms of tables, rankings and/or maps as shown in Figure 2.9.

Figure 2.9 Results by ranking and maps

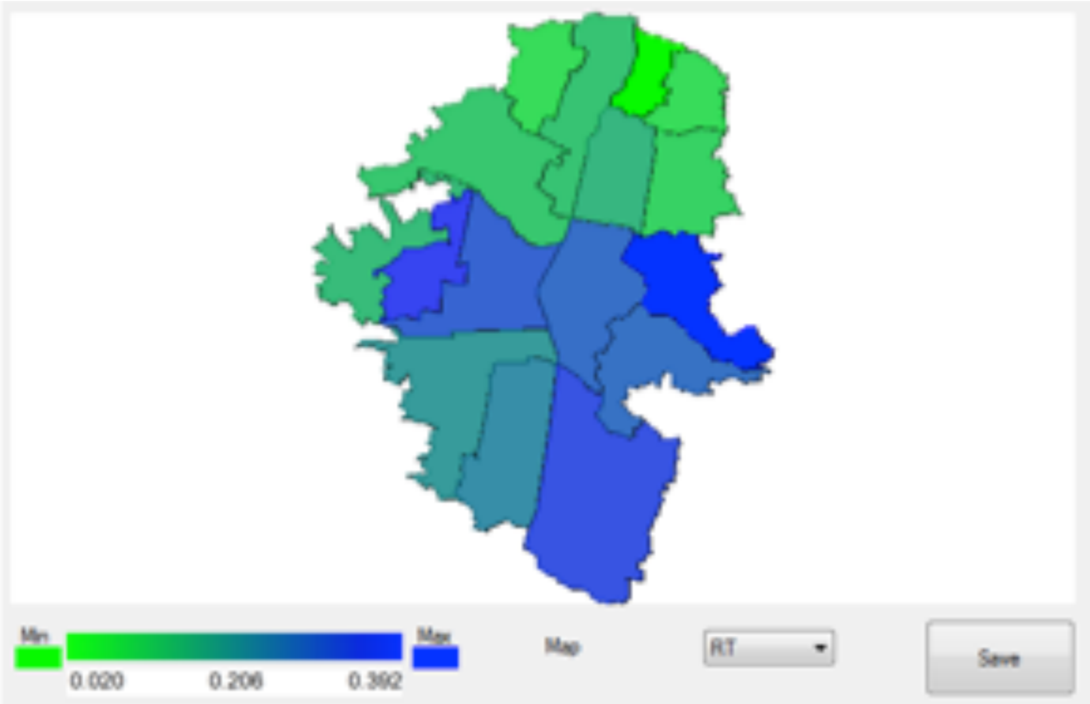


Figure 2.9 Results by ranking and maps

DISAGGREGATION OF THE COMPOSITE INDEX

The main objective of performing a holistic risk assessment besides locating the "hot-spots" is to identify the risk drivers that needs intervention. The tool disaggregates the results for each analysis unit for each of the indexes (physical risk, social fragility and lack of resilience) showing which descriptors contribute the most to the overall results. Facilitating the understanding of the risk results to the decision makers and the stakeholders. This disaggregation also allows the development of sensitivity analysis to better understand and validate the obtained results. The disaggregation results can be exported in Excel (*.xls) format as shown in Figure 2.10.

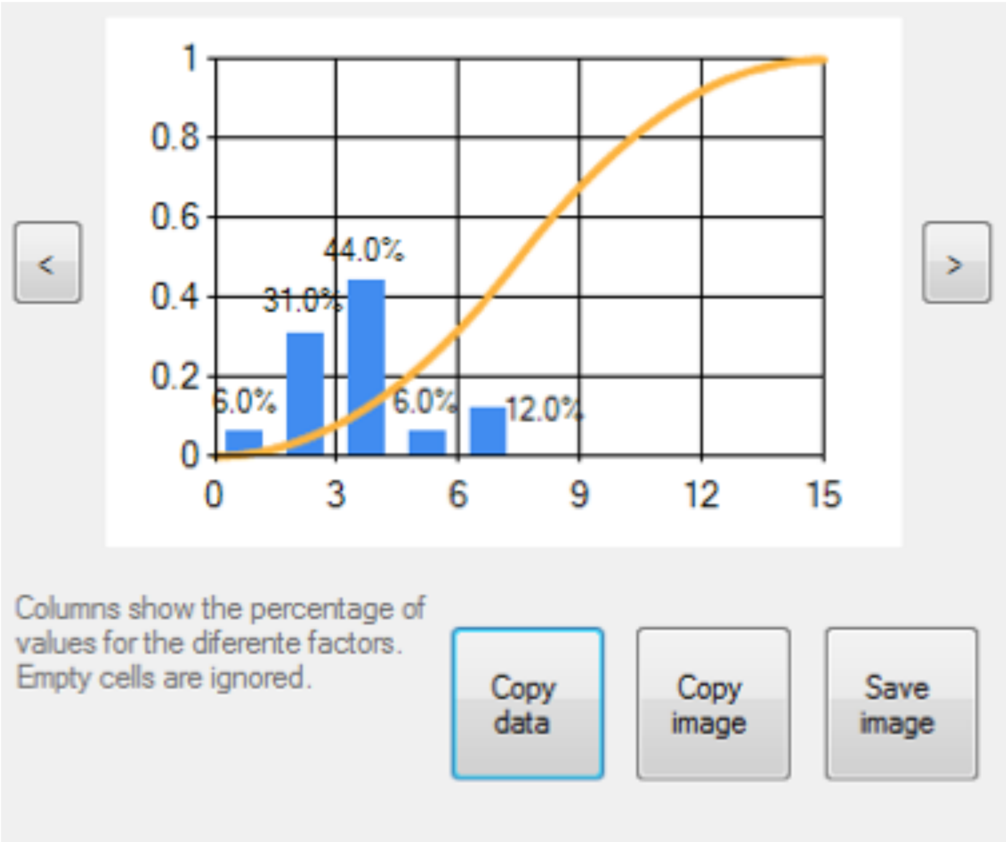
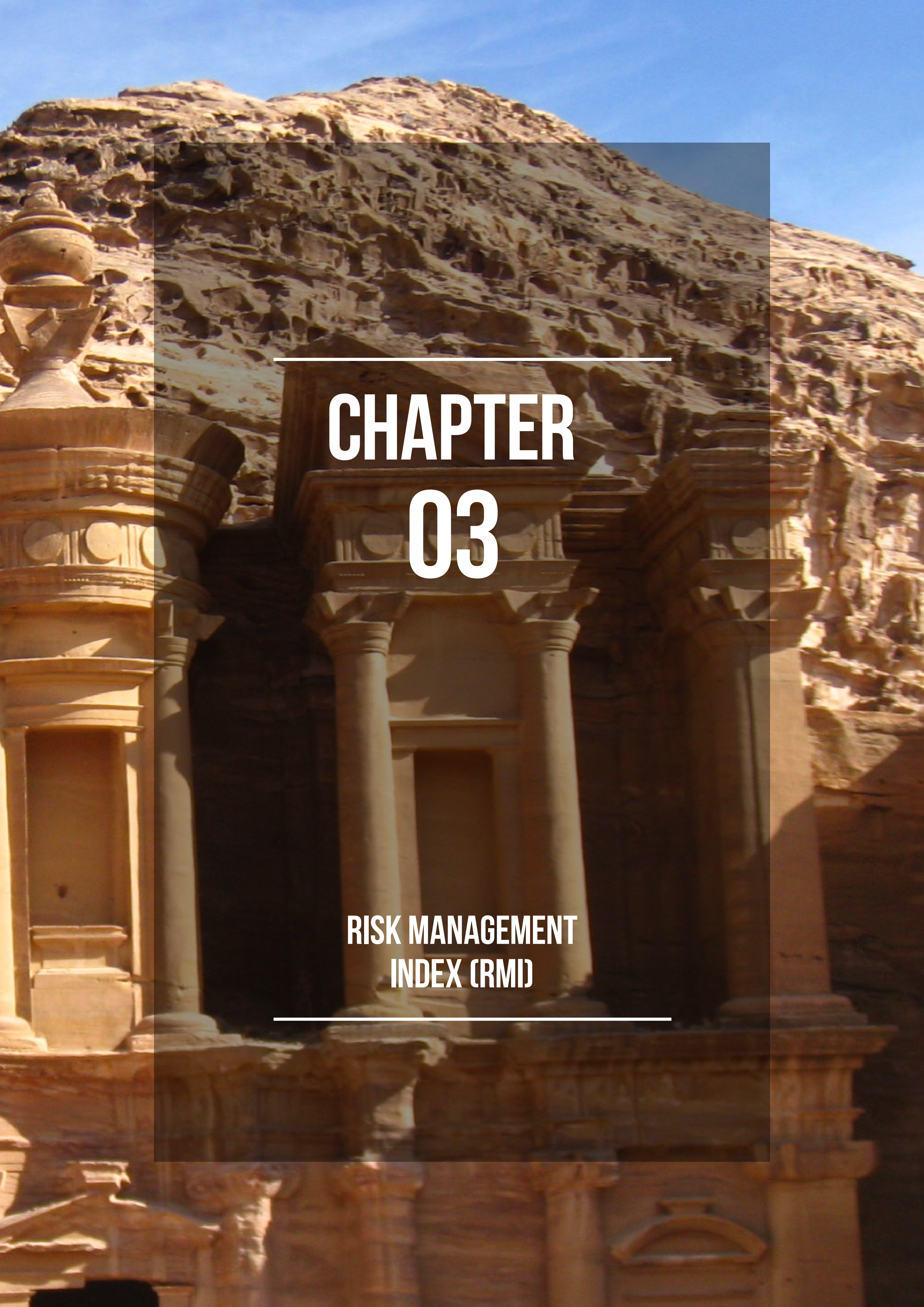


Figure 2.10 Disaggregation of the results

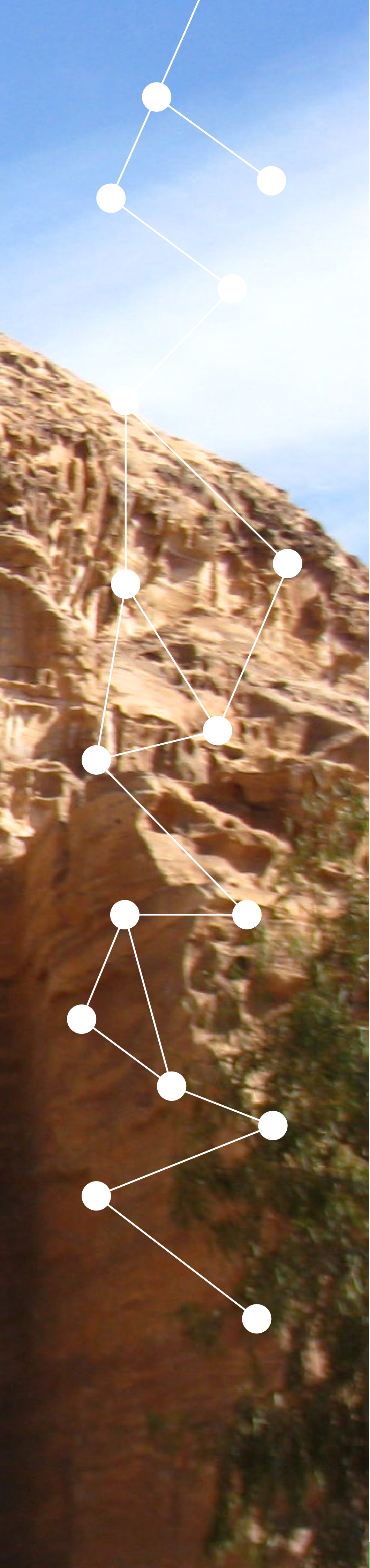
COMMUNICATION OF THE RESULTS

The CAPRA Holistic Risk Assessment post-processing tool incorporates a section where the user can visualize the UDRi results by means of tables, bar graphs and maps. Results are presented by analysis unit and can be exported directly to any of the above mentioned formats.



CHAPTER 03

RISK MANAGEMENT INDEX (RMI)



CHAPTER 3

METHODOLOGY

The Risk Management Index (RMI) is designed to assess risk management performance and its effectiveness. RMI provides a quantitative measure of management based on predefined qualitative targets or benchmarks that risk management efforts should aim to achieve.

The design of the RMI involves establishing a scale of achievement levels (Davis, 2003; Masure, 2003) or determining the distance between current conditions and an objective threshold or conditions in a reference country (Munda, 2003). The RMI is constructed by quantifying four (4) public policies each having six (6) indicators. Risk identification index, RMIRI, is a measure of individual perceptions, of how those perceptions are understood by society as a whole, and the objective assessment of risk. Risk reduction index, RMIRR, considers the existence of prevention and mitigation measures. Disaster management index, RMIDM, considers the measures of response and recovery, and governance. Finally, the financial protection index, RMIFP, measures the degree of institutionalization and risk transfer within the analysis area. These four (4) public policies and their indicators were defined following an agreement with several stakeholders and evaluators. The index can be applied at different scales (i.e. country, urban center), and any analysis area could redefine them according to own specificities. In order to make a consistent follow-up of the risk management, the parameters are maintained in the distinct evaluations over time. The RMI is defined as the average of the four (4) composite indicators:

$$RMI = \frac{\left(RMI_{RI} + RMI_{RR} + RMI_{DM} + RMI_{FP}\right)}{4} \quad (3.1)$$

Six (6) indicators are proposed for each public policy. These indicators characterize the risk management performance of a country, region or city. Using a larger number of indicators could be redundant and could make the weighting of each indicator difficult, as in the case of the USRi. Following the performance evaluation of risk management method proposed by Carreño et al. (2004, 2007b), the valuation of each indicator is based on five (5) performance levels: low, incipient, significant, outstanding, and optimal, which correspond to a range from 1 (low) to 5 (optimal). This methodological approach allows the use of each reference level simultaneously as a performance target and also allows for comparison and identification of results or achievements. Government efforts at formulating, implementing, and evaluating policies should bear these performance targets in mind. Alternatively, RMI can be estimated as the weighted sum of crisped numeric values (1 to 5, for example), instead of fuzzy sets of linguistic valuation, as in the proposed method, using a computer application. However, this simplification eliminates risk management non-linearity, having less appropriated outcomes.

Indicator	Description	Weight
RI1	Systematic disaster and loss inventory	w_{RI1}
RI2	Hazard monitoring and forecasting	w_{RI2}
RI3	Hazard evaluation and mapping	w_{RI3}
RI4	Vulnerability and risk assessment	w_{RI4}
RI5	Public information and community participation	w_{RI5}
RI6	Training and education on risk management	w_{RI6}

RMI_{RI}

RR1	Risk consideration in land use and urban planning	w_{RR1}
RR2	Hydrographical basin intervention and environmental protection	w_{RR2}
RR3	Implementation of hazard-event control and protection techniques	w_{RR3}
RR4	Housing improvement and human settlement relocation from prone-areas	w_{RR4}
RR5	Updating and enforcement of safety standards and construction codes	w_{RR5}
RR6	Reinforcement and retrofitting of public and private assets	w_{RR6}

RMI_{RR}

Indicator	Description	Weight
DM1	Organization and coordination of emergency operations	w_{DM1}
DM2	Emergency response planning and implementation of warning systems	w_{DM2}
DM3	Endowment of equipment, tools and infrastructure	w_{DM3}
DM4	Simulation, updating and test of inter institutional response	w_{DM4}
DM5	Community preparedness and training	w_{DM5}
DM6	Rehabilitation and reconstruction planning	w_{DM6}

RMI_{DM}

FP1	Interinstitutional, multisectoral and decentralizing organization	w_{FP1}
FP2	Reserve funds for institutional strengthening	w_{FP2}
FP3	Budget allocation and mobilization	w_{FP3}
FP4	Implementation of social safety nets and funds response	w_{FP4}
FP5	Insurance coverage and loss transfer strategies of public assets	w_{FP5}
FP6	Housing and private sector insurance and reinsurance coverage	w_{FP6}

RMI_{PF}

RMI

Figure 3.1 Component indicators for RMI (Cardona et al., 2005; Carreño et al., 2007b)

The sub-indexes of risk management conditions for each type of public policy are obtained as

$$RMI^{t}_{c(RI,RR,DM,FP)} = \frac{\sum_{i=1}^{N} w_i I^{t}_{ic}}{\sum_{i=1}^{N} w_i} \Big|_{(RI,RR,DM,FP)} \quad (3.2)$$

where wi is the weight assigned to each indicator, corresponding to each indicator for the territorial unity c taken into consideration and in the time period t, normalized or obtained by the de-fuzzification of the linguistic values. These represent the risk management performance levels defined by each public policy, respectively. Such linguistic values, according to the proposal of Cardona et al. (2005) and Carreño (2006), are the same as a fuzzy set that have a membership function of the bell or sigmoidal (at the extremes) type, given parametrically by the equations

$$bell(x;a,b,c) = \frac{1}{1+\left|\frac{x-c}{a}\right|^{2b}} \quad (3.3)$$

or

$$sigmoidal(x;a,c) = \frac{1}{1+\exp\left[-a(x-c)\right]} \quad (3.4)$$

where the parameter b is usually positive and a controls the slope at the crossing point, at 0.5 of membership, and x=c. Figure 3.2a shows these membership functions.

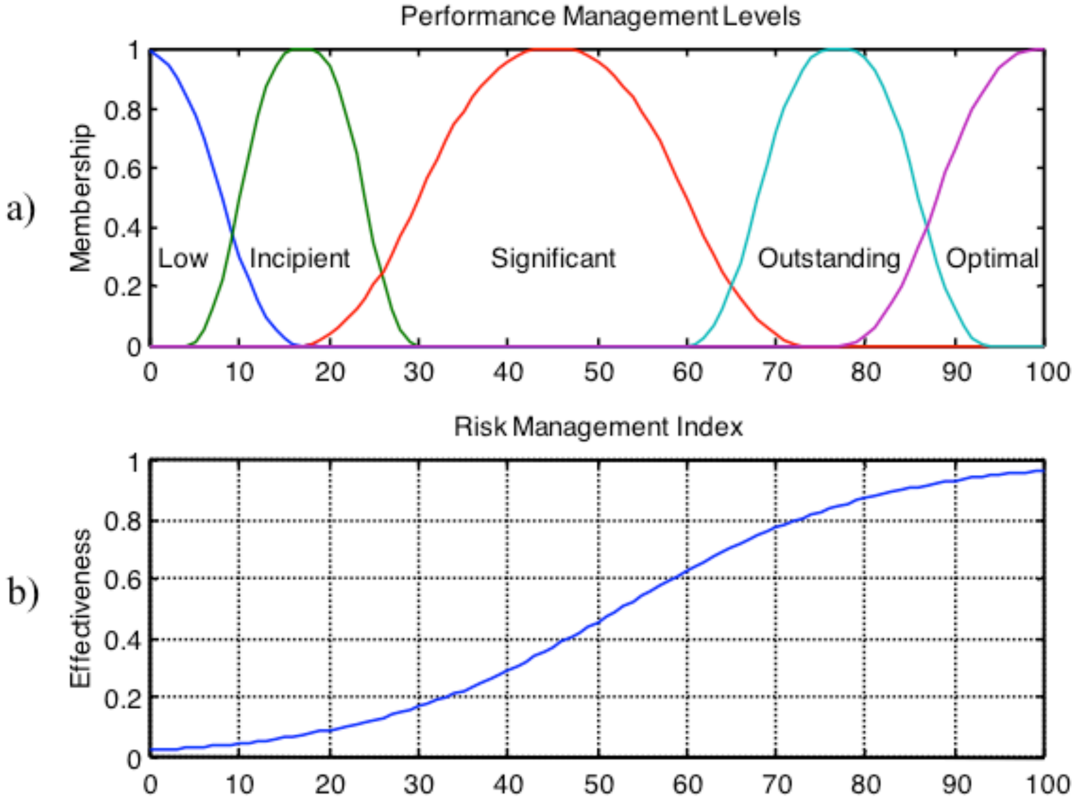


Figure 3.2 a) Functions that represent the quantification level; and b) Effectiveness degree of the risk management (Carreño et al., 2004; 2007b)

The shape of these membership functions follow a non-linear behaviour described by a sigmoid, as proposed by Carreño et al. (2007b), in order to characterize the performance of risk management and the level or feasibility of effectiveness.

The response of a socio-technical system to risk is equivalent to a level of adaptation according to the level of effectiveness of its technical structure and its organization. These produce various patterns of action, inaction, innovation and determination when faced with risk. According to Comfort (1999), various types of response may occur depending on the technical structure, the flexibility and the cultural openness to the use of technology. These types of response are: non adaptive response (inadequate for the existing level of risk and the performance is low or non-existent); emergent adaptation (insufficient but incipient); adaptive operational (adequate management but with restrictions, significant) and auto adaptive (innovating, creative, and spontaneous; that is, outstanding and optimal).

Membership functions for fuzzy sets are defined and represents the qualification levels for the indicators used in processing information. The value of the indicators is given in the x-axis of Figure 3.2a and the membership degree for each level of qualification is given in the y-axis, where 1 is the total membership and 0 the non-membership. Risk management performance is defined by means of the membership of these functions, whose shape corresponds to the sigmoidal function shown in Figure 4.2b, in which the effectiveness of the risk management is represented as a function of the performance level. Figure 3.2b shows that increasing risk management effectiveness is nonlinear, due to the fact that it is a complex process. Progress is slow in the beginning, but once risk management improves and becomes sustainable, performance and effectiveness also improve. Once performance reaches a high level, additional (smaller) efforts increase effectiveness significantly but, at the lower levels, improvements in risk management are negligible and unsustainable and, as a result, they have little or no effectiveness.

The following table presents an example of the benchmarks for the indicator RR5 of Risk Reduction policy. The tables for each indicator can be consulted in the Main Technical Report of Indicators of the IDB-IDEA Project (p.88-91; 122-131) at http://idea.unalmzl.edu.co and http://idea.bid.manizales.unal.edu.co/ and in Carreño et al. (2004), IDEA (2005).

Table 3.1. Example of subindicator and the feasible levels of performance

RR5. Updating and enforcement of safety standards and construction codes:
1. Voluntary use of norms and codes from other countries without major adjustments.
2. Adaptation of some requirements and specifications according to some national and local criteria and particularities.
3. Promulgation and updating of obligatory urban norms based on international or national norms that have been adjusted according to the hazard evaluations.
4. Technological updating of the majority of security and construction code norms for new and existing buildings with special requirements for special buildings and life lines.
5. Permanent updating of codes and security norms: establishment of local regulations for construction in the city based on urban microzonations, and their strict control and implementation.

It is necessary that experts who know the actual risk management progress in the studied area give qualifications of the indicators and assign relative importance between them for each public policy according to their experience and knowledge. These qualifications are processed and assigned weights using the Analytic Hierarchy Process (AHP). Once these are weighted and aggregated, a fuzzy set is formed from which a result is obtained. In order to achieve this transformation, a process of de-fuzzification of the obtained membership function is undertaken and extracted from this its concentrated or crisp value. This is the same as extracting an index.

The sum of all assigned weights is 1. These are used to give height to the membership functions of the fuzzy sets corresponding to the qualifications made

$$\sum_{j=1}^{N} w_j = 1 \qquad (3.5)$$

where N is the number of indicators which intervene in each case. Qualification for each public policy (RMIIR, RMIRR, RMIDM and RMIFP) is the result of the union of the weighted fuzzy sets

$$\mu_{RMI\,P} = \max\left(w_1 \times \mu_C\left(C_1\right), \ldots, w_N \times \mu_C\left(C_N\right)\right) \qquad (3.6)$$

where w_1 to w_N are the weights of the indicators of Figure 4.2, μC(C1) to μC(CN) are the membership functions of the estimates made for each indicator and μRMIi is the membership function of the RMI qualification of each public policy p. The risk management index value is obtained from the de-fuzzification of this membership function, using the centroid of area method, COA

$$RMI_P = \left[\max\left(w_1 \times \mu_C\left(C_1\right), \ldots, w_N \times \mu_C\left(C_N\right)\right)\right]_{centroid} \tag{3.7}$$

This technique consists in estimating the area and the centroid of each set and obtaining a concentrated value by dividing the sum of the product amongst them by the sum of the areas

$$\bar{X} = \frac{\sum A_i \bar{x}_i}{\sum A_i} \tag{3.8}$$

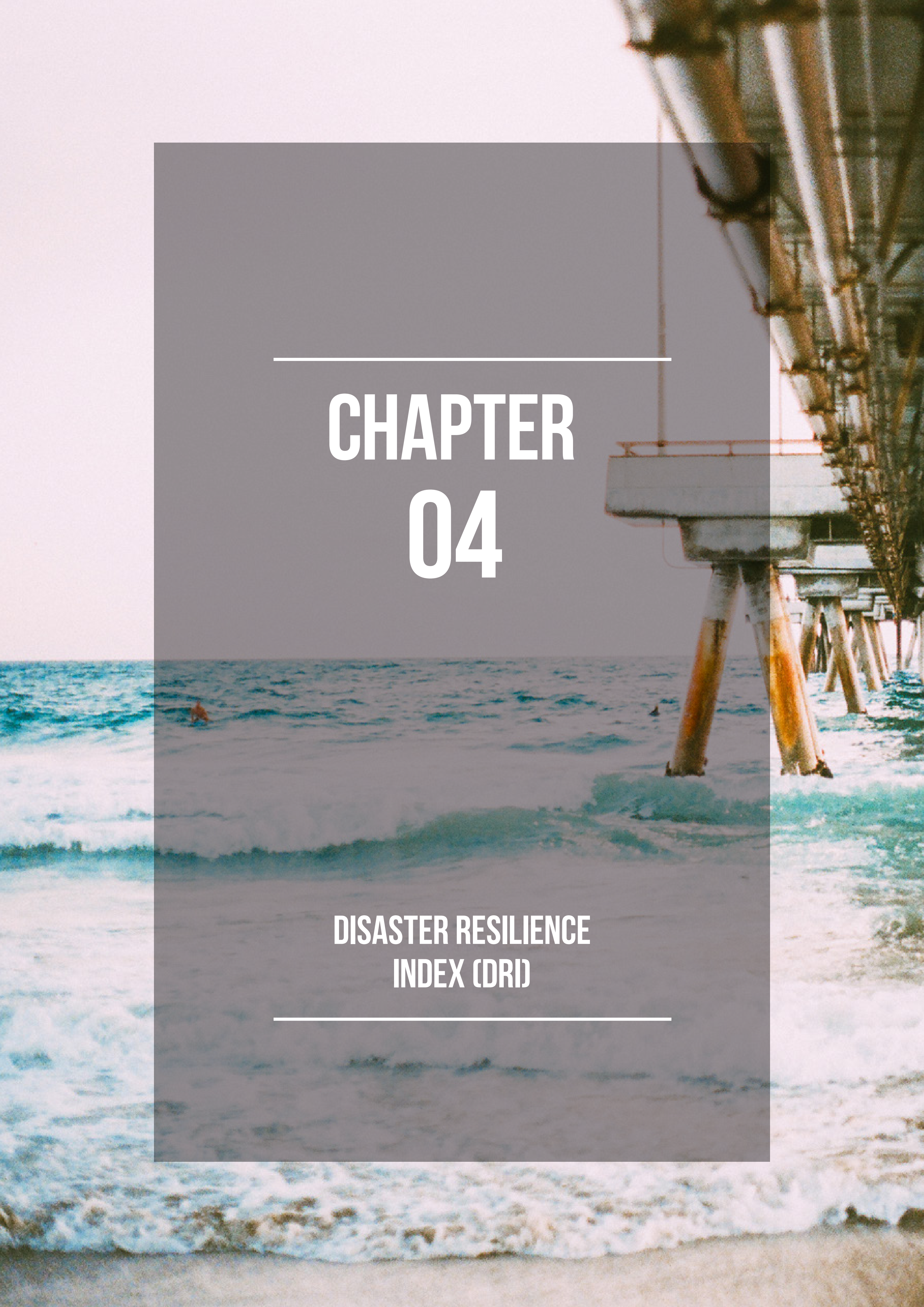
or

$$COA = \frac{\int_X \mu_A(x) x dx}{\int_X \mu_A(x) dx} \tag{3.9}$$

Finally, the average of the four (4) indexes provides the total risk management index or RMI.

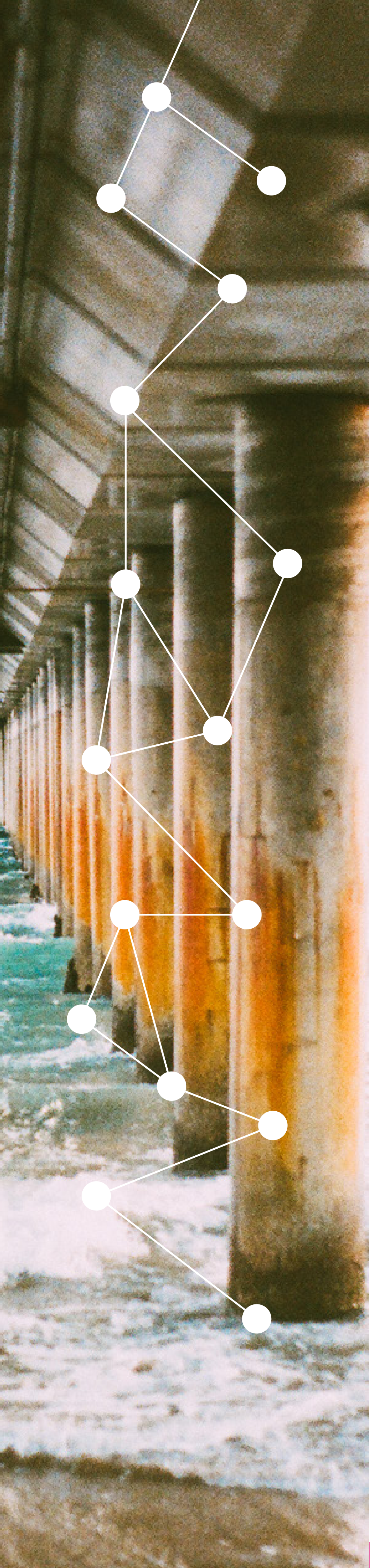
In order to properly evaluate the RMI and consider the different aspects of disaster risk management, the participation of local multi-disciplinary group of stakeholders is needed. Since the evaluation is performed on different time spans, local officials who are a living memory of the disaster risk management experiences in the study area, whether enrolled in the institutions at the time of the assessment or not, should participate in the evaluation. Several approaches have been developed to conduct the surveys aimed to qualify the performance of the public policies. These approaches range from workshops where policies are qualified individually or by groups to targeted online surveys addressed to those who have been explained on the RMI framework.

The Risk Management Index was the first systematic and consistent international technique developed to measure risk management performance. The conceptual and technical bases of this index are robust, despite the fact that it is inherently subjective. The RMI permits a systematic and quantitative benchmarking of each city or country during different periods, as well as comparisons across cities or countries. This index enables the depiction of disaster risk management at the national level, but also at the subnational and urban level, allowing the creation of risk management performance benchmarks in order to establish performance targets for improving management effectiveness. The RMI is novel and far more wide-reaching in its scope than other similar attempts in the past. It is certainly the one that can show the fastest rate of change given improvements in political will or deterioration of governance. This index has the advantage of being composed of measures that directly map sets specific decisions/actions onto sets of desirable outcomes. The RMI approach is quite innovative because it allows the measurement of risk management and its feasible effectiveness. The results of the assessment will be very useful as the base to formulate of an integrated disaster risk management plan or to identify the needs to improve certain aspects of the disaster risk management.



CHAPTER 04

DISASTER RESILIENCE INDEX (DRI)



CHAPTER 2

PRINCIPLES AND THEORY

Resilience is "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).

How communities will be affected following disasters may be conceptualized in terms of their resilience, and numerous perspectives have been developed to advance the underpinnings of the concept. In general, resilient communities are those that take deliberate action to reduce hazard risks, prepare for, and accelerate recovery in the face of disasters. Making a city disaster resilient means understanding the capacity of communities and decision-makers to actively adapt to, cope with, and transform in view of potential threats. Hence resilience is considered a multi-dimensional concept, visible at multiple levels of the city environment, and highly dynamic. How communities will be affected following a natural and/or manmade disaster may be conceptualized in terms of their resilience, and numerous perspectives have been developed to advance the underpinnings of the concept.

There are a number of characteristics of what makes up a resilient community. These include, but are not limited to: 1) the prevalence of institutions and leaders that provide enabling conditions through community involvement and governance; 2) the engagement in diverse livelihoods; 3) the management of environmental services; 4) the utilization of effective land use and structural design controls that complement environmental, economic, and community goals; 5) having community members that are aware of hazards and risk information; 6) having the capability of receiving notifications and alerts and warning at-risk populations; 7) having mechanisms established to address emergency needs at the community level; and 8) having plans in place prior to a hazard event that accelerate disaster recovery, engage communities in the recovery process, and minimize negative environmental, social, and economic impacts. Additional examples of disaster resilient communities are those that employ mitigation and planning programs aimed at hazard avoidance. Governments are coming to realize that planning can be a powerful tool for building disaster resilient communities and great potential exists for disaster loss and other impact reduction.

Moving from understanding to action and tracking progress on disaster resilience is a great challenge for local stakeholders and practitioners. Approaches that make resilience tangible and operational for decision makers have to effectively deal with the degree of impact and change required through different strategic actions in addressing agreed-upon resilience goals. From a policy perspective, indicators play a key role in operationalizing resilience as they can provide information and track progress on complex issues in a way that is simple and accessible to decision makers. Various resilience indicator frameworks with considerable variation in their structure, content and complexity have been used to establish baselines and comparing disaster resilience of different cities (e.g. UNISDR-Resilience Scorecard (IBM-AECOM), Rockefeller City Resilience Index (ARUP), Torrens Scorecard, etc.). Every city is unique and no single model or approach has been universally accepted, and indeed the diversity and unique requirements of different organizations and stakeholders suggest that no one-size-fits-all approach will ever do the job. While information from generalized indicators developed for comparative purposes between cities can adequately capture the broader aspects of resilience, a different approach that accounts for the local context and unique conditions is needed. In order to move towards the eventual and desirable outcome of stimulating change in stakeholders and to take action towards a more resilient tomorrow, a "localized" understanding of risk and resilience is needed through an on-going process of negotiation, participation and learning.

The Disaster Resilience Index (DRI) was developed within this context as a customizable, self-evaluation tool, empowering city stakeholders to assess key dimensions of resilience within a city's functional and operational activities through a fully participatory process. While the DRI is fully linked to the key priorities in the Hyogo Framework for Action 2015-2015 (HFA) and the UNISDR's 10 Essentials for Making Cities Resilient, it was developed as a disaster risk management planning tool to capture local processes and key dimensions within a city or community's functional and operational activities. This cannot be achieved using pre-defined indicator systems, and requires a reflexive approach that integrates local knowledge, conditions, and context into the design of the DRI indicators, while at the same time ensuring that key dimensions of resilience are captured in a systematic way.

While the DRI is fully linked to the key priorities in Hyogo Framework for Action 2015-2015 (HFA) and the UNISDR's 10 Essentials for Making Cities Resilient, the Disaster Resilience Index (DRI) was developed as a customizable and reflexive disaster risk management planning tool to capture local processes and key dimensions of resilience within a city or community's functional and operational activities.

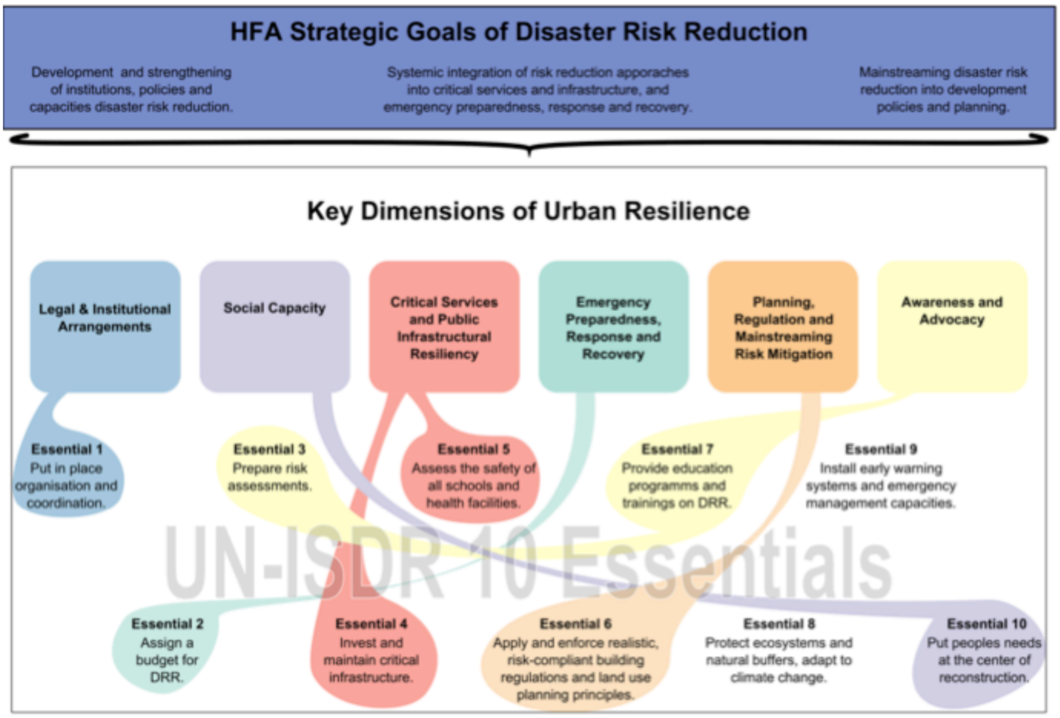
Thus the DRI is conceived as a Monitoring & Evaluation Tool (M&E Tool) that stimulates mutual learning and can be designed to facilitate the complete resilience management process at all stages. The DRI basically allows the stakeholders to go through an iterative self-evaluation process by defining, assessing and monitoring their resilience objectives and respective benchmarks themselves. In general, the DRI enables stakeholders to put their experience, expectations, and knowledge at the forefront of the resilience management process, enhances feedback loops and reflexive learning, and allows implementing agencies to keep track of the contextualized and self-imposed target benchmarks. In this way the DRI framework is connected to the adaptive planning and policy processes in which the DRM policy process in a city is conceived as a repeating cycle, allowing for periodic adjustment and adaptation.

METHODOLOGY

The DRI methodology was developed as a monitoring and evaluation tool for benchmarking and measuring progress (or lack of progress) on the mainstreaming of risk reduction approaches in the city's development policies and processes (Khazai et al., 2011a, 2011b, Khazai and Bendimerad, 2011). Besides its original implementation in Mumbai from 2008-2010, the tool was also used in Aqaba, Jordan (EMI, 2012). AIn addition, the DRI was customized and implemented in eight (8) municipalities and 4 provinces across the Philippines in compliance with the Philippine Disaster Risk Reduction and Management Act of 2010 and aligned with UNISDR's 10 Essentials (EMI, 2014). The dimensions of the DRI framework were also adapted to a Scorecard approach and implemented as part of the Global Earthquake Model Integrated Risk and Social Vulnerability project in Lalitpur, Nepal (Khazai et al., 2015; Anhorn et al., 2014).

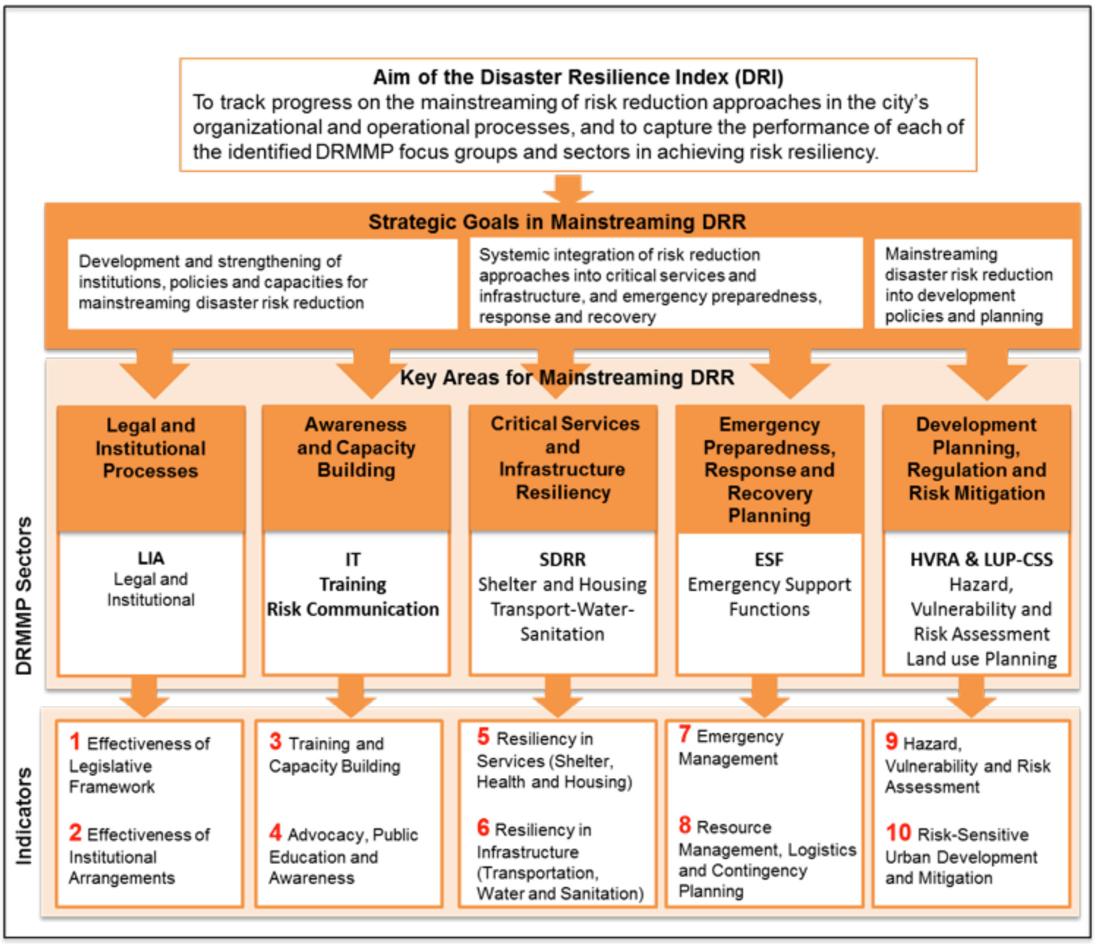
The Disaster Resilience Index (DRI) has been developed to address resiliency of key dimensions of urban resilience within a City government's functional and operational activities. The indicators are tied to EMI's analytical Disaster Risk Management Master Planning (DRMMP) model, which consists of strategies, policies, actions and processes for mainstreaming disaster risk reduction at the local level through a participatory planning process (Bendimerad et al., 2016). Thus, the structure of the DRI is based on the thematic areas of the DRMMP and presented in key areas crucial to the DRMMP process of mainstreaming. In addition, these key areas of the DRI are tied to the strategic goals of the HFA. The DRI also specifically links to the UNISDR 10 Essentials which break down the HFA strategic goals into 10 key action areas, but do not provide enough depth (Figure 4.1).

Figure 4.1



The targets and indicators for measuring mainstreaming in each of the five key areas are based on best practices identified for mainstreaming disaster risk reduction (Mitchell 2004; Twigg, 2004; Carreño et al., 2004, Cardona et al., 2005). Two performance indicators that are directly linked to the strategy and policy recommendations of each of the DRMMP sectors were assigned to each one of the five areas. The aim is to drill down along each of the five key dimensions of the DRI and develop together with city stakeholders a set of contextualized indicators for achieving risk resiliency along that dimension. This aspect of the methodology is fully customizable. In most applications of the DRI so far, two key localized performance indicators were developed for each of the five dimensions to produce a total of 10 indicators (e.g., Mumbai, Dhaka, Aqaba). However, as shown in the Lalitpur Case Study of the Guidebook each dimension can be explored by additional indicators based on in-depth interviews. In this adaptation of the methodology, an additional dimension "Social Capacity" was added to the DRI construct to represent the effects of social ties, integration, participation for different areas in the city. Furthermore, the DRI was developed to address key issues of urban resilience at multiple-levels of geography. While the key dimensions of the DRI are consistent across different scales, the indicators and targets along each of the themes within the five dimensions are adjusted to represent the appropriate scale. For example, "enforcement and implementation of building codes" is a function at the Municipal and not the sub-municipal level.

Figure 4.2



The rationale for selecting these five dimensions can be traced in Figure 4.2 by following the information from top to bottom of the chart. The main aim of the DRI is to track progress on the mainstreaming of risk reduction approaches in the city's organizational, functional, operational and development systems and processes. The urban resilience goal is further divided into three strategic goals shown in the chart. Each of the strategic goals corresponds to key dimensions of urban resilience analyzed in the DRI where these goals are to be implemented. Finally, it is shown how the key dimensions are connected to topical areas which can be represented by one or more indicators. Table 4.1 provides an overview of the main areas covered by each of the key dimensions of urban resilience.

Table 4.1 Outline for the six dimensions of the DRI and the characteristics of each of these dimensions.

SECTORS	INDICATORS	CHARACTERISTICS
LEGAL AND INSTITUTIONAL	Indicator 1: Effectiveness of Legislative Framework	• Laws, acts and regulations • DRR Policies • Compliance and Accountability • Resource mobilization and allocations (financial, human)
	Indicator 2: Effectiveness of Institutional Arrangements	• Organizational structures that define roles and responsibilities • Review, update, enforcement, monitoring and reporting process • Partnerships with civil society and communities
AWARENESS AND CAPACITY BUILDING	Indicator 3: Training and Capacity Building	• Institutional commitment to training and capacity building with dedicated resources and evaluations • Knowledge Management, Research and Development
	Indicator 4: Advocacy, Communication, Education and Public Awareness	• Commitment to advocacy and public awareness and education programs that engage all relevant audiences and stakeholders including civil society and community organizations • Commitment to participatory processes and community involvement • Research facilitation, Use of Information, Information Technology and Communication (ITC) to disseminate information • Pro-active and constructive Media relations

SECTORS	INDICATORS	CHARACTERISTICS
CRITICAL SERVICES, INFRASTRUCTURE RESILIENCY	Indicator 5: Resiliency of Critical Services	• Inclusive, participatory and transparent slum rehabilitation policies and programs • Protection of living (i.e. shelter) and livelihood conditions (i.e. access to and availability critical services including opportunities for livelihood) against disasters • Resiliency of health services to deliver services during a disaster
	Indicator 6: Resiliency of Infrastructure	• Resiliency of water, sewer and storm drain systems • Resiliency of transportation systems • Contingency for delivery of essential services
CRITICAL SERVICES, INFRASTRUCTURE RESILIENCY	Indicator 7: Emergency Management	• Functioning EOP with Basic Plan and ESF system • Year-round Response Planning and functioning SOP's • Drills and Simulation involving relevant stakeholders including civil society and communities • Preparedness programs for first respond-ers and leaders and representatives of communities at risk
	Indicator 8: Resource Management, Logistics and Contingency Planning	• Self analysis of resource management and logistics • Contingency planning for key institutions for pre-defined scenario analysis and planning parameters • Ability to manage delivery of resources to most vulnerable populations
DEVELOPMENT PLANNING, REGULATION AND RISK MITIGATION	Indicator 9: Hazard, Vulnerability and Risk Assessment	• Awareness of hazards and vulnerabilities (natural and man-made) • Risk Identification and Assessment, Vulnerability and Capacity Analysis, • Impact Assessments (loss analysis) by relevant sectors and segments of popula-tions at risk • Use of forecasting and early warning in preparedness and response planning
	Indicator 10: Risk-Sensitive Urban Development	• Risk-Sensitive Land use planning and urban re-development, • Enforcements of codes and standards, particularly in slum upgrading programs; quality control norms in construction • Reinforcing and retrofitting of critical assets and infrastructure

The Disaster Resilience Index (DRI) has been developed as a self-assessment tool with a ranking corresponding to five pre-defined benchmarks and target levels of attainment: 1) little or no awareness, 2) awareness of needs, 3) engagement, and commitment, 4) policy engagement and solution development and 5) full integration. The transition of an institution from a negative to positive ranking The transition of an institution from a negative to positive ranking indicates movement from a stage where some commitments which were not yet sustainable were made, to a stage where risk reduction is fully absorbed into planning and development processes, as well as the institutions' core services.

In the schematic below green is positive territory and red/orange is negative territory. An institution in yellow is in transition between positive and negative territory meaning there is commitment, but this may not be sustainable. The "bull's eye" representation depicts in one glance how close to target an institution in meeting the goal of fully integrating DRR along key areas of the DRI. The above schematic is flexible, and can be used to show the evolving mainstreaming of an institution through time.

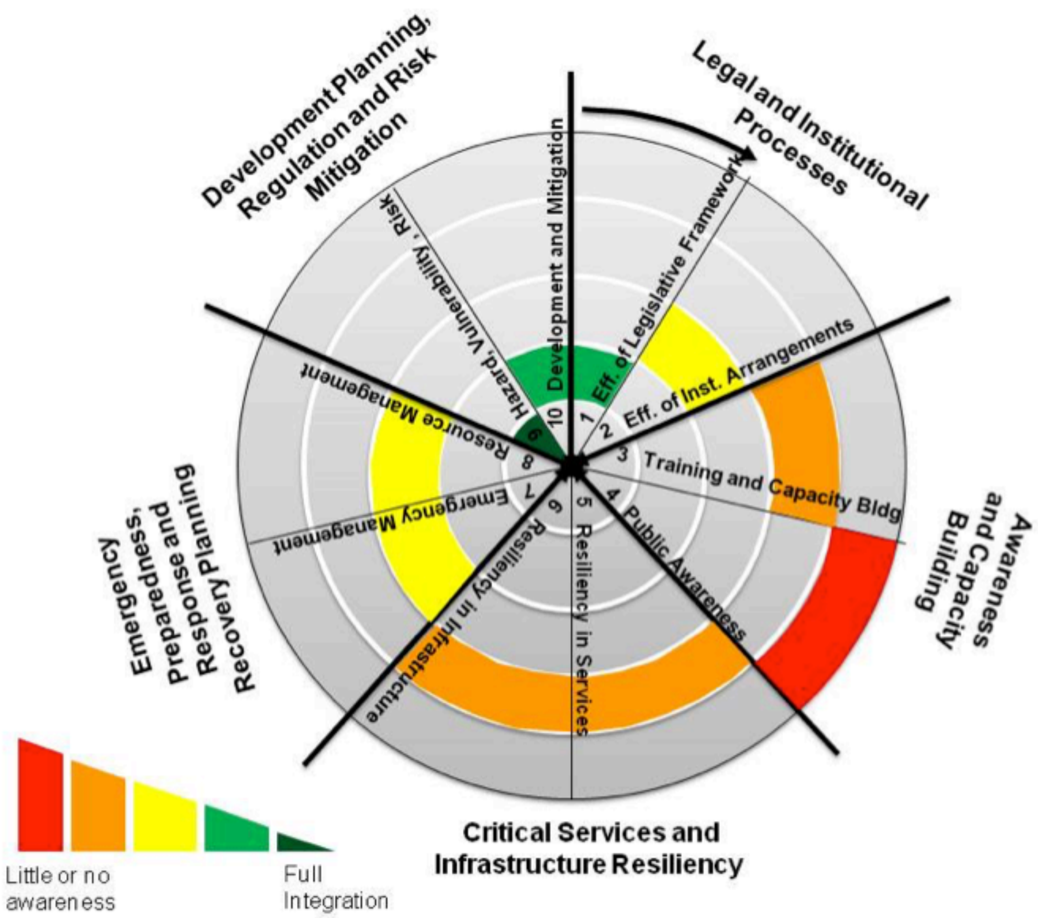


Figure 4.3 Schematic representation of the mainstreaming scale presented as an example. Goal is full integration (direction towards the "bulls-eye", represented by dark green). The chart should be read clockwise, where each of the 10 indicators is represented by a pie.

Table 4.2: Defining Target Levels of Attainment

LEVEL 1	'Little or no awareness' Level 1 represents little or no awareness and understanding of mainstreaming. There is no institutional policy or process for incorporating risk reduction within the functions and operations of the organization. Further, in some cases there is an adverse attitude and adverse institutional culture towards adopting measures to reduce risk. As a result, significant resistance is expected from any risk reduction initiative resulting in greater vulnerability and higher losses in the future.
LEVEL 2	'Awareness of needs' Level 2 refers to an early stage of awareness. The organization has a growing level of awareness, and there is support for disaster reduction among the policy makers. The institution may have activities and dedicated efforts for preparedness but these are simply limited to response. However, support is limited and does not necessarily carry through all levels of the organization; resistance to change is expected at various levels where business as usual is judged sufficient. In general, the institution has no established policy, guidelines or system for mainstreaming, and action will be needed at the highest level to establish such policies and systems. This level is expected not to result in risk reduction in the long term. Vulnerability is expected to increase.
LEVEL 3	"Engagement and Commitment". Level 3 refers to a high level of engagement and commitment to DRR by the institutions. However, the policies and systems have not been fully established yet. The institution may not have a deep understanding of the mainstreaming process and requirements and still has limited capacity, but overall it is willing to make the investments and has already taken some action; commitment for change, and in particular to shift from response only to mainstreaming DRR. There maybe "pockets of resistance" but these are expected to be overcome with time.
LEVEL 4	'Policy Engagement and Solution Development' Level 4 refers to an intermediate stage in mainstreaming, where there is already an established policy for mainstreaming, an overall institutional process/system, and identifiable actions that render the system sustainable and irreversible. In general DRR is seen as an asset by policy makers who are willing to invest in it. The organization is engaged into planning and control processes to address the requirements of integrating risk reduction into its planning and development processes, and in building resiliency in the core services. Processes of coordination and regular drills and exercises have been put in place.
LEVEL 5	'Full integration' Level 5 refers to a situation where risk reduction is fully absorbed into planning and development processes as well as core services. The organization places high importance on reducing disaster risks in a sustainable program of action at multiple levels and within multiple sectors, and there is a comprehensive demonstration of practice. Level 5 describes a situation where disaster risk reduction is 'institutionalized'. However, this is not to suggest that an optimum level of attainment has occurred: there is still a need for further progress. The process of mainstreaming should be viewed as open-ended: while organizations should aim to achieve Level 5, they should also aim to make continuous improvements to their approach.

DRI PARTICIPATORY MODELLING PROCESS

The DRI is comprised of a four-step analysis, which is particularly decision-maker driven and employs institutional learning and adaptive governance as a key concept to ensure sustainable solutions are focused on. Utilizing the latest risk models as an important input, the DRI advances from the existing hazard, vulnerability and risk knowledge and targets specifically the current lack of knowledge transfer to practice, governmental enforcement, and vision-oriented (spatial) decision-making. The following multi-step process is followed in the implementation of the DRI through a participatory process:

STEP 1: STAKEHOLDER IDENTIFICATION

Identify a "Focus Group" (FG) as key city stakeholders along each of the five themes of the DRI who will test, monitor, and validate the results of the implementation phase for each of the DRI. In addition, put together a "Core Group" (CG) for each implementation of the DRI. The DRI "Core Group" (CG) should be composed of the Focus Group leader for each of the sectors/themes represented in the DRI, thus ensuring that adequate knowledge regarding each of the 5 sectors is contained. The optimum number of members of the FG will be decided by the CG; in any case it should have at least three members and a maximum of 10 so that the group is easier to handle.

STEP 2: STAKEHOLDER CONSULTATIONS

The Core Group will focus on contextualizing the selected resilience dimensions/themes (e.g. emergency response capacities, shelter planning, or legal institutional arrangements) to local needs and consider fully and interactively input through structured interviews with the Focus Group. This step includes engagement with local stakeholders through a process of collectively defining resilience goals (i.e. target performance outcomes) for the city along each of the key dimensions, and specifying the respective monitoring and evaluation indicators according to these goals.

STEP 3: INITIAL INDICATOR DEVELOPMENT

An initial set of indicators for the DRI should be developed by the Core Group based on the outcomes of the interviews along each of the five themes of the DRI. The indicator should include guiding questions and expected outcomes and define the five different target levels of attainment according to the context in the city. The questionnaires for the DRI should be tested by the CG before sending to a larger FG for validation.

STEP 4: VALIDATION OF THE DRI IN WORKSHOPS

The DRI indicators and questionnaires should be validated by selected members from the FG in an interactive workshop setting. Utilizing the results of the workshops and interactions with the Focus Group members, the key indicators and target performance levels of the DRI defined by the "Core Group" are improved upon to further refine and contextualize them. This iterative process of contextualization and validation of the DRI questionnaire, serves multiple purposes: first to identify the current level of understanding of resilience, second getting to know existing challenges in the politicized environment of local governments, third familiarize potential facilitators with the background understanding and concept to ensure proper translation and management of group processes. The final result of this is a customized questionnaire with a concise set of questions along the key resilience themes. The themes are covered by representative indicators along with precise guiding questions with the target performance levels having a defined logic order. Additionally the facilitators are prepared to provide examples and explanations if necessary.

STEP 5: PARTICIPATORY EVALUATION OF THE DRI

In a final participatory workshop the DRI survey can be administered to the FG individually or in groups. One way of administering the self-evaluation is through an interactive display of results where the participants cast their votes (via remote keypads) for each indicator and discuss their evaluation. Engaging with the participants in such a way, helps to reduce initial apprehension by minimizing the fear of data manipulation as well as providing the conditions for communication to take place around key issues. Hence it is possible to discuss relevant matters on the spot, while not imposing pre-existing ideas and concepts.

Figure 4.4 Evaluation of the DRI indicators (through an adapted Scorecard) in Lalitpur, Nepal using remote key pads to promote communication and discussions in the scoring of the indicators among the Focus Group members

CHAPTER 05

CASE STUDIES

ISTANBUL

Background

Located on the North Anatolian Fault, the megacity Istanbul is highly prone to earthquakes. The city's high population. commercial and industrial density and social vulnerability mean that frequent earthquakes can cause significant economic losses, damage, and human suffering. In 2007 the Istanbul Metropolitan Municipality wanted to develop an indicator system specific to the needs of the city that would: 1) communicate and raise awareness of stakeholders on earthquake risk from an integrated perspective; 2) provide information on risk profiles of the city for foreign and domestic investment; 3) set up benchmarks on DRM practices in the city, monitor and track progress and 4) help in prioritizing urban transformation decisions based on a rational and transparent system that can make decisions more acceptable in the public eye.

The UDRi and DRI indicator systems were evaluated and implemented to communicate risk and promote discussion about relevant local-level risk parameters in Istanbul. The overall goal was for Istanbul Metropolitan Municipality (IMM) to use the indicator systems in managing its disaster risk and for the entire process to be a sustainable city effort. Thus, ensuring the adaptability and long-term use of the indicator systems by the Municipal government, was a key aim of the implementation of risk and resilience indicators in Istanbul and has led to a long-term perspective and engagement. This required a participatory process and a willingness to to go through great lengths in order to to ensure that selected indicators are immediately relevant and easily understood by policy makers and disaster management professionals in Istanbul, and that the methodology is fully compatible with Istanbul's Disaster Risk Management (DRM) framework (Khazai et al., 2009).

Implementation

The implementation of urban risk and resilience indicators in Istanbul has gone through three distinct phases described below:

Phase 1

In an initial project from 2007-2009, a local "Core Group" that consisted of a project manager and technical staff from the Department of Earthquake Risk Management and Urban Development at the IMM Directorate of Ground and Earthquake Research as well as research scientists from Karlsruhe Institute of Technology (KIT), Earthquake and Megacities Initiative (EMI), and Bogazici University (Center for Disaster Management) was organized to carry out the implementation work in Istanbul. The project also benefited from additional input from an advisory board consisting of additional experts from Technical University of Catalonia's International Center of Numerical Methods in Engineering (CIMNE) and the National University of Colombia's Institute of Environmental Studies (IDEA).

The conceptual frameworks of the UDRi and DRI were adapted to the megacity context in Istanbul and the combined indicator systems was termed in the Istanbul applications as the "Megacity Indicator System for Istanbul" or MegaIST. The first stage of implementation can be characterized by numerous consultations and engagements with various organizations in the city for the development of the data, and devising and agreeing upon a structure and set of criteria for selecting suitable indicators in Istanbul. This phase relied on close collaboration between the Core Group with a Focus Group consisting of stakeholders from IMM, Boğaziçi Univesity and other private and public institutions in Istanbul to identify the main factors of disaster vulnerability and lack of resilience in Istanbul. Accordingly, a significant output by the local Core Group during the first stage of the implementation process (2007-2009) was the identification of the needs and goals of the Focus Group and the adaptation of the indicators for the specific responsibilities, tasks, and mandates of the target stakeholders. This stage of the implementation process consisted of organizing and working with the Focus Group in three consecutive workshops to discuss and iterate on the selection of indicators for the MIS. Through this process the Core Group was able to demonstrate to the larger group of stakeholders how the indicator system addresses their needs and may be useful to them as well as gain their input and trust in the selection of indicators and their relative importance. In many ways this first implementation period from 2007-2009 served as a pilot that developed local capacity at IMM in using the indicator systems and sealed.

Phase 2

In a second implementation from 2009-2011 the UDRi indicators were refined and adapted to the needs of IMM. The first implementation stage of the UDRi revealed that representative indicators of social fragility and lack of resilience – such as such as available means of disaster preparedness and risk mitigation, solidarity and social networks, savings and other buffers and resources for reconstruction and recovery - are not available from publically available surveys such as the Census data. Furthermore the publically available data was for the most part not available at the appropriate spatial resolution of sub-district or Mahalle level. This led to a series of engagements by the Core Group with national and international experts and social scientists to design a specific survey on social vulnerability and lack of resilience that could be used to construct the UDRi for Istanbul as part of its MegaIST program. Furthermore, the indicators used for physical earthquake risk were also updated using the ELER risk assessment of Istanbul and extended to the new districts and administrative boundaries of Istanbul.

In addition, the UDRi system was extended by the Core Group to include a set of factors that describe "Coping Capacities" of the Municipality based on its functional and operational mandate to provide for the continuity of specific services after a disaster event. This was deemed as a critical need for the UDRi to be operationalized as a useful risk communication and DRM tool for the Municipality. In this way, IMM could interpret the holistic risk outcomes of UDRi in terms that would be relevant to its own operational needs. Thus the Impact Factor of UDRi was extended to include 3 categories: factors of social fragility which describe social vulnerability at the household level (i.e. personal attributes, living situations, finances); factors of resilience (or lack of resilience) as factors which operate at the community level, such as available means of disaster preparedness and risk mitigation, solidarity and social networks, and other buffers and resources for reconstruction and recovery; and a new set of IMM coping capacity factors to capture the operational capacities of

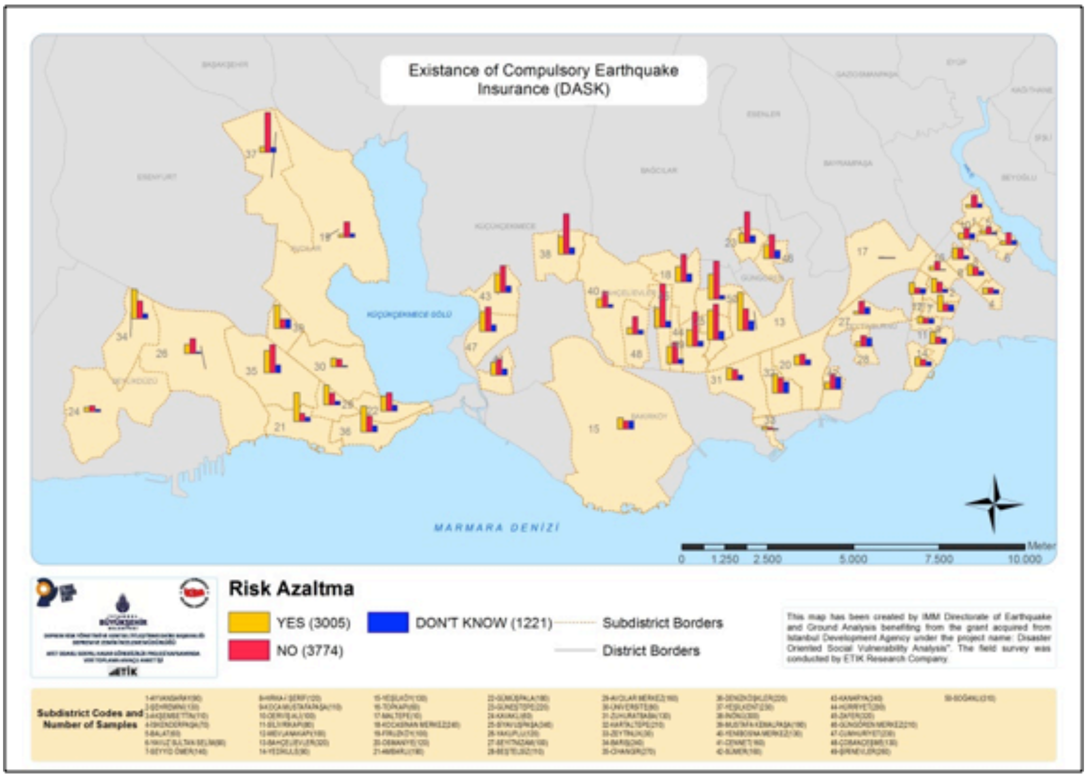
Figure 5.1 Schematic representation of the MegaIST indicators as the adaptation of the UDRi framework, representing physical risk indicators, impact factors (social fragility and lack of resilience) as well as the addition of a set of IMM coping capacity

IMM for emergency management and response such as: 1) Search and Relief Capacity; 2) Debris Removal Capacity; 3) Lifeline Recovery Capacity and 4) Shelter site support capacity. A close collaboration between the municipal organizations was needed to collect data at the IMM scale for the coping capacity indicators. A methodology was developed within the project to derive indices for each of the four IMM coping capacity (Khazai et al., 2009).

Phase 3

In a third implementation phase which started in 2013, the UDRi was constructed based on the results of the "social structure survey" that was designed and sent for tender at the end of the second phase. This survey was administered to approximately 8000 households throughout 50 sub-districts of Istanbul. The results of the survey were collected and analyzed to derive values for the selected indicators of social vulnerability. The outcomes updated with the detailed results of the social survey were presented in a workshop in June of 2014 to a wide group of stakeholders in Istanbul (Figure 5.2).

Figure 5.2 Spatial representation of Social Structure Survey outcomes for one of the survey questions "Existence of Compulsory Earthquake Insurance (DASK).



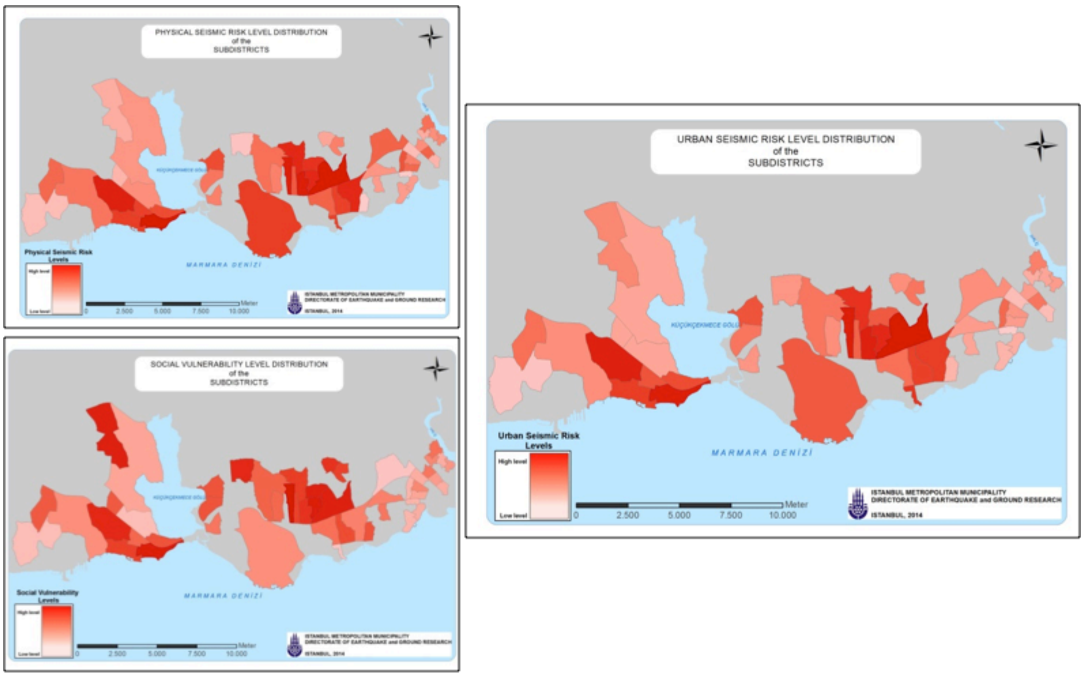
The final indicators for the UDRi Impact Factor were quantified from the survey questions and were structured into the following categories: 1) Family Structure; 2) Economic Status; 3) Education Status; 4) Disability and Special Treatment Needs; 5) Access to health services; 6) Mobility and 7) Community Preparedness. These indicators may have impact in both directions of vulnerability and resilience. Utilizing the results of the social survey and the results of the ELER earthquake risk assessment of Istanbul (Erdik et al., 2011), the UDRi framework was developed to obtain a ranking of holistic risk from earthquake hazards in Istanbul (Figure XX). In order to follow the same methodological approach as in the UDRi, only the negative levels for these indicators are taken into account for determining the Impact Factor. In this regard, indicators are divided into sub-indicators and their condition of being vulnerable is defined in Table 5.1:

Table 5.1 Indicators used in developing the Impact Factor for UDRi in Istanbul using results of the social structure survey as the measures.

	INDICATORS	SUB-INDICATORS	MEASURES
Social Fragility (SF)	SF1: Family structure	SF1$_1$: Age	Children under 7, elderly over 65
		SF1$_2$: Single parents	Parents living alone with spouse(s)
	SF2: Economic status	SF2$_1$: Employment	Unemployed inhabitants
		SF2$_1$: Debt status	Existence of debt
		SF2$_1$: Savings	Absence of saving
		SF2$_1$: Income level	Under the hunger level
		SF2$_1$: Property ownership	Not a single property owned
		SF2$_1$: Social security	Absence of social security
	SF3: Disability and special health treatment needs	SF3$_1$: Disability	Existence of a mental or physical disorder
		SF3$_1$: Special treatment	Need for a special medical care Need for a special care due to age
	SF4: Education status	SF4$_1$: Graduation level	Below the primary school level

	INDICATORS	SUB-INDICATORES	MEASURES
Lack of Resilience (LR)	LR1: Access to health services	$LR1_1$: Social security	Absence of social security
		$LR1_2$: Private insurance	Absence of private insurance
		$LR1_3$: Health facility distance	Absence of a facility in a walking distance
	LR2: Mobility	$LR2_1$: Vehicle ownership	Absence of a motor vehicle
		$LR2_2$: Disability and/or special medical care need	Existence of inhabitant with a disability/need for special care
		$LR2_3$: House ownership outside of the hazard area	Absence of a house outside of the hazard area
		$LR2_3$: Possibility of gathering of household members	Binary value when the distance between work, school and house is more than walking distance
	LR3: Community Preparedness	$LR3_1$: Risk perception	Low level of perception
		$LR3_2$: Household based risk reduction	Where proper actions are not taken
		$LR3_3$: Sub-district based risk reduction:	Where proper actions are not taken
	LR4: Solidarity	$LR4_1$: NGO Membership	Absence of membership
		$LR4_2$: Neighbor relationships	Low level of relations
		$LR4_3$: Participation in neighborhood events:	Low level of participation
		$LR4_4$: Period of residence in neighborhood	Lower than 5 years

Figure 5.3 Ranking of urban seismic risk in Istanbul according to the UDRi framework.



The contextualization of the DRI as a planning tool for IMM is currently underway through a process which is being led by the Department of Earthquake Risk Management and Urban Development at the IMM Directorate of Ground and Earthquake Research. Two key documents are guiding the development and framing of the DRI indicator systems: The 2002 Istanbul Earthquake Master Plan (IEMP) and the IMM Strategic Plan (2007-2014). The DRI must also reflect the operational mandates of IMM that cannot be quantified through data collected for the development of the Coping Capacity indicators discussed earlier. In this respect, a specific set of qualitative indicators focusing on the Municipalities implementation and preparedness activities, emergency response and recovery capacity, communicating and coordinating mechanisms at IMM departments are currently being considered. For this the Core Group has been working in close collaboration with other institutions such as contributors from AKOM (the Municipality's disaster management facility) and conducted many interviews with key informants to identify and document the current Disaster Risk Management (DRM) practice in the city. This information will be used to develop a structure of the DRI indicators and its representation of the disaster risk management practice in Istanbul.

The overall goal will be for the UDRi and DRI is to be used as part of the MegaIST by the City to plan and track progress of the Municipality's operational capacities – the capacity of the Municipality to respond to emergencies and restore services – as well as functional capacities – the policies and planning measures at the Municipality which lead to reduction of risk and protection of people.

MUMBAI

Background

The UDRi and the DRI were customized and applied in Mumbai in collaboration with Municipal Corporation of Greater Mumbai (MCGM) as a risk communication and planning tool for measuring progress (or lack of progress) on the mainstreaming of risk reduction approaches in the city's development policies and processes. The indicators were developed as a tool complimenting the Disaster Risk Management Master Plan (DRMMP) of Mumbai. The DRMMP is an analytical model developed by the EMI to guide local authorities in developing a "master plan" which consists of strategies, policies, actions and processes for mainstreaming disaster risk reduction at the local level through a participatory planning process (Bendimerad et al., 2016). In this context, the development of the UDRi and DRI indicator systems was a collaborative process between EMI and the Municipal Corporation of Greater Mumbai (MCGM) which took place over a 2 year period from 2009-2011.

Implementation

To ensure adaptability and ownership over the indicator systems a two-pronged participatory set-up was needed: A core group (CG) composed of technical staff and officials at MCGM who understand the conceptual framework and indicator methodology; and are responsible for its periodic updating and upgrading; and a Focus Group (FG) of MCGM agencies and city stakeholders who were consulted to evaluate and validate the structure of the indicators and their relevance to the local DRM processes. In the DRMMP, 130 stakeholders representing various organizations in Mumbai were identified and participated in Focus Groups (FG) in the following sectors: 1) Legal and Institutional Arrangements; 2) Hazard, vulnerability and risk assessment; 3) Shelter and disaster risk resiliency; 4) Land use planning and development; 5) Advocacy and strategic communication; 6) Construction standards and practice; 7) Emergency support functions; 8)

Information technology; and 9) Capacity building and training. Thus the Core Group and Focus Groups were instrumental in Mumbai in the adaptation and validation of the indicators systems for the city. In particular, the DRI indicators systems was first developed in the context of the Disaster Risk Management Master Plan (DRRMP) of Mumbai to capture the potential for achieving risk resiliency in key areas analysed as part of this planning process (Khazai et al., 2011a and 2011b).

UDRi

The UDRi was applied in Mumbai through descriptors comprising both the physical risk, and the aggravating factors comprised of social fragility and lack of resilience factors relevant to the context of Mumbai and available from existing publically available data. Physical earthquake risk descriptors were used from the IIT Seismic Risk Assessment Mw 6.5 (Focal Depth of 10km) earthquake damage scenario which was considered to be the most credible worst case scenario (Sinha et al, 2012). The physical risk indicators used describe the impact of the postulated earthquake at the sub-city district or Ward level in terms of: 1) damaged area, 2) deaths, 3) injuries, 4) displaced persons; 5) water supply systems loss and 5) economic losses. The indicators for social fragility and lack of resilience were derived after an intensive data collection effort from publically available data and were selected by the Core Group to represent the local context of the Mumbai. The stakeholders in Mumbai identified an important criterion in the design of the UDRi for Mumbai: Indicators should be readily available and selected from publicly available data so that they are reproducible and can be used for benchmarking over time without the need for special surveys. The localization and adaptation of the UDRI in Mumbai was achieved by identifying a set of sub-indicators representing local conditions and issues in Mumbai for the different thematic areas of social fragility and lack of resilience. For example, the disproportionality of four key indicators of social vulnerability – poverty, housing, employment and education/literacy – were compared between all wards of Mumbai in a disparity analysis and presented as one composite indicator – social disparity index. The composite indicators and sub-indicators used for social fragility and lack of resilience are shown in Figure 5,4 (Khazai et al, 2011b). Selected indices for the social fragility factors included: 1) social disparity index; 2) slum dweller vulnerability; 3) population density; 4) delinquency index and 5) sensitive disease rate. Similarly lack of resilience factors were selected by the Focus Group in Mumbai through a participatory consultative process. The final selection included the following indices: 1) lack of healthcare capacity; 2) lack of shelter capacity; 3) lack of emergency response and 4) lack of preparedness.

	ID	Physical Risk Indicators
Physical Risk	R_{F1}	Damaged Area
	R_{F2}	Deaths
	R_{F3}	Injuries
	R_{F4}	Displaced Persons
	R_{F5}	Water Supply Systems Loss
	R_{F6}	Economic Losses

	ID	Social Fragility and resilience indicators
Social Fragility	F_{S1}	Population Density
	F_{S2}	Slum Status
	F_{S3}	Social Disparity
	F_{S4}	Delinquency
	F_{S5}	Sensitive Disease
Lack of Resilience	F_{R4}	Preparedness
	F_{R4}	Emergency Response
	F_{R4}	Healthcare Capacity
	F_{R4}	Shelter Placement

	ID	Lack of Resilience sub-indicators
F_{R1} Preparedness	F_{R11}	Nr. of Food Suppliers
	F_{R12}	Nr. of Labour Suppliers
	F_{R13}	Nr. of NGOs
F_{R2} Response	F_{R21}	Nr. of Bus Stations
	F_{R22}	Nr. of Fire Stations
	F_{R23}	Nr. of Police Stations
F_{R3} Healthcare	F_{R31}	Nr. of Hospital Beds
	F_{R32}	Nr. of Doctors
	F_{R33}	Nr. of Nurses
	F_{R34}	Nr. of Ambulances
F_{R4} Shelter	F_{R41}	Shelter area of Schools (m^2)
	F_{R42}	Shelter area of Open Spaces (m^2)
	F_{R43}	Shelter area of Parking Lots (m^2)

	ID	Social Fragility sub-indicators
F_{S1}	F_{S11}	Population Density
F_{S2} Slum Health	F_{S21}	Slum Dwellers Rate
	F_{S22}	Female Illiteracy Rate
	F_{S23}	Marginal Workers Rate
	F_{S24}	Scheduled Castes Rate
F_{S3} Social Disparity	F_{S31}	Illiteracy Disparity Rate
	F_{S32}	Sub-standard Housing Disparity
	F_{S33}	Under Poverty Disparity Rate
	F_{S34}	Unemployment Disparity Rate
F_{S4} Delinquency	F_{S41}	Murder Rate
	F_{S42}	Theft Rate
	F_{S43}	Housebreaking Rate
	F_{S44}	Rape Rate
F_{S4} Sensitive Disease	F_{S51}	Tuberculosis Rate
	F_{S52}	Malaria Rate
	F_{S53}	Diabetes Rate
	F_{S54}	Diarrhea Rate
	F_{S54}	Hyper Tension Rate

Figure 5.4 List of Indicators and sub-indicators used in the development of the UDRI for Mumbai.

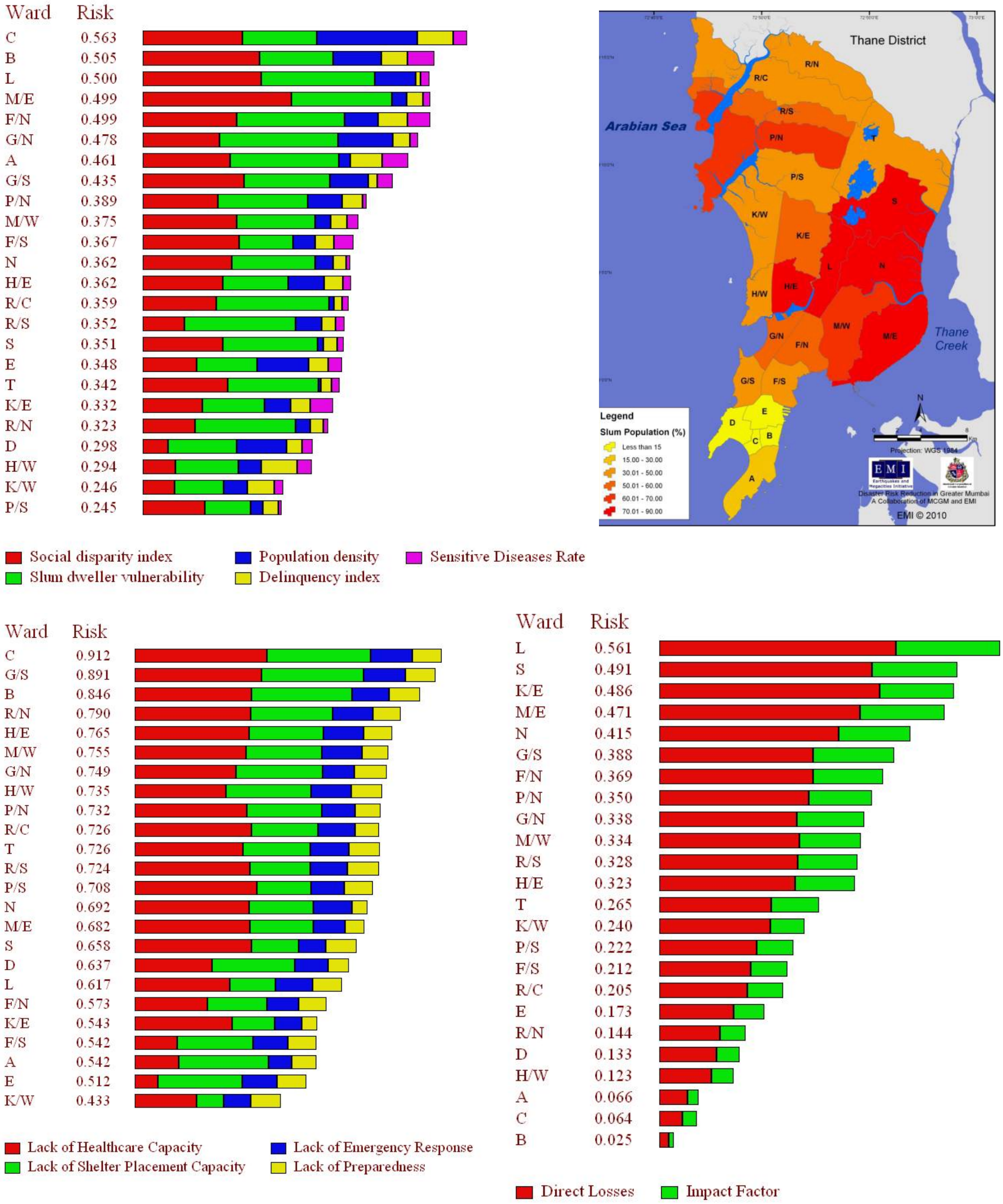


Figure 5.5 Ranking of the Social Fragility Indicator (Top left) and Lack of Resilience Indicators (Bottom left) and Total Risk (Right) according to application of the UDRi framework in Mumbai.

DRI

The Disaster Resilience Index (DRI) was originally developed in Mumbai as a necessary tool that reflects key areas of mainstreaming disaster risk reduction at a local level based on the detailed sectoral analysis in Mumbai and outcomes of the Disaster Risk Management Mast Plan (DRMMP) developed by EMI from 2009-2011 (Khazai et al., 2011a). At the same time the resilience indicators were designed to be aligned with the priorities of the Hyogo Framework for Action 2015-2015 (HFA) and cross referenced to the guidelines set forth by the National Disaster Management Authority (NDMA) in India. To ensure relevancy and familiarity with the activities of the Focus Groups, each of the strategic goals of the HFA corresponds to one or more key areas analyzed in the DRMMP where these goals are to be implemented. Thus, the structure of the DRI is based on the thematic areas of the DRMMP and presented in five key areas crucial to the DRMMP process of mainstreaming. In the Mumbai implementation, these five key areas correspond to: 1) legal and institutional processes; 2) Awareness and capacity building; 3) Critical services and infrastructure resiliency; 4) Emergency preparedness, response and recovery planning; and 5) Developmental planning, regulation and risk mitigation. Two indicators corresponding to each of the five key areas of mainstreaming are developed and contextualized for the Mumbai application (Table 5.2). These indicators were designed to be simple at an initial stage so that the indicators can be adapted and used by the stakeholders. While being relatively simple, the proposed indicators were designed to permit a systematic and quantitative benchmarking of the key sectors through a self-evaluation.

Table 5.2 DRI indicators corresponding to the DRMMP sectors in Mumbai

DRMMP Sectors	DRI Indicators
Legal and Institutional	Indicator 1: Effectiveness of Legislative Framework
	Indicator 2: Effectiveness of Institutional Arrangements
Awareness and Capacity Building	Indicator 3: Training and Capacity Building
	Indicator 4: Advocacy, Communication, Education and Public Awareness
Critical Services, Infrastructure Resiliency	Indicator 6: Resiliency of Critical Services
	Indicator 5: Resiliency of Infrastructure
Emergency Preparedness, Response Planning	Indicator 7: Emergency Management
	Indicator 8: Resource Management, Logistics and Contingency Planning
Development Planning, Regulation and Risk Mitigation	Indicator 9: Hazard, Vulnerability and Risk Assessment
	Indicator 10: Risk-Sensitive Urban Development and Mitigation

A DRI Handbook was developed during the project to describe the organization of the indicators, rationale for their selection and provide guidelines for their interpretation and scoring (Figure 5.6) (See Annex 2). The Handbook included double sided sheets for each of the 10 indicators. On the front side specific measures that could be used to describe the indicators and a set of guiding questions were defined. Furthermore references that could be used as evidence for discussion were presented. On the back side 5 performance target levels for each of the indicators were described based on the sectoral analysis in the DRMMP, corresponding to the categories: 1) little or no awareness, 2) awareness of needs, 3) engagement, and commitment, 4) policy engagement and solution development and 5) full integration. The transition of an institution from a negative to positive ranking indicates movement from a stage where some commitments have been made, which may not yet be sustainable, to a stage where risk reduction is fully absorbed into planning and development processes as well as the institutions core services. For example, level 1 (little or no awareness) for one of the DRI indicators - Resiliency of Infrastructure - was described as: "no studies of impacts to infrastructure systems, or if there are, the City is not aware of these studies and is not able to understand their significance for disaster risk management. Consequently, there is no investment in increasing resiliency of infrastructure systems. The infrastructure would suffer extensive losses and massive disruptions would occur before services are restored". Level 5 or full integration, on the other hand, was described as detailed studies which have been carried out to assess the magnitude of infrastructure losses and recovery times for multiple hazards.The level of investment in increasing resiliency of infrastructure is adequate relative to the available resources. Infrastructure is maintained and inspected regularly and strengthened based on impact studies. Infrastructure services can be restored to pre-disaster levels at suitable quantities and durations to minimize impacts to society and businesses." In this way, each performance target level for each of the 10 indicators were described and contextualized based on the sectoral assessments in the DRMMP to provide guidance and context for the ranking of indicators by the stakeholders.

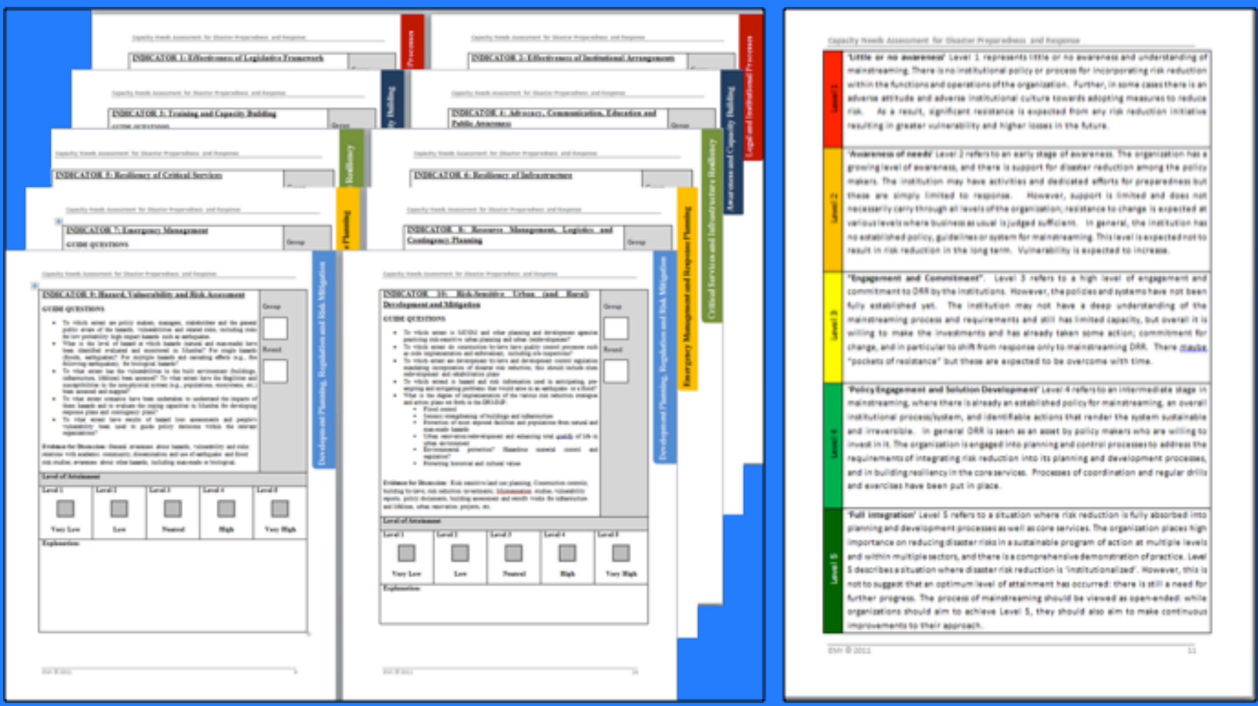
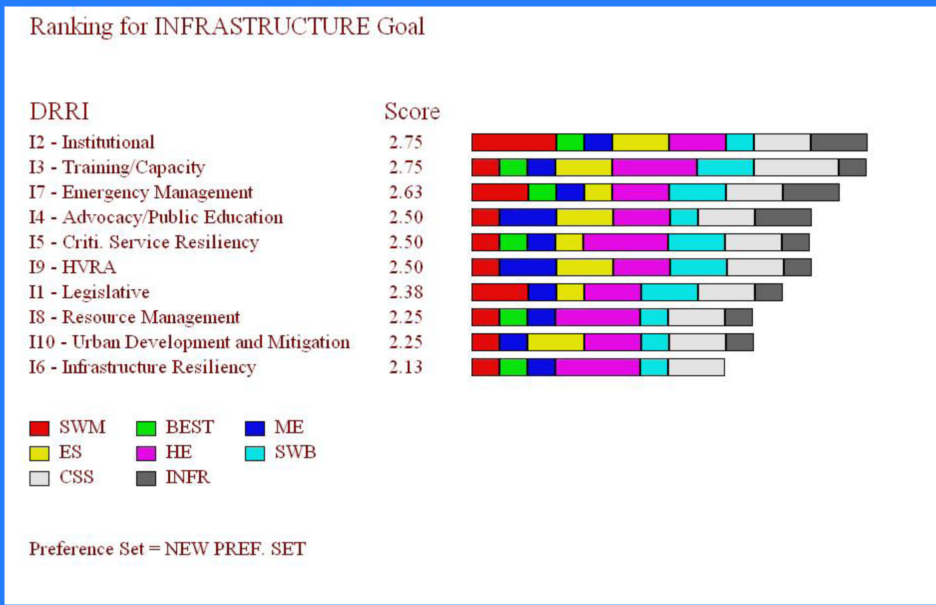


Figure 5.6 DRI self-assessment and validation

In a set of two participatory workshops with the Focus Groups representing various constituencies in Mumbai in February 2011, the stakeholders were asked to validate the structure of the DRI and its representation of the disaster risk management practice in Mumbai. Following the validation process, they were asked to provide their assessment on the 10 resiliency indicators. The results show that there is a bias in scoring the areas in which the stakeholders are most closely associated with, where the stakeholders with most knowledge of an area provide the lowest scores for that area. For example, the average score by members of the “Infrastructure and Service Resiliency” Focus Group was the lowest for the “Infrastructure Resiliency” indicator amongst all stakeholders. Similarly the “Planning, Regulation and Mitigation” Focus Group gave the lowest average score to the “Urban Development and Mitigation” indicator.

Figure 5.7 Ranking of the DRI in Mumbai by the different Focus Groups

Infrastructure and Service Resiliency (SDRR)



Planning/Regulation/Mitigation (HVRA/ LUP/CSS)

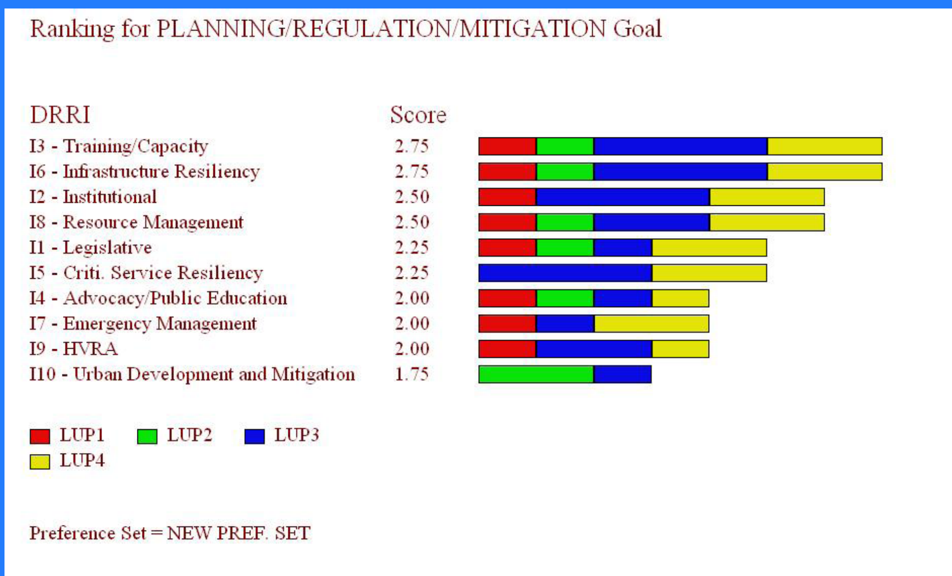
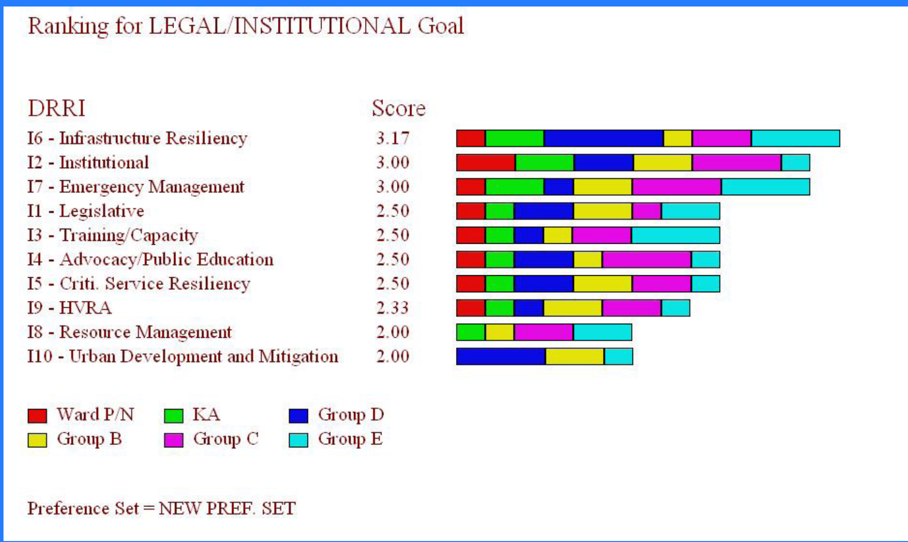


Figure 5.7 Ranking of the DRI in Mumbai by the different Focus Groups

Legal and Institutional (LIA)



IT, Training, Risk Communication

All Stakeholders

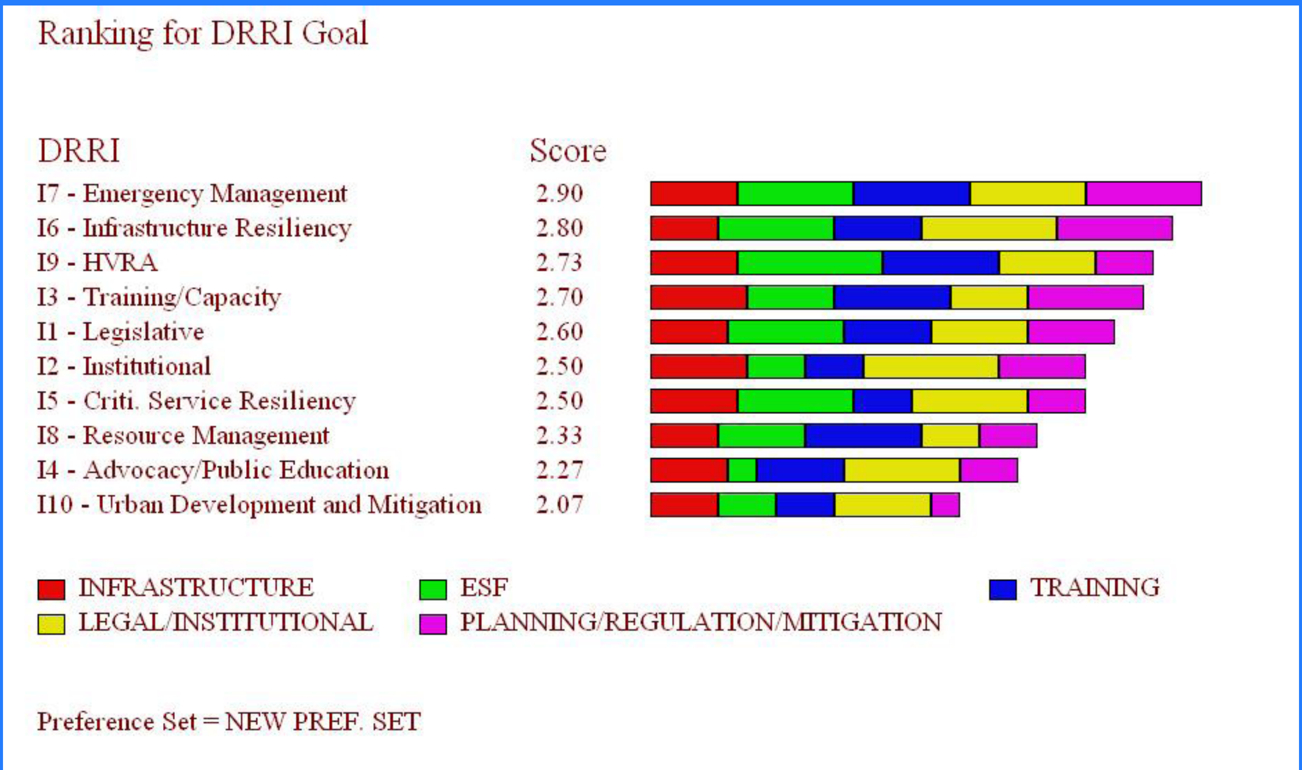


Figure 5.7 Ranking of the DRI in Mumbai by the different Focus Groups

The purpose of these workshops was to introduce UDRi and DRI indicators, and in particular, demonstrate and motivate the larger Focus Group of stakeholders to use them as an instrument to discover key policy and action areas where performance needs improvements. The use of interactive indicator software – in this case the commercial software Logical Decisions - allowed the stakeholders display the indicators using various output and visualizations formats, manipulate the existing weights and interactively investigate the changes upon the total ranking outcome.

QUEZON CITY

Background

The UDRi and the DRI indicator systems were applied in Quezon City as part of the Building a Disaster Resilient Quezon City Project. The project is a collaborative effort between EMI and the Quezon City Government with participation of local and national stakeholders. The project, conducted from August 2012 to August 2013, employed a participatory process in the development of the city's Disaster Risk Reduction and Management Plan (DRRMP) 2014-2020. It also established a DRRM system within the city and institutionalized DRRM protocols, policies, procedures, and functions within the city government. One important objective of this project was to identify the highest earthquake impact areas at the sub-city level of geography in Quezon City and use these information for the decision-making needs of local government authorities of the city.

Implementation

The implementation of UDRi in Quezon City outlines a participatory process for the development of social fragility and lack of resilience indicators and assigning respective weights. This process engaged over 40 stakeholders from 21 city offices and organizations in Quezon City. The adaptation of the UDRi indicator system in Quezon City presents an example of how different dimensions of physical earthquake risk (e.g. losses of population, buildings, critical facilities) are integrated with indicators of social vulnerability and lack of resilience. This obtains a holistic view of risk within the city following the UDRi framework and methodology. The goal of the integrated risk analysis is to identify concentrations of the highest impact areas or "hotspot" areas within a limited geographic area to focus respective risk-sensitive land use planning and decision-making. In this case, the hotspots are defined as "barangays" as these sub-city administrative units are relevant for emergency planning, preparedness, and policy-making. The "barangays" constitute the smallest units in the study for which building and population census data areavailable, and in which both physical and socio-economic dimensions can be used to identify the hotspots.

UDRi

The existing Metro Manila Earthquake Impact Reduction Study (MMEIRS, 2004) is the authoritative and comprehensive earthquake loss estimation study for Metro Manila and was used as the primary reference source for development of the physical risk indicators of the UDRi. The scenario earthquake of Model 08 pertains to a 7.2 magnitude on the West Valley Fault system, with seismic intensity of VIII (Very Destructive) or IX (Devastating) alongside Marikina River and Manila Bay. This provides the crucial planning parameters for assessing earthquake impact on Quezon City. The indicators used for the physical risk descriptors in the UDRi based on this scenario include: 1) fatalities; 2) injuries; 3) building damage (in four differently weighted categories of collapsed buildings, severely damaged buildings, highly damaged buildings, and partially damaged buildings); and 4) affected critical and high loss potential facilities. The set of indicators for critical facilities were obtained through a spatial overlay analysis by counting the number of critical and high loss potential facilities that were contained in different earthquake intensity contours of Peak Ground Acceleration (PGA): intense (PGA: 0.86-1.49g), violent (PGA: 0.66-0.85g), severe (PGA: 0.46-0.65g), and very strong (PGA: 0.37-0.45g) ground shaking levels. Critical facilities considered as part of the physical risk indicators were: 1) hospitals and healthcare centers; 2) emergency and rescue operation centers (fire stations, helipads, barangay halls); 3) hazardous facilities and gas stations); and 4) transportation Infrastructure such as bridges and roads. High loss potential facilities considered were schools, malls and markets.

The first step in the selection of social fragility and lack of resilience factors is ranking and evaluating key indicators which are aligned with the core indicators. The core indicators on social vulnerability were developed by various researchers in the context of megacities, particularly in developing countries. In the case of Quezon City, a workshop on developing the indicators was held on April 3, 2013 which was participated by different stakeholders to gain insights and reach consensus on two aspects of risk and vulnerability drivers: 1) key socio-economic factors describing vulnerable groups in the city, and 2) key socio-economic factors describing drivers that limit the resiliency of the city.

he proposed indicators were ranked in terms of their perceived importance to describe socio-economic vulnerabilities to natural disasters in Quezon City. This was done through a participatory modelling approach together with the Quezon City Focus Group (See Annex 1). Furthermore, discussions with the Focus Group included soliciting additional indicators aside from the proposed list of indicators. The results of the ranking are shown in Table 5.3, where a median score of 1 represents most important drivers and 3 as less important. The average and median score in Table 5.3 show the individual rankings, while the "Top 3" shows the frequencies each indicator was listed among the three most important drivers.

Table 5.3 DSV: Ranking of drivers of social vulnerability in Quezon City by the Focus Group

Drivers of Social Vulnerability	Avg.	Median	Top 3
Level of awareness	1.32	1	8
Condition of Critical Infrastructure	1.32	1	4
Poverty	1.40	1	4
Urban Congestion	1.55	1	4
Sanitation situation	1.59	1	
Education	1.60	1	4
Basic Health Status	1.61	1	2
Sub-standard Housing	1.63	1	
Rapid Growth	1.69	2	
Nutrition	1.85	2	
Lack of Public Space	1.90	2	4
Level of Solidarity and social networks in livelihood	2.03	2	
Livelihood generation	2.07	2	
Unemployment	2.19	2	
Crime	2.34	2	
Gender Role	2.76	3	
Race and Ethnicity	3.27	3	

After initial discussions on drivers of social vulnerability, the participants were asked to rank different socio-economic and demographic groups in terms of vulnerable groups to natural disasters in Quezon City. Table 5.4 shows results of these rankings where a median score of 1 represent most critical vulnerable groups and 3 less critical vulnerable groups. The average and median score in Table 5.4 show the individual rankings, while the "Top 3" shows the frequencies each group was listed among the three most critical vulnerable groups. Besides the vulnerable groups indicated in Table 5.4, the level of access to social services, orphans and pregnant women were nominated by the participants as being important.

Table 5.4: Stakeholder importance ranking of vulnerable groups to disasters in Quezon City

Vulnerable Groups	Avg.	Median	Top 3
Persons with Disabilities and Chronic Illness	1.27	1	9
Children	1.05	1	8
Elderly	1.29	1	8
Women	1.54	1	
Urban Poor	1.56	1	1
Slum Dwellers	1.83	1.5	
Homeless	1.85	2	1
Single Parent Households	2.39	2	
Unemployed	2.43	2	
Large Households	2.45	2	
Religious/Ethnic Minorities	2.56	2	
Migrants	2.60	2	
Renters without permit	2.90	3	

In the final part of the workshop, stakeholders were asked to rank different themes in terms of their importance in describing coping capacities with respect to natural disasters in Quezon City. Table 5.5 shows results of these rankings where a median score of 1 represent most important themes of coping capacity and 3 less important areas. Among additional important factors of coping capacity that were not listed in the survey, the following were nominated: Psycho-social support services, trained Barangay volunteers, availability of community centers such as recreational centers for youth and elderly, implementation of livelihood training programs, budget preparation for women, and number of charitable institutions and philanthropists in a Barangay. The average and median score in Table 5.5 show the individual rankings, while the "top 3 frequency" is the number of times a driver was listed in the top 3 most important drivers when participants worked together in groups in the second part of the workshop. In terms of coping capacities and preparedness strategies, among other factors listed as drivers that were not included in the survey were: lack of technical knowledge, lack of engagement and participation of vulnerable groups in developing preparedness strategies, lack of resources for disaster response and preparedness, lack of information dissemination and education, and lack of full implementation of awareness raising programs.

Figure 5.8 Ranking of the UDRi indicators in Quezon City workshop

Table 5.5: Stakeholder ranking of the most important factors describing coping capacity to natural disasters in Quezon City

Lack of Resilience/Coping Capacities	Avg	Median	Top 3
Search and Rescue Resources	1.07	1	7
Fire Fighting Resources	1.07	1	6
Community and Volunteer Organizations	1.24	1	6
Health Human Resources	1.29	1	3
Shelter Placement Capacity	1.51	1	3
Mobility	1.51	1	2
Commercial and Industrial Development	2.33	2	
Insurance Mechanisms	2.38	2	
Voting Participation	3.63	4	

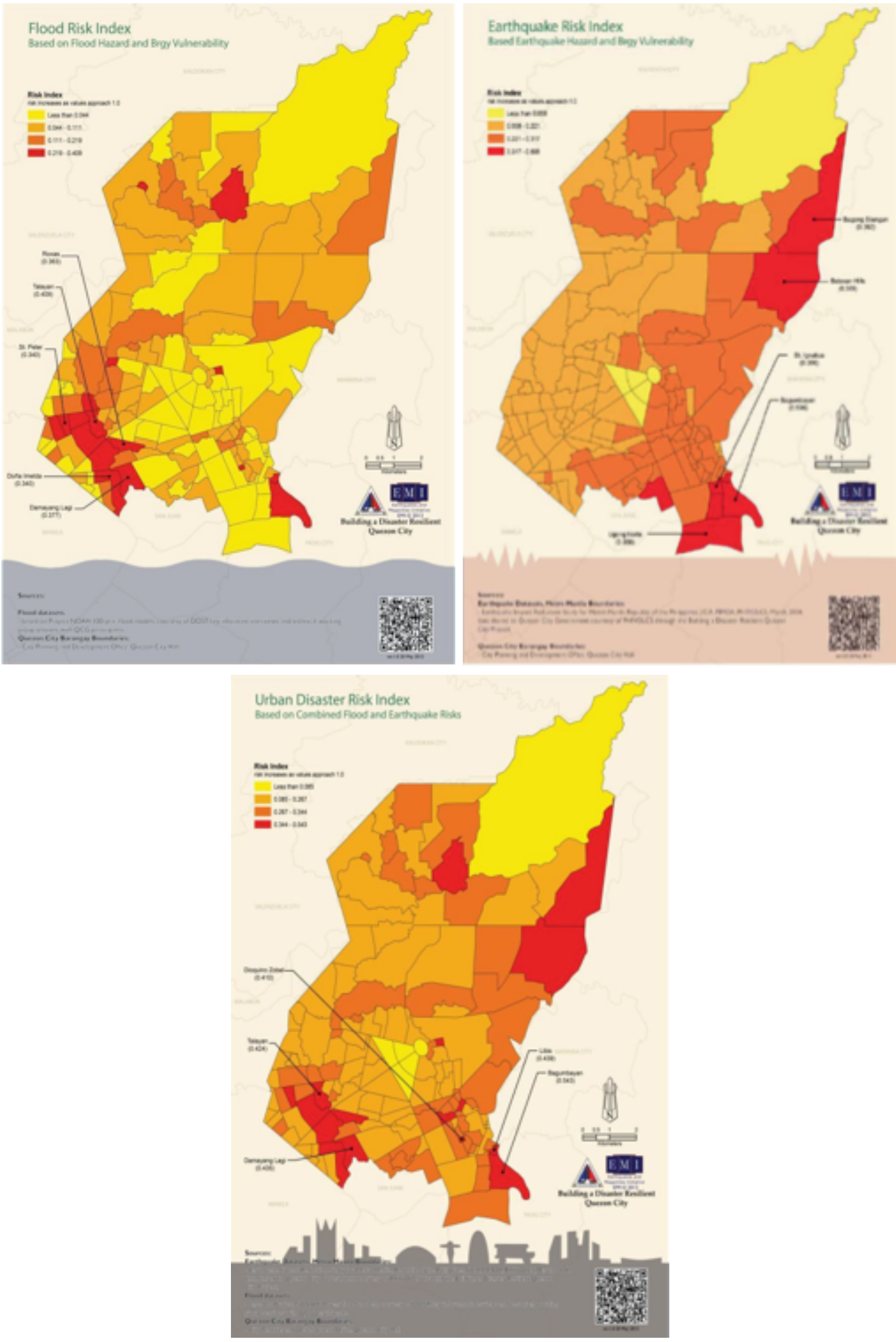
Given results of the participatory workshop and availability of data in Quezon City the final set of indicators selected are presented in Table 5.6. An important criteria for the selection of indicators for the UDRi in Quezon City is that they should be reproducible and used for benchmarking over time. Thus, in a second evaluation round, the Focus Group narrowed down the list to indicators which are readily available and can be collected over time without the need of special surveys or for which proxies can be found. Several of the highly ranked indicators were not available and proxies had to be found. As can be seen in Table 5.6, there was strong agreement among the participants that level of awareness is an important indicator for describing social vulnerability. As it is very difficult to measure level of awareness in Barangays, other than through administering a direct survey, education was deemed as an important proxy of lack of knowledge which in some cases can represent lack of awareness. On the other hand, crime was not ranked very high in the indicator development workshop with the Focus Group, however, in it was included in the final UDRi set of indicators as it was deemed an important factor in a later validation by the Core Group. In the final selection of indicators for UDRi in the “lack of resilience” category many compromises had to be made, as the data for these indicators were not readily available and would have required large data collection efforts. Thus, healthcare capacity, fire fighting capacity and another indicator representative of budget spent on disaster preparedness activities in the Barangays was used.

Table 5.6 shows the final set of indicators and respective weights used in the analysis.

	INDICATORS	SUB-INDICATORS	WEIGHT	
Physical Risk (RF)	RF1: Human Losses	$RF1_1$: Casualties	0.45	0.70
		$RF1_2$: Injuries		0.30
	RF2: Building Losses	$RF2_1$: Collapsed buildings	0.30	0.40
		$RF2_2$: Severely damaged buildings		0.30
		$RF2_3$: Highly damaged buildings		0.20
		$RF2_4$: Partially damaged buildings		0.10
	RF3: Affected Critical Facilities	$RF3_1$: Hospitals and healthcare centers	0.20	0.30
		$RF3_2$: Emergency rescue and operation centers		0.25
		$RF3_3$: Hazardous facilities		0.25
		$RF3_4$: Transportation infrastructure		0.20
	RF4: High Loss Potential Facilities	$RF4_1$: Schools	0.05	0.30
		$RF4_2$: Malls and Markets		0.60
		$RF4_3$: Daycare facilities		0.10
Social Fragility (SF)	SF1: Vulnerable Groups	$SF1_1$: Disabilities	0.40	0.35
		$SF1_2$: Children		0.25
		$SF1_3$: Elderly		0.25
		$SF1_4$: Urban Poor		0.15
	SF2: Urban Congestion	$SF2_1$: Population Density	0.25	
	SF3: Lack of Awareness	$SF3_1$: Illiteracy rate	0.15	
	SF4: Urban Poor	$SF4_1$:Dilapidated Housing	0.10	
	SF5: Crime	$SF5_1$: Crime rate	0.10	
Lack of Resilience	LR1: Healthcare capacity	$LR1_1$: Nr. of hospital beds	0.45	0.70
		$LR1_2$: Hospital accessibility		0.30
	LR2: Fire fighting capacity	$LR2_1$: Fire fighting resources (manpower/machinery)	0.30	0.70
		$LR2_2$: Accessibility		0.30
	LR3: Prevention and mitigation capacity	$LR3_1$: Amount of contracted awards in completed and planned projects in disaster preparedness and mitigation projects	0.25	0.25

The selection and weighting of the indicators were then finalized with a Core Group of experts from EMI and Quezon City Hall based on the workshop outputs with the Focus Group and an intensive data collection effort was carried out to populate the selected indicators. After the weighted aggregation of the social vulnerability and coping capacity indicators to obtain the impact factor (F) and the aggregation of earthquake risk indicators to obtain Physical Risk (RF), these two are combined to obtain a holistic risk ranking of the Barangays according to the Urban Disaster Risk Index (UDRi) shown in Figure 5.9.

Figure 5.9. Earthquake, Flood, and Combined Earthquake and Flood Risk Profiles for Quezon City, Philippines, Showing Hotspot Districts. 2013



MEDELIN

Background

A fully probabilistic seismic risk assessment of Medellín, Colombia, was conducted using a building by building resolution level database with more than 240,000 dwellings. The city is the second with largest population in Colombia with more than 2 million inhabitants in the urban area. For this assessment, a set of stochastic seismic scenarios was generated based on the more recent seismic hazard assessment in Colombia where also, the dynamic soil response was taken into account. A set of building classes was identified and vulnerability functions were developed to calculate the seismic risk in terms of probabilistic metrics using several modules of the CAPRA Platform. Risk premiums by sectors, as well as casualties and other direct effects were calculated on a building by building basis and then aggregated at county level, the analysis unit for the estimation of the USRi. The a holistic risk assessment was performed using the holistic evaluation module of CAPRA to take into account social fragility and lack of resilience conditions in each county that could increase the second order effects in case a strong earthquake strikes the city. These conditions were inferred from a set of indicators that are meant to capture the aggravating conditions of the direct physical impact, the second order effects and the intangible impact of future seismic events. The comprehensive USRi was obtained at county level in order to communicate risk to stakeholders and decision-makers, helping identify areas that would be particularly problematic in terms of vulnerability, both in physical and socioeconomic dimensions. This study constitutes a complete example of how an integrated research on disaster risk reduction has been performed with the aim to decrease the gap between the risk analysis and its relevance for disaster risk management decision-making processes. More details about this assessment can be found in Salgado-Gálvez et al. (2014a; 2014b). As a complement of the holistic risk assessment of the city, the RMI was evaluated taking into account the perspective of internal and external stakeholders, providing the main issues to improve the disaster risk management plan with the support of the Administrative

Department of Planning of the city. More details of this participative and analytical process of achievements and needs to improvement can be found in López (2010).

Implementation

The implementation and results of the UDRi in Medellín are shown herein to highlight how the outputs of a fully probabilistic seismic risk assessment at local level, where details related to the dynamic soil response were considered (Salgado-Gálvez et al., 2014b), can be used as inputs for the estimation of a physical risk index that is subsequently amplified by an aggravating coefficient to account for second order effects. Descriptors for the UDRi were selected depending on the best available information that best captured the issues to be included in the methodology as explained in Chapter 2. Local stakeholders were involved in the process and provided valuable opinions, comments and suggestions that were considered in several stages of the evaluation. Medellín municipality has an interinstitucional system for disaster risk management (Sistema Municipal de Prevención y Atención de Desastres, SIMPAD) coordinated at present (with the new and updated national legislation on disaster risk management) by the Administrative Department of Disaster Risk Management of the city. The processes of evaluation were implemented by groups with internal experts (officers of the SIMPAD institutions) and with external experts (consultants, professors, stakeholders of NGOs) with the support of the Administrative Department of Planning. Several workshops were made to discuss the objectives and the methodologies of the assessment techniques. Agreements by groups and a collective dialogue in plenary to debate the validations of the responses (reasons why the answers of individuals or teams) were made to provide the support and the proceedings of the evaluations for future review and update.

Figure 5.10 Workshops of internal and external experts (López 2010)

The UDRi

Figures 5.11 to 5.13 show the results for the physical risk index, the aggravating coefficient (accounting for both, social fragility and lack of resilience) and USRi at county level. Figure 5.14 shows the numerical values of the composite index as well as the ranking in terms of USRi by county. These results allow direct comparison among the different counties and are very useful for the identification of the underlying risk drivers that should be intervened to mitigate risk from different disciplines and perspectives.

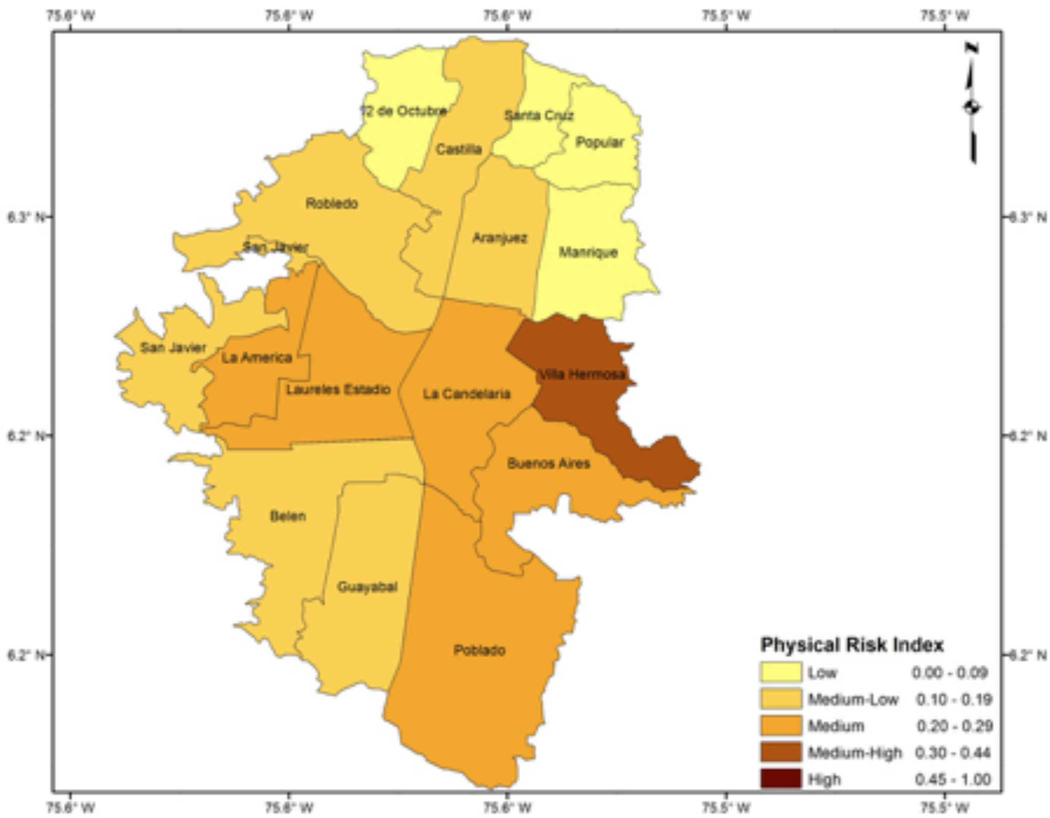


Figure 5.11 Physical risk index by county for Medellín (Salgado-Gálvez et al., 2014a)

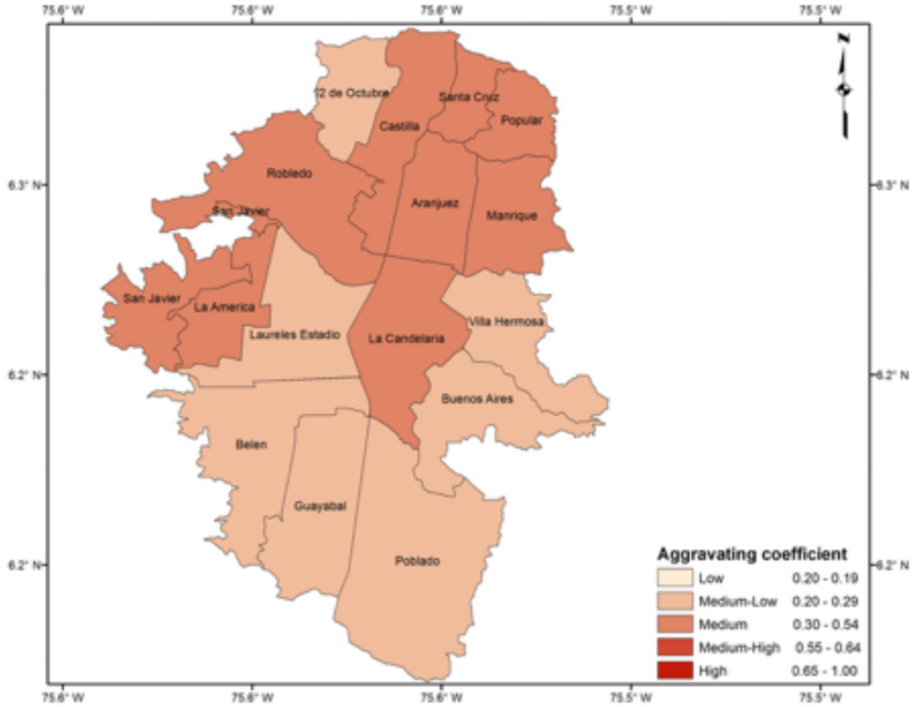


Figure 5.12 Aggravating coefficient by county for Medellín (Salgado-Gálvez et al., 2014a)

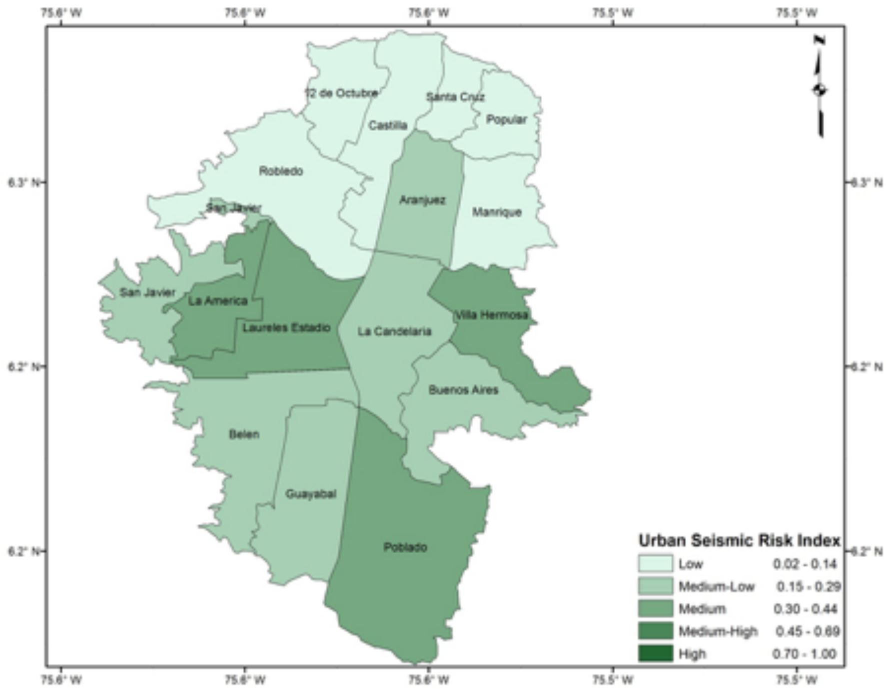


Figure 5.13 USRi by county for Medellín (Salgado-Gálvez et al., 2014a)

County	R_F	*F*	*USRi*
8 - Villa Hermosa	0.31	0.28	0.39
12 - La América	0.28	0.32	0.37
14 - Poblado	0.28	0.20	0.34
11 - Laureles Estadio	0.24	0.27	0.31
10 - La Candelaria	0.22	0.33	0.29
9 - Buenos Aires	0.22	0.28	0.28
15 - Guayabal	0.18	0.29	0.23
16 - Belén	0.17	0.20	0.21
4- Aranjuez	0.12	0.32	0.16
13 - San Javier	0.10	0.41	0.15
5 - Castilla	0.10	0.30	0.13
7 - Robledo	0.09	0.31	0.12
3 - Manrique	0.08	0.33	0.10
6 - Doce de Octubre	0.07	0.28	0.08
1- Popular	0.06	0.34	0.08
2 - Santa Cruz	0.02	0.29	0.02

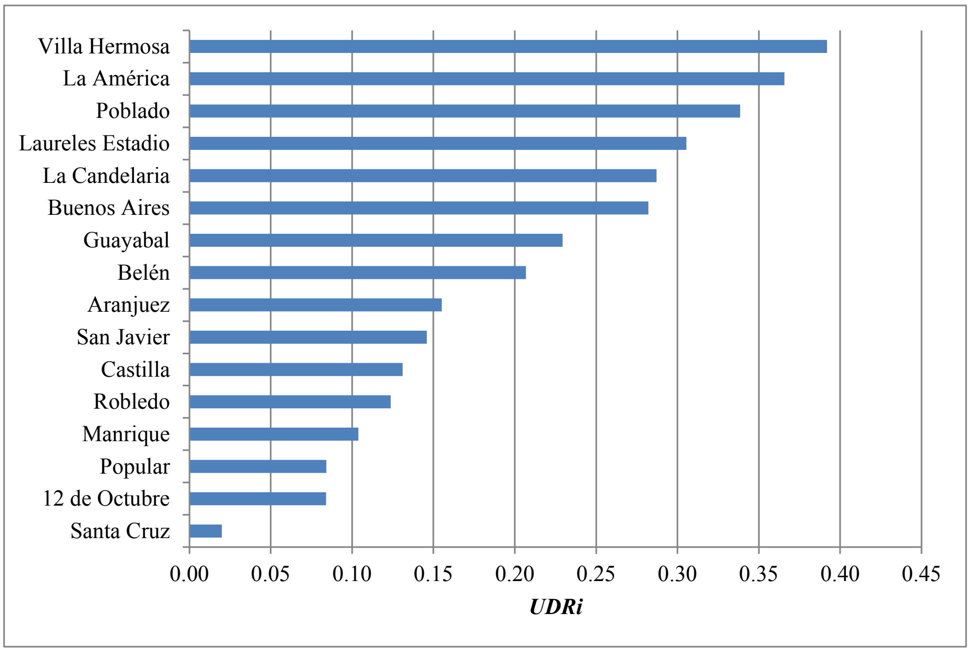
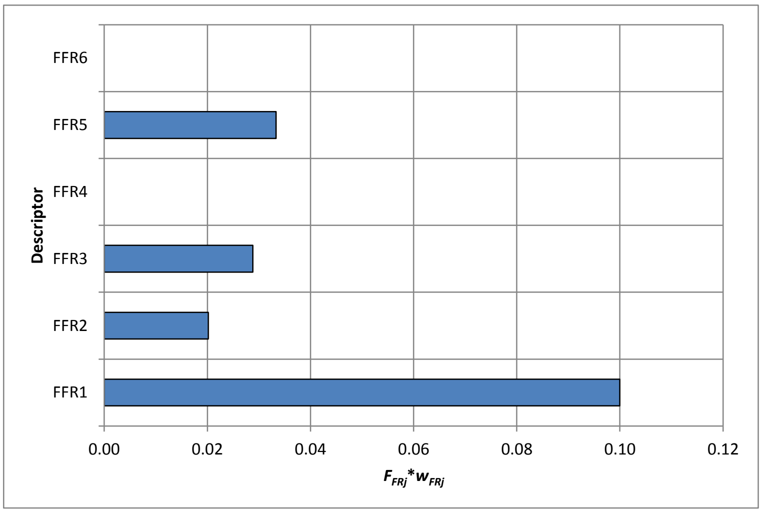


Figure 5.14 Results and USRi ranking by county for Medellín (Salgado-Gálvez et al., 2014a)

It is interesting to highlight that El Poblado and Laureles Estadio counties, although considered the wealthiest areas of Medellín, rank in the top 5. This is mostly because of high human density values associated to the existence of high-rise buildings and the lack of available public areas, a consequence of the disorganized urban planning. Given that the USRi is a composite indicator, after obtaining the final results, it is possible to disaggregate it and to see the contribution of the different descriptors related to the physical risk and/or the social fragility and lack of resilience. This disaggregation can be made for the 16 counties of Medellín.As an example, the mentioned disaggregation is presented for the Villa Hermosa County, the one with the highest USRi and for the lack of resilience descriptors. From the results it can be concluded that the descriptor with higher overall participation is FFR1, associated with the available public space, as shown in Figure 5.15.



ID	Descriptor
F_{FR1}	Public area
F_{FR2}	Distance to closest hospital
F_{FR3}	Distance to closest health center
F_{FR4}	Human development index
F_{FR5}	Development level
F_{FR6}	Emergency operation level

Figure 5.15 Disaggregation and contribution of lack of resilience descriptors in Villa Hermosa County (Salgado-Gálvez et al., 2014a)

The RMI

Figure 5.17 shows the RMI results for Medellín for different years, first disaggregated by each of the four considered policies (risk identification, risk reduction, financial protection and disaster management) and finally the overall RMI calculated as the average of each public policy. The assessment of the public policies was performed by means of workshops where 51 experts, affiliated to the academia, political institutions, NGOs, environmental authorities, local and national order entities were involved. The survey was either performed remotely or in presence during workshops constituting a participative example of the disaster risk management performance assessment of a major urban center in Colombia. The formats for evaluations and the scores were discussed collectively using computer tools designed for the participatory work. More details about the assessment can be found in López (2010).

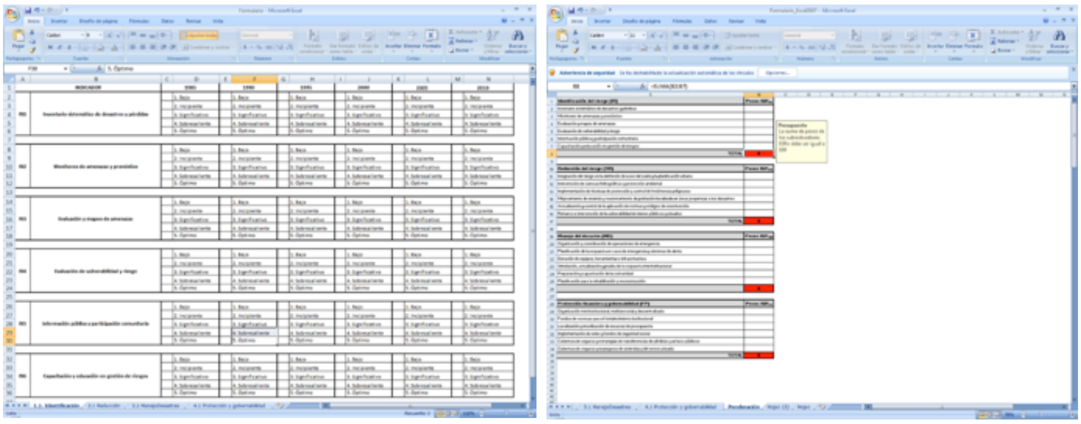
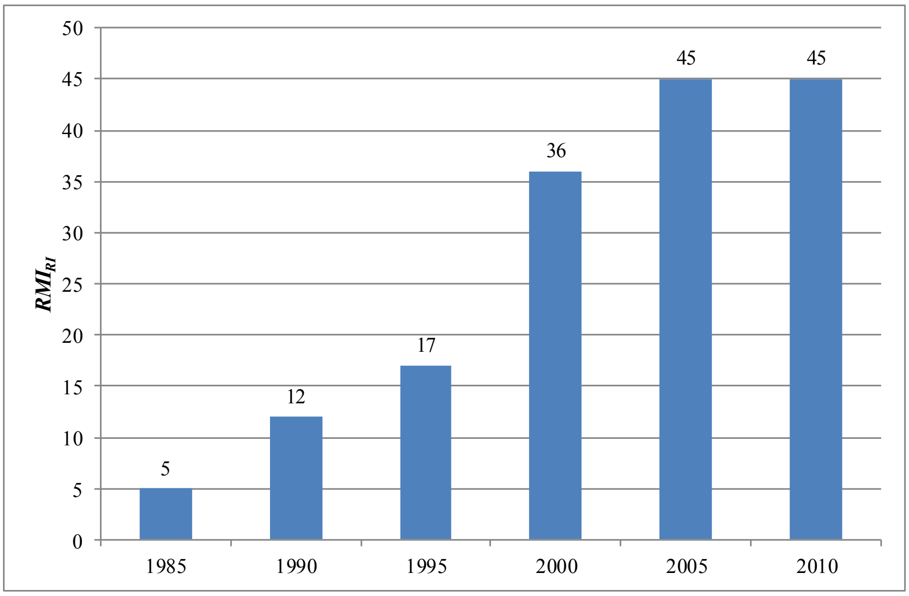
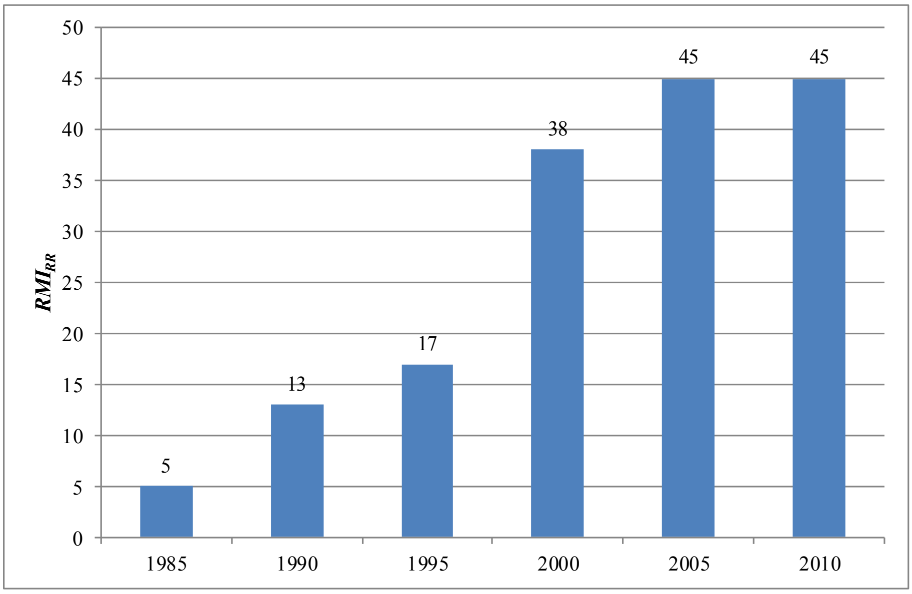


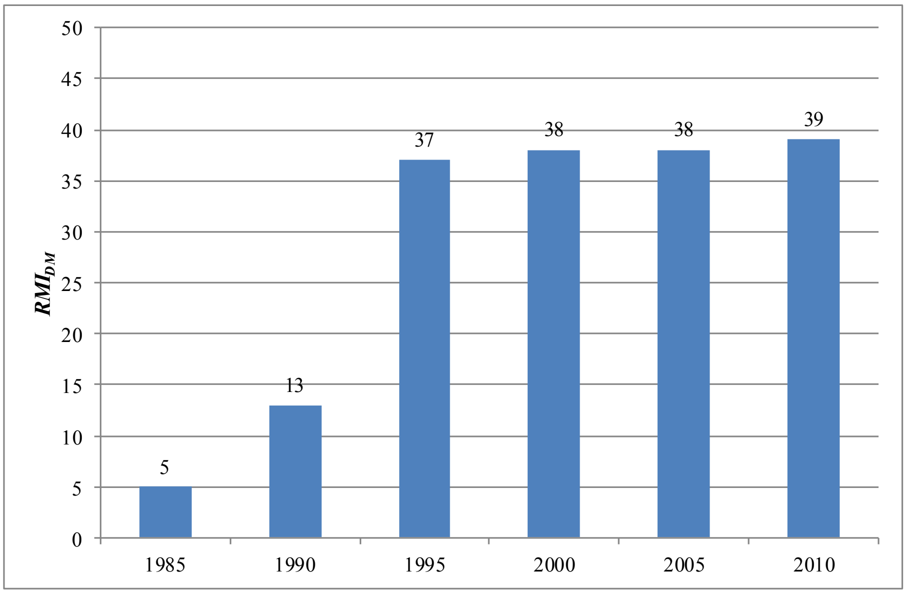
Figure 5.16 The RMI evaluation formats were implemented for interactive work (López, 2010)

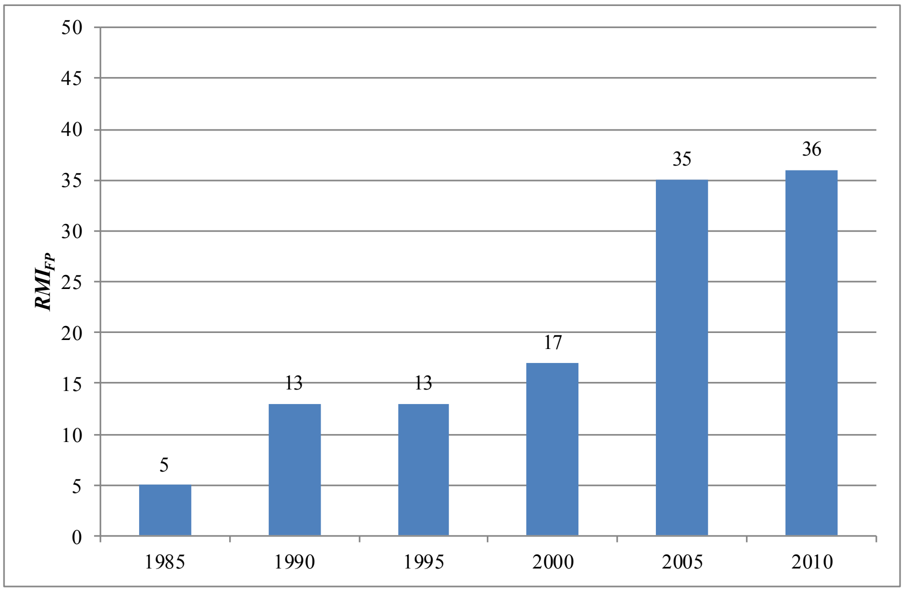
This evaluation was made making a retrospective analysis of the advances and evolution of disaster risk management in the city from 1985 and each 5 years until 2010 (a new evaluation is envisioned during 2015 and according the assessment of the new holistic risk assessment).

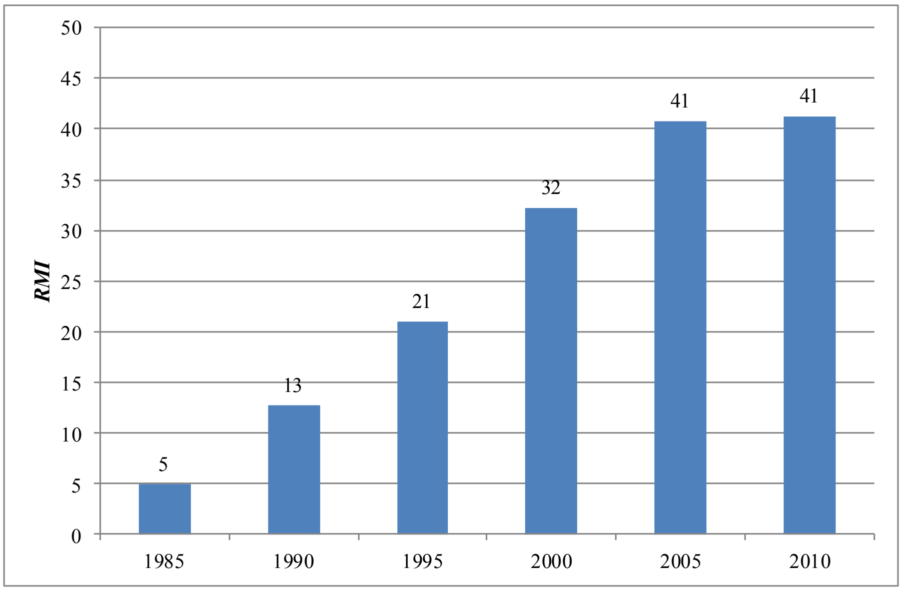
Figure 5.17 RMI by public policy and overall results for Medellín (López, 2010)











Special attention was taken to explain the reasons of the scores made by individuals and teams and why the changes in each subindicator or topic and their weights and in each policy. Risk Identification and Risk Reduction have been mainly relevant only in the last decade with the overall best and higher values. Disaster Management has been similar since 1995 and Financial Protection only has had a slight advance during the last decade. The total RMI for 2005 and 2010 was the same.

BOGOTÁ D.C.

Background

Bogotá, the capital city of Colombia with more than 9 million inhabitants has had several studies where seismic risk has been assessed from different perspectives (Carreño and Cardona, 2006; Carreño et al., 2007a; ODCA-ITEC, 2008; Salgado-Gálvez et al., 2013). The first application of the URDi and the RMI in a city was made in Bogotá, D.C. in 2003 in the framework of the Program of Indicators of Disaster Risk and Risk Management of the inter-American Development Bank (IDEA 2005, Carreño et al. 2005a,b; Cardona 2005, 2006). What has been interesting in this case is that, based on the previous studies and the holistic risk assessment methodologies proposed, the City Administration has developed its own studies and updates involving different official institutions and external observers and stakeholder in the process. A new calculation of the USRi was concluded in 2011 by the Fund for Prevention and Attention of Emergencies (FOPAE) which results are presented herein. The first application of the RMI at city level was made in 2003 and it was the first example of this type of evaluations at subnational level of the System of Indicators of IDB-IDEA (Suárez and Cardona, 2007). The more recent application of the RMI at subnational level (for the 32 provinces of the country) has been made in the framework of the Competitiveness Report of the Private Committee of Competitiveness (Comité Privado de Competitividad, 2014). The RMI was included as one of the indicators to evaluate the competitiveness index and governance of the subnational and local governments.

Implementation

The implementation of UDRi in Bogotá D.C. shows how the city officials have arrogated the process and, based on previous works and experiences, developed a holistic risk assessment using the framework and methodologies presented in this guidebook. Besides the completion of the work, it is important to highlight the clear understanding of the different aspects of a comprehensive disaster risk management scheme that exists at FOPAE where a multidisciplinary group has participated in the task of assessing risk from a holistic perspective. As in all the cases where UDRi has been applied, the main objective has been to identify not only the critical areas but the reasons for them being critical. Regarding the RMI is important to mention that the application to Bogota was considered the first successful experience of the risk management performance assessment made by officials of the System of Disaster Risk Management of Bogotá. This was very important example that was followed by other cities such as Manizales, Pereira, Armenia and Medellin in the country. This efforts were useful to compare the capital cities in the country and the first attempt to provide information of the progress using a robust methodology of assessment. The last evaluation of the RMI was made in 2014 for the 32 provinces and capital cities of Colombia.

The UDRi

The analysis unit has been set to both localities (the largest administrative sub-division at urban level in the city) and Zonal Planning Units-UPZ (the second larger administrative sub-division at urban level in the city) in order to broader the audience of the assessment. Instead of a fully probabilistic seismic risk assessment, the physical risk index has been obtained by means of scenario approaches (considering different magnitudes and locations) and the results shown in Figures 5.18 and 5.19 correspond to those of the 475 years return period scenario, associated to a regional fault with magnitude 7.3. Complete details about this study can be found in FOPAE (2011). In this case, the social fragility and lack of resilience indexes are presented separately as shown in Figures 5.18 and 5.19 respectively.

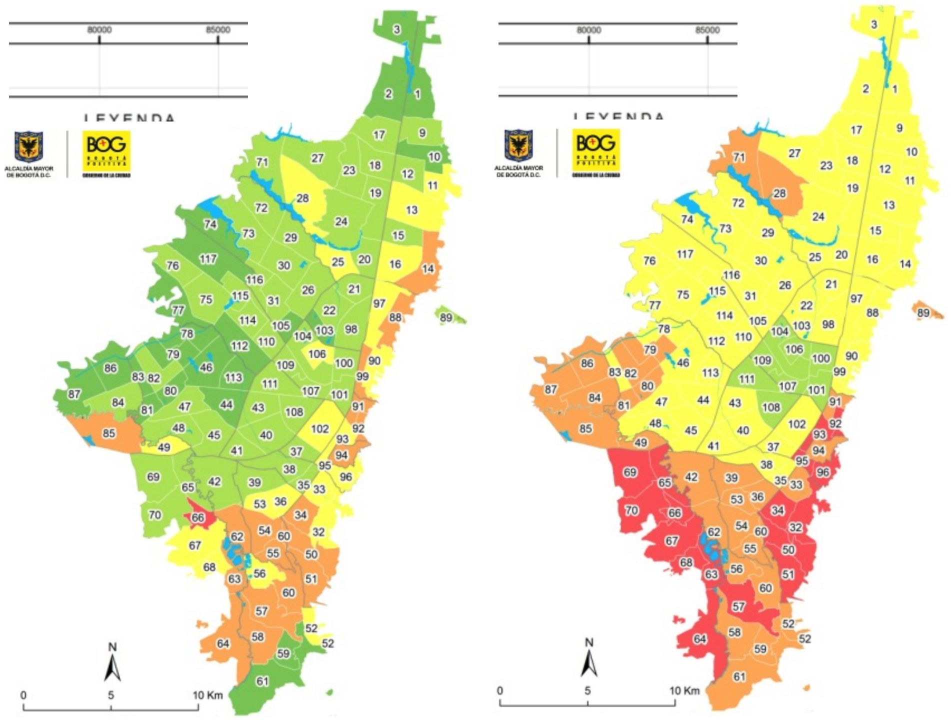


Figure 5.18 Left: Physical risk index by UPZ for M7.3 earthquake scenario
Right: Social fragility index by UPZ (FOPAE, 2011)

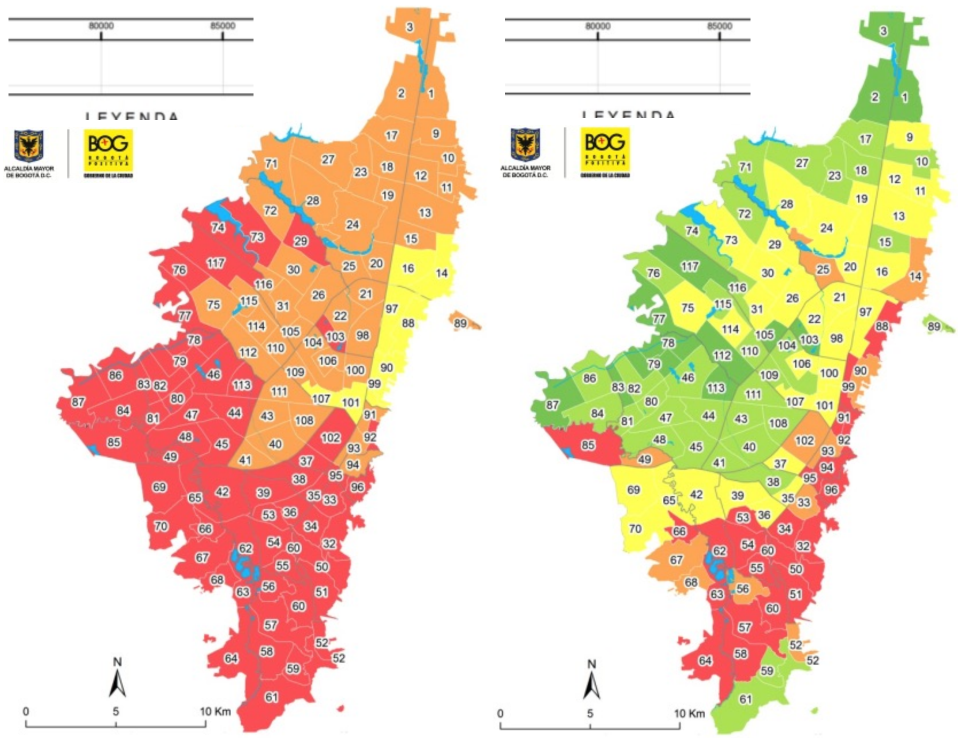
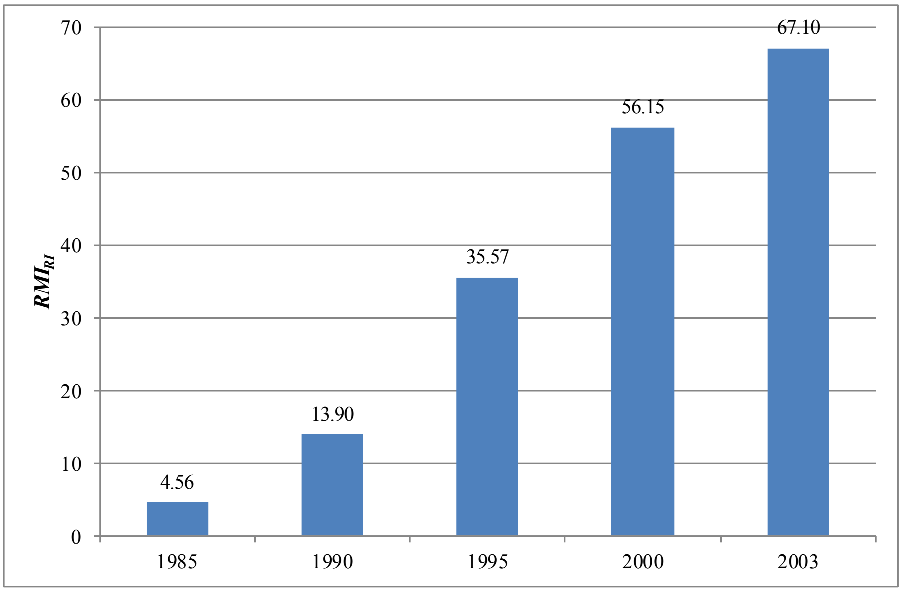


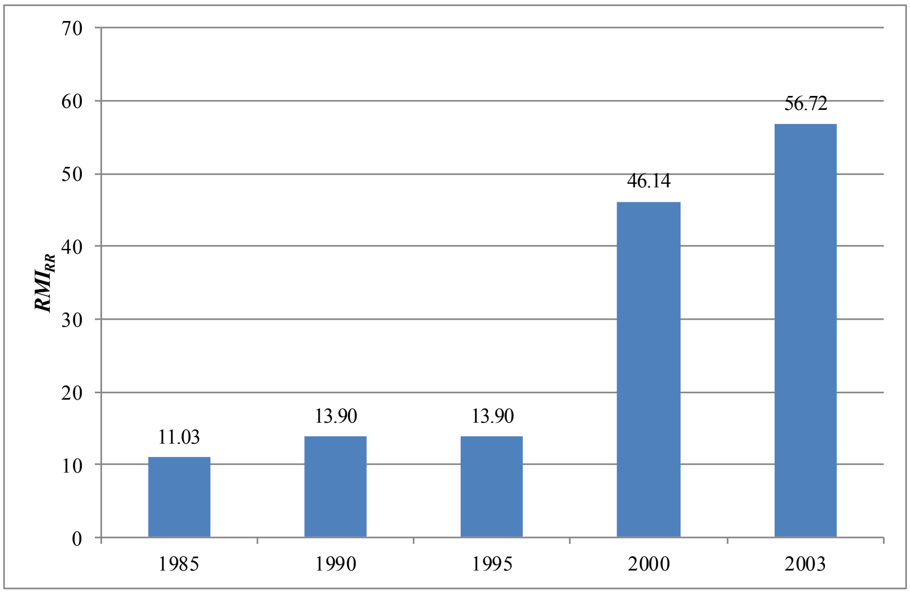
Figure 5.19 Left: Lack of resilience index by UPZ
Right: UDRi by UPZ for M7.3 earthquake scenario (FOPAE, 2011)

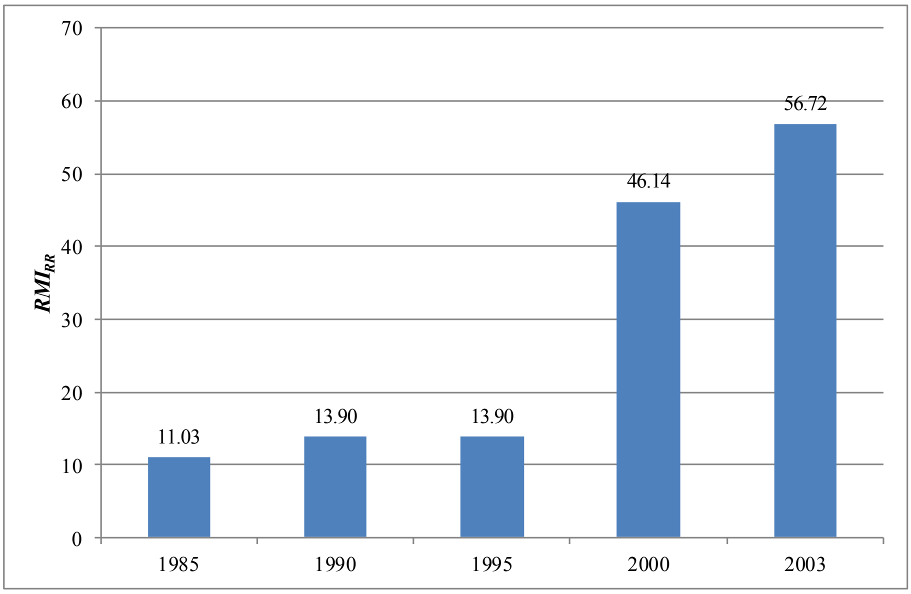
The RMI

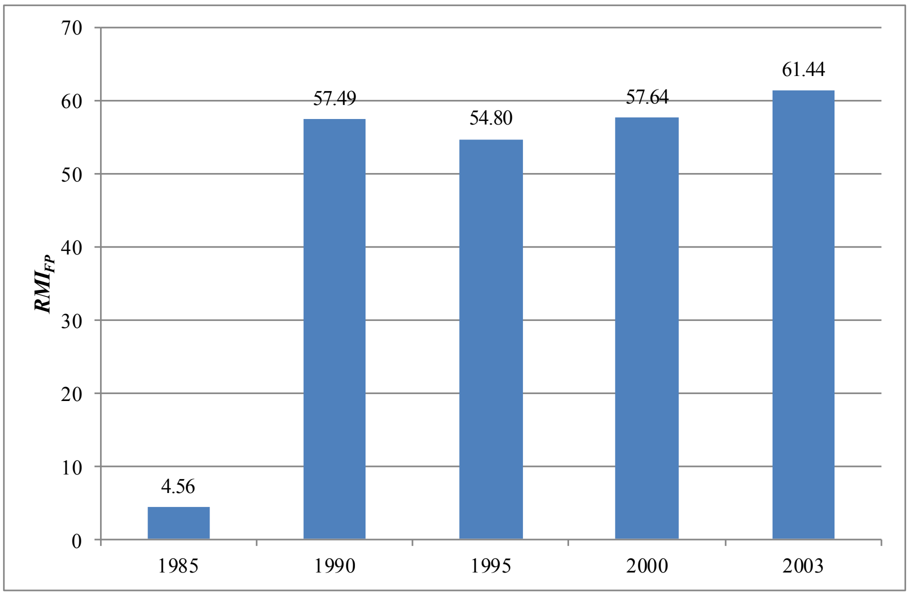
Risk management benchmarking and weights of each indicator were evaluated by the officials of the Directorate for Risk Mitigation and Emergency Preparedness of Bogotá (DPAE) and also by consultants and academics of the city. Figure 5.20 shows the RMI results for Bogotá for different years (from 1985 to 2005, each five years), first disaggregated by each of the four considered policies (risk identification, risk reduction, financial protection and disaster management) and finally the overall RMI calculated as the average of each public policy. Full details about this assessment can be found in Carreño et al. (2007b).

Figure 5.20 RMI by public policy and overall results for Bogotá (Carreño, 2010)






70
60
50
40
30
20
10
0
RMI_{RR}
11.03
13.90
13.90
46.14
56.72
1985
1990
1995
2000
2003


70
60
50
40
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0
RMI_{FP}
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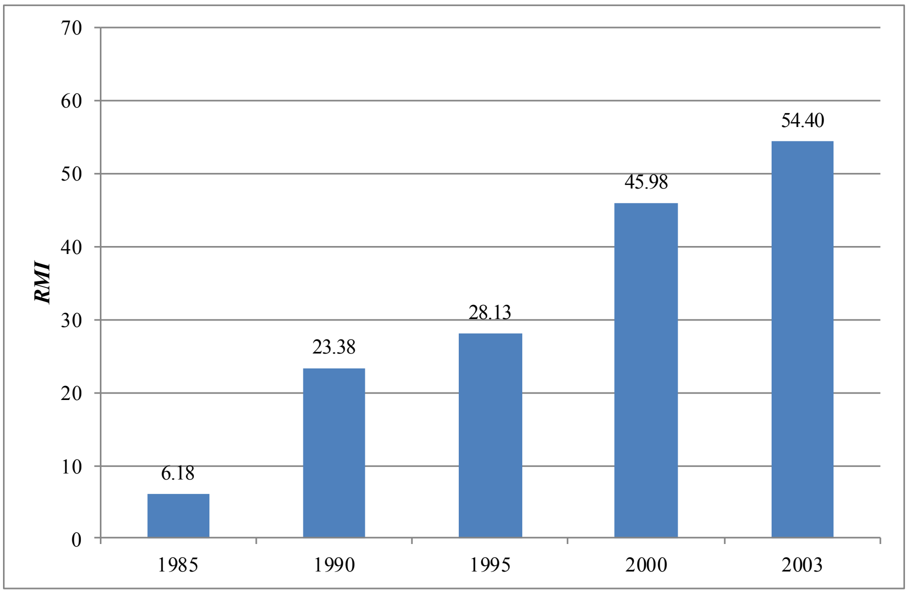
54.80
57.64
61.44
1985
1990
1995
2000
2003


70
60
50
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30
20
10
0
RMI
6.18
23.38
28.13
45.98
54.40
1985
1990
1995
2000
2003

The results of the RMI for Bogotá, illustrate the high level of performance in Risk Identification in 2003. Bogotá began microzonation in the 1990s and had relied on its university and research sector. It became a model for other cities in Colombia seeking to reduce earthquake-related damage. The city in that moment already had also landslides and flood hazard and risk maps and technological hazard assessments. Using microzonation data, a study was made of the vulnerability of the bridges and the impact on city mobility in case of an earthquake. This was the basis for detailed evaluation and retrofitting of all vehicle and pedestrian bridges and the airport terminals of the city in the second half of the 1990s and the first half of the 2000s. Regarding Risk Reduction the city in 2003 still had not implemented notable public investments that were identified as priorities, such as the seismic retrofitting of public schools. More than 200 public schools were evaluated and retrofitted. More than US$460 million have were invested to reduce the seismic risk of children and teachers through reinforcement and construction of new facilities for the benefit of 300,000 students. In the last decade all public services of the city have completed detailed vulnerability studies and the retrofitting of telephone and energy substations, natural gas and water pipelines, water storage tanks and pumps, and landfills. The vulnerability of public infrastructure is now low and the redundancy of services is high. In the last fifteen years, the vulnerability of all hospitals has been evaluated, and all of them have been retrofitted according to the national earthquake-resistant construction code. Disaster Management was incipient but according to the 2003's RMI evaluation. The priority was to strength the emergency response simulations, involving people, and the development of a recovery plan in case a big disaster. Using different scenarios of damage based on seismic hazard microzonation, the Directorate of Prevention and Attention of Emergencies (DPAE) developed a new earthquake emergency response and recovery plan for Bogotá and has conducted public information campaigns and simulations. Lastly, in relation to Financial Protection the city in 2003 already had a very strong financing fund for disaster risk management and housing resettlement. According to the RMI evaluation the Finance Secretariat developed a risk-transfer strategy for the financial protection of public assets and the promotion of insurance of private buildings. In summary, the RMI has been a key methodology to identify the priorities of disaster risk management and for the follow-up of the actions and goals of disaster risk management plan of Bogotá.

MANIZALES

Background

Manizales is an intermediate city of Colombia with more than 400,000 inhabitants that, although located in an area prone to different natural hazards (earthquakes, landslides, floods, volcano), has been a pioneer in all of the stages involved in a comprehensive disaster risk management schemes such as risk assessment, vulnerability mitigation, financial protection and emergency planning that have served to become the city a worldwide recognized example of good practices in disaster risk management. Using a property tax for disaster risk management the city is undertaken an Integrated Disaster Risk Management Program lead by CORPOCALDAS (the regional environment authority) and the IDEA of the National University of Colombia at Manizales, as an International Center of Excellence of the Integrated Research Disaster Risk of ICSU. The update of the UDRi and the RMI is part of this innovative initiative of improvement of knowledge for disaster risk reduction.

Implementation

The implementation of UDRi and RMI in Manizales started in 2005 within the framework of the development of the disaster risk indicators system of the Inter-American Development Bank (IDEA, 2005). This was the first case where the results of a fully probabilistic seismic risk assessment at urban level were used as input for a holistic risk assessment. The estimation of both urban risk indexes has been possible thanks to the existence of a multidisciplinary group of local experts that have make it possible to develop a sustainable participatory process that has led to continuous improvements and updates of the estimation of the results. More recently, under an ambitious disaster risk management project that covers all the aspects of a comprehensive disaster risk management scheme (Cardona, 2009) the update of the UDRi and the RMI is expected for late 2015 and some preliminary results are shown in this guidebook.

The UDRi

The estimation of the USRi for Manizales was based on a fully probabilistic seismic risk assessment performed on an element by element resolution level for the building stock of the city such as shown in Figure 5.21 and, as in the case of Medellín, the earthquake risk results were grouped into counties, the unit of analysis for the USRi.

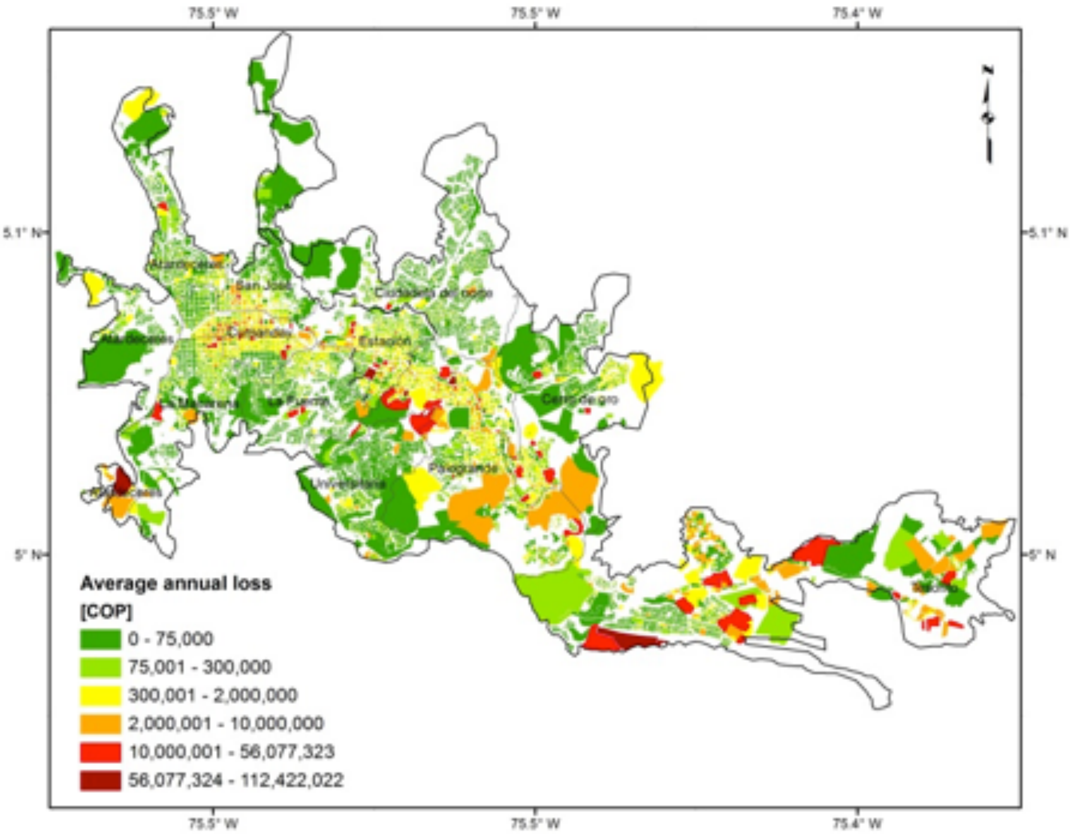


Figure 5.21 Average annual loss (AAL) by dwelling for the building stock of Manizales (Suárez, 2008)

Figures 3.22 to 3.24 show the results for the physical risk index, the aggravating coefficient (accounting for both, social fragility and lack of resilience) and USRi at county level. Finally, Figure 5.25 shows the numerical values of the composite index as well as the ranking in terms of USRi by county. Full details about this study are found in Suárez (2008, 2009) Suárez & ardona (2008) and Suárez et al. (2009).

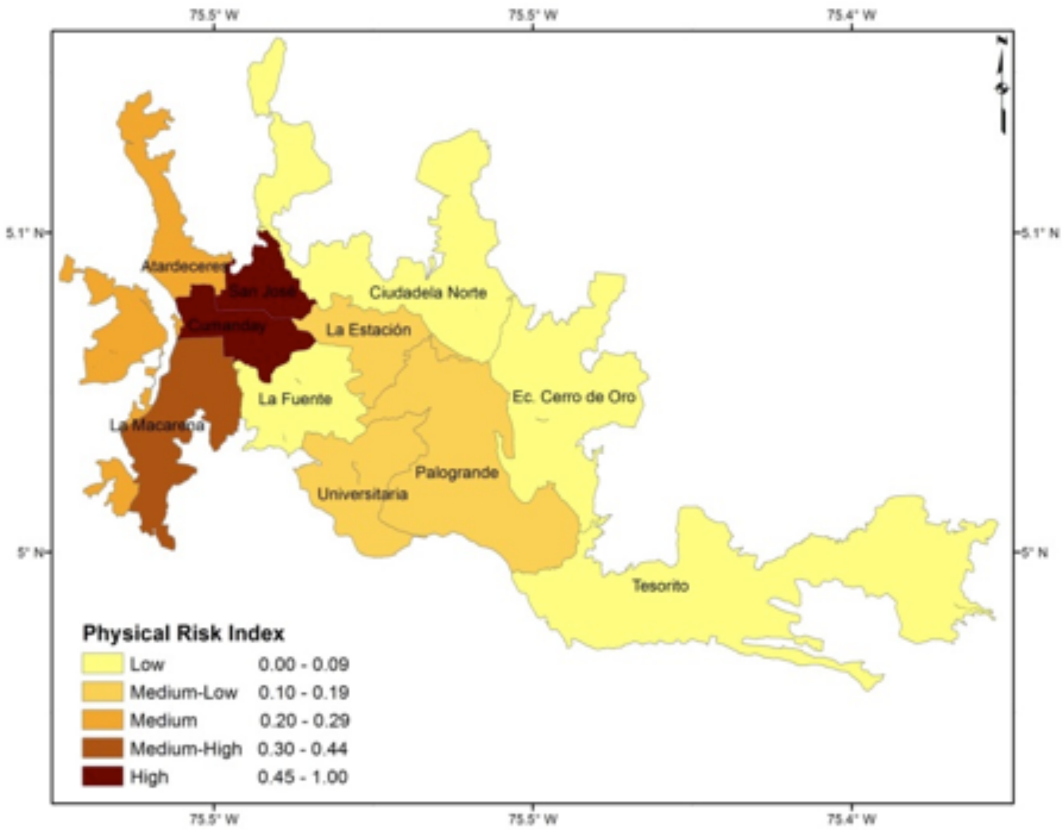


Figure 5.22 Physical risk index by county for Manizales (Suárez, 2008)

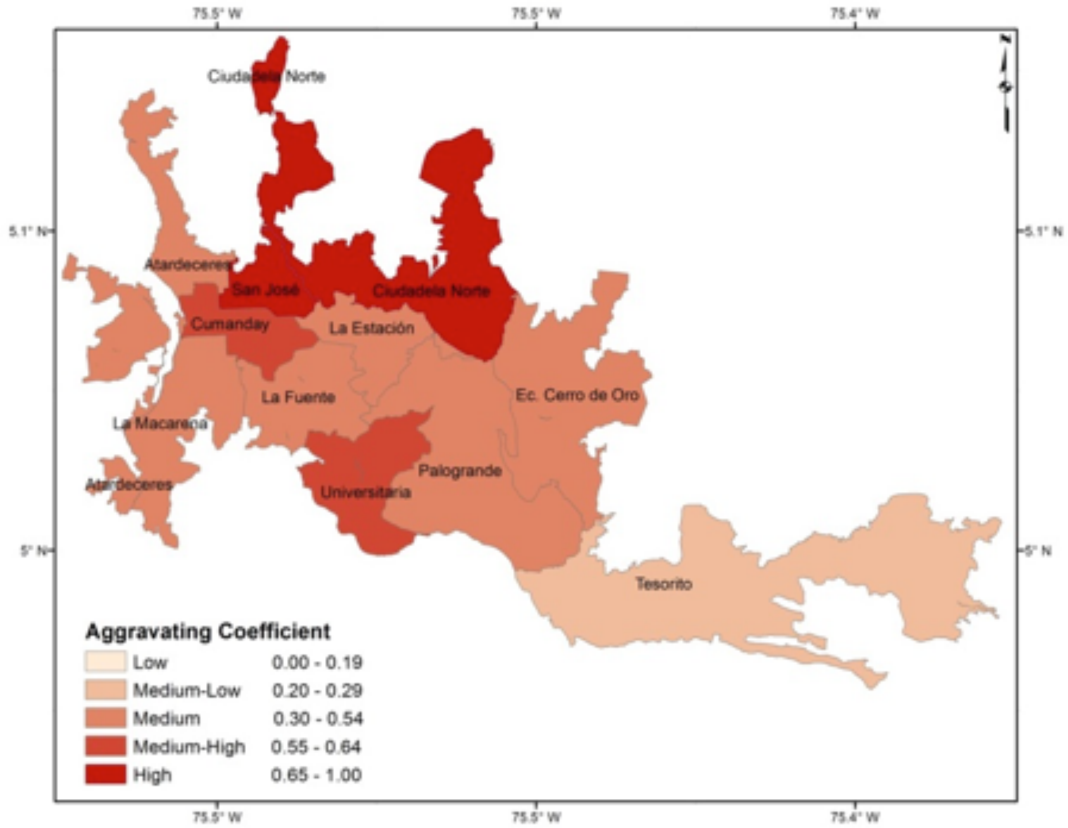


Figure 5.23 Aggravating coefficient by county for Manizales (Suárez, 2008)

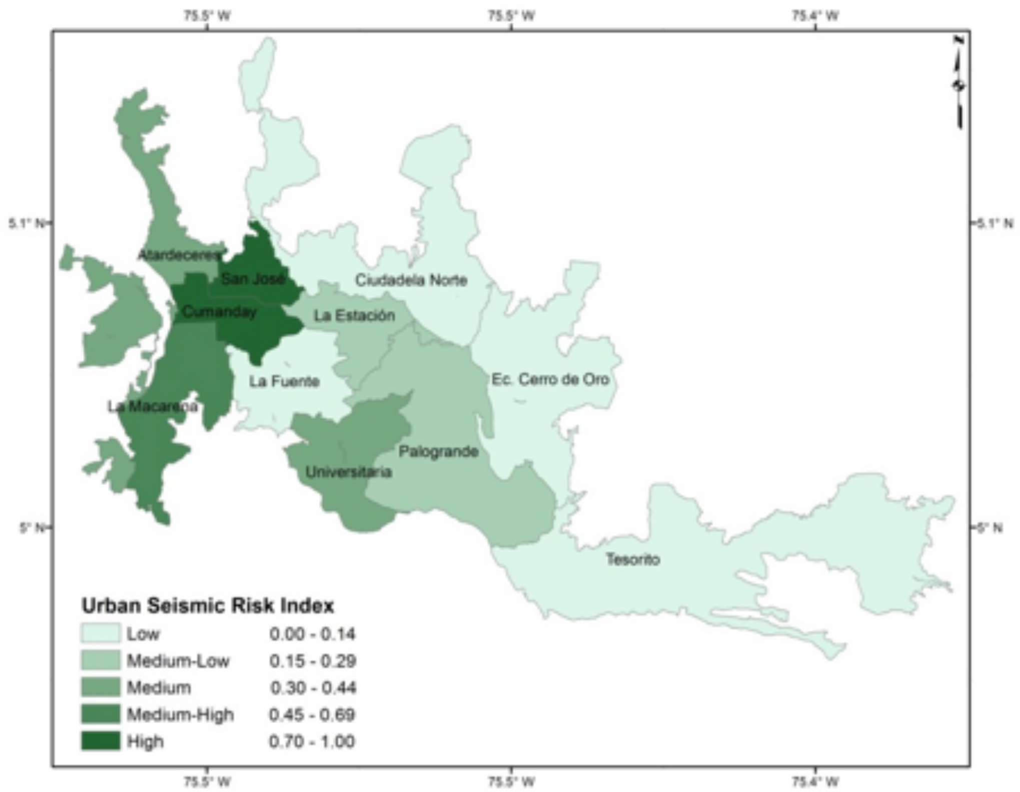


Figure 5.24 USRi by county for Manizales (Suárez, 2008)

County	*R F*	*F*	*USRi*
2 - San José	0.55	0.77	0.97
3 - Cumanday	0.47	0.61	0.75
11 - La Macarena	0.39	0.43	0.55
1 - Atardeceres	0.25	0.34	0.33
9 - Universitaria	0.18	0.63	0.3
8 - Palogrande	0.18	0.32	0.24
4 - La Estación	0.15	0.41	0.21
10 - La Fuente	0.07	0.52	0.11
5 - Ciudadela Norte	0.04	0.73	0.07
6 - Ec. Cerro de Oro	0.03	0.36	0.04
7 - Tesorito	0.00	0.26	0.00

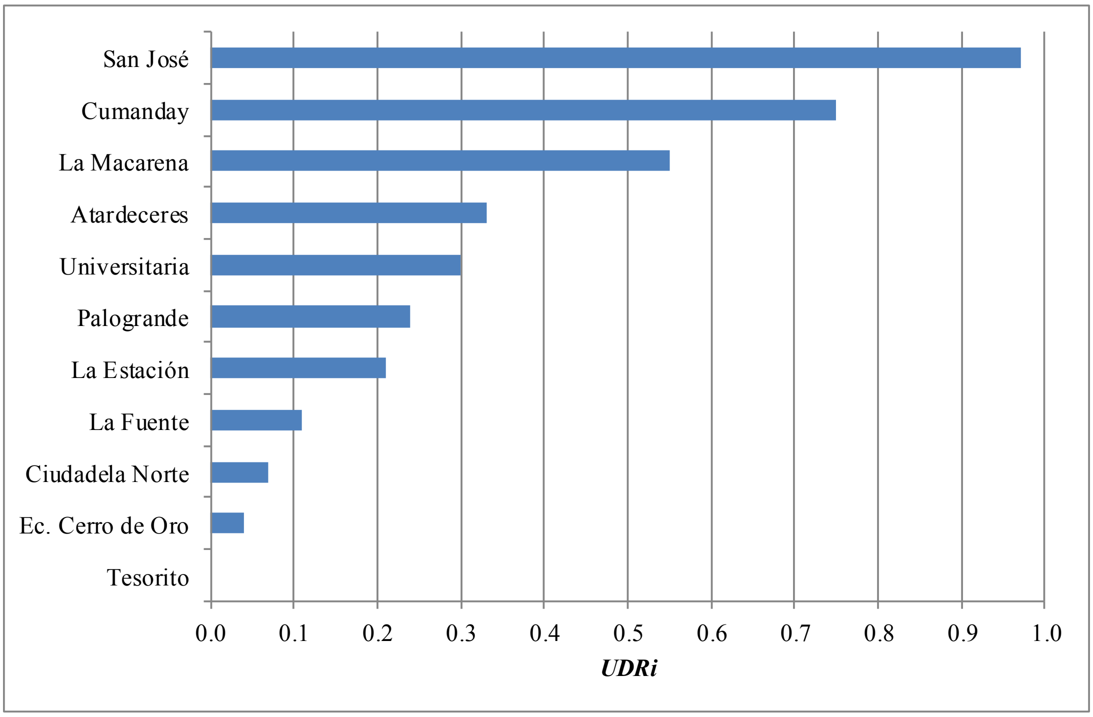


Figure 5.25 Results and USRi ranking by county for Manizales (Suárez, 2008)

San José County has the largest RF, F and subsequently USRi in Manizales due not only to the physical vulnerability of the structures but to the prevalent social fragility and lack of resilience of the area and its inhabitants. Due to these results, a project of urban renovation and risk intervention was proposed by the Municipality of Manizales as the Macro Project of San José. This ongoing project means the relocation and building of 5,500 housing units, risk reduction landslides instability works, and social improvement in the county.

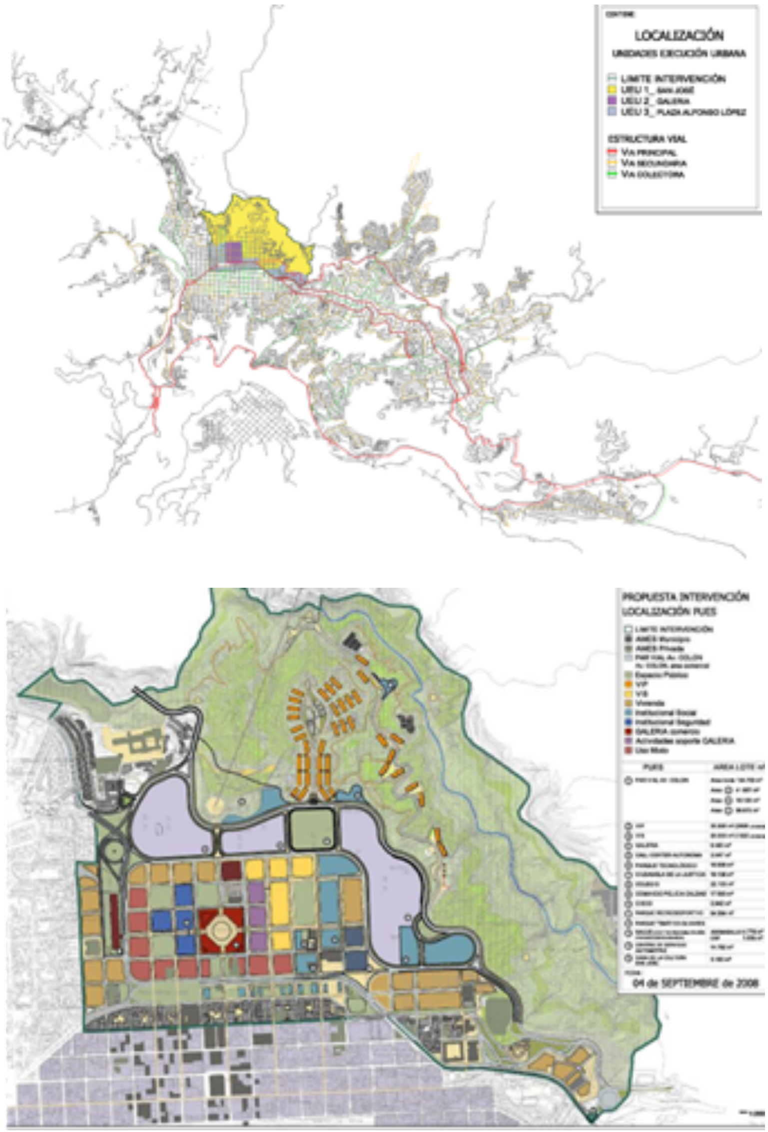


Figure 5.26 Macro Project of Urban Renovation and Risk Reduction of San Jose

The RMI

The first evaluation of the RMI in Manizales was made in the framework of the Program of Indicators of Disaster Risk and Risk Management IDB-IDEA (Suárez 2008). The Municipal Office of Prevention and Attention of the city administration (now the Unite of Disaster Risk Management of the city) and the Local Committee of Prevention and Attention(now the Local Council for Disaster Risk Management were the institutional support to implement the evaluation of the RMI involving the different public and private stakeholders. A comparison was made between Manizales and other capital cities of other provinces of the region (Pereira and Armenia) and with Bogotá (Suárez and Cardona 2007). In 2005 Manizales already was the city with the best performance in Disaster Risk management of the country. Risk Reduction has a score of 82, Risk identification of 70 and Financial Protection of 67. Disaster Management, has been the less advanced, unlike other cities where preparedness and emergency response usually is the public policy with more achievements.

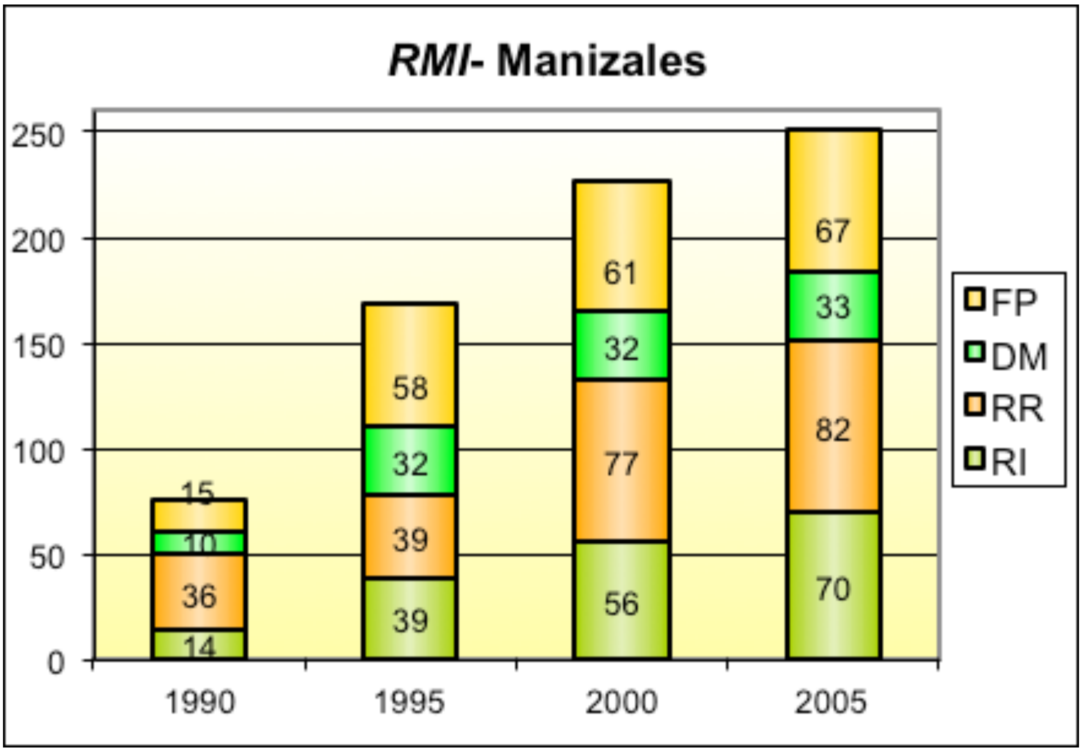
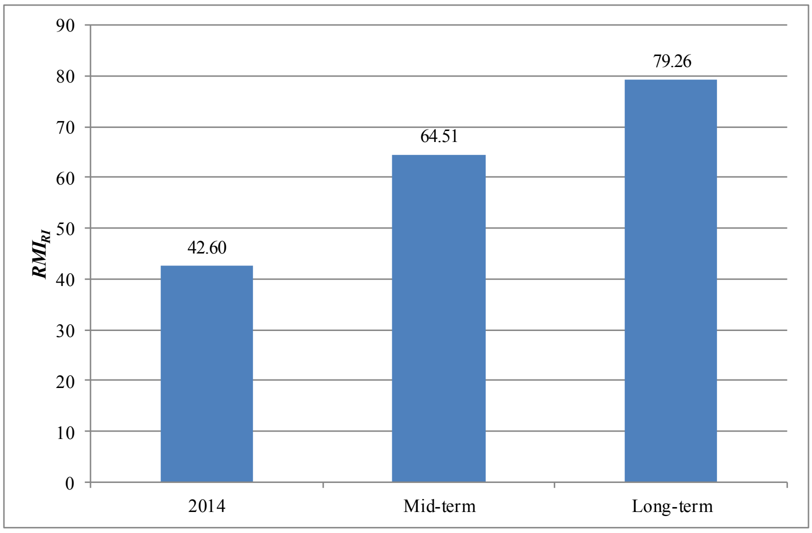
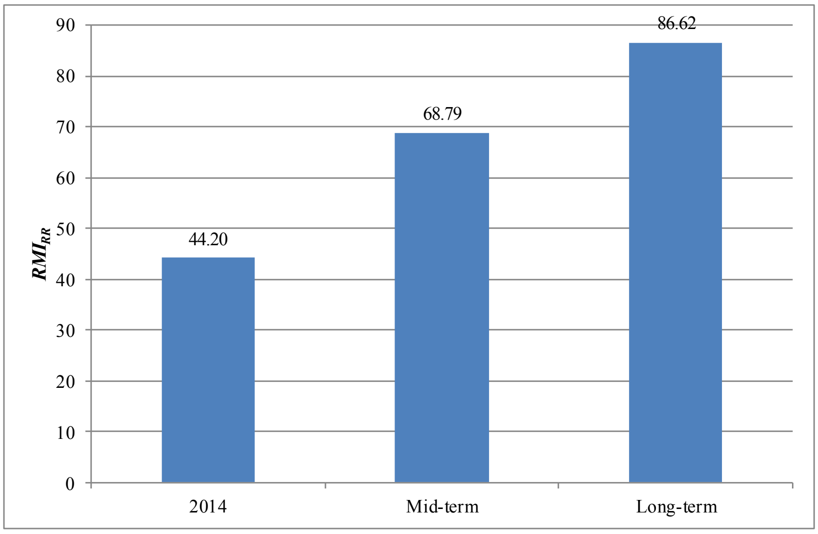


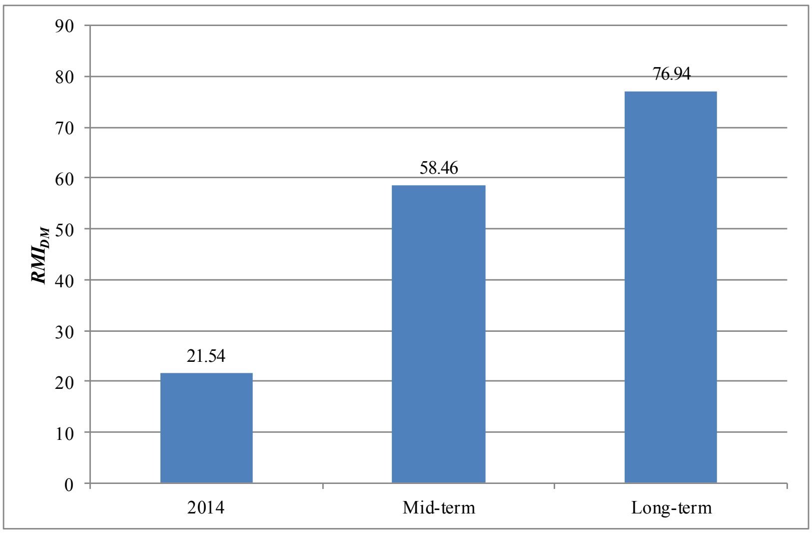
Figure 5.27 Aggregated RMI by public policy for Manizales (Suarez, 2008)

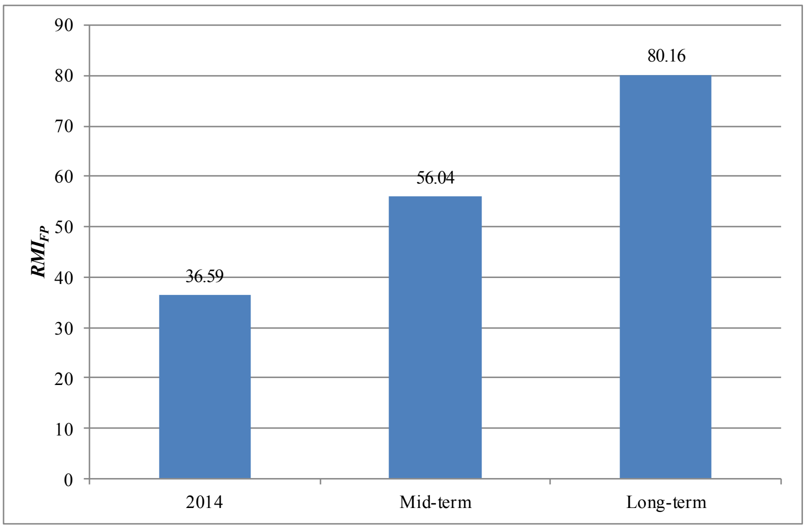
In the framework of the comprehensive Integrated Disaster Risk Management Program of Manizales (2012-2015), based on a collective debate, a participative RMI evaluation was performed deriving on it. A core group of 42 participants affiliated to the local and regional institutions participated in the assessment at the end 2014 and the beginning of 2015. A new scale and benchmark for the RMI was developed according to the reality of Manizales (the new results are not comparable with the evaluation of 2005). Several workshops by public policy were developed to define with other invited stakeholders the strategies, objectives and the program of activities of the new Integrated Disaster Risk Management City Plan for twelve years as the Land-use urban Plan. In this case, the RMI was evaluated for year 2014 and future estimations (as collective goals) were performed for the Mid-term (3 to 6 years) and for the Long-term (7 to 12 years) to provide the priorities to 2020 and 2026 to the plan. Complete details about the assessment can be found in Narvaez (2015).

Figure 5.28 The RMI by public policy and overall results for Manizales (Narváez, 2015)






90
80
70
60
50
40
30
20
10
0
$RMI_{D,M}$
21.54
58.46
76.94
2014
Mid-term
Long-term


90
80
70
60
50
40
30
20
10
0
RMI_{FP}
36.59
56.04
80.16
2014
Mid-term
Long-term

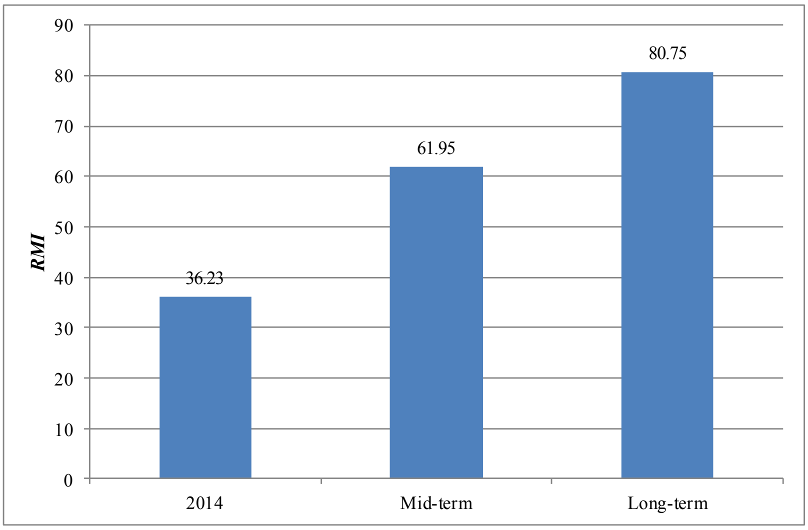

90
80
70
60
50
40
30
20
10
0
RMI
36.23
61.95
80.75
2014
Mid-term
Long-term

Figure 5.29 The Core Group for the evaluation of the RMI for 2014, 2020 and 2026 (Narváez, 2015)

In the case of Manizales, the National University of Colombia is very important because it plays the role of being the technical soul of the city administration regarding disaster risk management. This means that the Focus Group in the case of Manizales is based on the IDEA as a multidisciplinary institute of the university. Meanwhile the Core Group is integrated by the city officers from the different secretariats, other representatives of national and regional agencies, local NGOs, and other stakeholders from the private sector. The use of the RMI, which is not only to evaluate the performance and the need for improvements on disaster risk management but also to define the expected goals for the new integrated disaster risk management plan, is an innovation that can be replicated in other cities.

Lessons From Practice: Planning, Participation and Evaluation

The three indicator systems presented here were developed as a risk communication, benchmarking and planning tool, and aims to assists in policy development, decision-making, and monitoring effectiveness of specific DRM options and strategies. In using the indicator systems through a participatory development process to validate, implement and periodically update the system of indicators several case studies were presented that showed how both a Core Group (CG) and a wider range of city stakeholders, or Focus Group (FG) was engaged to take ownership over the indicator systems, and was made responsible for their periodic implementation, evaluation and validation.

Regarding the experience of the implementation of the three indicator systems – UDRi, RMI and DRI - both the selection of the indicators, to reflect the risk and resilience drivers, and the predefined benchmarks (qualification of progress or target outcomes) of the set of desirable DRM actions have been obtained from the opinion of a group of the city experts taking into account a flexible approach. The interviews with the stakeholders have been undertaken individually or with a team related to a specific sector or discipline (i.e. Focus Group) such as university professors, external consultants, staff from the Directorates of Disaster Risk Management, and from a secretariat or a relevant city agency.

Different views have been collected from each interview using more than one survey.

In order to ensure a smother process of application of the indicator systems in an urban environment, it is recommended that the in the implementation of a project, the management group look into the following recommendations prior to initiating the implementation process:

CHAPTER 6

It is recommended that prior to the project implementation, the management group consider the following recommendations to ensure a better application process of the indicator systems.indicator systems.

1 A “Focus Group” (FG) composed of a selected group of key city stakeholders who will test, monitor, and validate the results of the implementation phase for each of the three indicator systems, UDRi, RMI and DRI should be formed. These should involve:

A.) Persons from key organizational and functional areas of DRM in a city such as legal and institutional arrangements, land-use planning, transportation, public works, lifelines or public services, emergency response services, education, health, scientific and information institutes, industry, among others;

B.) It is also expected that the FG will count on representatives from academia, particularly someone who has been working on decision science and risk management;

C.) In all cases the risk and risk management framework understanding in the city is the key point of departure for a comprehensive assessment and the FG members should be selected accordingly.

D.) The optimum number of members of the FG will be decided by the Core Group; in any case many more than 30 persons in a Focus Group is difficult to handle based on our experience.

2 A “Core Group” (CG) for each of implementation of each of the indicators.

A.) The UDRI “core group” (CG) should be composed of technical persons trained in the use of indicator constructions, tools and application of the methodology and its key elements, such as how to estimate weights for the different descriptors and to develop transformation functions.

B.) The RMI “core group” (CG) should be composed of the head of an implementing institution with its advisors or colleagues from the respective institution, department, division, etc.

C.) The DRI “core group” (CG) should be composed of the Focus Group leader for each of the themes or sectors where resilience improvement is being considered (e.g., land use planning, emergency preparedness, etc.), thus ensuring that adequate knowledge regarding each of the 5 sectors is contained

CHAPTER 6

D.) It has been recommended to involve experts in one or several topics related to disaster risk management (e.g. building codes, emergency response, urban planning, engineering, and Earth and climate sciences). Their background can related to the academia, governmental institutions, NGOs and the private sector. The diversity of fields of expertise has been desirable.

E.) The optimal number of members of the Core Group has been found to be no less than 3 persons and it is desirable not to have not many more than 5 persons within the Core Group.

3 The generation of a common language, the acknowledgement of the responsibility of each sector or agency to deal with risk and their role regarding risk management has been strategic to control the excessive protagonism of some officers or agencies that usually support the status quo and the emergency response as the main or unique action. The possibility to disaggregate the results to identify the main components and weights of the risk drivers as well as the relevance of risk management actions in the context of development have facilitated the interinstitutional agreements and consensus about the priorities, actions, measures and public investments needed to reduce disaster risk.

4 The CG will review and suggest changes to improve the translation/ localization of the technicaldocuments on the methodology and adopt local terminology whenever possible, tofacilitate its comprehension.

5 The questionnaires for the UDRi, RMI and DRI should be tested by the CG before sending to a larger FG for evaluation.

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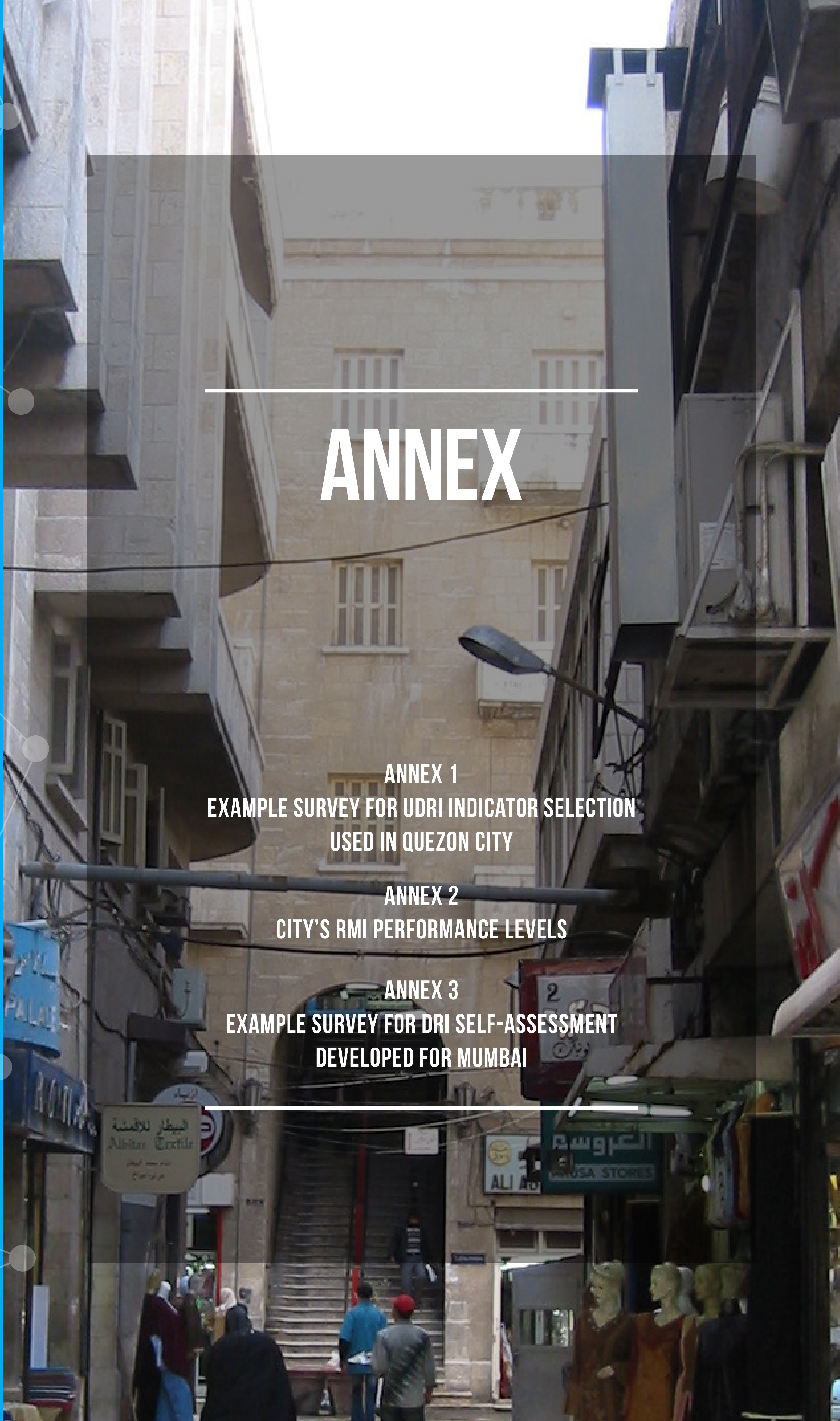


ANNEX

ANNEX 1
EXAMPLE SURVEY FOR UDRI INDICATOR SELECTION USED IN QUEZON CITY

ANNEX 2
CITY'S RMI PERFORMANCE LEVELS

ANNEX 3
EXAMPLE SURVEY FOR DRI SELF-ASSESSMENT DEVELOPED FOR MUMBAI

ANNEX 1: EXAMPLE SURVEY FOR UDRI INDICATOR SELECTION USED IN QUEZON CITY

(1) VERY IMPORTANT	(2) IMPORTANT	(3) SOMEWHAT IMPORTANT	(4) LESS IMPORTANT	(5) NOT IMPORTANT

1. Rank the following indicators in terms of their importance to describe social vulnerabilities to natural disasters people are facing in your city (from most important to least important):

- ☐ Nutrition
- ☐ Education
- ☐ Gender role
- ☐ Poverty
- ☐ Unemployment
- ☐ Crime
- ☐ Race and Ethnicity
- ☐ Condition of Key Infrastructure
- ☐ Sub-standard Housing
- ☐ Sanitation situation
- ☐ Basic Health Status
- ☐ Livelihood generation
- ☐ Level of awareness
- ☐ Level of Solidarity and social networks in neighborhood
- ☐ Lack of Public Space
- ☐ Urban Congestion
- Rapid Growth

List other parameters and indicate their level of importance below:

ANNEX 1

(1) VERY IMPORTANT	(2) IMPORTANT	(3) SOMEWHAT IMPORTANT	(4) LESS IMPORTANT	(5) NOT IMPORTANT

2. Rank the following indicators in terms of their importance in representing vulnerable groups to natural disasters in Quezon City:

- ☐ Elderly
- ☐ Children
- ☐ Persons with Disabilities and Chronic Illness
- ☐ Slum Dwellers
- ☐ Renters without permit
- ☐ Homeless
- ☐ Urban Poor
- ☐ Unemployed
- ☐ Migrants
- ☐ Women
- ☐ Migrants
- ☐ Religious/Ethnic Minorities
- ☐ Single Parent Households
- ☐ Large Households

List other parameters and their level of importance below:

ANNEX 1

(1) VERY IMPORTANT	(2) IMPORTANT	(3) SOMEWHAT IMPORTANT	(4) LESS IMPORTANT	(5) NOT IMPORTANT

3. Rank the following indicators in terms of their importance in describing coping capacities with respect to natural disasters in Quezon City:

- ☐ Firefighting Resources
- ☐ Search and Rescue Resources
- ☐ Community and Volunteer Organizations
- ☐ Shelter Placement Capacity
- ☐ Insurance mechanisms
- ☐ Mobility
- ☐ Health Human Resources
- ☐ Voting Participation
- ☐ Commercial and Industrial Development

List other parameters and indicate their level of importance below:

ANNEX 1

4. Do power and land ownership structures influence people's capacities to cope or adapt? If yes, why?

5. Does gender and gender roles influence the ability for women to cope and adapt after disasters? If yes, how?

ANNEX 1

6. Is the level of knowledge and education a dominant factor leading to vulnerable conditions? If yes, why?

7. Is the quality, and density of commercial and industrial development a relevant indicator of the state of economic health of a community? If yes, why?

8. Does a higher level of commercial and industrial development increase or decrease a community's vulnerability to recovery after an event?

9. Describe the current level of preparedness (E.g., EWSs, emergency plans, level of awareness, etc.)

a. What are key reasons for potential limitations or failures in preparedness strategies?

b. To what extent are preparedness activities influenced by available technical resources and capacities?

ANNEX 1

Is communication and information exchange between up- and downstream communities guaranteed? (This question refers to events, such as floods and heavy rainfalls). If not, why?

ANNEX 2: CITY'S RMI PERFORMANCE LEVELS

RISK IDENTIFICATION INDICATORS (RI)

INDICATOR AND PERFORMANCE LEVELS
RI1. Systematic disaster and loss inventory 1. Some basic and superficial data on the history of events that have affected the city 2. Continual registering of current events, incomplete catalogues of the occurrence of some phenomena and limited information on losses and effects. 3. Some complete catalogues at the national and regional levels, systematization of actual events and their economic, social and environmental effects. 4. Complete inventory and multiple catalogues of events; registry and detailed systematization of effects and losses at the local level. 5. Detailed inventory of events and effects for all types of existing hazards and data bases at the sub-national and local levels.
RI2. Hazard monitoring and forecasting 1. Minimum and deficient instrumentation of some important phenomena. 2. Basic instrumentation networks with problems of updated technology and continuous maintenance. 3. Some networks with advanced technology at the national level or in particular areas; improved prognostics and information protocols established for principal hazards. 4. Good and progressive instrumentation cover at the national level, advanced research in the matter on the majority of hazards, and some automatic warning systems working. 5. Wide coverage of station and sensor networks for all types of hazard in all the city; permanent and opportune analysis of information and automatic early warning systems working continuously at the local, regional and national levels.

ANNEX 2

RI3. Hazard evaluation and mapping

1. Superficial evaluation and basic maps covering the influence and susceptibility of some phenomena.
2. Some descriptive and qualitative studies of susceptibility and hazard for main phenomena and for some specific areas.
3. Some hazard maps based on probabilistic techniques at city level. Generalized use of GIS for mapping of the main hazards.
4. Evaluation is based on advanced and adequate resolution methodologies for the majority of hazards. Microzonation of the city based on probabilistic techniques.
5. Detailed studies for the vast majority of potential phenomena throughout the city using advanced methodologies; high technical capacity to generate knowledge on its hazards.

RI4. Vulnerability and risk assessment

1. Identification and mapping of the principle elements exposed in prone zones in the city.
2. General studies of physical vulnerability when faced with the most recognized hazards, using GIS having into account basins inside and near the city.
3. Evaluation of potential damage and loss scenarios for some physical phenomena in the principal cities. Analysis of the physical vulnerability of some essential buildings.
4. Detailed studies of risk using probabilistic techniques taking into account the economic and social impact of the majority of hazards in some cities. Vulnerability analysis for the majority of essential buildings and lifelines.
5. Generalized evaluation of risk, considering physical, social, cultural and environmental factors. Vulnerability analysis also for private buildings and the majority of lifelines.

ANNEX 2

RI5. Public information and community participation

1. Sporadic information on risk management in normal conditions and more frequently when disasters occur.
2. Press, radio and television coverage oriented towards preparedness in case of emergency. Production of illustrative materials on dangerous phenomena.
3. Frequent opinion programs on risk management issues at the national and local levels. Guidelines for vulnerability reduction. Work with communities and NGOs.
4. Generalized diffusion and progressive consciousness; conformation of some social networks for civil protection and NGOs that explicitly promote local risk management issues and practice.
5. Wide scale participation and support from the private sector for diffusion activities. Consolidation of social networks and notable participation of professionals and NGOs at all levels.

RI6. Training and education in risk management

1. Incipient incorporation of hazard and disaster topics in formal education and programs for community participation.
2. Some curricular adjustments at the primary and secondary levels. Production of teaching guides for teachers and community leaders in some localities or districts of the city.
3. Progressive incorporation of risk management in curricula. Considerable production of teaching materials and undertaking of frequent courses for community training.
4. Widening of curricular reform to higher education programs. Specialization courses offered at various universities. Wide ranging community training at the local level.
5. High technical capacity of the city to generate risk knowledge. Wide ranging production of teaching materials. Permanent schemes for community training.

ANNEX 2

RISK REDUCTION INDICATORS (RR)

INDICATOR AND PERFORMANCE LEVELS
RR1. Risk consideration in land-use and urban planning 1. Consideration of some means for identifying risk, and environmental protection in physical planning. 2. Promulgation of national legislation and some local regulations that consider some hazards as a factor in territorial ordering and development planning. 3. Progressive formulation of land-use regulations that take into account hazards and risk; obligatory design and construction with norms based on microzonations. 4. Formulation and updating of the territorial ordering plan with a preventive approach. Use of microzonations with security ends. Risk management incorporation into sectorial plans. 5. Approval and control of implementation of territorial ordering and development plans that include risk as a major factor and the respective urban security regulations.
RR2. Hydrographic basin intervention and environmental protection 1. Inventory of basins and areas of severe environmental deterioration or those considered to be most fragile. 2. Promulgation of legal dispositions that establish the obligatory nature of reforestation, environmental protection and river basin planning. 3. Formulation of the plan for organization and intervention in strategic water basins and sensitive zones taking into account risk and vulnerability aspects. 4. Environmental protection plans and impact studies that consider risk as a factor in determining investment decisions. 5. Intervention of deteriorated basins, sensitive zones and strategic ecosystems. Environmental intervention and protection plans.

ANNEX 2

RR3. Implementation of hazard-event control and protection techniques 1. Some structural control and stabilization measures in some more hazardous places. 2. Channeling works, sanitation and water treatment constructed following security norms. 3. Establishment of measures and regulations for the design and construction of hazard control and protection works in harmony with territorial ordering dictates. 4. Wide scale intervention in mitigable risk areas using protection and control measures. 5. Wide implementation of mitigation plans and adequate design and construction of cushioning, stabilizing, dissipation and control works in order to protect human settlements and social investment.
RR4. Housing improvement and human settlement relocation from prone-areas 1. Identification and inventory of marginal human settlements located in hazard prone areas. 2. Promulgation of legislation establishing the priority of dealing with deteriorated urban areas at risk for improvement programs and social interest housing development. 3. Programs for upgrading the surroundings, existing housing, and relocation from risk areas. 4. Progressive intervention of human settlements at risk and adequate treatment of cleared areas. 5. Notable control of risk areas of the city and relocation of the majority of housing constructed in non-mitigable risk areas.

ANNEX 2

RR5. Updating and enforcement of safety standards and construction codes

6. Voluntary use of norms and codes from other countries without major adjustments.
7. Adaptation of some requirements and specifications according to some national and local criteria and particularities.
8. Promulgation and updating of obligatory urban norms based on international or national norms that have been adjusted according to the hazard evaluations.
9. Technological updating of the majority of security and construction code norms for new and existing buildings with special requirements for special buildings and life lines.
10. Permanent updating of codes and security norms: establishment of local regulations for construction in the city based on urban microzonations, and their strict control and implementation.

RR6. Reinforcement and retrofitting of public and private assets

1. Retrofitting and sporadic adjustments to buildings and lifelines; remodeling, changes of use or modifications.
2. Promulgation of intervention norms as regards the vulnerability of existing buildings. Strengthening of essential buildings such as hospitals or those considered indispensable.
3. Some mass programs for evaluating vulnerability, rehabilitation and retrofitting of hospitals, schools, and the central offices of life line facilities. Obligatory nature of retrofitting.
4. Progressive number of buildings retrofitted, life lines intervened, some buildings of the private sector retrofitted autonomously or due to fiscal incentives given by government.
5. Massive retrofitting of principal public and private buildings. Permanent programs of incentives for housing rehabilitation lead to lower socio-economic sectors.

ANNEX 2

DISASTER MANAGEMENT INDICATORS (DM)

INDICATOR AND PERFORMANCE LEVELS
DM1. Organization and coordination of emergency operations 1. Different organizations attend emergencies but lack resources and various operate only with voluntary personnel. 2. Specific legislation defines an institutional structure, roles for operational entities and coordination of emergency commissions throughout the territory. 3. Considerable coordination exists in some localities or districts of the city, between organizations in preparedness, communications, search and rescue, emergency networks, and management of temporary shelters. 4. Permanent coordination for response between operational organizations, public services, local authorities and civil society organizations in the majority of localities or districts 5. Organization models that involve structures of control, instances of resources coordination and management. Advanced levels of interinstitutional organization between public, private and community based bodies.
DM2. Emergency response planning and implementation of warning systems 1. Basic emergency and contingency plans exist with check-lists and information on available personnel. 2. Legal regulations exist that establish the obligatory nature of emergency plans. Articulation exists with technical information providers at the national level. 3. Protocols and operational procedures are well defined in the city. Various prognosis and warning centers operate continuously. 4. Emergency and contingency plans are complete and associated with information and warning systems in the majority of localities or districts. 5. Response preparedness based on probable scenarios in all localities or districts. Use of information technology to activate automatic response procedures.

ANNEX 2

DM3. Endowment of equipments, tools and infrastructure

1. Basic supply and inventory of resources only in the operational organizations and emergency commissions.
2. Centre with reserves and specialized equipment for emergencies at national level and in some localities or districts. Inventory of resources in other public and private organizations.
3. Emergency Operations Centre which is well stocked with communication equipment and adequate registry systems. Specialized equipment and reserve centers exist in various localities or districts.
4. EOCs are well equipped and systematized in the majority of localities or districts. Progressive complimentary stocking of operational organizations.
5. Interinstitutional support networks between reserve centers and EOCs are working permanently. Wide ranging communications, transport and supply facilities exist in case of emergency.

DM4. Simulation, updating and test of inter institutional response

1. Some internal and joint institutional simulations between operational organizations exist in the city.
2. Sporadic simulation exercises for emergency situations and institutional response exist with all operational organizations.
3. Desk and operational simulations with the additional participation of public service entities and local administrations in various localities or districts.
4. Coordination of simulations with community, private sector and media at the local level, and in some localities or districts.
5. Testing of emergency and contingency plans and updating of operational procedures based on frequent simulation exercises in the majority of localities.

ANNEX 2

DM5. Community preparedness and training

1. Informative meetings with community in order to illustrate emergency procedures during disasters.
2. Sporadic training courses with civil society organizations dealing with disaster related themes.
3. Community training activities are regularly programmed on emergency response in coordination with community development organizations and NGOs
4. Courses are run frequently with communities in the majority of districts or neighborhoods on preparedness, prevention and reduction of risk.
5. Permanent prevention and disaster response courses in all districts within the framework of a training program in community development and in coordination with other organizations and NGOs.

DM6. Rehabilitation and reconstruction planning

1. Design and implementation of rehabilitation and reconstruction plans only after important disasters.
2. Planning of some provisional recovery measures by public service institutions and those responsible for damage evaluation.
3. Diagnostic procedures, reestablishment and repairing of infrastructure and production projects for community recovery.
4. Ex ante undertaking of recovery plans and programs to support social recovery, sources of employment and productive means for communities.
5. Generalized development of detailed reconstruction plans dealing with physical damage and social recovery based on risk scenarios. Specific legislation exists and anticipated measures for reactivation.

ANNEX 2

GOVERNANCE AND FINANCIAL PROTECTION (FP)

INDICATOR AND PERFORMANCE LEVELS
FP1. Interinstitutional, multisectoral and decentralizing organization 1. Basic organizations in commissions, principally with an emergency response approach. 2. Interinstitutional and multisectoral organization for the integrated risk management. 3. Interinstitutional risk management systems active. Work in the design of public policies for vulnerability reduction. 4. Continuous and decentralized implementation of risk management projects associated with programs of environmental protection, energy, sanitation and poverty reduction. 5. Expert personnel with wide experience incorporating risk management in sustainable human development planning in major cities. High technology information systems available.
FP2. Reserve funds for institutional strengthening 1. A reserve fund does not exist for a city. City depends of national disaster or calamity funds. 2. City depends on economic support from national level. International resources management is made. Incipient risk management strengthens. 3. Some occasional funds to co-finance risk management projects in the city exist in an interinstitutional way. 4. A reserve fund in the city exists, regulated for project co financing institutional strengthens and recovering in case of disaster. 5. A reserve fund operates in the city. Financial engineering for the design of retention and risk transfer instruments.

ANNEX 2

FP3. Budget allocation and mobilization

1. Limited allocation of national budget to competent institutions for emergency response.
2. Legal norms establishing budgetary allocations to local level organizations with risk management objectives.
3. Legally specified specific allocations for risk management at the local level and the frequent undertaking of interadministrative agreements for the execution of prevention projects.
4. Progressive allocation of discretionary expenses at the national and municipal level for vulnerability reduction, the creation of incentives and rates of environmental protection and security.
5. Local orientation and support for loans requested by municipalities and sub national and local organizations from multilateral loan organizations.

FP4. Implementation of social safety nets and funds response

1. Sporadic subsidies to communities affected by disasters or in critical risk situations.
2. Permanent social investment funds created to support vulnerable communities focusing on the poorest socio-economic groups.
3. Social networks for the self-protection of means of subsistence of communities at risk and undertaking of post disaster rehabilitation and reconstruction production projects.
4. Regular micro-credit programs and gender oriented activities oriented to the reduction of human vulnerability.
5. Generalized development of social protection and poverty reduction programs integrated with prevention and mitigation activities throughout the territory.

ANNEX 2

FP5. Insurance coverage and loss transfer strategies of public assets

1. Very few public buildings are insured.
2. Obligatory insurance of public goods. Deficient insurance of infrastructure
3. Progressive insurance of public goods and infrastructure.
4. Design of programs for the collective insurance of buildings and publically rented infrastructure.
5. Analysis and generalized implementation of retention and transfer strategies for losses to public goods, considering reinsurance groups, risk titles, bonds, etc.

FP6. Housing and private sector insurance and reinsurance coverage

1. Low percentage of private goods insured. Incipient, economically weak and little regulated insurance industry.
2. Regulation of insurance industry controls over solvency and legislation for insurance of house loan and housing sector.
3. Development of some careful insurance studies based on advanced probabilistic estimates of risk, using microzoning, auditing and optimal building inspection.
4. Design of collective housing insurance programs and for small businesses by the city and insurance companies with automatic coverage for the poorest.
5. Strong support for joint programs between government and insurance companies in order to generate economic incentives for risk reduction and mass insurance.

ANNEX 3: EXAMPLE SURVEY FOR DRI SELF-ASSESSMENT DEVELOPED FOR MUMBAI

Please fill out the following short questionnaire and submit. This information will help course facilitators to understand the skills and capacities of participants and to set up the course discussions and interactions.

Your name and institution:

Please summarize your role in the DRMMP (e.g., focus group):

Please summarize your main responsibilities and key functions in your institution:

Did you review the UDRI and DRRRI Handbook/Reports?

Please mark the sector you are involved in (you can mark more than one if applicable

- ☐ Policy/Governance/Inter-institutional finance
- ☐ Research & Development/ Knowledge Management
- ☐ Human Resources
- ☐ IT/GIS
- ☐ Emergency Management
- ☐ Public Safety, Security and Defense
- ☐ Land-use Management
- ☐ Building Safety
- ☐ Environmental and Natural Resource Management
- ☐ Utility/Public Service Provider
- ☐ Communication and Awareness Raising
- ☐ Training and Capacity Building
- ☐ Other (Please Specify):

ANNEX 3

Please read description of DRI indicators, review the guiding questions and the performance target levels for each indicator before completing the questionnaire.

LEGAL AND INSTITUTIONAL PROCESSES

INDICATOR 1: EFFECTIVENESS OF LEGISLATIVE FRAMEWORK

GUIDE QUESTIONS

- Has legislation been passed or amended (with necessary compliance and accountability process) that provides responsibilities and authorities of local government, including MCGM for disaster risk management?
- Does the legislation and resulting regulation require local authorities (i.e., MCGM to prepare DRM plans and/or take action to reduce disaster risk?
- Is state legislation at par with national legislation in terms of mandate and authority of local government?
- Does the legislation require institutional bodies and local authorities to undertake evaluations including independent reviews?
- Are there specific provisions in the law to specify funding mechanisms for DRM/ DRR?
- Are there specific provisions in the law to define planning instruments for implementing DRR at the local level?
- Are there specific provisions in the law that requires broad consultation and representation of stakeholders including representatives of civil society and communities?
- Have MCGM and other key institutions enacted explicit policies that are pro-actively engaged towards mitigation?
- Do the policies (if they exist) provide mechanisms for implementation including funding mechanisms?
- Are there specific policy/ instructions/guidelines for incorporating disaster risk management in developmental planning, and in particular in land use planning and construction bylaws?

Evidence for Discussion: (Refer to LIA Framework) Existence of clauses addressing risk mitigation, discrepancies and problems in legal structure, contradictory articles in laws and by laws, deficiency in enforcement of laws.

GROUP

ROUND

LEVEL OF ATTAINMENT

LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4	LEVEL 5
☐	☐	☐	☐	☐
LOW	VERY LOW	NEUTRAL	HIGH	VERY HIGH

EXPLANATION

ANNEX 3

PERFORMANCE TARGET LEVELS

LEVEL 1	Overall there is little or no understanding of the relevance and importance of disaster risk reduction and this is reflected in its laws, policy, practice and public statements
LEVEL 2	Relevant legislation exists at state or national level, but these are not paired with the mandates and authority of local government. There is awareness of this gap by some individuals, and such knowledge may translate into initiating legislation to empower institutional bodies and local authorities for DRM.
LEVEL 3	The need for legislation and policies to be linked in a coordinated approach for reducing disaster risks is generally recognized. Such knowledge may translate into action, and some relevant legislation is passed, but compliance and accountability remains ineffective with insufficient application within policy and practice.
LEVEL 4	The institution has a legislative framework for disaster management with voluntary compliance encouraged and successful. Policy and practice already reflecting pending legislation
LEVEL 5	The institution has laws and policies on disaster risk reduction with realistic, achievable goals for mainstreaming. This is understood and accepted across the organization. Compliance and accountability measures are effective and operational with policy and practice strictly following law.

ANNEX 3

Please read description of DRI indicators, review the guiding questions and the performance target levels for each indicator before completing the questionnaire.

LEGAL AND INSTITUTIONAL PROCESSES

INDICATOR 2: EFFECTIVENESS OF INSTITUTIONAL ARRANGEMENTS

GROUP

ROUND

GUIDE QUESTIONS

- Do clearly defined and appropriate institutional arrangements, roles, duties and responsibilities for disaster reduction exist?
- To what extent can the MCGM and affiliated organizations act decisively with clearly defined roles and responsibilities in pre- during or post-disaster situations?
- Are there inter-institutional mechanisms in place that define roles and responsibilities of various institutions as well as funding mechanisms for DRR?
- Do partnerships exist that link institutions with civil society and communities?
- Are there review mechanisms in place and have the institutional arrangements for DRR been successful in implementing changes?

Evidence for Discussion: (Policy documents, project reports, interviews with key actors at district and municipal level, analysis of practice, observations of results in the field, interviews with key actors (asking to what degree do you believe the strategic plans are being successfully implemented?)

LEVEL OF ATTAINMENT

LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4	LEVEL 5
☐	☐	☐	☐	☐
LOW	VERY LOW	NEUTRAL	HIGH	VERY HIGH

EXPLANATION

ANNEX 3

PERFORMANCE TARGET LEVELS

LEVEL 1	Non-functioning institutional arrangements with sporadic engagement of relevant institutions on DRR initiatives. Turbulent or disjointed relations between various institutions dealing with disaster issues. There is no viable strategy for DRR, institutions reactive in disaster planning, little political will or understanding of responsibility and issues to change current policies and practice.
LEVEL 2	Generally helpful relations within institutions on DRR initiatives, with limited evidence of cooperation on policy, practice and capacity improvements as a result of inclusion in some disaster reduction activities. Recognition that greater inter-institutional coordination for DRR is emerging. Inability for institutions to grasp the fundamental problems of risks and adopt pro-active management principles.
LEVEL 3	Generally functional institutional arrangements for relevant institutions to deal with disaster issues, with some evidence of practice and capacity improvements as a result of inclusion in many disaster reduction initiatives. Key figures supportive of DRR and an institutional strategy for inter-institutional coordination in planning phase. Institutions moving towards proactive disaster planning.
LEVEL 4	Evidence for mostly functional institutional arrangements exists for relevant institutions to deal with disaster issues, with some evidence of maturing practice and capacity improvements. Institutional strategy for DRR exists with successful implementation in some areas. However, adoption is disjointed in others because of lack of ownership, capacity or political will.
LEVEL 5	Functional and operational institutional arrangements with clearly defined roles and responsibilities regarding preparedness, mitigation, response and recovery issues of disaster management. Strategic plans clearly address risk reduction, and practice strictly adheres to the policy statements. A lead agency has driven a process of DRR and for achieving DRMMP targets, which has been adopted by all key institutions. Clear evidence of this is identifiable in policy, practice and institutional mentality.

ANNEX 3

Please read description of DRI indicators, review the guiding questions and the performance target levels for each indicator before completing the questionnaire.

AWARENESS AND CAPACITY BUILDING

INDICATOR 3: TRAINING AND CAPACITY BUILDING

GUIDE QUESTIONS

- Have the areas for which training is needed been determined (e.g., emergency response; risk sensitive land use planning, etc.)? Have the most appropriate training methodologies and techniques been identified?
- Which training programs have been taken by officers and personnel and what is the perceived level of knowledge in those areas?
- To what extent have training programs been adapted/implemented for the Wards and for other supporting MCGM Agencies (ESFs)?
- What are the relative importance/priorities placed on training programs?
- To what extent do relevant institutions have a strategy in place for implementing training programs that are coordinated and systematic (e.g., a formal recognition for trainees in terms of their professional situation or adoption of a Certificate Program)?
- Are resources and infrastructure in place to facilitate consistent training and capacity building programs between different entities with responsibilities for disaster risk management?

Evidence for Discussion: "Training Needs Assessment Survey"; Interviews of key officials; DRMMP recommendations for training; other institutional initiatives for training

GROUP

ROUND

LEVEL OF ATTAINMENT

LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4	LEVEL 5
☐	☐	☐	☐	☐
LOW	VERY LOW	NEUTRAL	HIGH	VERY HIGH

EXPLANATION

ANNEX 3

PERFORMANCE TARGET LEVELS

LEVEL 1	There is little or no capacity (skills, knowledge, and competency) to understand disaster risk issues and to put in place mainstreaming approaches for disaster risk reduction; and little or no recognition of the need to increase/develop its financial and human resources for this purpose. Sporadic training programs are offered but not well attended.
LEVEL 2	The organization recognizes that it must develop appropriate capacity including sufficient (human and financial) resources to support the process of mainstreaming risk reduction. The importance of disaster reduction training and capacity building is recognized and sporadic training programs are offered, but there is still a lack of institutional training vision
LEVEL 3	The organization has made plans to allocate sufficient (human and financial) resources to develop supportive institutional capacities for mainstreaming disaster risk reduction. Risk reduction training and capacity building programs are under development and some are offered in various sectors.
LEVEL 4	Institutional capacity for risk reduction is being strengthened in all sectors. A menu of training programs has been developed based on training needs surveys, and state-of-the-art international standards. A strategy to offer training and capacity building programs in a systematic and coordinated manner is in place.
LEVEL 5	Institutional capacity is sufficient to support all the processes outlined in the DRMMP. There is evidence of strong competency in different sectors/departments and there is access to extensive menu of training and capacity building programs based on international state-of-the-art standards to support the process of mainstreaming risk reduction. Tools are routinely and independently and comprehensively used to assess progress.

ANNEX 3

Please read description of DRI indicators, review the guiding questions and the performance target levels for each indicator before completing the questionnaire.

AWARENESS AND CAPACITY BUILDING

INDICATOR 4: ADVOCACY, COMMUNICATION, EDUCATION AND PUBLIC AWARENESS

GUIDE QUESTIONS

- How well publicized and how successful are MCGM's efforts to inform policy makers, relevant institutions, media, civil society, communities, and the general public of mitigation efforts, disaster threats and rally support for the implementation of DRMMP and its provisions?
- Are there mechanisms for engaging stakeholders such as media, civil society, community and the general as well as channels for collecting inputs and feedback from these stakeholders?
- Is there a consistent, coherent, centralized public awareness program and strategy that will communicate to the general public the importance of risk reduction and the threats facing Mumbai?
- To what extent have the recommendations of the DRMMP been communicated in formats that are accessible to many different groups?
- How many stakeholders, focus groups and volunteer organizations are involved into the DRMMP implementation outputs and how to what extent have they participated?
- Are there existing mechanisms for co-operation and exchange with Indian and international research institutions and to what extent are they being implemented?

Evidence for Discussion: Relations with the media, civil society, communities, and academe. Participations by MCGM in national and international conferences, forum, workshops, etc.

GROUP

ROUND

LEVEL OF ATTAINMENT

LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4	LEVEL 5
☐	☐	☐	☐	☐
LOW	VERY LOW	NEUTRAL	HIGH	VERY HIGH

EXPLANATION

ANNEX 3

PERFORMANCE TARGET LEVELS

LEVEL 1	Overall there is no institutional capacity to manage knowledge and facilitate research activities. There is no understanding of the importance in raising public awareness of disaster risks, and consequently there are no efforts undertaken in public education and communication. Few organizations or people are involved in disaster risk management or understand its significance to their activities.
LEVEL 2	Particular departments or sections may have protocols for knowledge management or are involved in research activities, but overall there is limited institutional competency or capacity. Efforts in public education and communication are sporadic and involvement in disaster risk management is based on individual efforts rather than as part of institutional policy.
LEVEL 3	There is a structured advocacy program and the value of risk communication is understood and supported institutionally. The institution is generally aware of the importance of knowledge management and facilitating research activities. It has made some investment to develop information and communication technology and protocols, and is developing some internal competency for use of communication tools. However, this process is still under development and not matured.
LEVEL 4	The institution has a policy that recognizes the importance of risk communication and public education and has an effective advocacy and strategic communication system involving a broad range of stakeholders. The process of facilitating research activities is advancing within the institution and the competency is adequate. It has invested in knowledge management and information and communication technology. Protocols and standards to communicate information internally and to the wider public and media have been setup. The mainstreaming process may not be institutionalized yet, but particular stakeholders are active and participate in the decision-making process. The need of risk reduction is becoming a reality among a growing population in the city and reflected in policies and political process.
LEVEL 5	Advocacy campaigns reach deeply into institutions and among the population including those most at risk. Risk communication and public education are an integral part of the institution's activities. Its leadership facilitates research activities and organizes events to address public concerns and educate. The technical professionals are well-advanced in their knowledge of information technology and are involved professionally to understand the state-of-the-practice and institutionalize it. Many people and organizations are involved in disaster risk management of the city and actively participate into the decision-making process, some through public-private partnerships and through community based initiatives. A paradigm shift has occurred and a culture of safety is being established and there is a strong awareness for the need of risk reduction among the public.

ANNEX 3

Please read description of DRI indicators, review the guiding questions and the performance target levels for each indicator before completing the questionnaire.

CRITICAL SERVICES AND INFRASTRUCTURE RESILIENCY

INDICATOR 5: RESILIENCY OF CRITICAL SERVICES

GUIDE QUESTIONS

- To what extent have allocations and plans been made for post-disaster shelter and healthcare services?
- How resilient is the healthcare and health service infrastructure to impacts of a disaster in Mumbai?
- To what extent are broad-based and long-term reconstruction and shelter strategies working in consolidating security, promoting recovery, protecting and promoting livelihoods and building local capacities?
- To what extent do current slum rehabilitation programs provide for livelihood means and promote sustainability?
- To what extent are communication bridges being built with the general public, including civil society, urban poor communities, and slum dwellers in terms of outreach programs?
- Are there mechanisms for discussion, conflict resolution, and problem solving that engage all relevant stakeholders of slum rehabilitation programs?
- To what extent are appropriate legal frameworks (within human rights framework) promoted to provide for more resilient and sustainable living conditions?
- To what extent are civil society and communities actively participating in building the city's resiliency?

Evidence for Discussion: Lack of secure tenure, slum upgrading, resettlement and in-situ rehabilitation of slum dwellers, "Transformation of Mumbai into World Class City Project"

GROUP

ROUND

LEVEL OF ATTAINMENT

LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4	LEVEL 5
☐	☐	☐	☐	☐
LOW	VERY LOW	NEUTRAL	HIGH	VERY HIGH

EXPLANATION

ANNEX 3

PERFORMANCE TARGET LEVELS

LEVEL 1	Overall there are little or no institutional programs and policies foreseen for managing post-disaster mass-care needs, planning ahead for the recovery process and building resilience in the critical service providing facilities such as healthcare centers and shelters. Few legislation exist in establishing the priority for dealing with slums and deteriorated urban areas for improvement, including social and economic interest in housing development.
LEVEL 2	Some protocols and plans have been adopted for provision of mass-care needs and ensuring resiliency of shelter and healthcare system, but these plans are not coordinated with different actors and stakeholders. Efforts in upgrading and rehabilitating slum areas, existing housing and relocation from risk areas do not protect livelihoods, build local capacities and incorporate risk resiliency.
LEVEL 3	The institution is generally aware of the importance of planning ahead for mass-care provisions, recovery and reconstruction processes and it has developed operational plans and made some investment to increase resiliency of critical services. This process is ongoing and has not yet matured. Efforts in upgrading and rehabilitating slums areas, existing housing and relocation from risk areas recognize the importance of protection of livelihoods and incorporation of risk resiliency, but are ultimately driven by other processes.
LEVEL 4	The institution has operational plans and coordination mechanisms for providing emergency mass-care, health and housing services based on an assessment of impact. It has invested in upgrading some of its critical services and in the process of developing greater resiliency. Strategic plans exist for the protection of livelihoods, ensuring of stability in economic activity and employment levels, and for adequately treating non-built areas. Progressive intervention mechanisms for at-risk human settlements and slums are actively pursued by some stakeholders for some of the city wards.
LEVEL 5	Operational plans and coordination mechanisms for providing emergency mass care are developed based on detailed analysis of impacts to housing and health systems. Investments have also been allocated based on assessment of impacts to upgrade the infrastructure and incorporate more resiliency in the provision of services. Broad-based strategies are in place, which enable sustainability and protection of livelihoods in rehabilitation programs for slum dwellers and urban poor. Legislation has been adopted (and enforced) to ensure fewer people are engaged in unsafe livelihood activities, and small enterprises have business protection and continuity/ recovery plans

ANNEX 3

Please read description of DRI indicators, review the guiding questions and the performance target levels for each indicator before completing the questionnaire.

CRITICAL SERVICES AND INFRASTRUCTURE RESILIENCY

INDICATOR 5: INDICATOR 6: RESILIENCY OF INFRASTRUCTURE

GUIDE QUESTIONS

- To what extent is MCGM aware of the vulnerability and risks associated with major hazards such as floods and earthquakes to infrastructure systems assessed in the DRMMP (i.e., water, sewer, and storm drain systems and transportation systems)?
- To what extent is MCGM implementing mitigation alternatives to enhance resilience of infrastructure systems?
- To what extent can the population of Mumbai cope with the socio-economic impacts of loss of the water, sewer, and/or storm drain systems?
- To what extent can the population of Mumbai cope with the socio-economic impacts of disruption to transportation systems?
- How resilient are the system's operational capabilities (collection/supply, treatment, transmission, distribution/disposal and other related operational aspects) in Mumbai?
- How prepared is MCGM to restore serviceability of infrastructure systems after an event in terms of manning emergency operations centers, performing damage inspection activities, coordinating damage reports, prioritizing emergency operations and repairs, dispatching crews including mutual aid and assistance, obtaining and coordinating use of materials and equipment?

Evidence for Discussion: DRMMP Impact Assessment of Water, Storm Water and Sewer Systems; DRMMP Impact Assessment of Transportation System. In addition, risk studies on infrastructure systems with quantifiable results, system vulnerabilities in relation to hazards (including ground failures), number of hazard mitigation projects (planned, designed and constructed), existence of mutual aid and assistance agreements, stockpile of repair materials, early warning systems in operation, mapping of vulnerable areas, public meetings to discuss vulnerabilities and mitigation solutions, funding and schedules for mitigation projects.

GROUP

ROUND

LEVEL OF ATTAINMENT

LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4	LEVEL 5
☐	☐	☐	☐	☐
LOW	VERY LOW	NEUTRAL	HIGH	VERY HIGH

EXPLANATION

ANNEX 3

PERFORMANCE TARGET LEVELS

LEVEL 1	There are no studies of impacts to infrastructure systems, or if there are, the City is not aware of these studies and is not able to understand their significance for disaster risk management. Consequently, there is no investment in increasing resiliency of infrastructure systems. The infrastructure would suffer extensive losses and massive disruptions would occur before services are restored.
LEVEL 2	Particular departments may have particular individuals or sections that have detailed information about different infrastructure systems. However, there is no institutional knowledge of the resiliency of infrastructure systems in terms of extent of service disruptions and time to recover of these systems after a disaster event. Consequently, there may be some localized positive impact but no process for sustainability or institutional investment. In general, much of the magnitude of infrastructure losses and duration of recovery cannot be dealt with in an adequate way.
LEVEL 3	The institution has carried out some studies of impact to its infrastructure and made some investment to update and strengthen some of its most vulnerable networks. There is also some internal competency to understand the operational capabilities and system resources to restore infrastructure after an event. However, this process is not driven by institutional guidelines, but mostly by awareness and a sense of good practice. While socio-economic disruptions as a result of infrastructure losses will be extensive, some of the most critical failures may be avoided due to planning and strengthening of vulnerable infrastructure.
LEVEL 4	The institution has a policy that recognizes the relevance and importance to assess how resilient its infrastructure systems are in a disaster. It invests in upgrading and strengthening its infrastructure against the most immediate threats. The mainstreaming process may not be institutionalized, but responsible departments have the competency to analyze vulnerabilities in their networks and mitigate against them as part of their day-to-day functions. In most Wards, infrastructure can be restored at an adequate rate and the magnitude of losses is reduced significantly due to timely intervention, sufficient operational capacities and ample system resources.
LEVEL 5	Detailed studies have been carried out to assess the magnitude of infrastructure losses and recovery times for multiple hazards. The level of investment in increasing resiliency of infrastructure is adequate relative to the available resources. Infrastructure is maintained and inspected regularly and strengthened based on impact studies. Infrastructure services can be restored to pre-disaster levels at suitable quantities and durations to minimize impacts to society and businesses.

ANNEX 3

Please read description of DRI indicators, review the guiding questions and the performance target levels for each indicator before completing the questionnaire.

EMERGENCY MANAGEMENT AND RESPONSE PLANNING

INDICATOR 7: EMERGENCY MANAGEMENT

GUIDE QUESTIONS

- Has a city-wide emergency operation plan been established?
- Does the plan include SOP's and mechanisms for inter-institutional coordination such as ESF's?
- Have drills and response simulations exercises been held to test and improve response capacities?
- Is there an institutional planning mechanism for updating and improving emergency operations plans and SOP's?
- Has emergency management staff been trained on how to use tools appropriately and perform their duties?
- Have planning assumptions been established based on risk assessment studies?
- Have Standard Operating Procedures been completed and tested?
- Are stakeholders, including community representatives involved in the drills?
- Are there specific plans towards most vulnerable populations and at risk groups?

Evidence for Discussion: ESF Framework

GROUP

ROUND

LEVEL OF ATTAINMENT

EXPLANATION

ANNEX 3

PERFORMANCE TARGET LEVELS

LEVEL 1	Overall there is no legal regulation to establish the obligatory nature of emergency plans. Articulation exists with technical information providers at the national level only. Few simulation exercises for emergency situations are carried out. Operational organizations have developed few mechanisms for institutional response without any coordination.
LEVEL 2	Some institutions have organizational plans for emergency management and undertake sporadic simulation exercises for emergency situations. Operational organizations have developed and coordinated some mechanisms for institutional response.
LEVEL 3	Emergency management protocols and operational procedures are well defined in the city. Coordination mechanisms are put in place but not necessarily well practiced for major disasters. Desk and operational simulation exercises with the additional participation of public service entities and local administrations is taking place in various wards.
LEVEL 4	Emergency operations plans and coordination mechanisms are well practiced and understood. Planning mechanisms enable stakeholders' participation; roles are understood; contingency plans are complete and associated with information and warning systems in majority of MCGM wards. Coordination of simulations with civil society, community, private sector and media at the local level and in some wards.
LEVEL 5	Emergency operations plan is compliant with international standards including competent staff and extended resources. Response preparedness is based on probable scenarios in all wards, and emergency management is integrated throughout all MCGM Departments and other organizations that provide critical services for Mumbai. Use of information and communication technology (ICT) to activate automatic response procedures. Testing of emergency contingency plans and updating of operational procedures based on frequent simulation exercises in the majority of wards.

ANNEX 3

Please read description of DRI indicators, review the guiding questions and the performance target levels for each indicator before completing the questionnaire.

EMERGENCY MANAGEMENT AND RESPONSE PLANNING

INDICATOR 8: RESOURCE MANAGEMENT, LOGISTICS AND CONTINGENCY PLANNING

GROUP

ROUND

GUIDE QUESTIONS

- Is there a self-analysis and reporting process to assess available resources for emergencies and procedures for mobilizing these resources?
- Are the resources identifiable and verifiable?
- Are logistical plans available on how resources are mobilized, activated, deployed and de-activated depending on the type and level of disaster?
- What is the extent of resources and budget allocations for emergency response activities (including the preparation for emergency response) at all levels?
- Are funding mechanisms and plans available for acquiring key resources that maybe missing, including equipment for fire fighting, search and rescue, and for distribution of food, medicines, water and other essentials?,
- To what extent does the Municipality have the logistical support and resource management capacity to achieve the response necessary on the scale of the risk and loss analysis performed for Mumbai?
- Are there contingency plans in place in key institutions that indicates alternate processes and resources for restoring services and continuing critical operations?

Evidence for Discussion: Available manpower and machinery for emergency response, budget processes, executive processes, mutual aid agreements, memoranda of understanding, contractual service agreements, business partnerships and contingency plans.

LEVEL OF ATTAINMENT

LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4	LEVEL 5
☐	☐	☐	☐	☐
LOW	VERY LOW	NEUTRAL	HIGH	VERY HIGH

EXPLANATION

PERFORMANCE TARGET LEVELS

LEVEL 1	Little or no legislation exists to define roles for operational entities and coordination of emergency commissions throughout the city. Little understanding of available resources and mobilization process. Reliance on ad-hoc initiatives and top down decision making during an event, instead of pro-active planning.
LEVEL 2	Specific legislation defines roles for operational entities and coordination of emergency commissions throughout the city. Some inventories of resources exist, but the mobilization process is not understood. A few critical institutions have contingency plans.
LEVEL 3	The emergency management policies and procedures are in place to require mobilization of resources in the case of disaster. There is a good inventory and understanding of resources and their use and mobilization in preparedness, communications, search and rescue, emergency networks and management of temporary shelters. There is a process for decision making that is understood and contingency plans among critical institutions.
LEVEL 4	There is a comprehensive understanding of the existing resources including among the private sector and within communities, as well as an understanding of the missing resources. A plan to mobilize the resources and to allocate them exists and is typically understood. Contingency plans exist among many organizations. Decision making for resource allocation is decentralized to the local levels (wards, community, etc.).
LEVEL 5	There is a comprehensive understanding of the existing resources among MCGM departments, the private sector and within communities, as well as an understanding of the missing resources, and mutual assistance agreements in place to acquire them. A plan to mobilize the resources and to allocate them exists and is typically understood. Contingency plans exist among many organizations. Advanced levels of inter-institutional organization between public, private and community based bodies have been tested and created.

ANNEX 3

Please read description of DRI indicators, review the guiding questions and the performance target levels for each indicator before completing the questionnaire.

DEVELOPMENT PLANNING, REGULATION AND RISK MITIGATION

INDICATOR 9: HAZARD, VULNERABILITY AND RISK ASSESSMENT

GUIDE QUESTIONS

- To which extent are policy makers, managers, stakeholders and the general public aware of the hazards, vulnerabilities and related risks, including risks for low probability high impact hazards such as earthquakes.
- What is the level of hazard at which hazards (natural and man-made) have been identified evaluated and monitored in Mumbai? For single hazards (floods, earthquakes)? For multiple hazards and cascading effects (e.g., fire following earthquakes); for biological hazards?
- To what extent has the vulnerabilities in the built environment (buildings, infrastructure, lifelines) been assessed? To what extent have the fragilities and susceptibilities in the non-physical system (e.g., populations, ecosystems, etc.) been assessed and mapped?
- To what extent scenarios have been undertaken to understand the impacts of these hazards and to evaluate the coping capacities in Mumbai for developing response plans and contingency plans?
- To what extent have results of hazard loss assessments and people's vulnerability been used to guide policy decisions within the relevant organizations?

Evidence for Discussion: General awareness about hazards, vulnerability and risks: relations with academic community, dissemination and use of earthquake and flood risk studies; awareness about other hazards, including man-made or biological.

GROUP

ROUND

LEVEL OF ATTAINMENT

LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4	LEVEL 5
☐	☐	☐	☐	☐
LOW	VERY LOW	NEUTRAL	HIGH	VERY HIGH

EXPLANATION

ANNEX 3

PERFORMANCE TARGET LEVELS

LEVEL 1	Overall there is no institutional understanding or competency for hazard, vulnerability or risk assessment. The City is typically not aware of studies that may have been undertaken by experts or specialized organizations and is not able to understand their significance for risk management. Consequently, there is no investment in risk assessment.
LEVEL 2	Particular departments may have particular individuals or sections that have information about hazards, vulnerability or risks. However, this is more individual knowledge than institutional capacity. Such knowledge may translate into action but on the basis of individual or localized initiative (i.e., initiative coming from a particular specialized unit of the institution) and not as part of institutional policy or competency. Consequently, there is some localized positive impact but no process for sustainability or institutional investment.
LEVEL 3	The institution is generally aware of the importance of hazard, vulnerability and risk assessments. It has made some investment to assess the most frequent hazards and develop some internal competency to understand the elements of hazard, vulnerability and risk and sometimes makes use of these into its planning and decision-making process. However, this process is not driven by an institutional policy, but mostly by awareness and a sense of good practice.
LEVEL 4	The institution has a policy that recognizes the relevance and importance to assess hazards, vulnerability and risks. Its leadership is fully aware of the relevance of the science and technologies related to hazard, vulnerability and risk assessments. It invests in assessing these elements and has internal competency to understand outputs and translate them into practice. The mainstreaming process may not be institutionalized, but particular departments are using risk assessments outputs as part of their functions, mainly for disaster risk management and developmental planning (e.g., risk sensitive land use planning or microzonation)
LEVEL 5	Hazards, vulnerability and risk assessments are an integral part of the day-to-day functions and decision-making process of the institution. The process of mainstreaming is fairly advanced within the institution and the competency is adequate. The technical professionals are well-advanced in their knowledge and are involved professionally to understand the state-of-the-practice and institutionalize it. The level of investment is adequate relative to the available resources.

ANNEX 3

Please read description of DRI indicators, review the guiding questions and the performance target levels for each indicator before completing the questionnaire.

DEVELOPMENT PLANNING, REGULATION AND RISK MITIGATION

INDICATOR 10: RISK-SENSITIVE URBAN (AND RURAL) DEVELOPMENT AND MITIGATION

GUIDE QUESTIONS

- To which extent is MCGM and other planning and development agencies practicing risk-sensitive urban planning and urban (re)development?
- To which extent do construction by-laws have quality control processes such as code implementation and enforcement, including site inspections?
- To which extent are development by-laws and development control regulation mandating incorporation of disaster risk reduction; this should include slum redevelopment and rehabilitation plans
- To which extend is hazard and risk information used in anticipating, pre-empting and mitigating problems that would arise in an earthquake or a flood?
- What is the degree of implementation of the various risk reduction strategies and action plans set forth in the DRMMP:
    - Flood control
    - Seismic strengthening of buildings and infrastructure
    - Protection of most exposed facilities and populations from natural and man-made hazards
    - Urban renovation/redevelopment and enhancing total qualify of life in urban environment
    - Environmental protection? Hazardous material control and regulation?
    - Protecting historical and cultural values

Evidence for Discussion: Risk sensitive land use planning; Construction controls; building by-laws; risk reduction investments; Microzonation studies, vulnerability reports, policy documents, building assessment and retrofit works for infrastructure and lifelines, urban renovation projects, etc.

GROUP

ROUND

LEVEL OF ATTAINMENT

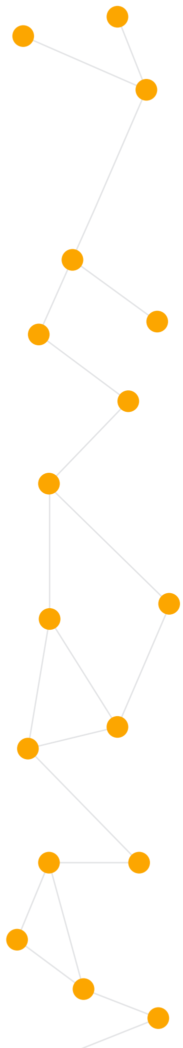
LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4	LEVEL 5
☐	☐	☐	☐	☐
LOW	VERY LOW	NEUTRAL	HIGH	VERY HIGH

EXPLANATION

ANNEX 3

PERFORMANCE TARGET LEVELS

LEVEL 1	There is little or no recognition for practicing risk-sensitive urban planning and urban (re) development as risk reduction tools. Development Plan and succeeding urban plans do not reflect risk considerations in zoning and in development controls. Overall there is no institutional policy or guidelines to prioritize any structural or non-structural mitigation of its public building and infrastructure. While safety and construction norms exist, these have generally not been updated and are not adequate. Consequently, there is very little investment in risk mitigation.
LEVEL 2	There is a growing recognition of risk-driven land-use planning and microzonation studies, but they are not systematically used in formulation of risk sensitive urban planning or site planning. There is no clear focus on most exposed population and infrastructure in terms of risk reduction. The importance of updating safety and construction norms for buildings with special requirements is recognized and new codes are developed for these structures. Particular departments are aware of the need to progressively retrofit critical facilities, infrastructure and lifelines; however, this is generally not based on institutional policy or hazard and risk information. There is little investment in risk mitigation.
LEVEL 3	Risk reduction is reflected in land use policies, strategies and in implementing tools (DCRs), as well as, land use related programs, projects, and activities. The land use zones & development control regulations are risk sensitive and have been adopted in some of the most disaster-prone Wards of the city, but not systematically used nor consistently enforced in succeeding planning and project implementation. Construction norms have also been adjusted according to the risk and hazard evaluations, however, quality control processes such as code implementation and enforcement, including site inspections are not in place or effective. The City is making some investments in assessing critical facilities and infrastructure and key public structures are planned to be retrofitted.
LEVEL 4	Land use zones and development controls from any participatory hazard are systematically considered as factors in urban development planning and project implementation. The institution has a policy for retrofitting of critical facilities and lifelines and to reduce the vulnerability of the most exposed populations. Some requirements of construction codes and specifications have been adopted according to local criteria and priorities. There is strict quality control of construction including peer reviews and site inspections. In some case, retrofit and rehabilitation programs are carried out as sporadic adjustments, but in most cases detailed hazard and risk studies are used in anticipating and mitigating problems that would arise in the event of a disaster. The City has invested large sums in retrofitting its most vulnerable infrastructure, including most public schools & hospitals.
LEVEL 5	Risk mitigation is mainstreamed in the day-to-day functions, city development and decision-making process of the institution. There is overall recognition to include risk as a major factor in decision making and implementation of urban renovation/redevelopment plans and in construction project development and management. Codes and security norms have been permanently updated and local regulation for construction have been established based on microzonation studies. Construction controls are put in place and systematically enforced. Progressive control processes such as code implementation and enforcement, including site inspections are in place. Systematic retrofitting of principal public and private buildings has taken place. Significant resources and programs are put in place to reduce the vulnerability of populations which are most at risk.



A GUIDE TO MEASURING URBAN RISK RESILIENCE

Principles, Tools and Practice of Urban Indicators