REDUCING DISASTER RISK BY MANAGING URBAN LAND USE

Guidance Notes for Planners

ASIAN DEVELOPMENT BANK

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FIGURES

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2005

A large coastal urban agglomeration was washed away by devastating floods caused by a combination of factors—excessive rainfall on a single day, high tides, unregulated construction on floodplains, and poorly maintained old drainage infrastructure.

2007

A devastating flood inundated this capital city, largely a result of an increase in exposure due to the large number of settlements located in low-lying areas, clogged canal networks, lack of maintenance of floodgates and related infrastructure, and the high rate of extraction of groundwater which is causing the city to sink.

A moderate rainfall event caused significant flooding in this port city. The flooding was clearly exacerbated by rapid development and urbanization on the floodplain.

2009

Two consecutive tropical cyclones battered this metropolitan region affecting more than 9 million people. The factors contributing to the high impact included a lack of land use planning, a proliferation of informal settlements, a heavily polluted urban environment, inadequate stormwater capacity and lack of maintenance of the stormwater drainage system, and limited capacity for flood risk management.

2010

A built-up portion of this coastal capital city was washed away by extreme floods, caused by the prolonged degradation of its ecosystems, that reduce the natural drainage and water storing capacities. This was exacerbated by an inadequate waste management system that led to continuous blockages of waterways, and insufficient maintenance and outdated dike designs based on rainfall patterns observed in the 1980s.

2011

This metropolis suffered one of its worst floods, the effect of which was particularly severe because of the high exposure of investments situated in former floodplains, weak urban planning, degraded watersheds, and lack of maintenance of canals.

2015

A severe earthquake followed by hundreds of aftershocks resulted in the damage and destruction of close to 100,000 properties in this capital city. The damage was largely due to improper adherence to building codes, violation of building bylaws, construction on liquefaction-prone areas, and infilling of depressed land by private land developers during land readjustments.

Severe flooding brought this coastal urban metropolis to a standstill. The flooding was caused by the filling of water bodies to accommodate rapid urban growth, lack of and poor maintenance of the stormwater drainage system, and heavy encroachment of the riverbanks.

PHOTO: ADB

FOREWORD

Urban areas in Asian countries continue to face significant disaster risk. While this is partly due to the interplay of economic and physical geography which has resulted in many Asian cities being located in natural hazard-prone areas, such as coasts and riverbeds, it is the rapid unplanned growth of cities—the alterations in the land use pattern; the location and choice of infrastructure, businesses, and housing, which is further increasing the exposure and vulnerability of urban populations and their physical assets to natural hazards. With the changing intensity and, in some cases, frequency of hazards with climate change, it is expected that urban areas in Asia will continue to be impacted by extreme events.

However, this need not be the case. The current trend of growing disaster risk in Asian cities can be reduced, halted, and even reversed, by adopting urban land use management processes, which provide opportunities to better understand how natural hazards in and around urban areas interact with existing and future urban growth patterns and the types of investments that can be undertaken to promote development in a risk-sensitive manner. While many land use management processes—land use planning, development control instruments, greenfield development, and urban redevelopment—are well established in most Asian cities, there remain large gaps in implementation. With large investments in infrastructure and services expected over the next several decades in Asian cities and the potential that land use management processes bring in reducing and/or at least limiting disaster risk, practicing risk-sensitive land use management has become more important than ever.

Reducing disaster risk through urban land use management processes requires long-term systemic thinking. It requires inputs from various disciplines and across different stakeholders; and, above all, it requires a good understanding of the land's natural, socioeconomic, and political dimensions. Urban planners with their proficiency in land use management and understanding of complex political economy are a unique resource. While institutionalization of urban planning as a profession within the larger process of city management remains uneven in Asian countries, greater effort is needed to strengthen a city's overall planning capacity so that important functions related to risk-sensitive development can be fully discharged. In cases, where such capacity exists—either at the city or national level or within national planning agencies—the urban planners as a professional group needs to step up and embrace disaster risk reduction and utilize the land use management-related tools at their disposal to reduce disaster risk, and contribute to strengthening urban resilience and sustainable urban development.

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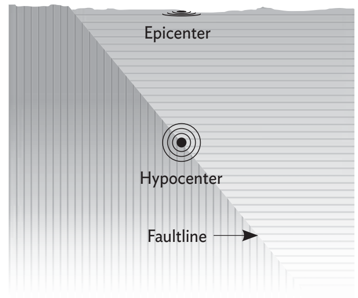
PHOTO: AUTHORS

GLOSSARY

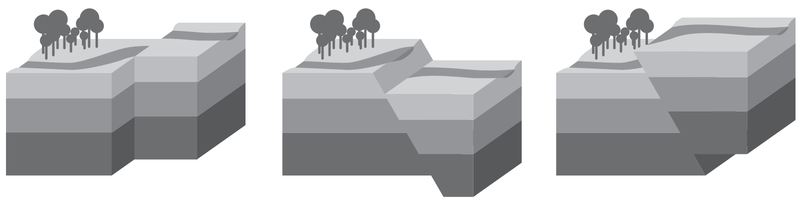
This glossary provides definitions of key disaster risk reduction-related terms used in this guidance note series that the urban planners would benefit from knowing.

Term	Definition
Climate change	A change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forces or due to persistent anthropogenic changes in the composition of the atmosphere or in land use (IPCC 2012).
Climatological hazard	A hazard caused by long-lived, meso- to macroscale atmospheric processes, ranging from intraseasonal to multidecadal climate variability (IRDR 2014).
Critical infrastructure	The primary physical structures, technical facilities, and systems that are socially, economically, or operationally essential to the functioning of a society or community, both in routine circumstances and in the extreme circumstances of an emergency (UNISDR 2009).
Disasters	A serious disruption of the functioning of a community or a society involving widespread human, material, economic, or environmental losses and impacts, which exceeds the ability of the affected community of society to cope using its own resources (UNISDR 2009).
Disaster risk	The potential disaster losses, in lives, health status, livelihoods, assets, and services, which could occur to a particular community or society over some specified future period of time (UNISDR 2009). *Extensive risk:* The widespread risk associated with the exposure of dispersed populations to repeated or persistent hazard conditions of low or moderate intensity, often of a highly localized nature, which can lead to debilitating cumulative disaster impacts (UNISDR 2009). *Intensive risk:* The risk associated with the exposure of large concentrations of people and economic activities to intense hazard events, which can lead to potentially catastrophic disaster impacts involving high mortality and asset loss (UNISDR 2009).
Disaster risk management	The systematic process of using administrative directives, organizations, and operational skills and capacities to implement strategies, policies, and improved coping capacities to lessen the adverse impacts of hazards and the possibility of disaster (UNISDR 2009).
Disaster risk reduction	The concept and practice of reducing disaster risks through systematic efforts to analyze and manage the causal factors of disasters, including through reduced exposure to hazards, lessened vulnerability of people and property, wise management of land and the environment, and improved preparedness for adverse events (UNISDR 2009).
Downscaling	Downscaling is a method that derives local-to-regional-scale (up to 100 kilometers) information from larger-scale climate models or data analyses (IPCC 2012).

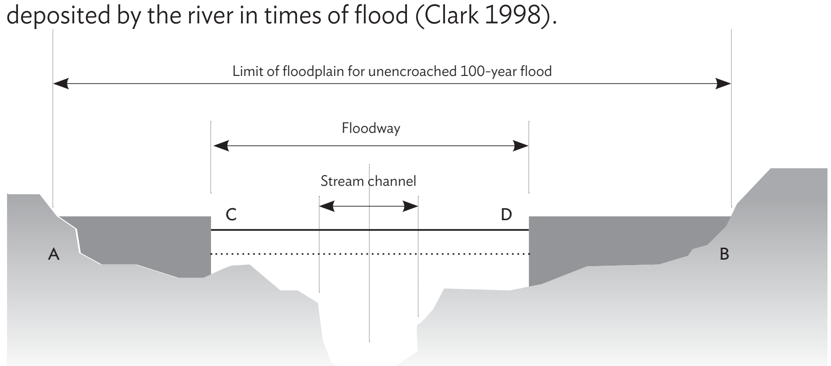
- **Epicenter** — The point on the earth's surface vertically above the hypocenter (or focus point) in the crust where a seismic rupture begins (USGS webpage).



- **Exposure** — People, property, systems, or other elements present in hazard zones that are thereby subject to potential losses (UNISDR 2009).
- **Fault** — A fracture along which the blocks of crust on either side have moved relative to one another parallel to the fracture (USGS webpage).



- **Floodplain** — The relatively level part of a valley bordering a river resulting from alluvium deposited by the river in times of flood (Clark 1998).



Source: Figure adapted from FEMA (2015).

- **Floodways** — The channel of a river or other watercourse and the adjacent land areas that must be reserved in order to discharge the base flood without cumulatively increasing the water surface elevation more than a designated height (FEMA webpage).
- **Geophysical hazard** — A hazard originating from solid earth (IRDR 2014).
- **Ground shaking** — The movement of the earth's surface from earthquakes or explosions. Ground motion is produced by waves that are generated by a sudden slip on a fault or sudden pressure at the explosive source and travel through the earth and along its surface (USGS webpage).
- **Hazard** — A dangerous phenomenon, substance, human activity, or condition that may cause loss of life, injury, or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage (UNISDR 2009).
  Note: The hazard categories in these guidance notes pertain to geophysical, hydrometeorological, meteorological, and climatological events.

■ Hazardscape	The exposure and vulnerability of a particular place, its people, and assets to the full range of hazards that it faces, including natural, environmental, health, and technological hazards. It links the dimensions of earthbound atmospheric, hydrologic, and geologic processes and human interventions with the spatial dimension of land use, the built environment, and ecosystems (ADB 2013).
■ Hydrological hazard	A hazard caused by the occurrence, movement, and distribution of surface and subsurface freshwater and saltwater (IRDR 2014).
■ Liquefaction	The transformation of (partially) water-saturated soil from a solid state to a liquid state caused by an earthquake. Liquefaction reduces the strength and stiffness of soil causing buildings to topple (IRDR 2014).  Source: USGS.
■ Meteorological hazard	A hazard caused by sho rt-lived, micro- to mesoscale extreme weather and atmospheric conditions that last from minutes to days (IRDR 2014).
■ Microzonation	Identification of separate individual areas having different potentials for hazardous earthquake effects (USGS webpage).
■ Return period	An estimate of the average time interval between occurrences of an event (e.g., flood or extreme rainfall) of (or below/above) a defined size or intensity (IPCC 2012).
■ Resilience	The ability of a system, community, or society exposed to hazards to resist, absorb, accommodate to, and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions (UNISDR 2009).
■ Risk	The combination of the probability of an event and its negative consequences (UNISDR 2009).
■ Risk assessment	A methodology to determine the nature and extent of risk by analyzing potential hazards and evaluating existing conditions of vulnerability that together could potentially harm exposed people, property, services, livelihoods, or the environment on which they depend (UNISDR 2009).
■ Risk management	The systematic approach and practice of managing uncertainty to minimize potential harm and loss (UNISDR 2009).
■ Risk model	The use of computer simulations to calculate the risk of disasters and resulting monetary loss based on asset values at risk, vulnerabilities, and a range of likely hazard occurrences (UNISDR 2009).)
■ Sea level change	Changes in sea level, globally or locally, due to (i) changes in the shape of the ocean basins, (ii) changes in the total mass and distribution of water and land ice, (iii) changes in water density, and (iv) changes in ocean circulation (IPCC 2012).
■ Seiche	Sloshing of a closed body of water from earthquake shaking (USGS webpage).
■ Slip	The relative displacement of formerly adjacent points on opposite sides of a fault, measured on the fault surface (USGS webpage).

- **Slip rate** — How fast the two sides of a fault are slipping relative to one another, as determined from geodetic measurements, from offset human-made structures, or from offset geologic features whose age can be estimated. It is measured parallel to the predominant slip direction or estimated from the vertical or horizontal offset of geologic markers (USGS webpage).

- **Structural and nonstructural risk reduction measures** — *Structural measures:* Any physical construction to reduce or avoid possible impacts of hazards, or application of engineering techniques to achieve hazard-resistance and resilience in structures or systems (UNISDR 2009).

  Nonstructural measures: Any measure not involving physical construction that uses knowledge, practice, or agreement to reduce risks and impacts, in particular through policies and laws, public awareness raising, training, and education (UNISDR 2009).

- **Systems in a city** — Include infrastructure, services, and functions (water supply and wastewater treatment systems, solid waste management, roads, power lines, food distribution, health, education, and finance) and ecosystems (agricultural land, parks, wetlands, and fishing grounds). Systems are designed and managed by people, but their performance depends on a multitude of factors that are difficult to manage, including human behavior and institutional context, which often lead to unintended side effects such as pollution. Systems are fragile if they are easily disrupted or broken, though their basic functioning may look very stable. Systems are linked and dependent on each other. The strengths or weakness of the links between systems can enhance adaptive capacity or increase the vulnerability of other systems (adapted from ISET-International 2012).

- **Tropical cyclone** — Originates over tropical or subtropical water and characterized by a warm-core, nonfrontal synoptic-scale cyclone with a low pressure center, spiral rain bands, and strong winds. Depending on their location, tropical cyclones are referred to as hurricanes (Atlantic, Northeast Pacific), typhoons (Northwest Pacific) or cyclones (South Pacific and Indian Ocean) (IRDR 2014).

- **Urban resilience** — The capacity of individuals, communities, institutions, businesses, and systems within a city to survive, adapt, and grow no matter what kinds of chronic stresses and acute shocks they experience (100 Resilient Cities webpage).

- **Vulnerability** — The characteristics and circumstances of a community, system, or asset that make it susceptible to the damaging effects of a hazard (UNISDR 2009).

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INTRODUCTORY NOTE

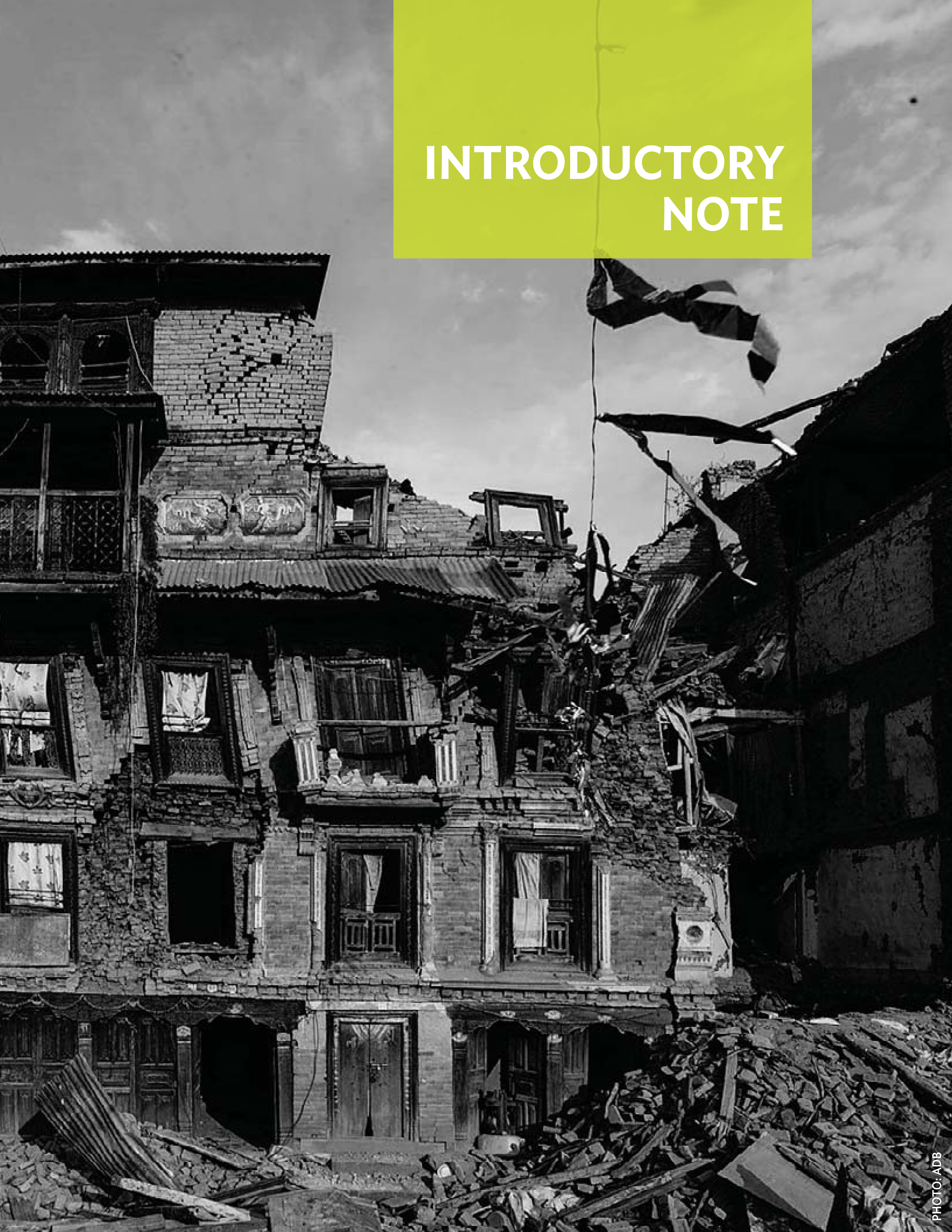


PHOTO: ADB

NOTE TO URBAN PLANNERS

Reducing disaster risk caused by natural hazards (e.g., floods, earthquakes, and tropical cyclones) in urban areas is largely a development issue and needs to be addressed within the context of a wider urban development framework. Reducing disaster risk will contribute to strengthening urban resilience and sustainable urban development.

Urban land use management processes such as land use planning, development controls, greenfield development, and urban redevelopment provide opportunities for reducing disaster risk.

- Land use management processes allow us to understand how natural hazards in and around urban areas interact with existing and future urban growth patterns, and identify what measures (policy, investments, and capacity) can be undertaken to promote development in a risk-sensitive manner.

- By framing disaster risk within the context of urban development processes, the economic and political viability of proposed risk reduction measures are enhanced.

Urban planners are in a unique position to reduce disaster risk because of the land use management tools at their disposal. Reducing disaster risk requires the following:

- Long-term systemic thinking: Urban planners can act as visionaries for their cities and both support and influence such thinking in long-term decisions, including decisions to institutionalize disaster risk reduction measures in the context of wider urban development.

- Multidisciplinary and multistakeholder inputs: Urban planners tend to have a good working relationships with different stakeholders—politicians, government, the scientific community, the private sector, and civil society.

- A good understanding of land conditions (natural, socioeconomic, and political dimensions of land): Urban planners with proficiency in land use management and understanding of complex political economy provide a natural vantage point.

In undertaking actions to reduce disaster risk, urban planners are likely to require support from national and city governments to ensure that effective legislation, strengthened institutions, leadership, and enhanced capacities are available. It will also require creating a high level of awareness among all urban stakeholders about the importance of having a disaster-resilient urban environment and empowering them to participate in relevant disaster risk reduction activities.

In order to reduce disaster risk through urban land use management processes, urban planners need technical capacity to interpret disaster risk information and its potential implications for a city's landscape. Planners may require political support and practical guidance on suitable entry points to incorporates disaster risk considerations into land use management processes, while recognizing that in doing so there may be financial, social, and political implications. This guidance note series is written for urban planners for the purpose of providing such directions.

I.1 WHY REDUCE DISASTER RISK IN URBAN AREAS THROUGH LAND USE MANAGEMENT?

Urban areas in Asian countries are often vulnerable to natural hazards.[1] This high disaster risk is mainly a result of the interplay of economic and physical geography, whereby Asian cities are located in hazard-prone areas—along coasts or on floodplains, on top of or near seismic faults, in the shadow of volcanoes, and in locations prone to tropical cyclones and severe storms. All of these physical conditions increase the exposure of urban populations and physical assets to hazards—flooding, storm surges, land movement, tsunamis, ash cover, and so on. Moreover, with climate change, the intensity and, in some cases, the frequency of climate-related hazards is expected to increase, and be accompanied by sea-level change and permanent coastal inundation, which will further exacerbate the level of disaster risk.

Equally important in the Asian context is that these urban areas are rapidly expanding, which presents a host of challenges for urban local bodies—the need to provide more affordable land, infrastructure, and housing; to create economic opportunities for all sections of the population; and to deliver basic services in an efficient and cost-effective manner. These challenges are being addressed through measures (policy, investments, and capacity), which in many cases do not take into account natural hazard considerations, thereby further increasing the exposure and vulnerability of people and assets to disasters. For example, in many cases, infrastructure is located in flood-prone areas; schools and hospitals are not constructed according to specifications to be resilient to seismic hazards; and new real estate development takes place over wetlands, thereby obstructing their natural drainage-related functions.

Consequently, disaster risk in urban areas is largely a development issue and needs to be addressed within the context of wider urban development—both formal and informal. Urban land use management processes such as **land use planning**, **development control**, **greenfield development**, and **urban redevelopment** can play an important role in reducing disaster risk for the following reasons:

- **Understand interaction between hazards and urban growth patterns.** Urban land use management processes provide opportunities to understand how hazards interact with existing and future urban growth patterns, and they can propose a combination of measures (policy, investments, and capacity) that lead to risk-sensitive development. For example, a land use plan can propose spatial growth strategies to direct development away from inundation-prone floodplains. Similarly, instruments for development control, such as incentive zoning, can discourage development in areas with high liquefaction potential in the event of an earthquake. Further, a master plan for a greenfield site can disclose disaster risk information, thereby allowing potential private investors to be better informed of the need to adequately assess the costs and benefits of developing land in certain ways.

- **Increase political and economic viability of disaster risk reduction solutions.** By incorporating disaster risk considerations in urban land use management processes, the chances of implementing risk-sensitive urban growth may become more politically acceptable and economically viable. For instance, acquiring a large parcel of land on an unstable slope and restricting development may not be politically and economically viable when landslide risk reduction objectives are considered alone, but it may become feasible when combined with objectives to address local development issues, such as the need for creating recreational and open spaces. Moreover, with

[1] In this document, "urban" is identified in the context of each country by applying the definition used in that country.

urbanization bringing more resources and providing economies of scale, disaster risk reduction becomes more affordable and can benefit more people.

- **Build on existing processes, capacity, and resources, instead of new approaches.** The broad principles guiding urban land use management—integrated, inclusive, and reflective—remain valid in the case of integrating disaster risk considerations. Incorporating disaster risk considerations in land use management does not necessarily involve a new approach, but rather requires reflection to introduce incremental adjustments to established processes, capacity, and resources.

With urban areas in Asian countries expected to invest billions of dollars over the next years in infrastructure and services, consideration of disaster risk through urban land use management processes will ensure such investments are sustainable in the long run.

I.2 INTRODUCING THE GUIDANCE NOTE SERIES

WHO ARE THE GUIDANCE NOTES FOR?

This guidance note series is intended for urban planners involved in land use management in Asian cities. It is recognized that some Asian cities may have urban planner positions within the city government, whereas others may depend on technical institutes (such as national or city urban planning institutes or universities) and/or national government agencies (such as a department of urban development) to provide support related to urban planning. Regardless, urban planners are in a unique position to reduce disaster risk through land use management for the following reasons:

- **Long-term planning horizon and systems approach.** Urban planners can act as visionaries for their cities, supporting and influencing long-term decisions across systems, and these attributes make them an ideal technical group to incorporate effective disaster risk reduction actions.

- **Multidisciplinary and multistakeholder inputs.** Urban planners tend to maintain an effective working relationship with many different stakeholders—politicians, government departments across sectors, the scientific community, the private sector, and civil society.

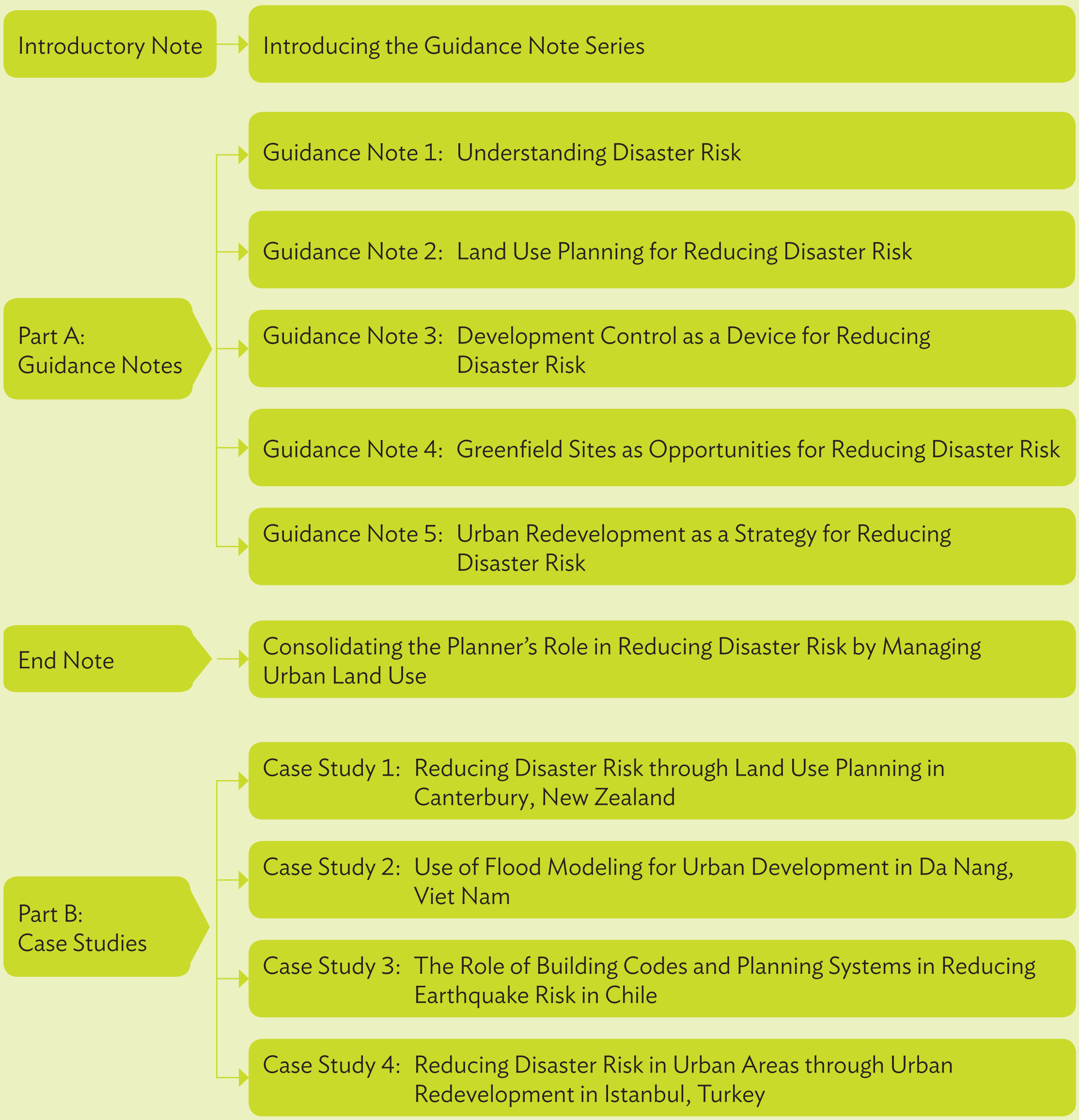
- **Good understanding of land conditions is critical for successful reduction of disaster risk.** Urban planners with proficiency in land use management have a good understanding of land conditions (natural, socioeconomic, and political dimensions of land) and thus have a natural upper hand.

WHAT DO THE GUIDANCE NOTES CONTAIN?

Recognizing the deficiencies in the urban planning-related practice in Asian cities and the limited capacity, urban planners may need guidance on *how* to integrate disaster risk considerations in land use management processes. This is important, especially because (i) the information on disaster risk may not always be available in appropriate formats or with levels of detail required for planning purposes; (ii) the uncertainties surrounding hazards make it difficult to factor them in planning processes; (iii) there might be financial implications of the measures being proposed as part of land use management to reduce disaster risk; and (iv) at times, the political acceptability of the proposed measures, such as restricting development, might be limited. This *Guidance Note Series on Reducing Disaster Risk by Managing Urban Land Use* aims to address all four points.

It is structured into two parts, as shown in Figure I.

Figure I: Structure of the Guidance Note Series



Source: Authors.

Part A includes five guidance notes. It begins with *understanding disaster risk* (Guidance Note 1), since it is the bedrock for the successful integration of disaster risk considerations into urban land use management processes. This is followed by four key topics related to land use management: (i) *land use planning* (Guidance Note 2), (ii) *development controls* (Guidance Note 3), (iii) *greenfield development* (Guidance Note 4), and (iv) *urban redevelopment* (Guidance Note 5). Part A is followed by an End Note, which consolidates the role of the planner in reducing disaster risk by describing the enabling environment required for taking action.

While the implementation of disaster risk reduction measures will depend on a host of other issues related to broader urban governance, such as decentralization of responsibilities in the country, private sector presence in the city, and civil society participation in decision-making processes—all of which are beyond the scope of this series—it is nonetheless imperative that urban planners know how urban land use management can reduce disaster risk and what role they play in the process.

Part B includes four case studies describing the application of the guidance provided in Part A in real-life contexts. Case Study 1 describes how in the aftermath of the 2010/11 Canterbury earthquakes in New Zealand, urban land use planning-related tools have been adopted to reduce disaster risk. Case Study 2 explains the use of flood risk modeling to inform urban planning-related decision making in Da Nang in Viet Nam. Case Study 3 describes how Chile has successfully reduced earthquake risk by strengthening the implementation of building code and planning system. Case Study 4 describes how urban redevelopment is being used as a tool in Istanbul, Turkey to reduce earthquake risk of individual buildings and neighborhoods.

HOW TO USE THE GUIDANCE NOTES

Guidance Notes 1–5 each start with a list of *key messages* that will help urban planners understand the key concepts covered in the guidance note, key actions required, and likely challenges to overcome. This is followed by a brief *introduction*, which establishes the rationale; a section on *getting started*, which describes the type of preliminary work and enabling environment that is required to integrate disaster risk considerations in the said land use management process; and, lastly, a detailed section on *actions* to be undertaken. Depending on the land use management process covered in the guidance note, the actions can range from step-by-step guidance to broader guidance on different approaches and instruments typically used in such a process.

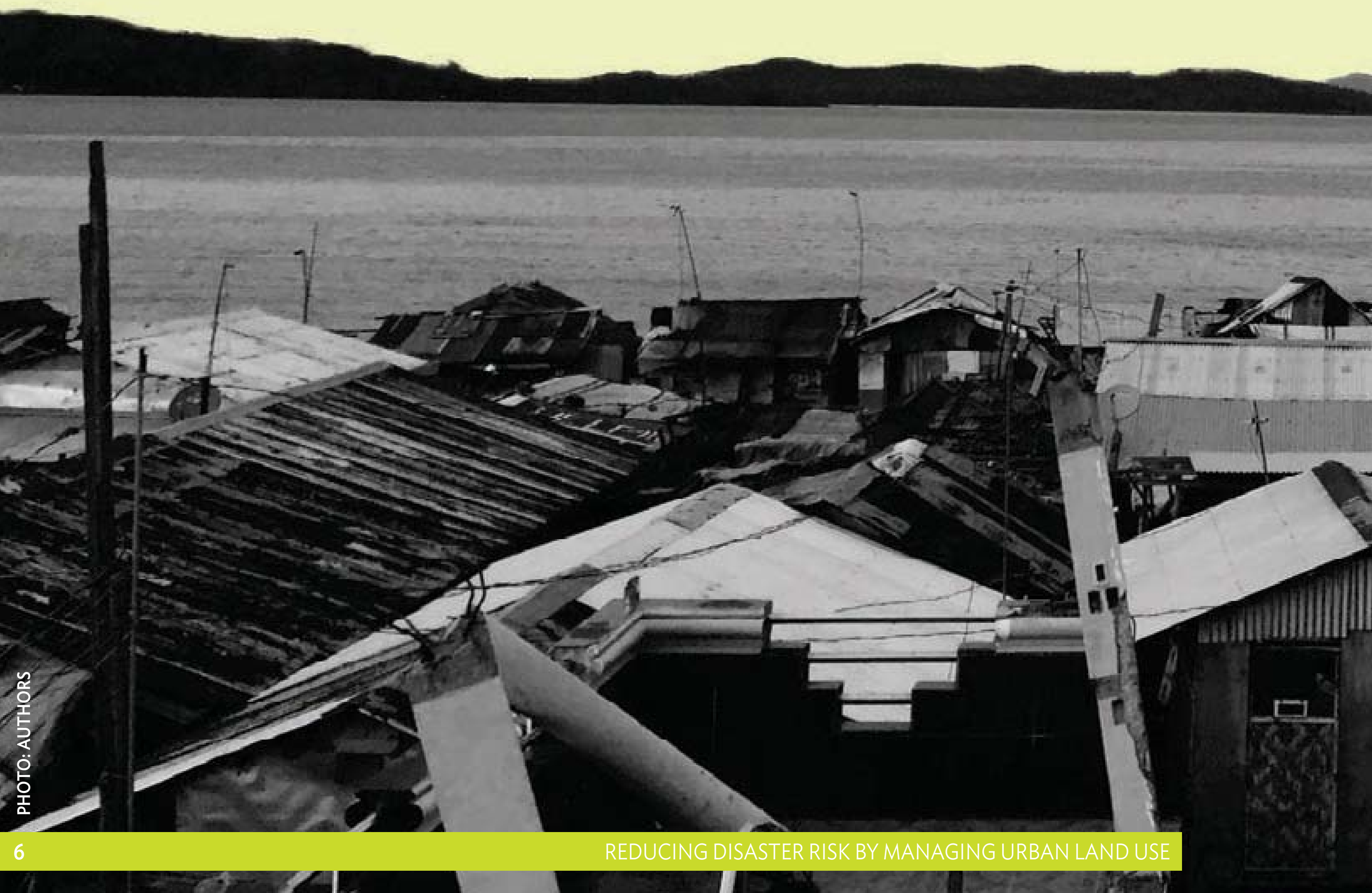


PHOTO: AUTHORS

Urban planners can choose which guidance note to refer to, depending on the land use management processes they are following in their city at a particular time. However, it is recommended that Guidance Note 1 also be read, to better understand what type of disaster risk information is required to guide the process of risk-sensitive land use management.

Unlike Guidance Notes 1–5, which discuss specific processes, approaches, and tools, the End Note looks at the various factors (legislation, land administration, knowledge, skills, and capacity) that are essential for strengthening the enabling environment required for integrating disaster risk considerations into land use management processes. While improving these factors is not the direct responsibility of the urban planner, it is nonetheless crucial for them to be aware of the importance of these wider matters and, where possible, provide effective inputs into the development of these factors. Thus, the End Note highlights *key considerations* for each of the factors covered.

Figure II presents a schematic diagram of the guidance notes: intended outcomes, entry points for integrating disaster risk considerations, key actions, and the likely challenges to overcome.

Part B of the document contains four *case studies*. Urban planners are encouraged to read the case studies as they not only illustrate the application of the guidance provided in Part A, but also highlight the challenges encountered, solutions found, and the importance of the larger enabling environment through policies, legislation, awareness raising, and capacity building for disaster risk reduction.

Figure II: Outline of Guidance Notes Covered in this Series

Guidance Notes	Outcome	Key Steps/Entry Points
1 **Understanding Disaster Risk**	Planners have a practical understanding of hazards, the elements at risk and the vulnerabilities present in the urban area, and how these factors are changing with land use activities.	Identify **hazards**. Assess **exposure** of people and physical assets. Assess **vulnerability**. Assess **disaster risk**.
2 **Land Use Planning for Reducing Disaster Risk**	A land use plan document provides an objective statement of how hazards will impact future development; presents a risk-sensitive vision and goals; identifies development constraints posed by hazards; and where relevant, proposes policy statements to reduce disaster risk.	Identify disaster risk as part of a situation analysis undertaken for land use plan preparation. Through consensus, formulate risk-informed vision and goals. Develop and promote policy measures that support disaster-risk-sensitive growth.
3 **Development Controls as a Device for Disaster Risk Reduction**	Development control instruments regulate activities in disaster risk areas.	Design zoning ordinances to factor hazard information. Land subdivision to require hazard-related studies to inform allowable density and layout of land. Building codes to provide guidance on the design, construction, alternation and maintenance of structures located in hazard-prone areas.
4 **Greenfield Sites as Disaster Risk Reduction Opportunities**	The location and nature of proposed investments (public and private) in greenfield sites are disaster resilient.	Use disaster risk information at the master planning stage to determine the location and nature of land uses and infrastructure and to formulate site design and development controls. Guided by the findings of detailed disaster risk assessment, prioritize disaster risk reduction-related investments.
5 **Urban Redevelopment as a Disaster Risk Reduction Strategy**	Urban redevelopment projects are resilient to hazards and do not increase levels of vulnerabilities.	Use results of disaster risk assessment to guide the formulation of a redevelopment master plan for formal built-up areas and brownfield development. In areas with high disaster risk, use urban redevelopment as an approach to reduce disaster risk. Use disaster risk information and participatory process to inform interventions related to upgrading of informal settlements.

Source: Authors.

Key Actions	Likely Challenges to Overcome
Collaborate with specialist technical agencies, local universities, emergency management agencies and development partners to understand what information on disaster risk is available and how the existing information can be used for urban land use management purposes. Discuss with technical specialists the type and scale of information that is required for planning purposes and develop the methodology and scope to undertake or update disaster risk assessment.	Identifying, documenting and discussing the implications of uncertainties associated with hazards. Engaging decision makers from the onset and use reputed technical agencies to demonstrate credibility of risk assessment results and ensure public release of the assessment findings.
Collaborate with technical specialists to understand how disaster risk changes with urbanization. Use disaster risk information in every stage of land use planning. Prevent the creation of new risk by introducing land use policies that restrict new development in hazard-prone areas and encourage investments to reduce risk in existing development. Communicate information on disaster risk to all stakeholders to encourage risk-sensitive investments.	Gathering information on hazards and, in particular, information on changing hazard patterns. Building consensus among stakeholders to adopt risk-sensitive land use policies and prioritize investments to reduce disaster risk.
Collaborate with technical agencies and the private sector to reflect disaster risk information in development controls and propose acceptable measures. Understand the implications of short-and long-term implications of risk-sensitive regulatory decisions, especially implication on urban poor and the vulnerable.	Obtaining the political buy-in in implementation of risk-sensitive development control instruments. Increasing the economic viability of implementing development control measures that restricts development in high-risk areas.
Where investments on disaster risk reduction are required, design interventions that include structural and nonstructural components and, where possible, serve multiple purposes in order to be cost-effective. Raise awareness of the private sector about the importance of incorporating hazard information in greenfield site development.	Collecting site-specific hazard information, especially information on changing hazard pattern with climate change. Gaining interest of the private sector to invest in risk reduction, especially for low-frequency and high-intensity disasters.
Collaborate with local technical agencies to assess disaster risk and disclose disaster risk information to all public. Adopt participatory processes, especially for reducing disaster risk as part of upgrading informal settlements.	Coordinating with stakeholders and encouraging stakeholder groups to be active in urban redevelopment projects. Ensuring that the economic objectives of redevelopment projects and disaster risk reduction objectives do not work at cross-purposes and exacerbate existing vulnerabilities.

PART A
GUIDANCE NOTES

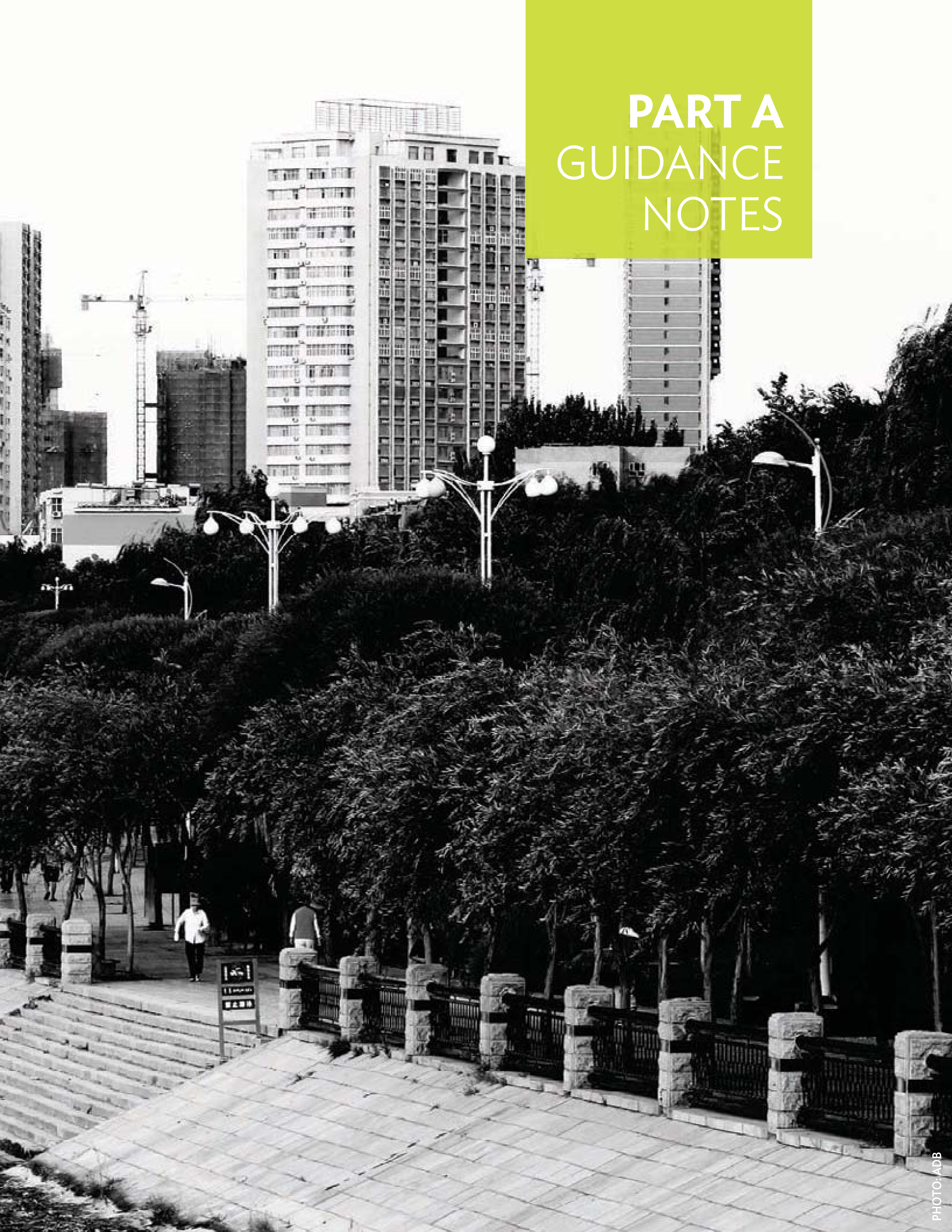
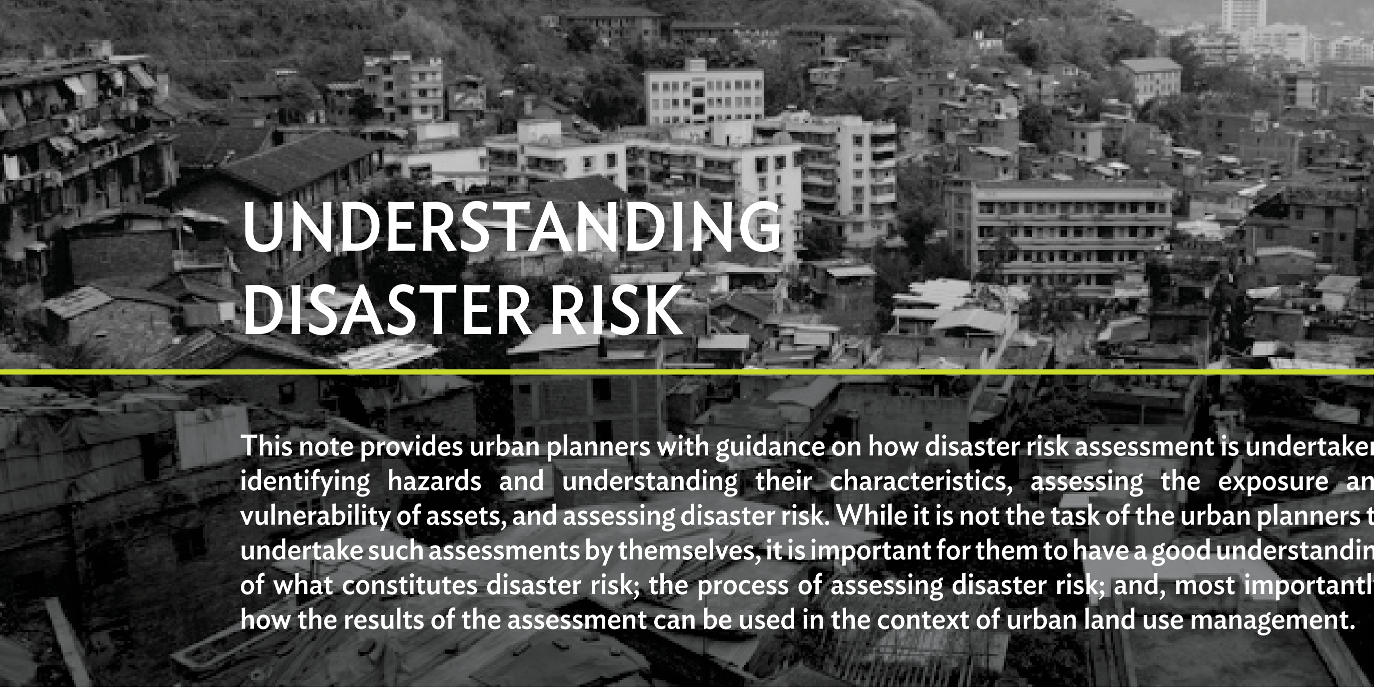


PHOTO: ADB



UNDERSTANDING DISASTER RISK

This note provides urban planners with guidance on how disaster risk assessment is undertaken: identifying hazards and understanding their characteristics, assessing the exposure and vulnerability of assets, and assessing disaster risk. While it is not the task of the urban planners to undertake such assessments by themselves, it is important for them to have a good understanding of what constitutes disaster risk; the process of assessing disaster risk; and, most importantly, how the results of the assessment can be used in the context of urban land use management.

PHOTO: ADB

KEY MESSAGES

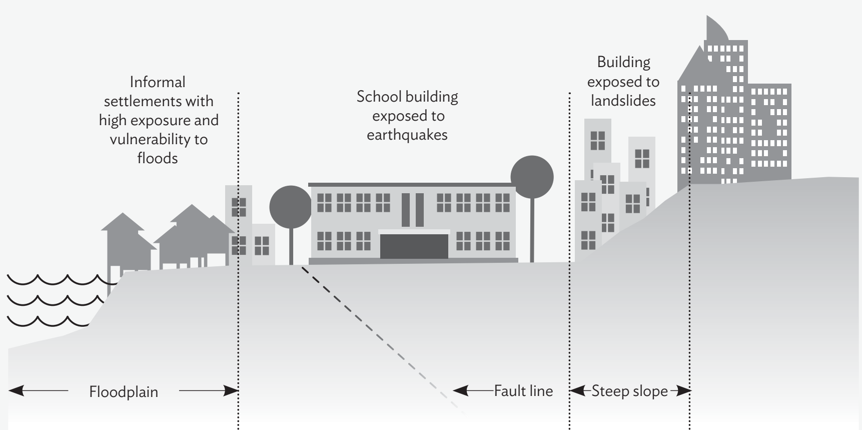
Disaster risk is a function of probability of occurrence of hazards $p(h)$, vulnerability v, and exposure e. It is expressed using the following formula:

$$\textit{Disaster risk} = f(p(hi),v,e)$$

- **Hazard** characterizes the features of likely hazards, such as floods, earthquakes, tropical cyclones, or landslides, in a specific location in terms of frequency, intensity, and spatial occurrence, as well as their interlap.
- **Vulnerability** is a measure of the fragility of the assets at risk (physical characteristics and/or socioeconomic conditions) and how they perform given the intensity of hazard impact (whereby intensity includes attributes such as magnitude and duration).
- **Exposure** identifies the elements at risk in a specific location, such as size, composition, and density of the population, buildings, infrastructure, their cultural significance, and economic activity that could potentially be affected by the hazards.

Figure 1.1 shows a schematic diagram of examples of disaster risk in an urban setting.

Figure 1.1: Components of Disaster Risk in an Urban Setting



Source: Authors.

Understanding the spatial correlation between the multihazard landscape, on the one hand, and the vulnerability and exposure of the population, buildings, and infrastructure, on the other, will help urban planners undertake urban land use management-related decisions that will (i) *reduce* disaster risk in urban areas in the present and (ii) *not increase* urban disaster risk in the future. For example, an understanding of the characteristics of flooding in and around a city encourages the adoption of a land use policy that steers new development away from floodplains, restricts the use of wetlands and unstable slopes through development control regulations, prioritizes investments such as flood embankments, and informs stormwater drainage planning for the city.

KEY ACTIONS

For the successful application of disaster risk assessment in urban land use management:

- **Consider the question *how do you want to use the results of the assessment?*—the end use of the disaster risk assessment—and agree on its methodology and scope.** Disaster risk assessment can vary in terms of objectives, scope, and methodology. Factors such as access to information, budget, and available technical capacity play an important role in determining the scope and methodology of the assessment. There is a wide range of tools and methodologies available to undertake disaster risk assessments (e.g., free open source tools vs. restricted commercial owner or operator tools, qualitative vs. quantitative, deterministic vs. probabilistic). Since no one size fits all, each city will need to determine what is most appropriate to its context. However, at the very least, for the disaster risk assessment to be useful for land use management purposes, the assessment must identify, categorize, and differentiate disaster risks spatially. Spatial analytical tools such as geographic information systems are particularly valuable.

- **Collaborate with specialist technical agencies, local universities, emergency management agencies, and development partners.** This will help urban planners to become familiar with existing and/or planned initiatives on disaster risk assessment—their objectives, scope, and limitations; to communicate the types and scale of information required for land use management related decisions; and, where needed, to undertake and update assessments. Collaboration with a variety of specialist technical agencies to interpret the results of the risk assessment will help ensure that a wide range of disaster risk-related issues are addressed in a comprehensive manner.

LIKELY CHALLENGES

Uncertainties are inherent to disaster risk assessment, especially when modeling changes in the magnitude and intensity of extreme weather events, assessing flood risk, or assessing the impact of extreme and sudden events like large earthquakes. It is important to appreciate that uncertainties exists and discuss the implication for the results and decision making.

Data required for developing exposure database for the urban area and for undertaking vulnerability assessments may not always be available.

The **public release of the disaster risk assessment** outcomes can have significant effects on land and properties values. Thus, it is important to engage decision makers from the onset and use reputed national and/or local technical agencies (with inputs from international experts, where required) to demonstrate the credibility of the assessment results.

1.1 INTRODUCTION

Disaster risk can be characterized as a function of (i) the probability of occurrence of hazards of varying severity in a particular location, (ii) the people and physical assets that are situated in the location and exposed to the hazards, and (iii) the level of vulnerability of those people and assets to hazards.[1,2]

For example, in an earthquake-prone urban area, disaster risk is a function of many factors including (i) the probability of ground shaking, slope failure, liquefaction, up- or downthrust, and seiching induced by an earthquake occurrence; (ii) the population, housing, infrastructure, and cultural and economic activity located in the area and thus exposed to the physical effects of the earthquake; and (iii) the level of vulnerability due to the physical characteristics of buildings and infrastructure (e.g., the vulnerability of a residential building is a factor of building height, layout, proximity to other structures, age of the building, choice of construction material, and standard of construction) as well as other socioeconomic conditions (poverty level, livelihood choices, gender equity, land tenure security, etc.) of the population.

In other words, it is not just the hazard level, but equally what is at risk (the exposure) and why (the vulnerability of population and assets), which in turn is largely dependent on development processes which drive the level of disaster impact. This is particularly true for urban areas. Each hazard type the city is exposed to—geophysical, hydrological, meteorological, and climatological (as well as biological and technological)—has its own risk-creating characteristics that produce spatial variations in vulnerability and exposure.

For an urban planner working on urban growth and development, it is critical, for the following reasons, to understand the spatial correlation between the evolving multihazard landscape and the elements (population, buildings, infrastructure, and businesses) that are/will be at risk:

- Urban areas are developing at a rapid pace. The growth in population and physical assets in hazard-prone areas, lack of basic infrastructure and access to affordable land, and substandard construction of buildings and infrastructure increase the vulnerability and exposure of the urban population and physical assets to hazards.
- Lack of awareness of disaster risk in rapidly growing urban areas. In many cases, the rapid growth in cities has taken place in a very short time frame compared to the return period of some hazards. These urban areas may not have experienced large-scale hazard events since they were established and, as a result, do not have an adequate understanding of the level of disaster risk.
- Urban development can change the disaster risk profile. The process of urban development itself can change the risk profile in any given area, for example by altering drainage patterns or filling natural flood retention areas. Rapid urban growth may create new risks in areas that were not previously exposed, without the awareness of residents, or emergency response planners.
- Climate change is expected to increase disaster risk. With climate change, the pattern of climate-related hazards is expected to change in terms of intensity, frequency, seasonality, and location. This may be accompanied by sea-level change, which will further exacerbate the trend of rising disaster losses in urban areas.

This requires assessing disaster risk and utilizing the findings of the assessment in decision making regarding urban land use management.

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[1] This is normally presented as the formula. *Disaster risk* = $f(p(hi),v,e)$

[2] ADB. 2014. *Operational Plan for Integrated Disaster Risk Management.* Manila.

1.2 GETTING STARTED

In order to apply disaster risk assessment in urban land use management:

- **Collect information on existing disaster risk assessments.** An important first step is to consult with technical agencies, local universities, emergency management agencies, and development partners and to collect information on disaster risk assessments that have already been undertaken for the city and the larger region. It is important to understand the purpose of any prior assessments (to raise awareness on disaster risk, to inform disaster risk reduction investment, to inform emergency contingency planning, etc.), their scope (single hazard or multihazard), methodology (deterministic or probabilistic), forms in which results were presented (maps, loss curves, average annual loss,[3] probable maximum loss,[4] etc.) scale, year of implementation, stakeholders and/or experts involved in undertaking the assessment, and application of assessment results.

- **Consult with relevant technical specialists:** Consult with a range of hazard specialists to understand the findings of the existing disaster risk assessments and discuss if the results can be readily used for land use management-related decisions (e.g., results of a qualitative citywide risk assessment may be sufficient to factor disaster risk considerations into land use policy and strategy formulation, whereas quantitative site-specific risk assessments may be required to frame investment projects on seismic retrofitting as part of larger urban redevelopment). The consultations should include the type of and scale at which disaster risk information are needed to inform urban land use management decisions, which would typically include (i) types of hazards present in the area; (ii) the expected severity, frequency, and impact area for each hazard type, now and in the future; and (iii) the elements at risk (infrastructure, buildings, etc.).

- **Commission an updated multihazard disaster risk assessment:** Depending on the need and availability of information, undertaking an updated citywide disaster risk assessment might be necessary. While the intended purpose of the results of the assessment should guide the scope of the assessment (multihazard assessment, climate change considerations, exposure mapping, vulnerability of key building typologies, etc.), it will be important to collaborate with technical agencies, local universities, and specialists and to involve them in undertaking or supervising the assessment. Even if the task of undertaking the assessment is commissioned to external consultants, local technical agencies should be closely involved to make sure the assessment can be updated by them when required and they are in a position to interpret the findings in ways that can be understood by decision makers, planners, the private sector, and local communities. It is also important to seek guidance from decision makers on the scope (spatial, multihazard, etc.) of the assessment, since this affects the extent to which the assessment results can be used—the wider the scope, the greater and more diverse the end-users are likely to be.

3 Average annual loss is the expected loss per year based on both historic and modeled potential future hazards averaged over many years.

4 The average maximum loss that could be expected within a given number of years.

1.3 STEPS INVOLVED IN DISASTER RISK ASSESSMENT

To make full use of disaster risk assessments in urban land use management processes, it is important to understand the broad steps involved in assessment and their limitations. This is illustrated in Figure 1.2.

Figure 1.2: Undertaking Disaster Risk Assessment in the Context of Land Use Management

Disaster Risk Assessment Steps	Actions	Outcome(s)
Identify **hazards**	Identify the full range of hazards relevant to the current and future growth boundaries of the urban area. Characterize hazard patterns: frequency, intensity, and location Develop hazard maps to illustrate the location, severity, and likelihood of occurrence of different hazards.	A good understanding of hazards (type and characteristics) and how the overall hazard patterns may change with climate change and other land use activities.
Assess **exposure** of people and physical assets at risk	Identify the elements at risk (population, buildings, and infrastructure) in the urban area that could potentially be affected by the hazards.	Elements at risk identified, mapped, and valued in terms of their replacement cost.
Assess **vulnerability**	Assess the physical vulnerability in terms of damage and losses to a structure and using functions that relate hazard intensity to damage. Understand social and economic factors that contribute to vulnerability.	Better understanding of the fragility of assets and their performance given the severity of a disaster event.
Assess **disaster risk**	Use the formula to assess disaster risk: *Disaster risk* = $f(p(hi),v,e)$ Adopt participatory methods to involve different stakeholders to identify and triangulate information on hazards, exposure, and vulnerabilities. Communicate the results of the assessment along with the limitations and uncertainties to all stakeholders.	Disaster risk assessed in the context of urban land use management.

Source: Authors.

1.3.1 IDENTIFY NATURAL HAZARDS

Hazards include a range of geophysical (e.g., earthquake or volcanic eruption), meteorological (e.g., storm), hydrological (e.g., floods and landslides), and climatological (e.g., drought) events. These hazards are largely driven by the natural environment, such as topography, latitudinal and longitudinal positions, altitude, and local and large-scale climate systems:

- Identify the range of hazards applicable to the current and future growth boundaries of the urban area, including rapid onset events (e.g., floods, earthquakes, and landslides) and slow onset hazards (e.g., drought), as well as the spatial and temporal interactions that may arise between them. For example, in cascading hazards, one hazard event triggers another hazard event (landslides triggered after an earthquake); or the occurrence of one event may be compounded by another (coastal inundation coincides with river inundation, a relatively frequent situation associated with tropical cyclones). Some hazards present seasonal patterns, in particular climate-related hazards, such as monsoonal floods and tropical cyclones. With multihazard considerations, it is important to identify (i) the hierarchy—both of in terms of level of seriousness and sequencing—of risks from the various hazards, (ii) the different organizations involved in the observation and/or monitoring and management of the effects of different hazards, and (iii) areas where efforts to manage risks from one hazard may conflict with or create synergies with the measures to manage other types of hazard.

- Recognize the time horizon of land use management processes since climate change will likely alter hazard patterns through change in frequency and intensity, latitudinal or altitudinal occurrence, or changes in the seasonality of climatic effects. It is important to capture possible changes in hazard patterns, but using climate modeling outputs for hazard assessments in urban areas can prove challenging because of the high resolution of data required for hazard modeling at the city level and the uncertainties associated with some climate variables (rainfall, in particular).

- Recognize that land use management activities themselves can aggravate existing hazard-inducing conditions or trigger new ones, either of which can change future hazard patterns. This includes draining and developing wetlands and swamps, which can reduce floodwater retention capacity in a catchment; clearing forest and other vegetation cover on slopes, which increase the likelihood of mass land movement and flash floods; and significant impervious surface development, which can worsen urban flooding through increased runoff.

1.3.2 CHARACTERIZE HAZARD PATTERNS

Hazards have three main interrelated characteristics: intensity, frequency, and location.

- **Intensity:** the observed or potential strength or energy and likely severity of a given hazard. The wind-speed category of a tropical cyclone storm or the magnitude of an earthquake is an indicator of its intensity.

- **Frequency:** how often a specific hazard of a particular intensity is likely to occur, or has occurred, in a given location. For example, the frequency of occurrence of a flood event (usually expressed as a return period) might be 100 years (a 100-year or 1-in-100 year flood), otherwise expressed as its probability of occurring, in this case 1/100 or 1% in any one year. The lower the return period, i.e., the more infrequent an event, the more severe the particular type of hazard will be.

- **Location:** hazards are inherently spatial phenomena. They originate in a particular location and affect a defined spatial area.

1.3.3 DEVELOP HAZARD MAPS

For the purposes of guiding land use management activities, hazard data are most useful when they are provided in geospatial form. Hazard maps usually illustrate geographically the location, severity, and likelihood of occurrence of different hazards. Unlike location, however, it is not easy to convey information on the intensity and frequency of a hazard in a map. While this information is sometimes represented by zones (low, moderate, or high), this only explains the hazard area and not how frequently a hazard might occur. To help users understand hazard maps, they should include statements on a map's purpose, level of accuracy, and limitations. Table 1.1 illustrates an example of the type of information needed to develop hazard maps for earthquakes and floods.

Table 1.1: Information Needed for Developing Hazard Maps

	Earthquake	River Flooding
Location	Epicenter	Channel
	Geologic formations	Floodway
	Fault lines	Floodplain
	Liquefaction potential	Elevation
Severity	Intensity	Volume
	Magnitude	Velocity
	Acceleration	Rate of rise
	Displacement	
Frequency of occurrence	Recurrence interval	Historical return periods
	Slip rates	Flood of record
	Historical seismicity	Design event

Source: Adapted from Organization of American States. 1991. *Primer on Natural Hazard Management in Integrated Regional Development Planning.* Washington, DC.

The scale used for hazard maps needs to be appropriate for land use management purposes. Different hazard maps may be available at different scales and, in some cases, maps may need to be enlarged or reduced to fit the scale of the base map used for land use purposes. Table 1.2 summarizes scales of hazard maps relevant to different types of use in the context of urban land use management and Box 1.1 provides an example of hazard information collected by Naga City in the Philippines for the preparation of its comprehensive land use plan.

Table 1.2: Scale of Hazard Maps by Intended Application

Scale	Coverage	Application(s) (indicative)
1:200–<1:2,000	Project site	• Design of detailed engineering works incorporating disaster resilience measures
1:2,000–<1:25,000	Part of a city	• Feasibility stage of disaster risk reduction investments • Contingency plans • Master plan of greenfield development and urban redevelopment
1:25,000–1:100,000	Municipality	• Land use planning

Source: Adapted from C.J. Van Westen, D. Alkema, M.C.J. Damen, N. Kerle, and N.C. Kingma. 2011. *Multi-hazard risk assessment. Distance education course. Guidebook.* United Nations University & ITC School on Geo-Information Management as cited in ADB. Forthcoming. *Disaster Risk Assessment Guidance Note for Project Preparation.* Manila.

Box 1.1 Hazard Information Collected for the Preparation of Comprehensive Land Use Plan in Naga City, Philippines

Naga City is located in the center of the Bicol Region of the Philippines. It has high exposure to tropical cyclones and experiences on average 2–3 cyclones every year. The city's location within the Bicol River Basin predisposes it to flooding. Disaster risk in the city has been further exacerbated by land use changes due to population growth and urbanization. The city recognizes the importance of factoring hazard consideration in its land use planning process. As part of formulating its comprehensive land use plan, the city has prepared a checklist of hazard information available from mandated agencies and national projects:

Hazard Maps	Data Source(s)	Scale[a]	Remarks
Flood susceptibility	Mines and Geosciences Bureau	1:50,000	Depicts areas susceptible to floods, classified as high, moderate, and low, with supplemental information on flood heights. Available for selected regions, provinces, and municipalities/cities.
	Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA), Office of Civil Defense (OCD) (READY Project)[b]	1:50,000 1:10,000	Identifies areas prone to floods representing a worst-case scenario. Available for selected provinces and municipalities/cities.
	Department of Science and Technology – Nationwide Operational Assessment of Hazards Project (DOST-NOAH),[c] DREAM Project[d]	Various scales	Flood hazard maps of selected areas within 18 major river basins. Provides flood inundation zones based on 5-, 10-, 25-, 50-, and 100-year rainfall recurrence intervals, with indicative flood heights.
Rain-induced landslide	Mines and Geosciences Bureau	1:50,000 1:10,000	Depicts areas susceptible to rain-induced landslide, classified as high, moderate, and low. Available for selected regions, provinces, and municipalities/cities. Partial coverage of Naga City.
Ground rupture	Philippine Institute of Volcanology and Seismology (PHIVOLCS), OCD (READY Project)	1:50,000	Depicts areas with known and inferred faults. Available for selected provinces and municipalities/cities.
Ground shaking	PHIVOLCS, OCD (READY Project)	1:50,000	Composite ground-shaking levels based on hypothetical maximum credible earthquake scenarios. Available for Naga City.
Liquefaction	PHIVOLCS, OCD (READY Project)	1:50,000	Composite liquefaction susceptibility map based on hypothetical maximum credible earthquake scenarios. Available for Naga City.
Earthquake-induced landslide	PHIVOLCS, OCD (READY Project)	1:50,000	Composite earthquake-induced landslide map based on hypothetical maximum credible earthquake scenarios. Available for selected provinces and municipalities/cities.
Volcanic hazards	PHIVOLCS, OCD (READY Project)	1:50,000	Areas depicting volcanic hazards (lahar and pyroclastic flow). Available for selected active volcanoes.

Notes:

[a] 1:50,000: Indicative maps are useful for wider area planning purposes (e.g., provincial), identifying at-risk municipalities and cities. 1:10,000 and higher: Definitive maps are useful for engineering works, locating evacuation and relocation sites, detailed land use planning, assessing escape routes, and land use zoning.

[b] Hazard Mapping for Effective Community-based Disaster Risk Mitigation or the READY Project is a multi-agency initiative of the Government of the Philippines with an aim to undertake multihazard and risk assessment, strengthen community-based early warning system, and mainstream disaster risk reduction into the local development process.

[c] Nationwide Operational Assessment of Hazards or Project NOAH of the Government of the Philippines has the objective of strengthening early warning systems by undertaking research and development, advancing the use of cutting edge technology, and introducing innovative information services for early warning.

[d] Disaster Risk and Exposure Assessment for Mitigation or the DREAM Program aims at producing up-to-date, high-resolution flood hazard maps for the critical river basins in the Philippines.

Source: Authors.

1.3.4 ASSESS EXPOSURE OF PEOPLE AND PHYSICAL ASSETS

Once the hazards are identified and mapped, it is important to identify the elements at risk in the hazard zones that could potentially be affected by a hazard event. At a very basic level, this should include information on the current characteristics of the population (including the diurnal population changes), buildings, infrastructure, and land use. Information on building characteristics (size, shape, height, etc.), occupancy, age of the building, construction type, and hierarchy of roads, among others, will further improve the understanding on exposure.

Information on existing land use can be a critical input for exposure mapping because it facilitates the analysis of buildings in groups rather than individually. Land use determines to a significant degree the types of buildings, key economic activities, and population density in a particular area. For instance, urban residential, commercial, and industrial zones will display different characteristics in terms of building occupancy and value. These characteristics are specific to each country and context.

A geospatially linked inventory of exposure of physical assets is not common in Asia and is only available for specific areas. Box 1.2 describes a georeferenced inventory of assets developed for Pacific countries.

Box 1.2 **Georeferenced Exposure Database of Public Assets for Pacific Countries**

The Pacific region is one of the most disaster-prone regions in the world, with all countries exposed to a range of natural hazards, variously including tropical cyclones, extreme rainfall events, floods, droughts, earthquakes, tsunamis, and volcanic eruptions. The Pacific Catastrophe Risk Assessment and Financing Initiative (PCRAFI) was initiated by the Secretariat of the Pacific Community, the World Bank, and the Asian Development Bank to quantify the relative financial risk that Pacific island countries face from natural hazards (focusing on earthquake, cyclone, and tsunami hazards) and to develop suitable risk financing options. As part of this work, an exposure database was developed for eight Pacific countries—Cook Islands, Fiji, Papua New Guinea, Samoa, Solomon Islands, Tonga, Tuvalu, and Vanuatu—costing a total of $1.12 million.

The database contained the following information:

- Population statistics (2010 estimates) for different spatial divisions (from the smallest aggregation zone—enumeration area, census area, or village—up to district, province, and country levels)
- Land use cover derived from moderate- and low-resolution satellite imagery
- Building dataset, which outlines approximately 450,000 structures covering all urban buildings, digitized from satellite images. Of these, 80,000 were physically checked, and building information and photographs collected for each one. A further 3 million, predominantly rural buildings, were geolocated and classified using remote sensing techniques.
- Spatial locations and key attributes of major infrastructure and critical facilities—hospitals, primary health-care centers, police and fire stations, emergency management and response offices, welfare or evacuation centers, and schools.

Source: ADB. 2012. *Technical Assistance: Strengthening Disaster and Climate Risk Resilience in Urban Development in the Pacific.* Manila.

In recent years, crowdsourcing techniques have started being used to collect data on exposure. Such techniques can involve university students surveying and collecting information on the structural soundness of public buildings, such as schools and hospitals; and preparing a base map by digitizing building footprints, mapping the road network, and so on. Through significant outreach to local universities, technical experts, and communities, the data can be further populated to include private buildings. Box 1.3 describes exposure mapping undertaken in Kathmandu City using crowdsourcing techniques.

Box 1.3 **Exposure Mapping in Kathmandu City, Nepal**

In Kathmandu Valley, the Government of Nepal worked in partnership with the World Bank-managed Global Facility for Disaster Reduction and Recovery to apply the open data concept to document earthquake exposure information related to educational and health buildings. University students and volunteer community groups were engaged in digitizing and creating a comprehensive base map of Kathmandu Valley using the Open Street Map (www.openstreetmap.org) platform. The Nepal National Society for Earthquake Technology (NSET) provided technical support in training mappers to carry out structural assessments. The geomatics and engineering departments of Kathmandu University and Tribhuvan University assisted in finding the core mapping and survey team for the project and also in providing technical guidance and quality control.

The Department of Education provided the initial list of schools with their administrative addresses, which served as a starting point to locate schools. Identifying the location of these schools, particularly private schools, was a challenge. The mappers and surveyors used a snowball approach to inquire and get references from teachers or school management committee members on other nearby schools, including private schools, and to collect detailed exposure information. For health facilities, the team used three different sources to generate a reference list of hospitals, health posts, and polyclinics: a list of 100 private and community hospitals received from the Ministry of Health and Population (MOHP); a list of 205 medical centers approved by MOHP, accessible through the official MOHP website; and the names of 70 hospitals and 27 polyclinics from a private health organization in Kathmandu. Together, these provided a list of over 400 health service providers that the team worked to locate and survey using a similar approach.

Surveys were conducted to collect information on the structural soundness of 2,256 schools and 350 health facilities. In addition to collecting a comprehensive list of structural data for health and school facilities, the team worked to create a comprehensive base map of the valley by digitizing building footprints, mapping the road network, and collecting information on other major points of interest. The Open Cities team also conducted significant outreach to universities, technical communities, and governments. This outreach and communication helped build and expand the Nepal Open Street Map community. Over 2,300 individuals participated in open source map trainings.

The Open Street Map platform has been expanded to cover and collect exposure information from private residential houses in a few select wards in Kathmandu municipality. The data have been used in planning the retrofitting of school and health facilities as well as in response to the earthquakes in April and May 2015.

Sources: Open Cities. Kathmandu, Nepal. http://www.opencitiesproject.org/cities/kathmandu/; World Bank. 2014. *Planning an Open Cities Mapping Project.* Washington, DC.

Moreover, with the rapid growth in urban areas, it is not enough to capture exposure in its current state, but also to draw on information from urban growth models. Population census data for building inventories for a minimum of two separate dates can be used to develop future projections.[5]

1.3.5 ASSESS VULNERABILITY

The vulnerability of urban areas is rapidly altering with changes in building forms, construction practices, and social, economic and environmental factors. Physical vulnerability represents the potential direct impact of a hazard on the built environment and people. It is important to assess physical vulnerability as it helps in understanding the fragility of assets and how they are likely to perform under hazard events of different severities. Vulnerability is expressed in terms of damage to a structure and is assessed using functions that relate hazard intensity to damage. Usually, groups of structural types developed under a specific building code (rather than individual buildings) are analyzed as they are assumed to be built to withstand similar intensities and hence manifest similar degrees and types of vulnerability in relation to specific hazard(s).[6] Box 1.4 describes an example of a vulnerability assessment undertaken for cities in Bangladesh.

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[5] D. Lalleman, S. Wong, K. Morales, and A. Kiremidjian. 2014. A Framework and a Case Study for Dynamic Urban Risk Assessment. Paper presented at the Tenth US National Conference on Earthquake Engineering, 21–25 July, Anchorage, Alaska.

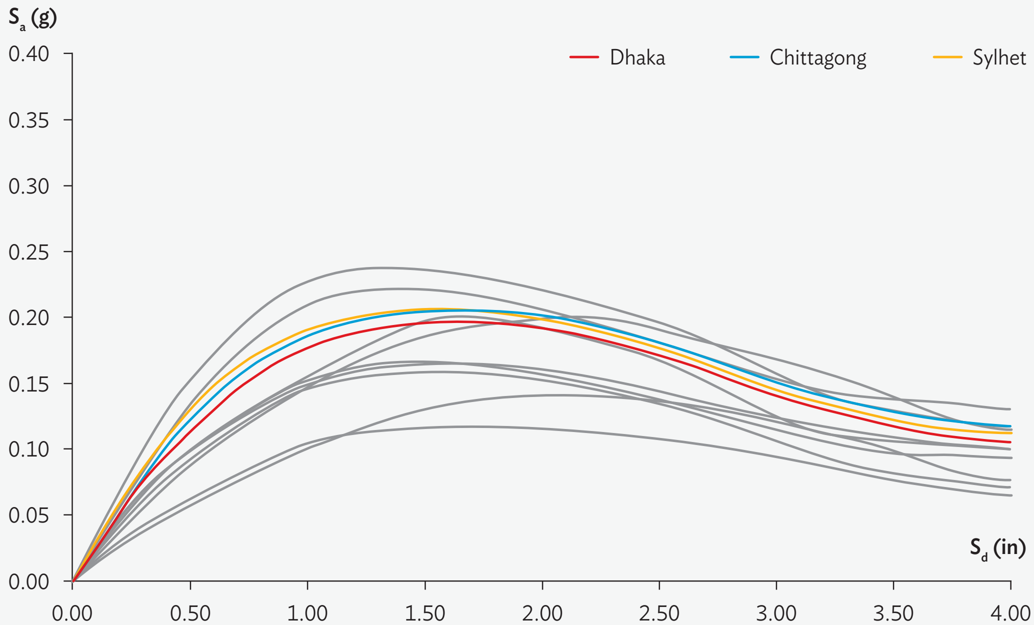
[6] ADB. Forthcoming. *Disaster Risk Assessment Guidance Note for Project Preparation.* Manila.

Box 1.4 **Assessing Building Vulnerability to Earthquake for Cities in Bangladesh**

Bangladesh is susceptible to earthquakes. Although there has been no major earthquake in the recent past, a moderate to large seismic event could cause significant damage to urban areas across the country. Under its Comprehensive Disaster Management Programme, the Government of Bangladesh therefore conducted city-level earthquake risk assessments for major cities to understand the potential risks.

This component of the program, costing $5.5 million for 12 cities, undertook comprehensive seismic risk assessments on the scale and the extent of damage—human and economic impacts that could result from potential earthquakes. The program identified a set of realistic earthquake scenarios and used the latest satellite images to prepare base maps showing the footprint of all buildings, road networks, water bodies, open spaces, and hilly areas. A detailed field survey was undertaken to understand the existing typology of buildings in the cities, and a multihazard loss estimation methodology was adopted to assess the seismic impacts on a wide range of assets as classified in the Bangladesh National Building Code: (i) general building stock, (ii) essential and high potential loss facilities, (iii) transportation systems, and (iv) utility systems. Finally, fragility curves were developed for each type of asset, as shown in the figure.

Earthquake Fragility Functions for Buildings of Major Cities in Bangladesh



Source: Earthquake risk assessment studies by the Comprehensive Disaster Management Programme of Bangladesh – CDMP-I (2009) and CDMP-II (2014).

In the graph, the y-axis refers to acceleration of gravity 9.8 (in meters per second squared or m/s^2), or the strength of the gravitational field, and the x-axis denotes displacement in distance (in inches). When a structure is subjected to force, initially it shows linear displacement proportional to the force applied. However, once the acceleration increases, it slowly passes the yield point, after which the structure shows nonlinear behavior and can have more displacement even when there is little increase in force. Finally, the structure collapses. The curves in the figure particularly show estimated displacement to lightly reinforced concrete frame structures with masonry infill in Dhaka, Chittagong, and Sylhet.

Based on the loss assessments, an analysis of building collapse (slight to extensive) was undertaken for various earthquake scenarios for major cities in Bangladesh. The analysis showed that a significant number of buildings (about 50%) could be damaged as a consequence of moderate to large earthquakes. The assessment identified current building construction practice, existing building patterns, and spatial expansions as the main reasons of the increasing vulnerability in the major cities. The results of the assessments are being used by the Government of Bangladesh and development partners to strengthen earthquake risk reduction in urban areas of the country.

Source: Earthquake risk assessment studies by the Comprehensive Disaster Management Programme of Bangladesh – CDMP-I (2009) and CDMP-II (2014).

Assessments of physical vulnerability can be done empirically or through risk modeling. The main methodologies for physical vulnerability analysis are listed in Table 1.3.

Table 1.3: Methods of Physical Vulnerability Assessment

Type	Method	Description
Empirical methods	Analysis of historical damage(s)	Based on historical damage statistics, relating observed vulnerabilities to specific hazard intensities
	Expert opinion	Based on expert opinion of damage potential for different structural types to specific hazard intensities
	Score assignment(s)	Completion of a questionnaire and/or score sheet to assign score(s) of damage to certain hazard level(s)
Analytical methods	Analytical model(s) for groups of assets	Computer-based models to simulate damage potential of groups of assets according to design characteristics (adobe, masonry, reinforced concrete, etc.) from hazards of varying intensity
	Detailed analytical modeling for individual assets	Modeled behavior of individual structures and their specific design characteristics in the event of hazards of varying intensity

Source: Adapted from C.J. Van Westen, D. Alkema, M.C.J. Damen, N. Kerle, and N.C. Kingma. 2011. *Multi-hazard risk assessment. Distance education course. Guidebook.* United Nations University & ITC School on Geo-Information Management and Lang, 2002, cited in ADB. Forthcoming. *Disaster Risk Assessment Guidance Note for Project Preparation.* Manila.

Analyzing social, economic, and environmental vulnerability requires an understanding of the level of capacity to adapt to, cope with, and recover from a hazard. In general, capacity is contingent upon a range of factors such as landownership; savings, insurance, and contingency reserves; access to adequate food and nutrition; the quality and accessibility of public services; education levels; local knowledge of risk; and governance arrangements. The analysis of vulnerability is typically based on indicators. These indicators can be hazard-specific or cover a range of hazards.

1.3.6 ASSESS DISASTER RISK

While the basic formula used in the disaster risk equation remains unchanged, depending on the types of data collected and methodology adopted, the nature of outputs of the disaster risk assessment will change.

Qualitative vs. quantitative assessments. Qualitative assessments can be undertaken in cases where there are limited data on the frequency and intensity of the hazard; the elements at risk and the type of vulnerability under investigation are difficult to quantify in relation to the hazard; resources are limited; or it is sufficient to have a broad understanding of disaster risk. In such cases, instead of determining absolute values for the probability or scale of expected losses, risk is expressed in relative terms—low, medium, or high. In the context of land use planning, the hazard maps can be superimposed with maps showing the location of population and assets to identify the geographical spread of hazards and to determine where potential (low, medium, or high) damage to assets could occur. This information can provide broad guidance for formulating spatial growth strategies, identifying sites for new area development, or proposing urban redevelopment programs (see Guidance Notes 2, 4, and 5).

However, qualitative assessments have limitations because they cannot provide an indication of the intensity of an event under varying return periods, the performance of different assets in an event, or actual losses. Obtaining this information requires quantitative risk assessments that allow (i) a clearer understanding of the geographical concentration of disaster risk, for different intensities and varying return periods; (ii) quantification of potential physical damage, business interruption, and casualties; and (iii) identification of key risk drivers (by quantifying the risk of specific assets and to see what percentage of the overall loss is contributed by a particular asset).[7]

Deterministic vs. probabilistic assessments. Disaster risk assessments can be *deterministic*, that is, based on the analysis of particular scenarios or events (e.g., the impact of past disasters); or *probabilistic*, which relies on stochastic hazard catalogs over thousands of years to assess the probability of various impact and loss scenarios in a given location.[8] For example, a deterministic risk model may show the impact of flooding that would result from a particular rainfall event (e.g., 1-in-100-year flood), whereas, a probabilistic risk model will allow the impact and likelihood of number of different flood events to be quantified (e.g., 1-in-100, 1-in-250, or 1-in-500-year event) while also accounting for the associated uncertainty. Measuring the likelihood of events means that decision makers are more informed and better able to select appropriate strategies for different scenarios.[9] With improvements in modeling techniques, the use of probabilistic risk assessment is increasing.

Open source vs. proprietary tools for assessments. A wide range of tools are available to undertake disaster risk assessments, such as free open source tools and restricted proprietary tools. For open source tools, models and calculations are developed with inputs from a wide range of specialist stakeholders. They are available to anyone and the analysis is undertaken by the user and/or "co-owner." They allow the user or "co-owner" to be better aware of the science and assumptions behind the model and to detect and correct errors, as required. Moreover, open source tools do not require payment for using the software package. Still, proprietary tools are developed by for-profit organizations that retain ownership of both the model and the results of any application. For a fee, the organization sells a specific analysis to a client. Proprietary tools do not permit the client to update the analysis as new information becomes available without incurring a fee. Moreover, being of black-box nature, it is important that users are fully aware of the assumptions used in the proprietary model and whether the latest scientific information and understanding is reflected in the model.

Participatory approaches for assessments. In undertaking disaster risk assessment, it is important to recognize that different stakeholders perceive risk differently and play different roles in shaping risk. This highlights the importance of adopting a participatory approach, where different stakeholders are involved in identifying information collected for hazards, exposure, and vulnerabilities and through a process of dialogue come to a conclusion about risk. In particular, involving community-based organizations would be very useful because of their familiarity with the location and people. Results of the risk assessment along with the limitations and uncertainties should be communicated in a clear fashion to all stakeholders, allowing them to make informed decisions regarding land use and investments.

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7 N. Pondard and M. Daly. 2011. Natural Hazards Risk Modelling: An Approach Providing Risk Management Solutions for Local Government. *GNS Miscellaneous Series* 38. Lower Hutt, New Zealand: Institute of Geological and Nuclear Sciences Limited. p. 12.

8 ADB. Forthcoming. *Disaster Risk Assessment Guidance Note for Project Preparation.* Manila.

9 PreventionWeb. http://www.preventionweb.net/risk/deterministic-probabilistic-risk (accessed 20 March 2016).

Tiered approach for assessments. Since the cost of undertaking a disaster risk assessment can vary significantly, a tiered approach may be adopted (as shown in Figure 1.3), where tier 1 describes the scope of a simplified assessment and tier 2 describes a detailed assessment. When performing tier 2 assessments and assuming that the data collected are georeferenced, it is possible to build a geographical information system (GIS) framework to analyze and display the information in a spatial manner. The hazard, exposure, and vulnerability information can be represented in a GIS framework and combined to create a risk map. Each element (hazard, exposure, and vulnerability) is in itself built from a range of socioeconomic and biophysical data layers. The framework can include hundreds of GIS layers.

A GIS framework presents a number of advantages, including modularity (new layers can be added to enhance the risk representation of the model); ease of update (e.g., as new census data become available, some of the socioeconomic layers can be updated); and dynamism (the interactions between layers can include complex calculations and weighting factors, and multihazard frameworks can be built). However, such models require significant georeferenced data, appropriate hardware and software, and capability to create the framework and perform the assessment.

Figure 1.3: Tiered Approach to Disaster Risk Assessment

	Hazard	X	Exposure	X	Vulnerability	=	Risk
Tier 1	Coarse assessment based on • community knowledge • national and global database • rule of thumb		Qualitative assessment based on simple assumptions (e.g., altitude or distance to shoreline for coastal flooding)		Qualitative description based on expert judgment and stakeholder feedback		• Qualitative description based on risk scenarios • Maps
Tier 2	Detailed site specific assessment with • long time series of observation data • high resolution hazard maps • numerical and dynamic modeling		Comprehensive exposure assessment with • mapping of individual properties and assets • documented attributes of exposed properties and assets • georeferences		Vulnerability assessment with • socioeconomic data • biophysical data • Building construction data		• Detailed and high-resolution risk information • Probabilistic risk modeling with estimate of losses

Source: Authors.

LAND USE PLANNING FOR REDUCING DISASTER RISK

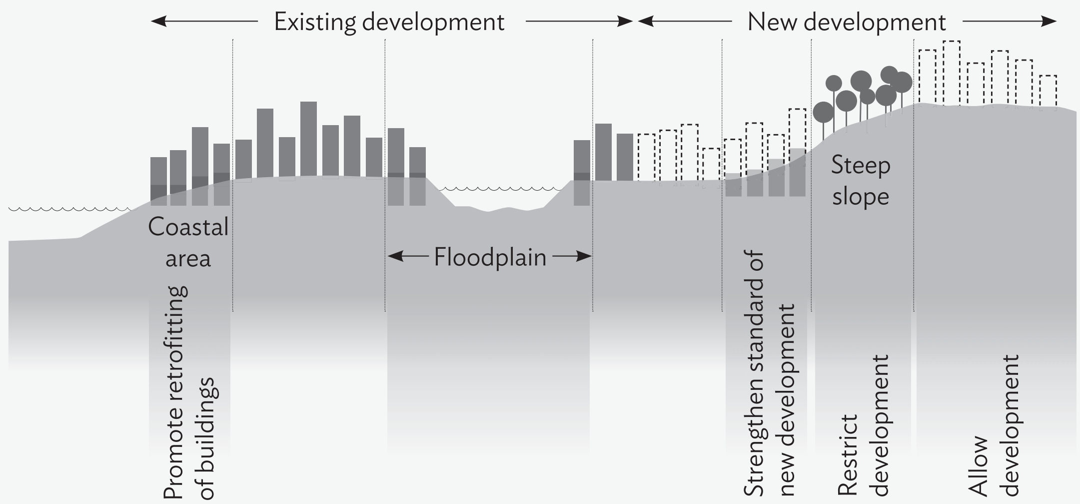
This note provides urban planners with guidance on integrating disaster risk-related considerations in different stages of the land use planning process: situation analysis, visioning, goal setting, land development scenario analysis, and land use policy formulation for cities situated in hazard-prone areas. It will be important for planners to read Guidance Note 1 before reading this note. They are also encouraged to read Case Studies 1–3 presented in Part B of this document to learn how different cities and/or countries are approaching risk-sensitive land use planning.

PHOTO: ADB

KEY MESSAGES

Urban land use plans should incorporate knowledge of the potential effects of disasters caused by hazards, so that most disaster risks in the city can be addressed through measures such as risk-sensitive development/redevelopment policies, development control instruments and disaster risk reduction-related public investments. Figure 2.1 shows examples of risk-sensitive policies that can be proposed in a land use plan. Implementing such measures by the government will create confidence among investors and citizens and encourage similar risk-informed private investments, thereby enhancing the overall resilience of the city.

Figure 2.1: Risk-Sensitive Policies Proposed in a Land Use Plan



Source: Authors.

KEY ACTIONS

For the successful integration of disaster risk considerations into land use planning:

- **Collaborate with hazard scientists, civil engineers, economists, researchers, emergency management staff and communities at risk** to identify hazards and understand how disaster risk changes with urbanization and climate change.

- **Use disaster risk information.** This includes the locational and temporal nature of risks from hazards in every stage of the land use plan formulation: situation analysis, visioning and goal setting, land development scenario analysis, and land use policy formulation.

- **Recommend policies that restrict new development in high-risk and environmentally sensitive areas.** For existing developments in hazard-prone areas, land use policies should encourage investments and development control regulations to strengthen disaster risk management, through practices such as retrofitting critical facilities and high-occupancy buildings, redevelopment, and the establishment and enforcement of appropriate building codes.

- **Communicate information on disaster risk to all stakeholders**—elected and appointed officials, government staff, civil society organizations, and the business community—to develop consensus on how current and future disaster risk will impact the city's vision and strategic development priorities, and what type of policies, investments (including investments for emergency management), and practices are required to reduce those risks.

LIKELY CHALLENGES

Given the lack of available data, one of the challenges may be to **gather information** on hazards, including likely altered patterns as a consequence of climate change; **collect data** on vulnerability and exposure of assets; and **estimate costs and benefits** of disaster risk reduction-related investments.

Building consensus among stakeholders and, in particular, gaining the support of decision makers to adopt land use policies and investments targeted at reducing disaster risk may prove difficult, because these policies may place additional economic and regulatory requirements on interest groups such as land developers and property owners and, in some instances, reduce the value of their land and assets.

2.1 INTRODUCTION

Almost all cities in Asia engage in some form of land use planning process. This is usually guided by relevant national legislation, and the output typically results in a land use plan that provides a framework to guide the future growth and development of the urban area over a time frame of usually 10–20 years.

Land use planning provides the potential to reduce disaster risks for the following reasons:

- The spatial nature of land use plans allows a demonstration of the locational constraints posed by hazards on existing and future developments of a city. This information can be used to build consensus among stakeholders around the need to address disaster risks through appropriate land use policies and investments.

- By proposing growth strategies, land use plans can encourage settlements and infrastructure investments. Once such investments take place, it is almost impossible (and expensive) to remove such investments. If such investments are located in hazard-prone areas or do not follow hazard-resilient standards, the risks are likely to persist.

- An integrated approach for land use planning is helpful for reducing disaster risk of infrastructure systems, such as water-related infrastructure, which comprises different components and potentially crosses diverse geologic areas. Damage in one part of the system due to a disaster may interrupt the performance of the entire system. For example, damage to a water transmission line in an earthquake can disrupt the operation of the entire system, even if the treatment plant and storage reservoir remain intact and functional. Land use planning helps to facilitate an understanding of the linkages between different infrastructure facilities and their various components and how failure in one component can affect the performance of others.

- The long-term outlook of land use plans (usually 10–20 years) provides an opportunity to factor in longer-term risk considerations, such as threats from changing hazard patterns due to climate change. This is particularly important to protect critical infrastructure and public utilities, which typically have a longer design life, usually at least over 50 years. The long design life also requires taking into consideration high-intensity/low-frequency events, such as 100-year floods, as there is an increased likelihood of a large event occurring during the useful life of the asset.

2.2 GETTING STARTED

In order to integrate disaster risk considerations into land use planning:

- **Gain consent of the city leader.** As a first step, it will be important to gain the consent of the city leader (mayor, city manager, city council head, or other type of local government leader) or of other higher authorities in the government to factor disaster risk considerations into the land use planning process. This is important for two reasons: (i) factoring disaster risk considerations into land use plans requires additional costs for collecting information on hazards, vulnerability, and exposure; for seeking inputs of disaster risk assessment specialists; for undertaking consultations with stakeholders; and, where needed, for undertaking a cost–benefit analysis of disaster risk reduction measures proposed as part of land use policy; and (ii) adopting measures to reduce disaster risk as part of urban land use planning may place additional economic or regulatory requirements or infringements on, or in some cases penalize, particular interest groups, such as property owners and land developers. The city leader needs to be informed of all the relevant issues pertaining to factoring in disaster risk considerations, both for and against, so that informed decisions can be made and the provision of financial and regulatory resources can be allocated.

- **Gather hazard information.** Adequate hazard information is critical for integrating disaster risk considerations into the land use planning process. Hazard information can be collected from available multihazard maps, preferably illustrating the intensity and frequency of hazards. Discussions with local academic and research institutes, scientists, libraries, and the private sector can assist in identifying what data are available and can help provide explanations and briefings. Other local and national government departments are likely to also have relevant data and can help in information outreach activities. If formal hazard maps are not available, obtaining local knowledge about land conditions and historical hazard events from local communities, businesses, and developers will take on greater importance. Facilitating discussions between the scientific and local communities will be important to validate available information based on best evidence and collective judgment (see Guidance Note 1).

- **Collect information on vulnerability and exposure.** Information about underlying factors contributing to the vulnerability and exposure of assets located in hazard-prone area is important. With advancements in open source mapping, communities can be engaged to collect such information. Reports on the impacts of past disasters in the area can help identify the root causes of vulnerability. Discussions with local research institutes, libraries, and newspapers can assist in identifying information. These and other specialists, such as social and health services, can help with explanations (see Guidance Note 1).

- **Compile data on climate projections.** Understanding likely changing hazard patterns from climate change will be important as this will have implications on decisions related to spatial growth strategy and the location and design of infrastructure. Discussions with local and national research institutes and scientists can assist in identifying what data are available and can help with information outreach activities. At this stage, spatial refinement in data is not an absolute must; it is more important to raise awareness among decision makers and to factor available information into policies related to the future growth of the area.

- **Engage with a wide range of stakeholders.** In view of the uncertainties related to hazards and their consequences, information gaps, and the need to build consensus, it is crucial to engage closely with elected and appointed officials, specialist technical groups (e.g., hazard scientists, emergency managers, engineers, and economists), and members of the community to identify hazards and determine perception of risks; as well as with government staff, utility infrastructure providers, civil society organizations, and the business community to develop a consensus on how the current and future challenges related to disaster risk will shape the city's vision and the policies and investments required to reduce the risk.

- **Raise awareness among stakeholders on disaster risk.** It is important that all stakeholders involved in the urban planning process understand how the interaction of known hazards and current and future development actions within and beyond the city's jurisdiction will shape future levels of disaster risk, and how a hazard event can have different effects on different economic sectors and populations. This understanding will support the formulation of a risk-informed city vision, goals, and land use policies. It will also help resolve disputes that may arise with the disclosure of hazard information. Eliciting the assistance of local research institutes and scientists, and other technical specialists within local government (e.g., emergency planners, engineers, and social and health services) will help provide credibility and depth to issues that need to be discussed and resolved.

2.3 ACTIONS TO INTEGRATE DISASTER RISK CONSIDERATIONS IN URBAN LAND USE PLANS

An urban land use plan formulation process typically includes the following stages: (i) a situation analysis, (ii) an articulation of the city's vision and goals, (iii) a land suitability analysis to consider different growth scenarios, and (iv) identification and formulation of policies to guide the desired pattern of growth and development. Disaster risk considerations should guide every stage of this process as shown in Figure 2.2.

Figure 2.2: Integrating Disaster Risk Considerations in the Land Use Plan Formulation Process

Land Use Plan Formulation Stages	Actions to integrate disaster risk considerations	Outcome
Situation Analysis	Identify hazards and environmental resources Identify underlying factors contributing to vulnerability from hazards	A situation analysis report presents an objective statement on how hazards will impact projected demands for land, housing, infrastructure, transportation, employment, and waste management and what the key causal factors are (covering physical, social, economic conditions).
Visioning and Goal Setting	Raise awareness and initiate dialogue among stakeholders on the future performance of the city in the context of changing disaster risks. Formulate risk-informed goals and, where relevant, develop explicit land use goals aiming at reducing disaster risk	Vision statement and goals informed by disaster risk considerations.
Land Development Scenario Analysis	Examine the implications (within geographical and time frames) of disaster risk on proposed land use scenarios Highlight areas at risk and develop policy measures to ensure that all occupancy types can be safely undertaken.	Maps developed for various growth scenarios show development constraints posed by disaster risks.
Land Use Policy Formulation	Promote policy measures that support disaster-risk-sensitive growth by (i) protecting hazard-prone and environmentally sensitive areas; (ii) reducing disaster risk in development that has already encroached onto hazard-prone areas, and factoring in future alternative land use options; and (iii) promoting development in areas not prone to hazards, through regulations and incentives.	Land use policy statements factor in disaster risk considerations.

Source: Authors.

2.3.1 SITUATION ANALYSIS

This component provides a statement of current land usage as well key information about likely future occupancy and city expansion rates. Key components are (i) the analysis of existing demographic indicators and past growth trends, past and current land use, natural features, and resources within the city jurisdiction and in the wider urban catchment; (ii) the identification of key problems and issues faced by the urban area; and (iii) population, social, and economic projections.

In order to understand the issues posed by disasters on the development of the area, consider the following:

- **Location of hazards and the population, area, and infrastructure that can be affected by a potential hazard event.** For example, in the case of a landslide-prone area, identifying potential unstable slopes and the area likely to be affected by landslide debris is important. This will provide an understanding of current and future elements at risk. Similar analyses should be undertaken for infrastructure, as described in Box 2.1 for the case of water-related infrastructure. It will

Box 2.1 Understanding Disaster Risk of Water-Related Infrastructure

In the case of water-related infrastructure, disaster risk is a factor of location; the physical characteristics of the system; its age, operation, and maintenance; and its linkages with other infrastructure. As part of understanding disaster risk of water-related infrastructure, the following will be important:

- Identify the hazards such as fault lines, landslides, or floods which can impact water-related infrastructure and the physical vulnerability of different elements of water infrastructure.
- Recognize that climate change may have potential impacts on water-related infrastructure. For example, the increase in the intensity of floods may result in the contamination of water sources and may increase the incidence of waterborne and water-related diseases; and service disruptions may increase due to breakdowns in water distribution pipelines from extreme events, such as unseasonal precipitation patterns and flash floods.
- Understand the systemic nature of water-related infrastructure. Water-related infrastructure components are interdependent on other infrastructure networks (energy, transport, health, etc.), and it is important to understand how all the infrastructure systems interact.
- Identify backbone elements of water sector infrastructure. This will allow identifying the critical elements needed to provide water-related services and to strengthen those elements with the goal of reducing the potential damage. For example, in the case of water supply, valves are an essential component of the backbone infrastructure, allowing the backbone system to be isolated from damaged parts of the system and minimizing water loss. In the case of wastewater, it is essential that the sanitary sewers are separate from stormwater drains, because if they are shared or cross-connected, there is a risk that the excess flow would damage the treatment plant in a heavy storm. So too, in the case of stormwater, the backbone system consists of the infrastructure needed to store and move stormwater, such as detention and pumping stations.

Typically, the water utility company will be involved in undertaking such disaster risk assessments. However, it will be crucial for urban planners to engage in the assessment process as well, especially because (i) the expected growth in population and new development activity in the urban area could have an impact on the vulnerability of existing water-related infrastructure (e.g., greater usage will require greater maintenance, which, if not met, will increase vulnerability) and its capacity to withstand disaster events, and thus the water specialists may need the support of urban planners in developing demand forecasts; and (ii) in many cases, urban development activities may have an impact on the quality of surface and groundwater, which will further increase the vulnerability of the sector (e.g., urban development, which increases areas with impervious surface, may result in increased stormwater runoff, which when flowing will pick up potential pollutants, such as sediments, nutrients, petroleum by-products, and so on, and dispose them in water sources). However, such engagement of urban planners with water utility companies may require facilitation and top–down directives, especially when the departments and/or companies looking after the two functions are not under the same institutional umbrella.

If sector-specific assessments are not available, it will be important to refer to other disaster risk assessments that may be available for the urban area to help understand the risk posed by hazards to the water sector.

Source: Authors.

be important to remember that (i) the location of the hazard can be outside the jurisdiction of the city, but its impact may be felt on the city and hence may require a regional planning lens; and (ii) the way hazards have interacted with urban development in the past may not be the same in the future due to the changing intensity and frequency of climate change and the urban development process which might have encroached on, for example, earthquake faults. Discussions with hazard specialists and climate change experts, as well as the collation of hazard maps, will help to secure this information.

- Location of environmental resources and sensitive areas, such as wetlands, coastal ecosystems, and natural water and drainage systems, which help regulate and reduce hazard exposure. Discussions with environmental specialists and hydrologists will help identify such resources.

- Factors contributing to the exposure and vulnerability of a community, such as the proximity of properties and critical infrastructure to fault lines, liquefaction zones, floodways, and unstable hills; and construction and maintenance practices. Documents on the impacts of past large-scale disasters and recurrent hazards on different sectors (the poor, the business sector, etc.), as well as the broader macroeconomic impact of these events had on the city (effects on output, investor confidence, etc.) will help identify the underlying factors that contribute to hazard vulnerability.

Based on this information, the risk posed by hazards on the development suitability of the area and infrastructure can be analyzed: how the hazards will interact with future projected household and business sector demands for land, housing, infrastructure, transportation, employment, recreation, and waste management. The outcome of the situation analysis should identify the disaster risk. For example, in a city with high earthquake risk, a map showing the city's development constraints should include information on fault rupture zones, liquefaction areas, and landslide-prone slopes; and the accompanying description should explain how the hazard characteristics of the city will interact with future urban development, for instance how new construction on hills or the location of underground water and wastewater pipes, if broken, may induce slope failure.

2.3.2 VISIONING AND GOAL SETTING

"Visioning is the process of developing consensus among stakeholders on what the strategic development priorities of the city are within a defined timeframe, and to help stakeholders align their priorities and investments accordingly."[1] It (i) articulates the guiding principles on which the city will base decisions that will shape key issues such as the size, composition, and look of the city, the focus of its economic and cultural activities, and its quality of life today and in the years to come; (ii) provides a framework within which decision makers and planners can set priorities; and (iii) guides the development of the goals that the land use plan should aim to achieve over its period of implementation.

In order to ensure the visioning exercise factors in discussions about how existing and future disaster risks can adversely affect the realization of a city's vision, and how to efficiently reduce those risks, the following will be important:

- Highlight the disaster risk-related development constraints identified in the situation analysis (refer to section 2.3.1) and take stakeholders through the choices they have (as well as articulating the downsides each choice has). A useful approach is to illustrate how past developments have

1 S.C. Sandhu and R.N. Singru. 2014. Enabling GrEEEn Cities: An Operational Framework for Integrated Urban Development in Southeast Asia. *ADB Southeast Asia Working Paper Series* No. 9. Manila.

either created or exacerbated risk through inappropriate planning, development, or redevelopment decisions, and what risk reduction alternatives could have been achieved instead. This exercise can be conducted as a "hazards road show"—taking key stakeholders on a coach trip of the city to look at high-risk sites and discuss who and/or what is at risk, what the underlying factors that have created the risk are, and what risk reduction options could be deployed. Such an exercise is useful to reinforce the message that decisions made in the past and the ones made in the future regarding the location and type of construction of property and assets will, in large part, determine the level of disaster risk a city faces. It is also important to understand that the wider socioeconomic and political contexts also shape risk. For example, lack of access to well-located affordable land for the urban poor means that they settle in highly exposed areas that can be acquired more cheaply. Risk-sensitive visioning does not always imply that the vision statement has to explicitly include disaster-related considerations or that there should be a stand-alone citywide agenda for disaster risk, although these are preferable for high-risk cities. Nonetheless, city visioning needs a risk sensitivity component if long-term growth expectations are to be realistic. More importantly, risk-sensitive city visioning highlights the need for a collective understanding of how current and future challenges related to disaster risk will impact the strategic development priorities of a city.

- If disaster risk is identified as a potential development constraint, formulate an explicit land use goal designed to reduce disaster risk. The goal can focus on a number, or a combination, of risk reduction targets, such as reducing loss of life and property damage; reducing economic and social disruption; ensuring adherence of land use zoning requirements; updating and applying building codes in all types of new construction; ensuring the continuity of critical infrastructure and services; and raising awareness of communities on disaster risk management. While an explicit disaster risk-related goal may or may not translate into investments and development control mechanisms, it can unquestionably improve community awareness on disaster risk.

- Ensure that other land use goals (e.g., developing specific economic potential for the city, preserving historic and cultural resources, defining the future boundaries of growth in a manner that preserves the community characteristics of the city, etc.) recognize the linkages with disaster risk and do not unwittingly increase existing levels of risk. It will be important to adopt a systems approach to better understand the interlinkages between sectors such as water and energy or energy and transport, and how goals to address disaster risk in one sector can support or exacerbate risk in other sectors.

2.3.3 LAND DEVELOPMENT SCENARIO PLANNING

The purpose of land development scenario planning is to understand how particular land use policies and regulations can potentially affect a specific site when implemented. The scenarios analyze various forces—economic, social, physical infrastructure, and environmental—that affect land use and allow stakeholders to generate and evaluate alternative future land use patterns.

Factoring disaster risk considerations in land development scenario planning will help answer the following questions and guide formulation of relevant land use policies:

- What are the hazards present in and around the city, including areas where rapid urban land conversion is taking place?

- Is there a noticeable shift in the pattern of climate-related hazards in the area? For example, is there more/less rainfall, greater/lesser river flow, a difference in tidal variations, variation in agricultural output, or a higher incidence of skin and bronchial irritations? What is the impact on the urban population, assets, and the economy?

- Which land uses (e.g., residential, commercial, and mixed occupancy) are growing the fastest? What has been the typical impact of past disasters on such land uses and why?
- Where are the informal settlements currently located in relation to known hazard areas (e.g., alongside flood-prone waterways, close to fault lines, or on active volcanic slopes)? How could their location change over time? And what measures can be included in future urban growth plans and future changes in land use to relocate these settlements to safer sites?
- Will proposed infrastructure development, urban redevelopment, and new area development reduce or exacerbate the disaster risk profile of the area?
- What options might be available to minimize the implementation costs of new planning standards and building codes that integrate disaster risk considerations, and/or to incentivize developers and owners to adopt the new standards and codes?

In land development scenarios that provide maps of locations and characteristics for desired growth as well as areas in which growth is not desired, an important entry point exists to factor in disaster risk information by doing the following:

- Examining the implications (spatial and temporal) of proposed land use scenarios (e.g., densifying existing built-up area or developing satellite towns, or a combination thereof) on the level of disaster risk of the people, settlement, and infrastructure. For example, densification may create pressure on existing vulnerable building stock and might require a retrofitting program. Likewise, expansion of the urban growth boundary into hazard-prone areas will encourage investments that will increase the city's overall disaster risk exposure. Box 2.2 describes possible implications of land use policies on water-related infrastructure.
- Highlighting land use options for high-risk areas, including upgrading of infrastructure or better infrastructure maintenance. Identifying land where the low-income population can settle in future, rather than continued growth in exposed areas.

2.3.4 LAND USE POLICIES

Land use plans with disaster risk reduction components consist of a package of policy measures to implement agreed goals and guide public and private investments that promote disaster-risk-sensitive growth:

- protecting hazard-prone and environmentally sensitive areas through regulations and incentives, and managing development activities that can escalate risks (e.g., filling in wetlands that serve as natural flood management areas; logging upstream forested areas, which can lead to increased runoff and flooding in downstream urban areas; filling in natural drainage channels, which can increase risk of flooding; or building roads in catchment areas, which can in effect become drainage barriers during storm events and increase the risk of flooding);
- reducing disaster risk in development that has already expanded in hazard-prone areas, through regulations that restrict the type, density, and design of existing development, and policies that encourage investments in risk reduction measures; and
- promoting development in areas not prone to hazards, through regulations and incentives.

Box 2.2 **Possible Implications of Land Use Scenarios on Disaster Resilience of Water-Related Infrastructure**

It will be important to understand the implications of the proposed land use scenario on disaster resilience of water-related infrastructure and accordingly recommend policies to reduce the risk:

- The factors that contribute to the siting of water supply and wastewater-related infrastructure include the location of water sources, location of customers, hydraulics of the area, and land availability. While some of these factors are fixed, the extent and location of the area to be served by the water-related infrastructure (the system end points of the infrastructure) are delineated by spatial growth policies adopted by the land use plan. For example, spatial policies targeted at expanding the urban boundary to accommodate future growth will require new land and should factor hazard considerations in the selection of this land and locating of water-related infrastructure. Spatial policies to increase the density of the existing urban area need to plan for an increase in existing water-related infrastructure capacity and at the same time recognize the potential of urban flooding due to increases in impervious surfaces. Spatial growth policies formulated during the land use planning process should ensure growth occurs in locations that best protect water resources and where water infrastructure is robust enough to support growth.
- For land use scenarios aiming to expand the urban boundary, water sources should be selected taking into account the potential impact of climate change on the water system. This is critical from a disaster risk reduction perspective. Surface water often represents the largest and most convenient source of water, which includes rivers, natural lakes, and ponds (including associated intakes) and human-made reservoirs (e.g., dams). Groundwater provides a complementary source of water with natural storage. During source selection, while it is normal to project future water supply demand for the next 10–20 years against total population—and urban planners can be of great support in demand forecasting—it is also important to use climate scenario information to understand the potential impact of climate change on water supply and demand. For example, with increases in precipitation, groundwater levels may rise, thereby decreasing the efficiency of the natural purification process. With potentially more intense wet and dry seasons, it may become necessary to store the excess water collected during the wet season for it to be available during a longer, warmer dry season. While water specialists will lead decisions around these issues, it is important for urban planners to remain engaged since these decisions in many cases are closely related to land use management issues and require land use policy measures to support their implementation.
- Urban planners should work with water specialists to determine land use implications of utilizing stormwater as a resource. Cities have large areas of land covered by hard, impervious surfaces, such as bitumen, concrete, and buildings. This results in increased amounts of stormwater runoff during rains and storms, both in terms of volume and velocity. The traditional response to managing stormwater runoff has been to convey the stormwater away from the urban area through drainage channels and concrete stormwater networks. The current focus of stormwater management is to recognize this water as a resource that can be used to supplement the existing water supply. Land use planning can support this by reserving land areas to retain stormwater (e.g., through constructed wetlands). Green infrastructure facilities include porous pavements for parking lots, driveways, and sidewalks, as well as green parks with flood-tolerant plants.

Source: Authors.

Different ways in which disaster risk reduction measures could be formulated include:

- **Promoting risk-sensitive planning.** Identify hazard locations and (i) promote development in areas with lower hazard exposure, and (ii) restrict development in high-risk and environmentally sensitive areas. Guide development in a manner that properly accounts for hazards, including designating no-build zones, enabling access to safe land, allowing only planned development in new areas as outlined in the master plan, developing zoning incentives to encourage development in ways that will not increase risk exposure, and enforcing strict regulations for incremental development. Box 2.3 discusses possible incentives that could be provided to reduce disaster risk in the context of urban land use management.

- **Promoting disaster risk awareness.** Implement programs to raise community awareness on hazard likelihood and existing socioeconomic vulnerability, such as how improper building construction contributes to disaster risk; disseminate the results of disaster risk assessments (e.g., in disaster risk maps which show where it is unsafe to build) and demonstrate how they can be used in decision making; and strengthen understanding of the importance of following development controls, such as limiting building heights, types, and densities for reducing disaster risk.

Box 2.3 **Incentives for Disaster Risk Reduction in the Context of Urban Land Use Management**

Incentives typically operate on the principle that actions that exceed the minimum level of compliance—or "business as usual"—are rewarded with a bonus, which may increase as the level of performance improves. The promise of the bonus, or reward, provides an incentive to act. Depending on the context, the bonus may be awarded before or after the action has been taken. However, in environments in which the basic level of compliance is not the norm, stakeholders may require the reward to enable them to act.

In the context of reducing disaster risk through land use management, incentives can be provided to encourage or motivate stakeholders—local governments, businesses, and households—to take action to reduce exposure and vulnerability to natural hazards. Incentives typically fall into one of two categories: financial incentives and nonfinancial incentives.

Nonfinancial incentives offer a nonmonetary reward for a change in behavior or practice and/or improved performance. Nonfinancial incentives and their potential rewards may include

- urban planning initiatives
  - incentives zoning to avoid hazard-prone areas resulting in a density bonus
  - transfer of development rights from hazard-prone areas resulting in a permit to build a higher-density development
  - conservation easements over hazard-prone areas resulting in reduced risk for adjacent developments
  - disclosure laws resulting in access to disaster risk information, thereby encouraging risk-informed decision making
- urban development initiatives
  - resettlement *resulting in* access to secure land tenure in less exposed locations, thereby reducing vulnerability
  - access to code-compliant building and infrastructure designs *resulting in* disaster-resilient development
  - free advice on design and construction and/or retrofitting of housing in hazard-prone areas *resulting in* disaster-resilient housing
  - free or low-cost building materials and tools *resulting in* compliance with building codes
- technical capability and capacity
  - provision of guidance and/or training on the preparation of risk-sensitive land use plans, policies, and procedures *resulting in* risk-sensitive urban development
  - training of tradespeople in disaster-resilient construction *resulting in* access to knowledge and access to construction opportunities
  - competency-based assessment and registration *resulting in* access to skilled and knowledgeable engineers
- access to technology
  - technology transfer *resulting in* access to new, locally appropriate disaster-resilient technology
- access to information
  - access to reliable and credible information about current and future risks *resulting in* informed risk-sensitive decision making
- certification by an internationally recognized organization and/or endorsement of good practice
  - recognition for expertise in good risk reduction practice *resulting in* access to credit, concessional loans, and/or assistance program
  - awareness building *resulting in* informed decision making
- participation by urban stakeholders in decision making
  - participation in decision making *resulting in* the potential to favorably influence disaster-resilient development

Financial incentives offer a monetary reward for a change in behavior, practice, and/or improved performance. Examples of financial incentives to reduce disaster risk in the context of urban land use management include (i) grants—intergovernmental, or government to person or company; (ii) personal or company tax credits; (iii) personal or company tax rebates; (iv) subsidies; (v) access to concessional loans or credit; and (vi) rebates on fees for development approvals and services.

Source: ADB. 2016. *Incentives for Disaster Risk Reduction: Experiences from Da Nang, Viet Nam; Kathmandu Valley, Nepal; and Naga City, the Philippines.* Manila.

- **Investing in structural and nonstructural risk reduction measures.** Depending on the level of disaster risk, promote investments in large protective infrastructure such as flood embankments or reinforcement of landslide-prone slopes. Decisions for such investments require in-depth cost–benefit analysis; understanding their impact on the surrounding land and population, especially poor residents; and the need to combine them with nonstructural interventions such as ecosystem-based measures and early warning systems.

- **Strengthening the application of and compliance with building codes for new construction.** Propose local amendments to the national building code that can specifically address local hazard conditions; incentivize developers and owners to comply with code requirements; and strengthen building inspection (especially to assess and reduce the vulnerability of important high-occupancy buildings such as hospitals and schools).

- **Ensuring the design of critical infrastructure factors in disaster risk considerations.** Initiate a program to identify critical facilities, assess their vulnerability, prioritize investments to increase their robustness, introduce redundancies where needed, and strengthen their emergency preparedness.

- **Reducing disaster risk in informal settlements.** Upgrade in situ services and structures, and promoting emergency preparedness among communities living in high-risk areas; and encourage future development in safer places, by making affordable services land available.

- **Promoting the retrofitting of high-occupancy buildings and critical facilities.** Develop appropriate legislative, institutional, and financial systems to encourage the retrofitting of high-occupancy building and properties in high-risk areas; require retrofitting of buildings when alternations are made from the approved building plans; and incentivize property owners to undertake retrofitting, etc.

The successful implementation of disaster risk reduction measures will depend on a combination of factors, including robust consultation with all relevant stakeholders, the political acceptability of the measures within various interest groups, the accountability of all relevant stakeholders, the cost of implementation, operation and maintenance, and capacity for execution. These issues should be part of the stakeholder discussions during the visioning and goal-setting phase, but they will likely need to be revisited as more information becomes available. For example, the cost of implementing measures to strengthen the application and compliance of building codes includes undertaking a disaster risk assessment to assess the risk characteristics; updating the building code to address the local hazards; strengthening capacity of municipal engineers and/or building inspectors involved in the approval of building permits and making them accountable for building approvals; building the capacity of stakeholders involved in the construction sector to follow the specifications recommended in the building code; and developing financial and/or nonfinancial incentives to motivate private developers and homeowners to comply with the requirements of the building code. Different agencies may be involved in different elements of this work, and they may need to seek budgets and approvals for these activities independently as the details are developed.

Moreover, with the uncertainties relating to possible change in intensity and frequency of climate-related hazards, it may be difficult at times to adopt a predetermined approach to select disaster risk reduction measures and may require considerable judgment on the part of decision makers, as well as the adoption of no- or low-regret measures that deliver wider economic, social, and other environmental benefits in the immediate term and are flexible enough to accommodate possible changes in hazard frequency and intensity. For example, even in the absence of data showing an increase in flooding in the city due to climate change, increased investments such as for periodic maintenance of drainage channels will have wider health- and environment-related benefits.

DEVELOPMENT CONTROL AS A DEVICE FOR REDUCING DISASTER RISK

3

GUIDANCE NOTE

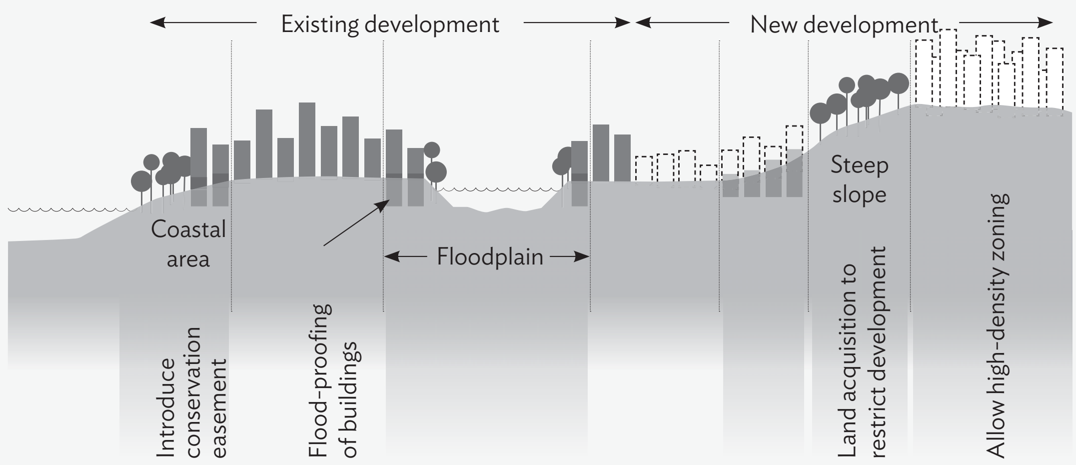
This note provides guidance to urban planners on how disaster risk-related considerations factoring in development control instruments can help reduce or at least contain disaster risk in urban areas. The note focuses on commonly used development control instruments in Asian cities, such as zoning, land subdivision, and building control. It is recommended that planners read Guidance Note 1 before undertaking actions suggested in this note. They are also encouraged to read Case Studies 1 and 3 presented in Part B of this document to learn how different countries are using development control instruments such as zoning and building codes to reduce disaster risk.

PHOTO: ADB

KEY MESSAGES

Hazard considerations should be factored into the design and implementation of development control instruments, such as zoning, land subdivision, and building control. This will help reduce vulnerability and limit the exposure of development to hazards by controlling their location, density, and design characteristics as illustrated in Figure 3.1.

Figure 3.1: Use of Development Control Instruments to Reduce Disaster Risk



Source: Authors.

KEY ACTIONS

For integrating disaster risk considerations into development control instruments:

- Work closely with engineers, scientists, and hazard specialists to factor in hazard-related information during the design phase of development control instruments. For example, indicate hazard-prone areas in zoning maps, factor hazards into the calculation of permissible density, and include locally relevant hazard-resilient design specifications in building codes.

- Understand how patterns of urban development influence the local land market and what the short- and long-term implications of disaster risk reduction regulatory decisions will be, especially on informal settlement areas where the poor and most vulnerable reside. These patterns include, among others, location of development zones, land subdivisions, land and housing prices, rents, and infrastructure development.

- Understand the linkage between disaster risk and the relevant legislation in order to ensure that legal instruments appropriate to the context are applied consistently and comprehensively to address disaster risk. Urban development control is typically enabled through various pieces of legislation (e.g., laws related to town and country planning, land, environment, and public health).

LIKELY CHALLENGES

Lack of hazard information (at an appropriate scale) and **outdated records** on land use and/or cover, tenure and/or ownership, and land valuation will affect the design of risk-sensitive development control instruments.

The implementation of development controls is affected by **political dynamics** since there are costs involved, can be administratively complex, and might provoke resistance from interest groups such as private developers. Being sensitive to the political dimension will help the planner establish credibility and will help to smooth the acceptance of development control instruments that can reduce disaster risk.

Use of development control instruments for the large-scale prohibition of development in hazard-prone areas may be a challenge in the face of **land scarcity and market pressures**. One solution could be to combine the objective of reducing disaster risk with other development objectives, such as using hazard-prone sites to locate public recreational facilities.

3.1 INTRODUCTION

Development control instruments support the implementation of land use policies, especially policies that require binding rules and are aimed at protecting public interest measures, such as health, safety, social equity, environmental quality, and energy efficiency. Development control instruments commonly used in the urban areas of Asian countries include zoning, land subdivision, land acquisition, and building control.

The primary purpose of development control instruments is to regulate the location, density, layout, and design of permitted development. However, if ignored, these factors can also potentially increase disaster risk by increasing the vulnerability of citizens and the exposure of assets to hazards. Conversely, if development control instruments have hazard considerations factored into their design and implementation, they can contribute substantially to reducing or at least containing urban disaster risk. For example, through land acquisition, the full bundle of development rights of a hazard-prone area can be purchased, development restricted, and the area converted into public parks. Similarly, the development rights for hazard-prone areas can be transferred to rights for less hazard-prone areas, with commensurate compensation to landowners where necessary, for instance in the form of higher density allowances for less hazard-prone areas.

3.2 GETTING STARTED

In order to integrate disaster risk considerations into development control instruments:

- **Understand the governance system.** The effective application of development control instruments requires information on landownership; efficient systems for processing and approving building permits; coordination regarding the roles and responsibilities of agencies involved in all aspects of development control; management of the interests of stakeholders (land and property owners, developers, building inspectors, and decision makers); human and financial resources; and regular review and revision of laws, policies, and standards. In order to integrate disaster risk considerations, it is important to understand the strength and weaknesses of the governance system and identify the key stakeholders.

- **Collect disaster risk information.** Disaster risk assessment is an important requirement to ensure disaster risk considerations are factored into development control-related regulations. However, the associated disaster risk maps must be prepared at a scale consistent with planning decisions and statutory plans, and they must provide suitable interpretive information so they can be clearly understood by all planning professionals, decision makers, and the public (see Guidance Note 1).

- **Build consensus among stakeholders.** Factoring disaster risk considerations into development control instruments may result in enforcing development restrictions, thereby impacting certain groups of stakeholders such as private developers. Thus, dialogue with the stakeholders and gaining consensus by explaining the long-term importance of such regulations will be essential. Equally important will be to understand the types of incentives and support required by the developers to facilitate the implementation of the regulations (e.g., preparation of coastal inundation maps to support decision making related to buffer zones in consultation with tourism sector stakeholders).

3.3 ACTIONS TO INTEGRATE DISASTER RISK CONSIDERATIONS IN DEVELOPMENT CONTROL INSTRUMENTS

Disaster risk considerations can be factored into the design and implementation of development control instruments as summarized in Figure 3.2 and discussed in detail in the case of commonly used instruments such as zoning, land subdivision, and building control.

Figure 3.2: Integrating Disaster Risk Considerations into Development Control

Development Control Instruments	Actions to integrate disaster risk considerations	Outcome
Zoning	Indicate hazard-prone areas in zoning maps	Zoning ordinances clearly integrate hazard information (along with hazard maps) and requires specific standards to be followed for development in hazard-prone areas.
	Factor hazard information into density calculations	
	Introduce set-backs or buffers in hazard-prone areas	Specific zoning instruments, such as setbacks adopted for high-risk areas.
Land Subdivision	Identify land that is prone to hazards and land use activities that can exacerbate existing levels of risks.	Land parcels and associated development are safe from risks from hazards.
	Require hazard-related studies (e.g., geotechnical studies in seismic-prone areas, hydrology and hydraulic studies for floodprone areas) and disclosure of study findings as well as integrating hazard resilient standards in the design of utilities.	
	Introduce covenants as part of the requirement for obtaining development permits.	
Land Acquisition	Identify high hazard-prone areas, publically acquire land (where feasible) and restrict development	Development in hazard-prone area restricted/limited
Purchase or Transfer of Development Rights	Identify hazard-prone areas and either purchase or transfer the right to development from these areas to less hazardous areas.	Development in hazard-prone area restricted/limited
Building Control	Integrate locally relevant hazard-resilient design standards into building codes and enforce implementation.	Culture of compliance strengthened where all stakeholders are knowledgeable about the current and future risks from hazards and how such risks interact with building location and construction practices.
	Provide specifications for retrofitting of buildings in high-risk areas.	
	Build the capacity of the private sector to identify and initiate hazard-resilient design and construction measures.	

Source: Authors.

3.3.1 ZONING

Zoning is a common regulatory tool for controlling the type of land use permitted in a specific area (e.g., residential, commercial, industrial, and mixed), through which limitations can be imposed on the physical characteristics of a property being developed, such as density, height, and lot coverage. Zoning ordinances typically contain a zoning map showing the boundaries of a designated zone, and the regulation detailing the permitted uses, standards, and requirements for each zone.

Zoning can be an effective tool to regulate development in hazard-prone areas and thereby reduce the exposure of people and property to hazards. For example, on unstable slopes, development can be restricted and the area zoned for open green space for public use. In areas with flood risk, zoning can require the ground floors of new buildings to be built above the base flood elevation to avoid future flood damage, and further through incentives that encourage homeowners to include a freeboard (elevate a building's lowest floor above the base flood elevation) in anticipation of a future change in flood characteristics.

In order to use zoning tools to reduce disaster risk, consider the following:

- Identify disaster risk areas and highlight them on zoning maps.
- Factor in information on hazards while calculating density of permitted development. Box 3.1 shows an example of using hazard considerations in density calculation. Density limits can be reduced in hazard-prone areas and increased in nonhazard-prone areas and/or for development that incorporates risk reduction features, thereby allowing developers to achieve economically viable development densities and at the same time avoid hazardous areas. Similarly, cluster zoning can be adopted to promote concentrated development in nonhazard-prone areas, and, in doing so, limit development in higher-risk areas while ensuring the total density requirement is met.

Box 3.1 **Consideration of Hazards in Calculating Permissible Density in Clackamas County, Oregon, United States**

The zoning and development ordinance of Clackamas County, Oregon, in the United States has developed a system for linking density with natural features and transferring density and development from restricted portions of the site to usable portions. This density system applies to housing developments, which are limited to a maximum density calculated as follows:

(i) Calculate the land area of the subject property: this is the gross site area (GSA).

(ii) Among other features, subtract the following from the GSA:

- Slopes greater than 50%
- Floodway of the Floodplain Management District (a specific zone established for select floodplain areas)
- Habitat Conservation Areas
- Water Quality Resource Areas
- 50% of areas with slopes equal or greater than 20% and less than or equal to 50%
- 50% of areas outside the floodway but within the floodplain management district

(iii) Divide the net result by the district land area (minimum land area required per primary dwelling unit) of the applicable zoning district: this is the base density.

Thus, hazards are systematically considered in determining allowable density.

- Introduce setbacks or buffers in hazard-prone areas, for instance setbacks in fault rupture zones to restrict the proximity of development to fault lines, or coastal buffers to protect against tsunami, storm surges, and coastal erosion.

- Special overlay zones and special area ordinances can be used to restrict development in environmentally sensitive areas, where these are legally allowed. Such ordinances should include maps demarcating the sensitive area and stipulating specifications for density and design characteristics of buildings to be constructed in and around the area.

The successful implementation will depend on the following:

- **Flexibility in design and implementation.** The success of zoning ordinances in reducing disaster risk depends in large part on how flexible they are. Flexibility is necessary because of the incomplete information on specific disaster risks (e.g., information on hydrology and uncertainties around flood risk assessment, building characteristics in high-risk areas, and the number of buildings exposed) to guide the formulation of ordinances. For example, while there may be a mandatory requirement for private developers in earthquake-prone areas to undertake geotechnical studies and disclose disaster risk information, flexible approaches can be introduced in zoning since the risk information will encourage seismic design standards to be used to offset possible drops in the market value of the property. Of course, this will require risk information and risk reduction measures to be widely publicized and understood by all. Moreover, rigid zoning ordinances can be expensive for urban residents, especially the urban poor and may result in unscrupulous construction practices and increases in squatter settlements.

- **Synergy in enforcement.** There should be no contradiction in the enforcement of zoning ordinances. For example, delineating an environmentally sensitive area, such as a protected forest and water basin to be a no-build zone, could force informal settlements to move out, with the additional benefit of removing them from a potential flood hazard zone. However, if not properly aligned with zoning ordinances for neighboring land, it may result in land speculation and the surrounding area being identified as "green" and ultimately attracting a high-income population, yet still have a flood risk problem.

- **Regular updating of zoning regulations.** With the rapidly changing urban form, cities should review their zoning ordinances routinely, especially for already developed highly hazard-prone areas, and, where appropriate, consider rezoning to promote strengthening disaster resilience. For example, based on the lessons learned from recent relevant disasters, cities with market demand for increased development density could revise their zoning ordinances to allow changes such as an increase in building heights to encourage habitable spaces to be located above flood levels.

3.3.2 LAND SUBDIVISION

A land subdivision ordinance is used to regulate the conversion of raw land into building sites and to propose the type and extent of improvements required. It is a particularly important tool for areas where the outskirts of a city have received sporadic bursts of residential development (sometimes retaining rural residential features), and which are in small and/or scattered parcels making it difficult to put together viable projects to improve infrastructure.

Land subdivision controls the density, configuration, and layout of divisions, helping to regulate development in hazard-prone areas and to adjust the layout of development sites in ways that minimize exposure to hazards. Moreover, since it deals with new development, it can be an important tool to prevent the creation of new risks.

To ensure land subdivision contributes to reducing disaster risk, consider the following:

- Understand the relationship between the hazards (including changing hazard patterns) and the factors determining land subdivision—growth trends, the economic and employment opportunities in the area being considered for land subdivision, infrastructure constraints, the need to protect natural features, and the existing subdivision pattern.

- Consider how the parcel of land and the intended structure(s) will be impacted by local hazards. Be aware that not all hazard-prone land can be easily identified at the time of plan preparation and at times potential risks can be better understood only when detailed site analysis for a subdivision application is under way.[1] In such cases, require the land subdivision applicant to demonstrate that appropriate risk reduction measures will be implemented.

- Require geotechnical studies in seismic-prone areas and the public disclosure of study findings, as well as the integration of seismic standards in the design of utilities, such as water supply, sewerage, stormwater drainage, and power. Development that meets these standards can be eligible for a reduction in development fees. Covenants, where there is legal provision for such instruments, should also be included in the development permits, binding developers and homeowners to undertake design and maintenance measures to reduce risk.

- Ensure that economies in infrastructure development do not compromise emergency preparedness and response requirements. For example, road width is a determinant of plot cost, but narrow roads compromise fire engine and other emergency service vehicle access. Narrow road width may also have an effect on other risk reduction features, such as the diameter of standard drainage pipes to accommodate increasing rainfall intensity.

- Monitor and manage the impact of land subdivision on disaster risk over time. For example, land subdivision may affect the water cycle through the loss of vegetation and the expansion of concrete surfaces, thereby reducing the water absorptive capacity of the land. Such effects should be documented in the planning maps and measures identified to reduce the risks.

1 The RMA Quality Planning Resource. Plan Topics—Land—Subdivision. http://www.qualityplanning.org.nz/index.php/planning-tools/land/subdivision (accessed 20 September 2015).

3.3.3 BUILDING CONTROL

The building sector can have a significant effect on vulnerability levels in a given area through decisions regarding the design and construction, as well as location, of structures. Typical factors that contribute to building collapse from hazards are related to both locational and construction practices, as described in Box 3.2.

Box 3.2 Typical Factors Contributing to Building Collapse

The following are factors that typically contribute to building collapse:

- **Geological conditions and hazard characteristics.** For example, distance of a property from the earthquake source, type of soil on which a property is built in a seismically active area, force of storm surge, and level of inundation will influence the type of damage the structure suffers.
- **Physical characteristics of buildings.** Building height, design (including change in design over time), construction type, proximity to other structures, will contribute to the vulnerability of the structure.
- **Rapid urban growth.** Unprecedented growth in the urban population results in heavy demand for housing, sometimes forcing owners to build high-rise structures on small lots of land and possibly compromising the structural integrity of the buildings, encouraging property developers to give less priority to open and green spaces, and enticing unqualified individuals into the construction sector.
- **Lack of disaster risk information.** Building regulations may require an inspection of the site and the issue of a clearance certificate by engineers and geologists. However, a lack of disaster risk information may not trigger this requirement.
- **Rigid specifications and lengthy building approval processes.** Rigid conditions in building codes and extensive processes for obtaining building permits may increase the likelihood that owners seek approval for their blueprints but later make incremental changes from the originally approved building design since undertaking such changes does not require meeting standards and seeking approvals. The outcome may be a more vulnerable structure.
- **Challenges and shortcomings in code enforcement.** Lack of enforcement of zoning codes and building regulations, particularly for privately built housing, is often a result of a lack of trained professionals in municipalities and the absence of a system for licensing contractors, engineers, and architects.
- **Older structures.** Buildings are often used far beyond their intended design life period before being replaced. Unless a building has been significantly renovated or altered, the current building code requirements may not be met.
- **Cost savings and corruption.** Cost-saving concerns typically lead to the use of inappropriate and/or cheap building materials, which increases the likelihood of structural vulnerability of buildings. Builders and developers might also put pressure on local authorities to alter construction rules in the name of construction cost savings but without realizing or caring for the impact on the vulnerability of affected structures.
- **Changes in construction materials.** A shift in the choice of construction materials, such as when locally appropriate traditional building materials to build non-engineered residential structures are replaced by concrete blocks and cement construction, may not always be accompanied by local masons acquiring the new skills required to ensure the quality of the new materials are adequate or are used appropriately.
- **Vulnerability in informal settlements.** Informal settlements are often located on hazard-prone land, such as steep slopes, unstable alluvial soil along the riverbanks, and coastlines. The lack of municipal services and infrastructure in these areas typically results in inappropriate practices and/or inadequate investment, resulting in unsafe practices, such as the disposal of solid waste in riverbeds. Moreover, the lack of land title and the costs associated with building code compliance discourage residents from investing in strengthening their property.
- **Change in urban governance.** The trend of increasing the number of regulatory bodies managing urban growth, but not increasing the human and financial resources for planning, implementing, and monitoring, at a time when governments favor a free-market economy approach, has led to the liberalization of construction regulations and the emergence of unqualified private sector developers.

Source: Authors.

Policies and regulations for building control, such as building codes and building bylaws, can act as effective instruments to reduce disaster risk.

Building codes are sets of regulations governing the design, construction, alteration, and maintenance of structures. They specify the minimum requirements to adequately safeguard the health, safety, and welfare of building occupants. Some components of building codes are intended to ensure that structures can effectively resist the impact of hazards, for example resist seismic forces during earthquakes, high winds, and so on. While typically adopted at the national level, building code enforcement is the responsibility of the local government.

To ensure the successful implementation of building codes at the local level, consider the following:

- **Create a culture of compliance.** It is important to create a culture of compliance where all stakeholders are knowledgeable about current and future risks from hazards and how such risks interact with building location and construction practices, and are willing to comply with building codes. Undertaking awareness-raising and education campaigns can help create the necessary social pressure and a culture of compliance.

- **Undertake local adoption of building codes.** Disaster risk is largely shaped by the level of exposure and vulnerability of people and assets in the local area. Thus, building codes should include specifications for all types of locally relevant hazards. Special consideration is needed for potential localized changes in hazard intensity and frequency, such as changes in coastal storms, sea-level rise, and the expansion of floodplains, as well as for expected increases in the exposure of assets. Specifications should also match the capability of local professionals or those applying the code.

- **Introduce flexibility in specifications.** The aim in providing specifications should go beyond human safety and include recommendations for reducing losses and maintaining functionality of structures after a disaster. Thus, the specifications should look at building location and the physical characteristics of the building. This will include height, construction type, usage, age, and proximity to other structures. It is important to recognize that with the uncertainties associated with changing hazard patterns, building codes cannot prevent damage completely. The local code should therefore include specifications that allow flexibility for structures to prevent collapse and include design features that allow time for evacuation.

- **Ensure cost-effectiveness.** It is important to find a balance between recommending strict specifications versus ensuring cost-effectiveness. Overly rigid specifications can become economically challenging to implement and an impediment to adoption. The overall idea is to enable better construction practice while not inhibiting development or encouraging corruption.

- **Introduce systems for building permits.** Robust systems for obtaining building permits need to be initiated. These include clarifying the roles and responsibilities of the agencies involved in building permits, using hazard maps to inform decisions on the issue of permits, encouraging owners to seek advice from qualified and certified technical specialists in selecting specific locations (e.g., seismologists in earthquake-prone areas and geologists for steep slopes prone to landslides), requiring a qualified engineer to design structures, and introducing accredited third-party building validators to ensure quality and safety during construction and to raise confidence of investors. However, these systems should pay attention to simplifying procedures for approval, including introducing tamper-proof electronic approvals.

- **Provide specifications for retrofitting.** Specifications for retrofitting existing buildings, especially buildings in high-risk areas and with high occupancy, are essential. Urban site conditions such as high-density row housing, mixed land use, and multifamily occupancy can make retrofitting in urban areas particularly challenging.

- **Design incentives to encourage retrofitting of buildings in high-risk areas**. Since retrofitting can have significant financial implications for property owners, it may not be popular and readily accepted, but should be an option considered nonetheless to reduce disaster risk. Carefully designed incentives should be provided to encourage investments in retrofitting, for instance by providing subsidized credit or tax breaks. Mandatory disclosure of risk information during rental contract negotiations, including whether the building meets current building code standards, can exert pressure on landowners to engage in retrofitting.

- **Strengthen partnership with the private sector.** Effective public–private partnerships between governments and the construction industry are crucial for successful application of building codes. Measures to consolidate the partnership include strengthening the disaster risk reduction capacity of private planners, engineers, architects, and construction workers involved in building construction, and working with private sector financial and insurance companies to develop incentives, such as premium reductions or reduced-rate loans for properties that adhere to specifications of the building code.

- **Undertake revisions.** Revisions to the local building code should be carried out routinely to incorporate changes in the disaster risk environment, for instance linked to rapid socioeconomic development, the changing intensity and frequency of hazards, and technical and/or scientific developments. Lessons learned from past disasters can be very useful in informing such revisions. Any revisions should take into account local conditions (cultural as well as physical), should seek inputs from various interest groups, and should ensure synergy with other policies and legislation related to civil protection, insurance, and so on.

GREENFIELD SITES AS OPPORTUNITIES FOR REDUCING DISASTER RISK

4

GUIDANCE NOTE

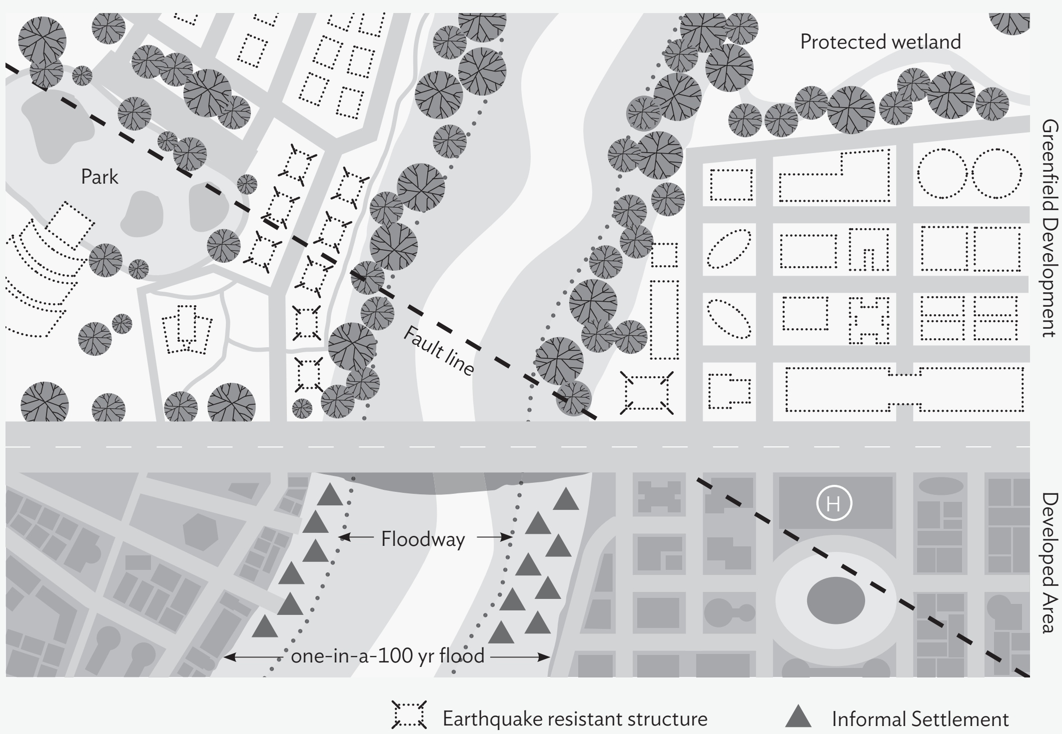
This note provides urban planners with guidance on integrating disaster risk considerations in new development being pursued in greenfield sites—master planning, site development, and infrastructure for risk reduction. It is recommended that planners read Guidance Note 1 before undertaking actions suggested in this note. They are also encouraged to read Case Studies 1 and 2 presented in Part B of this document to learn how different countries and/or cities are factoring disaster risk information into development.

PHOTO: ADB

KEY MESSAGES

A greenfield site is undeveloped land. It offers the opportunity to take into full account any constraints posed by hazards in the site selection for different land uses and infrastructure, as well as in the individual site layout. Developing greenfield sites should factor in hazard risks while formulating site design concepts and development control regulations, and, where needed, prioritize disaster risk reduction investments such as flood defenses, green buffers, and so on, as illustrated in Figure 4.1. This will ensure the location and nature of proposed investments in greenfield areas are disaster resistant and will encourage resilience strengthening of additional individual investments by the public and private sectors.

Figure 4.1: Factoring Hazard Considerations in Greenfield Development



Source: Authors.

KEY ACTIONS

For integrating disaster risk considerations into greenfield site development:

- **Use hazard information to guide the development process of greenfield sites—**master planning, site planning, and selection of infrastructure. Since a greenfield site is expected to attract large investments with a long design life, it is important that the site development process factors in information on potential changes in the intensity and frequency of extreme weather events and, at the same time, takes into account how the proposed development can itself change the original hazard pattern in the area or in the surrounding areas.

- **Give priority to disaster risk reduction investments in greenfield site development processes in hazard-prone areas.** Designing these investments should be guided by the results of disaster risk assessments, include a combination of hard and soft infrastructure, and, where possible, serve multiple purposes in order to be cost-effective.

- **Raise awareness in the private sector of the importance of incorporating hazard information at an early stage of greenfield site development**, and of how such action can improve the overall quality and value of investments.

LIKELY CHALLENGES

Collecting hazard information, especially **downscaled data on climate projections** may prove difficult.

Gaining **interest of the private sector** to invest in risk reduction, especially for low-frequency and high-impact disasters, particularly if hazard maps and information on past the local impact of past disasters are limited, will be a challenge. The interest of the private sector is likely to vary depending on the level of risk they face (e.g., hoteliers involved in coastal tourism should be more interested in investing in cyclone-resistant infrastructure) and the demand for resilient structures from consumers (e.g., a demand for green development may encourage the private sector to invest in flood risk reduction).

4.1 INTRODUCTION

Many cities in Asia are expanding to accommodate future growth. This expansion is sometimes undertaken in greenfield sites—undeveloped or agricultural areas on the urban periphery. The planning requirements for greenfield sites may be specified in legislation and policies related to land use or urban development. These potential growth areas are usually designated in the land use plans (see Guidance Note 2), and activities such as preparing master plans and installing trunk infrastructure are pursued by the city to promote development. While city governments themselves actively pursue land acquisition and create development sites, it is becoming common practice for the private sector to undertake land acquisition and develop both internal infrastructure and individual sites. In the latter case, the city government may enforce development controls such as land subdivision and/or zoning regulations (see Guidance Note 3). It is in the best interest of the city government and investors to avoid new areas being developed in a piecemeal, and often incoherent, fashion.

Greenfield development provides the potential to reduce disaster risks for the following reasons:

- Being vacant sites, greenfield development offers flexibility in site selection for different land uses and infrastructure, individual site layout, and building and infrastructure design. It is ideal to factor in various development constraints, including those imposed by hazards in the area.

- It is more cost-effective to factor in disaster risk-related considerations in the design of new infrastructure and buildings than to retrofit later. Experience from school buildings in Nepal has shown that using seismically resistant techniques increase the construction costs by only 4%–8% whereas the cost of retrofitting a building later is in the 25%–50% range of the cost of the building.[1]

4.2 GETTING STARTED

In order to integrate disaster risk considerations into greenfield site development:

- **Undertake hazard assessments.** Information about hazards is critical for integrating disaster risk considerations into greenfield site development. Data from existing hazard assessments can be used or the consultants involved in undertaking the master and site planning processes can be tasked to undertake an assessment. Since a greenfield site is expected to attract large investments with a long design life, it is important that the site development process factors in information on changing intensity and frequency of extreme weather events and, at the same time, takes into account how the proposed development could itself change the original hazard pattern in the area or in the surrounding areas (see Guidance Note 1).

- **Raise awareness in the private sector about the importance and cost-effectiveness of pursuing disaster-resilient investment.** Raise awareness among private developers, individual households, and businesses that it is in their best interest to consider disaster risks at an early stage of development. Raising awareness will also create demand for disaster resilience, which will help to prioritize risk reduction infrastructure where needed and encourage the private sector to invest in risk reduction measures.

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[1] National Society for Earthquake Technology, Nepal (NSET). 2000. *Seismic Vulnerability of the Public School Buildings of Kathmandu Valley and Methods for Reducing It.* Kathmandu, Nepal. http://www.nset.org.np/nset2012/images/publicationfile/20130724114208.pdf (accessed 22 September 2015).

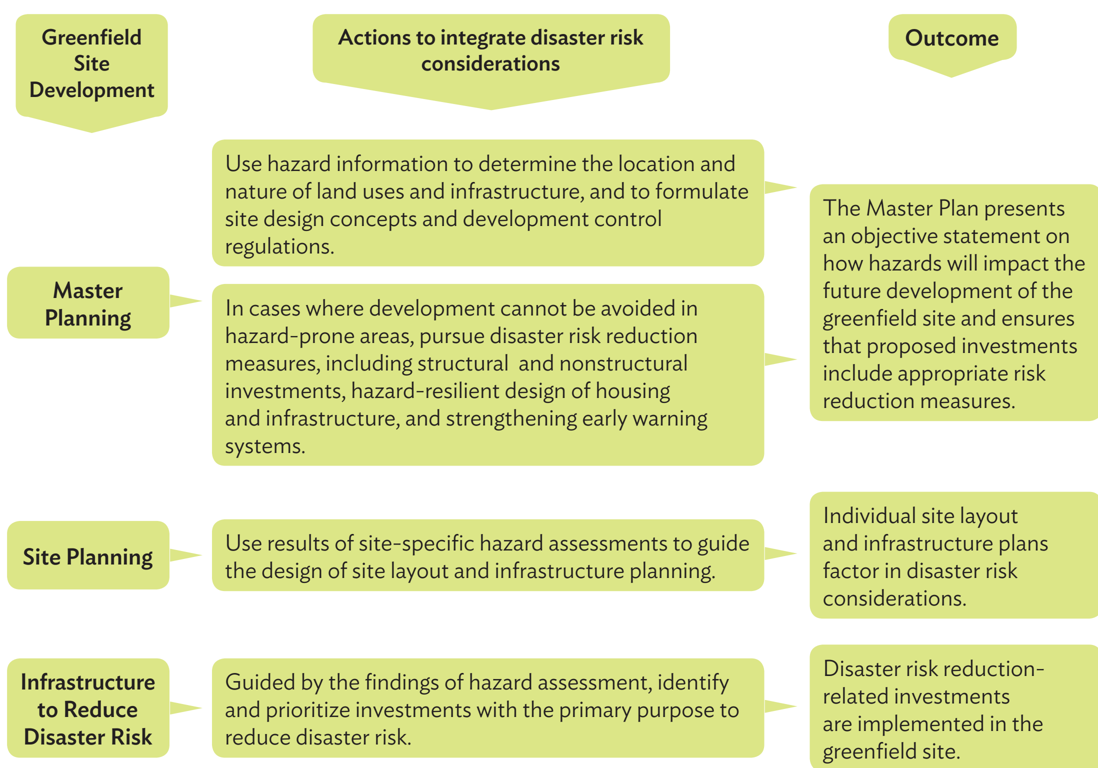
- **Increase engagement of the private sector in reducing disaster risk.** Make hazard information easily accessible to the private sector and require that mandatory disclosure of hazard information and corresponding disaster risk reduction measures be included in the sales documentation prepared by private developers. Target private sector operators whose activities will be carried out in known hazard-prone area (such as coastal tourism) to invest in risk reduction.

- **Establish partnerships with financiers.** Although financiers may already be considering locational risk while appraising requests for loans, risks from disasters are most likely given less priority than other locational factors, such as a view of the ocean from the property, which could promise a good return on the investment. It is important to establish partnerships with financiers, including raising their awareness of disaster risk, providing them with hazard information, and disseminating information on disaster-related regulatory requirements, to ensure that they are aware of potential disaster risk and related disaster risk reduction measures before approving financing.

4.3 ACTIONS TO INTEGRATE DISASTER RISK CONSIDERATIONS IN GREENFIELD SITE DEVELOPMENT

The development of greenfield sites typically includes the following processes: (i) master planning, (ii) site planning, and (iii) infrastructure planning. Disaster risk considerations should guide every stage of these processes, as described in Figure 4.2.

Figure 4.2: Integrating Disaster Risk Considerations in Greenfield Site Development



Source: Authors.

4.3.1 MASTER PLANNING

The master planning process typically identifies locations for future road alignments, development sites and development controls for different types of land use, and sites for municipal infrastructure. The master plan also proposes an implementation strategy, including the phasing of key actions such as land acquisition and construction of trunk infrastructure, as well as a description of government agencies responsible for undertaking implementation of activities. The master plan can become the basis of engaging the private sector in infrastructure and land development.

To incorporate disaster risk considerations in the master plan formulation process, consider the following actions:

- **Refer to existing hazard maps** to understand the geographical location of hazards, including their severity and likelihood of occurrence. This will require engagement with hazard specialists and technical institutions (e.g., local universities), although checking with other local government units (e.g., emergency management, and traffic and water departments) is advisable. Consultations should be undertaken with adjacent municipalities to understand the hazards existing in their jurisdiction and how it could possibly impact the greenfield site and vice versa, and also to coordinate the management of shared hazards. Since the greenfield development is expected to attract investments with a long design life, it is important to have a good understanding of how the hazard pattern will alter over the lifetime of the development due to climate change. Where feasible, existing hazard maps should be updated with new information, and modeled hazard data should be used (see Guidance Note 1). The expenses incurred in updating hazard maps or undertaking hazard modeling should be considered an investment since it helps ensure the sustainability of public investments and acts as the basis on which to encourage private sector investors to undertake risk-informed investments.

- **Establish the importance of risk reduction** for achieving the overall goal for the greenfield site development. Consultations undertaken with stakeholders during the master plan formulation process should emphasize the linkages between disaster risk and the desired goal, and seek to understand the perception of risk of the various stakeholders expected to settle in the area. Any committees formed to guide the development of the greenfield site should be educated on the importance of recognizing potential disaster risks in the area. Specific consultations should be held with private developers to make sure they are familiar with the disaster risk of the area and the disaster risk reduction requirements.

- **Factor hazard information in land suitability analysis.** Land suitability analysis is a crucial step as it supports site identification, which in turn can encourage speculative developers to invest in housing and infrastructure. Information on hazards should be factored in the land suitability analysis process and clearly articulate the development constraints due to the hazards. Such analysis will require superimposing hazard maps with the base map of the area to identify the geographical location, severity, and likelihood of occurrence of different hazards and to understand the potential exposure of the proposed development.

- **Develop disaster risk-sensitive design concepts.** The information from the land suitability analysis needs to be incorporated into design concepts that consider the following:

    - Prevent development in high-hazard areas, where possible, by using suitable development control instruments such as conservation easements or the acquisition of land (see Guidance Note 3). Where it is not possible, plan for low-intensity land use such as recreational or nature parks.

- ☐ Keep environmental resources, such as streams, in their natural condition to the extent possible to allow localized flooding to continue naturally, and minimize the potential for increasing the speed and volume of runoff that can lead to downstream flood problems.
- ☐ Establish road networks that avoid hazard-prone areas, and that are not built over natural drainage channels, which can lead to increased flood hazard, or along slopes prone to landslides.
- ☐ Locate critical infrastructure such as hospitals and water treatment plants outside high-hazard areas, or, if this is not possible, implement appropriate risk reduction measures, such as ensuring alternate safe access routes.
- ☐ Undertake site planning to select plots for development outside high-hazard areas (see section 4.3.2)

- **Revise zoning regulations** to allow high-density development in low-risk areas and low-density urban development in high-risk areas (see Guidance Note 3). In most cities, stricter regulations may be needed to limit development in hazard-prone areas. This will not be an easy task, particularly in situations where developers have already acquired large areas that may be subject to the new regulations. Introducing new regulations implies changes in development approval procedures, including the potential need for additional technical studies, and related time delays and added costs. Thus, regulations that impose additional restrictions should be developed in consultation with developers, demonstrating the long-term importance of introducing such regulations. Understanding the types of incentives and support required by the developers that may facilitate the implementation of the regulations (e.g., preparation of coastal inundation maps) will be necessary.

- **Pursue disaster risk reduction measures.** In situations where land in low-risk areas is scarce and it is unavoidable to develop in high-risk areas, the following measures can be pursued to reduce risks:

- ☐ Make the results of disaster risk assessments for the area available to the public to encourage risk-sensitive development (this might be best undertaken in conjunction with the mayor's office).
- ☐ Require housing to be designed using hazard-resilient standards, for example flood-proofing for buildings located in flood zones and roof tie-downs in high-wind areas. Where needed, provide specific guidance on standards, require technical evaluation by structural engineers, and help create an enabling environment by working with housing finance institutions to link access to credit with incentives to reduce risk.
- ☐ Encourage the practice of hazard-resilient construction of proposed public buildings and infrastructure following national building and structural codes as well as international best practice.
- ☐ Require the development of emergency management plans during site planning, detailing emergency evacuation and access routes. Plan development should be led by specialists from the city's emergency management office.
- ☐ With city emergency management specialists, explore developing emergency shelters and other public safety measures. In some cases, facilities such as schools or sports centers that are constructed to serve new populations could be designed to serve as emergency shelters as well. Determine the need for and location of open spaces that should be preserved to serve the dual purpose of fulfilling both recreational needs and temporary shelter requirements of the new community.
- ☐ Provide specifications for critical infrastructure and services, such as health facilities, and water and power supply, to serve as lifelines during a hazard event.
- ☐ Require the development of an area business continuity plan for industrial sites. This should be undertaken with assistance from city emergency management officials.

- **Include disaster risk reduction in the terms of reference (TOR) of consultants.** Since consultants may be engaged to develop the master plan, their TORs should describe the scope of work to factor disaster risk considerations in the master plan. The TORs should be developed with assistance from city emergency management officials.

4.3.2 SITE PLANNING

The site planning process involves the organization of land, buildings, access roads, vehicular and pedestrian circulation, parking, and open spaces within a development parcel. At the design concept stage, site planning can be applied to prepare and evaluate alternative layouts to accommodate the development program for the site. At later stages, site planning can be the basis for locating internal roads and buildings.

To ensure the site planning process factors disaster risk considerations, consider the following actions:

- **Conduct site-specific detailed hazard assessments.** For sites with high and medium exposure to hazards, land developers involved in the site planning exercise should be required to undertake site-specific multihazard assessments. This may involve site assessments of the local climate, geology, topography, hydrology, and soil conditions to understand the location of hazard-prone areas and severity and frequency of hazards.

- **Factor disaster risk considerations into site layout development.** Based on the hazard information, alternative layouts should be proposed to avoid development in high-risk areas. Where this is not feasible, low-intensity uses of high-risk areas should be proposed and given higher priority, and it should be demonstrated how the risks will be managed. For example, in areas where flooding is a likelihood, stormwater runoff should be managed by selecting a site layout that has the least impact on a site's hydrology or where risk reduction measures such as retention basins can be installed to reduce the potential for localized on- or off-site flooding. The applications for site planning submitted by developers should discuss in detail disaster risks and measures proposed to reduce risk. Box 4.1 provides typical questions that a developer may be asked to look into from a flood-risk angle.

Box 4.1 **Questions for a Developer to Consider for a Site with Flood Risk**

- What type of new development is proposed and where will it be located in the site?
- Is the proposed development consistent with the local and/or master plan for the area?
- What sources of flooding could affect the site? For each source of flooding, describe how flooding would occur, with reference to historic records where these are available.
- What are the existing surface water drainage arrangements for the site?
- Based on the results of the site-specific risk assessment, which flood zone is the site within? Does this match with the flood zone maps available in the master plan?
- What is the probability of the site flooding?
- If known, what (approximately) are the existing rates and volumes of surface water runoff generated by the site?
- How is flood risk at the site likely to be affected by climate change?
- In the alternative layouts being proposed, demonstrate how flood-sensitive facilities have been placed in areas that have the least risk of flooding.
- How will the site be protected from flooding (through structural and nonstructural measures) over the lifetime of the development?
- What stormwater runoff management measures have been recommended to ensure that (i) the proposed development will not increase flood risks on the property, and (ii) the flood risk has not been transferred elsewhere?
- Are there any opportunities offered by the development to reduce flood risk elsewhere?
- What residual flood-related risks will remain after the proposed measures have been implemented?
- How (e.g., flood warning and evacuation procedures), and by whom, will these risks be managed over the lifetime of the development?

Source: Adapted from Department for Communities and Local Government, United Kingdom. Planning Practice Guidance. http://planningguidance.communities.gov.uk/

- **Disaster risk and infrastructure planning.** It will be important to evaluate alternative alignments and locations of infrastructure to understand the impacts on the population, environmental resources, and costs. Specific to risk reduction, the evaluation should include an assessment of whether installation of new infrastructure increases the risks of hazards being transferred elsewhere or new hazards created (e.g., a proposed diverted natural waterway ponding in areas that previously were not flooded, or hill slopes being made unstable because a proposed new road will remove the toe of a hill). In cases where infrastructure development may create new risks, measures to address those impacts should be identified during the infrastructure selection and design process. As large infrastructure projects often require an environmental impact assessment, it can provide an appropriate conduit for such considerations.

4.3.3 INFRASTRUCTURE TO REDUCE DISASTER RISK

If the greenfield site has a known high-hazard risk, there might be a need to undertake specific investments to reduce disaster risk, such as terracing, "no-build" zones (e.g., in crush zones above earthquake faults), dams, levees, floodwalls, and/or drainage channels, as well as measures such as early warning, rainwater harvesting, green buffers, and so on. Depending on their scale, regional or local governments may be involved in implementing such investments.

In the decision-making process for risk reduction infrastructure, consider the following factors:

- Decisions on investments should be guided by a detailed disaster risk assessment that captures information on changing hazard patterns with climate change. It should be remembered that the design of infrastructure is rooted in traditional planning and engineering approaches, and this approach may be inappropriate (without modification) for responding to changing and/or future climate risks (see Guidance Note 1).

- Along with structural measures, investments to reduce disaster risk should also include nonstructural (soft and green) measures. For example, in the case of flood risks, cities could consider alternative landscape-based approaches that can help reduce the cost of defensive infrastructure. Termed "green infrastructure" or "water-sensitive urban design," these approaches take advantage of natural defensive systems, such as wetlands that offer storm surge protection or sand dunes that dissipate wave energies, to reduce the risk of disasters. Green infrastructure can be better integrated in cities by providing other services (such as recreation) in addition to environmental services during storm events. Similar nonstructural measures include managing stormwater in an integrated manner at a watershed scale and promoting methods such as on-site management of runoff, rainwater harvesting, and reforestation of upstream areas to reduce the amount and rate of runoff and potential for downstream flooding.

- **Cost of infrastructure.** Before deciding on structural, or hard, infrastructure investments, it is important to carefully consider alternatives to single-purpose infrastructure. The cost of constructing defensive infrastructure is usually very high, particularly when the use of the infrastructure is limited to specific purposes. To make these more cost-effective, explore possibilities of developing multipurpose infrastructure projects that support risk reduction goals but also serve other functions, such as developing high storm surge banks to act as secondary roads. During project identification, particularly when the infrastructure will create opportunities for new land development, planners should consider how defensive infrastructure facilities can serve additional purposes and be integrated into the new urban development. An example is the design of water detention basins that provide flood mitigation but also serve as recreational amenities in new neighborhoods.

URBAN REDEVELOPMENT AS A STRATEGY FOR REDUCING DISASTER RISK

5

GUIDANCE NOTE

This note provides guidance to urban planners for integrating disaster risk considerations into urban redevelopment projects—development in formal built-up city areas, vacant lands and brownfield sites, and upgrading of informal settlements. It is recommended that planners read Guidance Note 1 before undertaking actions suggested in this note. Planners are also encouraged to read Case Study 4 presented in Part B of this document to learn how urban redevelopment can be adopted as a strategy for disaster risk reduction.

KEY MESSAGES

Urban redevelopment projects should be required to include hazard considerations so as to ensure that project sites incorporate disaster risk reduction measures into their basic design, and do not increase existing levels of vulnerabilities (e.g., by relocating informal settlements to hazard-prone areas). While market forces play an important role in deciding the ultimate character and success of urban redevelopment, the inclusion of disaster risk considerations will add value to the results. In urban areas with very high disaster risk, urban redevelopment as an approach can be adopted to retrofit buildings and strengthen overall resilience as illustrated in Figure 5.1.

Figure 5.1: Use of Urban Redevelopment as a Disaster Risk Reduction Strategy

Source: Authors.

Retrofitted structure

KEY ACTIONS

For integrating disaster risk considerations into urban redevelopment projects:

- **Use hazard information to guide urban redevelopment-related decisions.** Undertake market analysis to identify the demand for urban redevelopment, identify locations of urban redevelopment projects, and ensure project implementation factors in disaster risk considerations in location and design of site layout, building, and infrastructure. Since urban redevelopment projects involve communities already living in the area, the results of disaster risk assessments should be widely disseminated and clearly communicated to raise awareness of the importance of disaster risk reduction.

- **In cities with very high disaster risk, collaborate with universities and scientific research institutes to undertake disaster risk assessments** to guide the formulation of urban redevelopment projects. These projects should be part of a wider city disaster risk management program and be accompanied with activities related to strengthening policies, institutions, and the capacities of local stakeholders.

- For urban redevelopment projects specifically targeted at in situ upgrading of informal settlements, it is particularly important to **undertake participatory processes to identify disaster risk**, prioritize low-cost risk reduction measures, and provide support for implementation. Relocation is only an option of last resort if all other upgrading options have been explored. In such cases, use hazard information in site selection processes.

LIKELY CHALLENGES

Coordination between stakeholders—residents, the public sector, and private developer—with different perspectives and interests in participating in an urban redevelopment project will require external facilitation and mediation skills.

There are times when the **economic objectives** of redevelopment may dominate and compromise social and environmental considerations, for example by infilling wetlands, uprooting trees, relocating informal settlements to high-risk areas, and so on.

Disclosure of disaster risk information may encounter **skepticism** from specific stakeholders, especially if the redevelopment project is located in high-risk areas, which will restrict redevelopment options and affect property values.

Urban redevelopment approaches—property clearance, conversion of old properties for new uses, and land and rent price increases as a result of gentrification—may result in **displacing the low-income population** and forcing them to locate in hazard-prone areas.

5.1 INTRODUCTION

Many Asian cities have been experiencing rapid and unprecedented population growth. The result has been a significant demand for housing and infrastructure that has expanded beyond city areas, and in the process has often caused deterioration in urban centers. The influx of migratory populations in many cases has created high-density, poorly built, and poorly located informal squatter settlements, a growing proportion of low-income populations, breakdowns in social and community relationships, and inadequate inner-city services. Such conditions necessitate the redevelopment of urban areas through the renewal and regeneration of housing stock and infrastructure, the upgrading of informal settlements, economic revitalization, and a broad-based improvement in the quality of life for all residents. In this respect, urban redevelopment involves the reorganization of a group of adjacent and often disparate properties into a well-defined area with clear objectives for redevelopment.

Urban redevelopment projects provide the potential to reduce disaster risks for the following reasons:

- In many cases, urban redevelopment projects are designed to address socioeconomic issues, such as informal settlements, substandard structures, and deteriorated areas in the city center (infill sites, etc.). Such issues often contribute to increases in hazard vulnerability.

- Large-scale urban redevelopment may be carried out in phases. With a good understanding of how disaster risk changes over time, phased development can help to incrementally embed investments targeted at disaster risk reduction.

- In areas with very high disaster risk, urban redevelopment as a tool can be adopted to retrofit buildings and strengthen the overall resilience of a city.

5.2 GETTING STARTED

In order to integrate disaster risk considerations into urban redevelopment projects:

- **Gather available hazard information.** It is important to have information on current and future hazards to safeguard against urban redevelopment projects being proposed in hazard-prone areas, and, where needed, to include risk reduction measures. Hazard information can be collected from available multihazard maps. Discussions with universities, local research institutes, and scientists can help identify what data are available and provide explanations. Other local government departments are likely to have relevant data and can offer explanations. For large-scale urban redevelopment projects, hazard models that have taken climate change information into account will be useful (see Guidance Note 1).

- **Undertake disaster risk assessments.** In cases where urban redevelopment projects are proposed with the primary objective to reduce disaster risk, it will be important to base decisions on probabilistic disaster risk assessments that assess the probability of various impact and disaster loss scenarios in the given location. At a very basic level, exposure data should include information on projected total population and density, land use, infrastructure, and building characteristics (size, shape, height, occupancy, construction type, etc.). Moreover, with the rapid growth in urban areas, capturing exposure in its current state is not enough; urban growth information also has to be provided. Vulnerability assessment will help in understanding the fragility of buildings and other assets and how they are likely to perform under different impact severity. This part of the assessment will include information on whether structures comply with current building codes, and understanding the characteristics of the people who live and work there, for example their livelihoods, education, health, access to essential services, and land tenure status (accounting for owners and tenants) (see Guidance Note 1).

- **Develop facilitation skills.** Since urban redevelopment projects typically require interaction with existing owners, tenants, the private sector (including small business owners), and the like, the urban redevelopment team must have the communication and facilitation skills to engage stakeholders in a participatory manner. These skills are particularly important for urban redevelopment aimed at upgrading informal settlements, where comprehensive engagement with the population is required to understand the perceptions of risk and the underlying causes of socioeconomic vulnerability. It should be remembered that local communities are also repositories of local hazard information.

5.3 ACTIONS TO INTEGRATE DISASTER RISK CONSIDERATIONS IN URBAN REDEVELOPMENT

Three broad types of urban redevelopment can be considered: (i) redevelopment of formal built-up city areas; (ii) redevelopment of vacant lands and brownfield sites; and (iii) up-grading of informal settlements. Each of these, if designed carefully, can significantly contribute to reducing disaster risk as described in Figure 5.2.

Figure 5.2: Integrating Disaster Risk Considerations into Urban Redevelopment

Urban development	Actions to Integrate Disaster Risk Considerations	Outcome(s)
Formal built-up city areas	Use results of disaster risk assessments to guide the preparation of the redevelopment project master plan.	The urban redevelopment plan sets out the natural hazard-related development constraints for the project and identifies measures to reduce disaster risk.
	Communicate the results of the disaster risk assessment to all stakeholders and raise awareness of the need to invest in risk reduction measures.	
	Formulate principles for redevelopment that will intentionally reduce population vulnerability and asset exposure to hazards.	
	Incorporate a range of disaster risk reduction measures in the urban redevelopment plan.	
Brownfield development	Use hazard information to determine the nature of land uses, and to formulate site design concepts and development control regulations.	The urban redevelopment plan sets out the hazard-related development constraints for the project and identifies measures to reduce disaster risk.
	If the brownfield site is located in a hazard-prone area, pursue disaster risk reduction measures, including structural and nonstructural investments, hazard-resilient design of housing and infrastructure, and strengthening early warning systems.	
	Use results of site-specific hazard assessments to guide the design of site layout and infrastructure planning.	
Upgrading of informal settlements	For in situ upgrading, use existing hazard information and involve the community in a participatory risk assessment process to identify common hazards and factors contributing to vulnerability.	Upgraded informal settlement areas will implement measures to reduce disaster risk.
	Engage the community to identify low-cost risk reduction implementation measures.	
	When relocation is necessary, use available hazard information and consult with the affected community to identify and understand the disaster risk in the proposed site and to implement countermeasures.	Relocation areas and new homes are selected and designed to minimize disaster risk.

Source: Authors.

5.3.1 REDEVELOPMENT OF FORMAL BUILT-UP AREAS OF THE CITY

Redeveloping a city's formal built-up area is often a political process and involves the reshaping and improvement of previously developed areas which, over time, have deteriorated in physical condition and usage, as well as the improvement of underutilized areas within the city center. Depending on the objective of the redevelopment project, interventions may include demolition of smaller-scale structures tied to economically inefficient land utilization and their replacement with larger modern buildings with improved infrastructure. Redevelopment may also include the renovation or restoration of unsightly or historical buildings to improve the visual character of an area.

In order to reduce disaster risk in the redevelopment of formal built-up areas, consider the following:

- **Use available information on hazards** and impacts of past disasters in the market analysis typically undertaken to identify the demand for urban redevelopment projects. Such analyses will provide initial insights on how disaster risk may impact the market value of potential urban redevelopment sites, and the need for disaster reduction measures. Tools used for generating maps of varying market types within a city should factor in disaster risk information.

- **Use detailed disaster risk assessments as guides.** If hazards are a development constraint for the city (e.g., they occur frequently, or large-scale events have occurred in the past and/or are forecasted to occur), undertake, or where available refer to, a detailed disaster risk assessment to (i) understand the potential impacts of disaster risk on strategies being adopted for the urban redevelopment project; (ii) guide the formulation of the redevelopment master plan; (iii) allocate resources for critical investments related to risk reduction; and (iv) establish no-build policies, where needed. Since the area is already built up, the concentration of physical assets and complexity related to social and economic development may require a quantitative risk assessment that models hazards and incorporates exposure and vulnerability data (see Guidance Note 1). The redevelopment master plan may call for a phased approach. Some slow growth areas may need only incremental redevelopment, while others with faster growth may be redeveloped with both incremental redevelopment and new projects. Thus, it is important to have a comprehensive understanding of how disaster risk is likely to change once the area is completely redeveloped, including how redevelopment in certain locations may increase disaster risk over time due to changes in natural drainage patterns and/or building coverage in environmentally sensitive areas.

- **Communicate the findings of the disaster risk assessment** to stakeholders in the urban redevelopment process—the private sector, homeowners, informal settlers, small and medium-sized business owners, etc.—as part of the public consultation process. This will help the city government to create a sense of awareness and responsibility among private developers and homeowners to follow disaster-resilient construction standards, and will ensure that incentives to encourage redevelopment contribute to long-term risk reduction. While market forces will play a strong impact on the ultimate character and success of urban redevelopment, considerations of disaster risk will add value to the results.

- **In the visioning process, engage with stakeholders** to understand the importance of addressing disaster risk to achieve the objective of the redevelopment project, as well as the city's overall disaster resilience vision. Recognizing that different stakeholders—investors, developers, public officials, and existing residents—are involved in urban redevelopment and that factoring in disaster risk reduction measures require investments by all, it is important during the visioning exercise to hold dialogues with each stakeholder group to make the case for investing in risk reduction measures and to understand the type of support (technical, financial, and incentives) that may be required from each for the implementation of such measures. Results from the visioning process will help to (i) formulate a sustainable vision for the redevelopment of selected areas and activities; (ii) identify key principles for redevelopment that intentionally aim to reduce the exposure and vulnerability of population and assets to hazards; and (iii) to develop specific design guidelines for actual project development, including guidelines for risk reduction measures.

- **Use disaster risk assessments to guide site suitability analysis** with regard to existing land use, site coverage, and the types of buildings to be improved or newly built. Ground water sources, infrastructure, and road accessibility are important elements of redevelopment projects that may be subject to disaster risks and should be fully evaluated.

- **Incorporate a range of disaster risk reduction considerations** in the urban redevelopment plan, which could include

  - a clear statement of the hazard-related development constraints;
  - a map indicating the boundaries of the redevelopment area, existing property ownership and uses, essential physical conditions of the area, and location, severity, and likelihood of occurrence of different hazards that may affect the redevelopment of the area;
  - a statement on or level of disaster risk when certain resources within the area are not protected (e.g., wetlands);
  - a land use plan of the area showing proposed postredevelopment uses and the ways in which these uses will address the identified disaster risks;
  - a preliminary site plan of the area that indicates the location of infrastructure measures to address disaster risks;
  - a statement of proposed changes in land use regulations, zoning ordinances, or building codes, as well as associated incentives to make disaster-risk-sensitive redevelopment work;
  - an environmental impact assessment that includes hazard considerations; and
  - a resettlement plan for any families that are displaced with sufficient importance given to disaster risk in the resettlement areas.

In some cases, the impact of a large-scale disaster, or the identification and awareness of high disaster risk for a city, may lead to the initiation of specific urban redevelopment projects for which the primary purpose is to reduce disaster risk, such as retrofitting of public and private buildings. The identification, development, and prioritization of such projects will require a detailed disaster risk assessment. Additional prerequisites for initiating such projects are a strong city government commitment to reduce disaster risk and a high level of community and private sector awareness, participation, and interest in disaster resilience. The impact of such redevelopment projects and their overall economic feasibility will increase when they are designed to include other urban redevelopment goals to maximize their benefits.

5.3.2 REDEVELOPMENT OF VACANT LAND AND BROWNFIELD SITES

Public action to promote the reuse and development of vacant land and brownfield sites, including public and privately owned infill areas, abandoned industrial sites that require special cleanup and/or treatment procedures, and decommissioned, inner-city military bases, can contribute significantly to the economic vitality of a city. The location of vacant land for infill development and the size and location of brownfield sites make them important areas to redevelop. The infill and development of these sites, in fact, may be a good option to respond to new market demands and densification needs within a city.

While the broad approach for integrating disaster risk considerations in the redevelopment of vacant land and brownfield sites remains the same as integrating disaster risk consideration in greenfield sites (see Guidance Note 4), the following additional considerations should be included:

- Redevelopment of a vacant or brownfield site usually takes advantage of major infrastructure that is already in place. Any upgrading or improvement of this infrastructure should take disaster risk management considerations into account.

- City governments can exercise the right of eminent domain to obtain all or part of vacant and/or brownfield properties, or they can work with existing property owners through forms of public–private partnership. Under the partnership approach, land parcels in a specified area can be redistributed to former owners following adjustment and consolidation on the basis of a new land use plan and approved layout. In this way, property owners, local government, communities, and developers can work together to reconfigure parcels in such a way as to increase the total value of the land. Such approaches provide opportunities to acquire properties located in high-risk areas, to change the layout of the site, and to upgrade infrastructure to higher standards of resilience.

- Usually financial assistance and/or incentives are provided by the city government to cover the cost of cleaning up, developing, and marketing brownfield sites. Such assistance could be tied to addressing disaster risk considerations. For example, funds provided to undertake environmental due diligence can factor in hazard considerations. Similarly, tax credits provided for site cleanup can ensure cleaning of clogged drainage channels, thereby reducing disaster risk.

5.3.3 UPGRADING OF INFORMAL SETTLEMENTS

Urban redevelopment may include interventions to upgrade informal settlements with the objective to improve living standards of low-income populations, ensure accessibility to municipal services, and reduce urban poverty. Three types of upgrading are common: (i) in situ upgrading, in which the public sector supports communities in informal settlements to improve a settlement in its present location; (ii) a public social housing or relocation strategy whereby the government moves informal settlements into subsidized housing that is either sold or rented to them at below-market rates; and (iii) sites and services, whereby governments provide sites, with services and utilities in place (e.g., water and electricity) to households for subsequent development by the household itself.[1]

All types of upgrading initiatives can contribute to disaster risk reduction. However, it will be important to prioritize based on (i) settlements that are located in hazard-prone areas; (ii) interventions that have high levels of public and political support; and (iii) settlements with well-established community groups, because this will facilitate linking disaster risk reduction with community needs, lend legitimacy to disaster risk reduction decisions, and generally lead to more sustainable, long-term reduction of disaster risk.[2]

To ensure that the redevelopment of informal settlements reduce disaster risk and do not create new vulnerabilities, consider the following:

- For in situ upgrading, engage in participatory processes to develop disaster risk maps to ensure greater understanding of the risks among the communities. It is necessary to understand the hazards present in the area, the location of the most hazard-prone sites within the settlement, and the factors contributing to vulnerability to hazards (inadequate infrastructure, substandard

1 Wakely, P. and E. Riley. 2011. Cities without Slums: The Case for Incremental Housing. *Cities Alliance Policy Research and Working Papers Series* No. 1. June 2011. Washington, DC: Cities Alliance.

2 Asian Disaster Preparedness Center (ADPC). 2013. *Integrating Disaster Risk Management into Urban Management.* Disaster Risk Management Practitioner's Handbook Series. Bangkok.

housing, lack of maintenance of drainage channels, etc.). For relocation initiatives, identify land that is not prone to hazards, or areas where known hazards can be acceptably reduced and/or managed. Risk assessments undertaken at city level should be referenced and communities adjacent to potential new sites should be consulted to build up an understanding of hazard, exposure, and vulnerability in these areas.

- For in situ upgrading, involve the community to identify and prioritize low-cost measures to reduce disaster risk, as described in Table 5.1. The implementation of such measures is far more likely to succeed if it is tied closely to addressing the underlying causes of vulnerability. For example, if there is a lack of land tenure, families in informal settlements will not be keen to invest in risk reduction measures that improve their housing. However, if the upgrading process can help address issues such as security of land tenure, households will be more willing to invest in disaster risk reduction measures. Community groups may require guidance to select measures that address current and future risks.

- All development measures identified and prioritized by a community as part of a larger upgrading should incorporate disaster risk considerations where relevant. For example, if a community prioritizes improvements in walkways throughout the settlement, these walkways should be made accessible by emergency services and capable of operating as evacuation routes (footnote 15). It is important to guide community groups to select those measures that address current and future risks.

Table 5.1: Examples of Grassroots, Low-Cost Disaster Risk Reduction Measures

Type	Actions
Structural	• Increasing inclination of roofs (for better run-off without damaging roof construction) • Changing direction of roof inclination (so rainwater is discharged without causing damage) • Installing provisional gutters as roof eaves (so rainwater is discharged without causing damage) • Improving roof fixing (to better withstand earthquakes and windstorms) • Replacing mud walls with brick walls (to better withstand heavy rains and floods) and wooden pillars with metallic ones to better understand earthquakes • Improving electricity installations by covering cables and putting electric connections higher up, out of reach of expected flood levels • Regularly replacing corrugated iron, wooden pillars and beams (to better withstand rain or earthquake impacts) • Repairing public infrastructure that passes through the settlement, such as wastewater pipes and drains (to avoid flooding and related contamination) • Building provisional water channels with corrugated iron or cement (to discharge rainwater without causing damage) • Building fences of recycled materials to hold back soil (reducing the risk of landslides) and/or to prevent children from falling (fences can be made of corrugated iron, mattress springs, wooden pillars and wire netting) • Compacting soil (to reduce the risk of landslides and minimize damage caused by rain and earthquakes) • Building retaining walls or embankments from old tires, stones and cement; old tires and soil; bricks and cement; stones only; nylon bags filled with soil and cement; and other materials (to reduce the risk of landslides)
Nonstructural	• Planting grasses, shrubs, and trees (to prevent landslides and create windbreaks) • Cutting down bigger branches and trees located close to house (to minimize the risk of them falling down and causing damage during storms) • Cleaning waste from slopes, drains, waterways and roofs (to reduce the risk of flood caused by blocked waterways and drainage systems) • Clearing objects blocking the flow of rivers, such as tires, plastic sheets, mattresses and branches or other natural debris (to reduce the risk of flood) • Diversify income sources by taking (additional) jobs outside own settlements, or carrying out different jobs simultaneously

Source: Adapted from Wamslar, C. 2007. Bridging the Gaps: Stakeholder-based strategies for risk reduction and financing for the urban poor. In *Environment and Urbanization*. Vol. 19. pp. 115–142, cited in Asian Disaster Preparedness Center (ADPC). 2013. *Integrating Disaster Risk Management into Urban Management.* Disaster Risk Management Practitioner's Handbook Series. Bangkok.

END NOTE

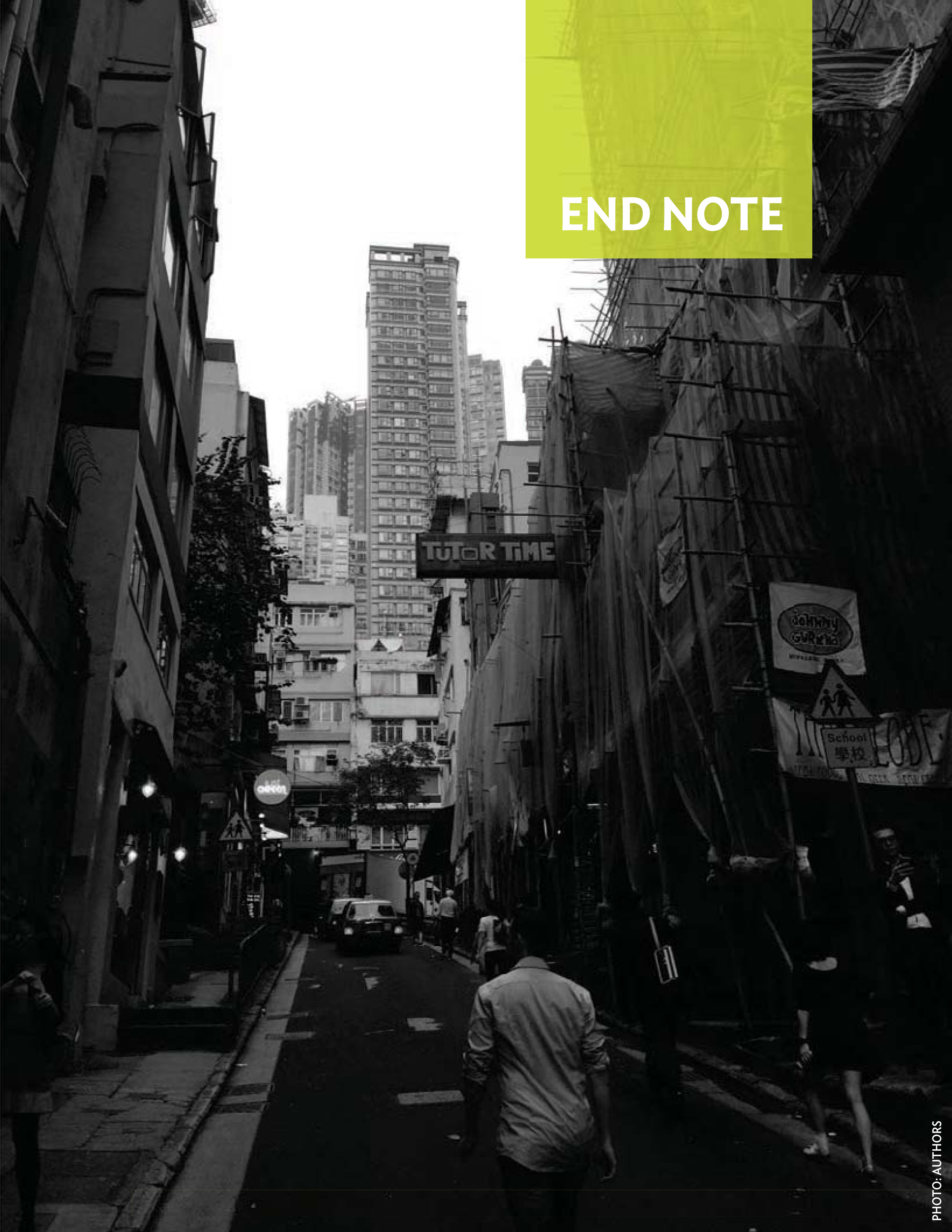


PHOTO: AUTHORS

CONSOLIDATING THE PLANNER'S ROLE IN REDUCING DISASTER RISK BY MANAGING URBAN LAND USE

Reducing disaster risk through land use management requires national and city governments to put in place effective policies, legislation, institutions, and financing arrangements; strengthen capacities; and build awareness among the private sector and citizens to support implementation. While improving these factors is not the direct responsibility of the urban planner, it is nonetheless crucial for planners to be aware of the importance that these wider matters have on reducing disaster risk. Hence, the information in this note will enable planners to provide effective inputs into the development of these wider aspects, especially so that these policies are not developed without having an urban planning and disaster risk reduction perspective. Planners need to be part of these discussions, and the information here can provide relevant insights and positions.

E.1 STRENGTHEN LEGISLATION

Legislation governing the management and development of urban areas is an important aspect of the enabling environment required to reduce disaster risk and forms the framework on which national and/or local governments develop regulations. Legislation across different topics has implications for the growth of an urban area, such as legislation guiding urban land use, building control, environmental protection, decentralization, and regional cooperation, and can effectively promote measures to reduce disaster risk.

It is important that legislation recognizes and encourages (i) the importance of addressing current and emerging risks from hazards that will help achieve sustainable urban growth; (ii) the linkages with legislation in other essential areas (water, transport, energy, food, construction, and finance), which are critical for urban growth but extend beyond city administrative limits; and (iii) urban land use management processes to analyze and address disaster risks through suitable measures. In particular, urban land use-related legislation should promote the following:

- **Use of disaster risk information.** Legislation should explicitly require local governments to use multihazard risk information as a basis for formulating urban land use plans, development control regulations, greenfield site development, and urban redevelopment-related investments. However, while incorporating such considerations in the legislation, it is important to be flexible and provide an enabling environment for risk reduction by specifying the type of actions to be undertaken by urban local bodies and not to be overly prescriptive about standards and regulations (these need to be developed at a later stage in accordance with local needs). Such flexibility will allow urban local bodies to undertake incremental actions based on their available resources and capacity.

- **Participatory approaches.** Legislation should require urban local bodies to adopt participatory approaches in preparing and monitoring the implementation of urban land use management tools. It should encourage the participation of elected officials, different government departments (local and national, where relevant) and utility companies, the scientific community, the private sector, civil society organizations, and community members. Such engagement will allow better understanding among the stakeholders about how the interaction of the "hazardscape" (including uncertain future weather conditions) on current development actions will shape future disaster risk. Such participatory approaches can also help in collecting, interpreting, and validating disaster risk information.

- **Linkage with planning across administrative boundaries.** Legislation should require urban local bodies to undertake consultations with neighboring urban local bodies and, where relevant, at a regional and national level to address issues related to transboundary hazards and the regional implications of disasters. Where legislation requires undertaking land use planning at both regional and local levels, clear guidance on scope, sequence, and hierarchy of planning; interlinkages between such plans; and the roles and responsibilities of agencies (local, regional, and national) involved in the plan formulation should be provided.

- **Linkage with socioeconomic development planning.** National legislation should provide a mandate for urban local bodies to link land use plans with socioeconomic development plans to ensure resources (public and private) are prioritized for implementing the measures stipulated in the land use plan.

E.2 ENHANCE THE LAND ADMINISTRATION SYSTEM

Land tenure and land valuation are critical for reducing disaster risk through land use management processes. Land tenure security provides an incentive for residents to invest in measures to reduce disaster risk, such as strengthening housing, consolidating hill slopes, protecting natural waterways, and upgrading community infrastructure. By recognizing the strong link between land values and disaster risk, the adoption of risk-sensitive development control measures such as zoning can influence the potential value and use of land.

At the same time, disasters affect the capacity of land administration systems through loss of land records, damage to boundary markers, and so on. Hence, it is important to strengthen land administration systems by addressing common weaknesses, such as out-of-date and incomplete land records, uncertain demarcation of informal tenures and public land, lack of land valuation records, and poor land taxation. The following are particularly important:

- **Improve cadastral mapping systems.** A cadastre forms the core of any land administration system and typically provides information on size, ownership, and buildings on the land parcel. In addition to boundary information, a cadastre also contains spatial information related to topography (slope, elevation, etc.), soil conditions, current land use, and geological features, among others. Such information is essential for undertaking disaster risk assessments and identifying parcels at high risk, and accordingly for undertaking measures to reduce disaster risks. It also enables more land to be available through formal means, for purchase and access. In the absence of such information or information being outdated, disaster risk assessments and resulting decisions (such as zoning) can be flawed.

- **Address land tenure issues.** Land that is readily understood as being hazard-prone, such as riverbanks and steep slopes, often does not have provision for formal land tenure and is typically held by the government as public land. Such land frequently attracts low-income populations who establish informal settlements (because the cost of living is generally lower and they are often in close proximity to their livelihoods), in the process exacerbating the disaster risk of this already high at-risk group. To reduce disaster risk through land use management, addressing land tenure issues is important. This includes undertaking land reforms and clarifying property rights (where appropriate), which could incentivize owners and occupiers to invest in risk reduction measures. Land reforms that support fair distribution of land reduce socioeconomic vulnerability. Accordingly, improving the land tenure system will provide an enabling environment for investments in risk reduction measures. Such improvement is a long-term process and is related to changes in overall land policy. However, documenting and showcasing lessons from previous similar disasters can act as a basis for undertaking changes in policies that consider land tenure issues in the context of disaster risk.

- **Reflect disaster risk in the land and property valuation process.** There is a close relationship between land and property prices and widely recognized disaster risk. Large-scale or frequent disasters may readjust land and property values depending on the location, geography, and economic importance of that land and property. Conversely, information on disaster risk reduction measures undertaken, including measures related to reducing exposure by selecting land that is not prone to disaster impact as well as measures to reduce the vulnerability of buildings by following safe construction standards, may improve land and property prices, especially in dense urban areas. Capturing such information as part of the land and property valuation process can incentivize people to invest in risk reduction measures. The price signals in the market tend to be stronger in terms of devaluating properties due to exposure to hazards compared with reflecting the value of vulnerability reduction measures in properties.

- **Strengthen capacity of land registration and administration offices.** It is important that the capacity of a land office reflect the reality of the land conditions under its jurisdiction. For a hazard-prone urban area, the land office will require the capacity to routinely update and digitize land and property records that capture disaster risk information.

E.3 IMPROVE KNOWLEDGE AND SKILLS

Achieving and sustaining an agenda for disaster risk reduction in the urban land use management context is difficult and requires champions to push the agenda, a heightened awareness among various stakeholders of disaster risk and the immediate safeguarding of life and property, and a commitment to translate awareness into individual and collective actions.

Recognizing that different stakeholders (the main ones being property owners, tenants, real estate developers, architects and engineers, construction workers, housing finance institutions, and housing insurance companies) attach different levels of attention to disaster risk, it is important to understand stakeholder perspectives and to propose a package of risk reduction measures that relate to as many perspectives as possible. For example, while real estate developers may be concerned about the disaster risk of residents, they are more likely to worry about the immediate economic implications of meeting new building bylaws that require incorporating disaster risk considerations. In such a situation, awareness raising should include providing information on the levels of on-site risks, the costs and benefits of various risk reduction measures (as well as the effects of not incorporating the measures), and how they can be amortized. The following focused actions can help in improving awareness of disaster risk:

- **Make disaster risk information available.** All stakeholders should have access to the disaster risk information in a format and language that is easily applied when they make investment-related decisions. Special attention should be paid to avoid misinterpretation of risk information, especially information related to the return period of hazard events and uncertainty.

- **Convey the costs and benefits.** The cost of strengthening individual development investments against hazard costs may be as low as a few additional percentage points on baseline construction costs. Existing cost–benefit analyses should be collated and placed in the public domain. Ex post analyses can be undertaken to examine how different hazard-resilient structural options performed in actual disasters and to compare the cost of ex ante strengthening with the cost of post-disaster reconstruction.[1]

- **Form disaster risk reduction advisory committees.** It will be useful to set up disaster risk reduction committees or forums comprising representatives of property developers, architects and engineers, the construction industry, regulators, hazard specialists, public relations experts, and community representatives to guide the use and dissemination of disaster risk information for urban land use management purposes. Risk reduction proposals generated by such a committee will hold higher political credibility and social acceptance for having incorporated these different stakeholder positions.

- **Organize mass awareness programs.** Mass awareness programs through television, radio, and the internet; organizing citywide simulation exercises; celebrating a disaster risk reduction day; and other such events can help raise awareness of disaster risk. The scope of such an awareness program should be expanded beyond preparedness planning (what to do in an event of an earthquake) to include risk reduction activities (how earthquake risk can be reduced).

E.4 ENHANCE THE CAPACITY OF URBAN PLANNERS

Urban local bodies in Asian countries often have insufficient urban planning positions to realistically develop plans and implement them. In many cases, they depend on inputs from technical agencies and/or national government agencies. Thus, strengthening the technical capability of urban planners on how to incorporate disaster risk considerations in land use management processes by working in close partnership with other stakeholders will be needed. It is important to ensure that the technical aspects such as undertaking exposure assessments, incorporating hazard information in density calculations, and interpreting the results of disaster risk modeling are well understood.

Equally important, however, is the need to strengthen a city's overall planning capacity by having an optimal number of permanent planning positions so that the urban planning unit is able to fully discharge important functions such as preparing plans, regularly updating plans, and incorporating disaster risk reduction in the planning process.

Planners' functions specific to disaster risk reduction include framing arguments on the importance of disaster risk reduction; convincing decision makers to support the formulation of risk-sensitive land use policies and investments; negotiating with the private sector to comply with the technical requirements of zoning, building control, and site-specific risk assessment; and effectively engaging the communities and interest groups to understand their perception toward changing risk and the type of support and incentives they would require to invest in risk reduction. In the long run, it will be important to introduce disaster risk reduction in the university curricula of urban planning, civil engineering, environmental engineering, and architecture.

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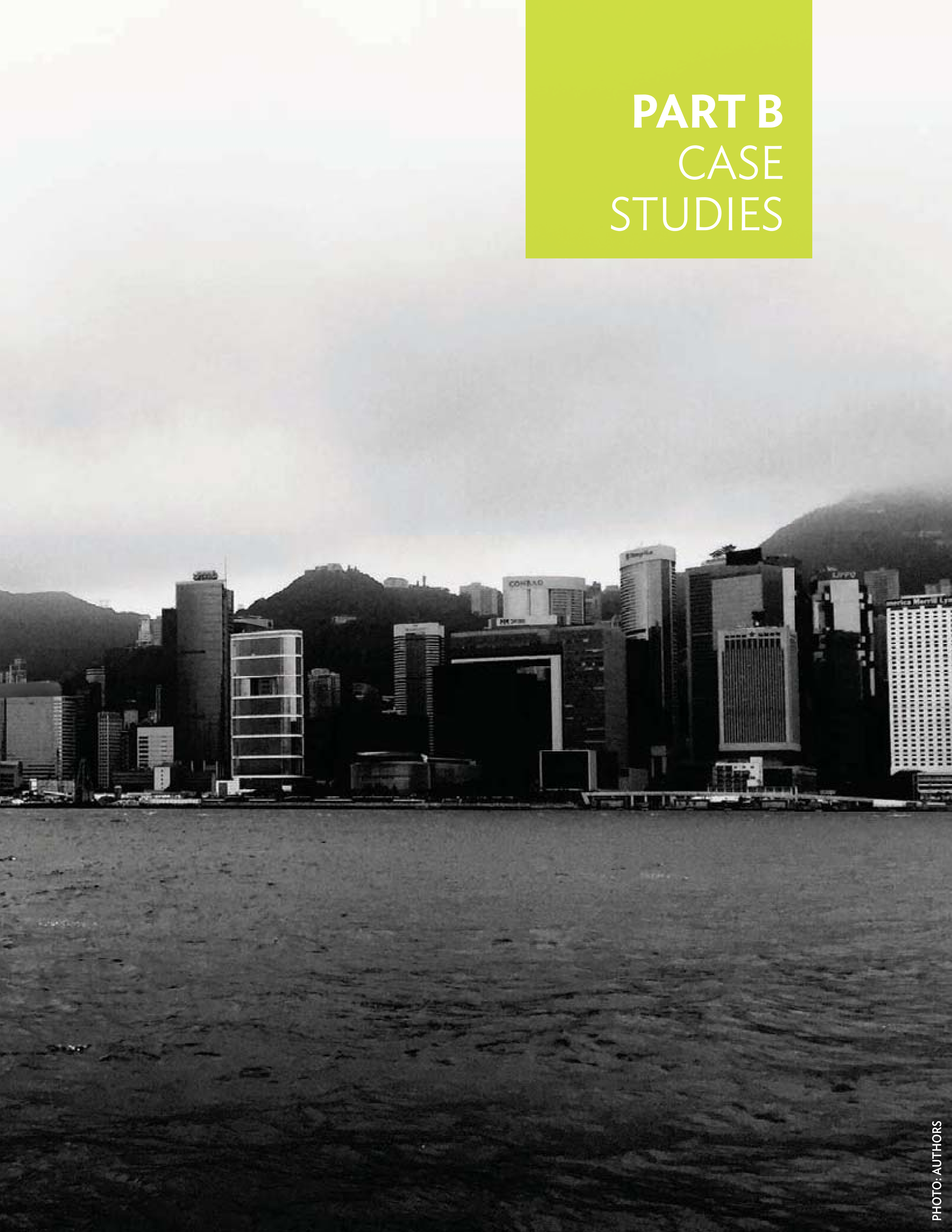
[1] *Ex ante* and *ex post* are terms that are used in the field of disaster risk management to create a distinction between actions taken in anticipation of disaster events (e.g., risk analysis, prevention, awareness, reserving, and insurance), which collectively are components of disaster risk reduction, and those taken in consequence of an actual disaster event (e.g., relief, response, and post-disaster construction). See ADB. 2013. *Investing in Resilience: Ensuring a Disaster-Resistant Future.* Manila.

PART B CASE STUDIES



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1

CASE STUDY

REDUCING DISASTER RISK THROUGH LAND USE PLANNING IN CANTERBURY, NEW ZEALAND

A sequence of earthquakes and thousands of aftershocks experienced in Canterbury during 2010–2011 generated widespread impacts for the city of Christchurch and the wider Canterbury region of New Zealand. There are many lessons for urban planners from this disaster. This case study reflects on the experiences in Canterbury and outlines a range of tools for urban planners to show how disaster risk reduction can be better integrated into land use planning.

PHOTO: BLUESANDVIEWS

1. CONTEXT

The Canterbury region earthquake sequence began with the magnitude 7.1 Darfield earthquake on 4 September 2010 which occurred on an unrecorded fault, 40 kilometers (km) west of Christchurch in New Zealand. This event caused liquefaction and lateral spreading damage to residential properties across greater Christchurch, particularly along the Avon River in Christchurch and in small settlements to the north of the city. However, a more significant event was a subsequent magnitude 6.3 aftershock event on 22 February 2011, referred to as the "Christchurch earthquake." Its epicenter was directly beneath the city of Christchurch, at a very shallow depth of 5 km, and the event had one of the highest ever recorded vertical ground accelerations at 2.2 times the force of gravity. The ground-shaking intensity experienced across much of Christchurch was greater than typically assumed for the design of buildings in this part of New Zealand. Two major central city buildings collapsed and around 1,200 commercial buildings were demolished in the central city because of damage.[1] A total of 7,857 properties were badly damaged by liquefaction and lateral spread, or subject to unacceptable risk to life from rockfall or cliff collapse as a consequence of the

[1] C. Gates. 2015. 1240 Central Christchurch Buildings Demolished. *The Press.* 20 February. http://www.stuff.co.nz/the-press/news/christchurch-earthquake-2011/66290638/1240-central-Christchurch-buildings-demolished

earthquake.[2] The cost of damage from the Canterbury earthquakes has been estimated by the New Zealand Treasury at about 20% of New Zealand's gross domestic product.

Christchurch is New Zealand's second largest city with a population of 341,469 (2013 census) and the largest city in the South Island. Most of the city is relatively flat and is located on the coastal fringe of a broad alluvial floodplain through which two spring-fed rivers meander eastward to the sea. The Waimakariri River to the north of the city is a braided river originating in the Southern Alps which presents a major flood hazard to the city, despite having engineered stop banks. The Port Hills, part of a peninsula, lie to the southeast of the city comprising extinct volcanoes and large valleys. Around 50 km to the west are the foothills of the Southern Alps along which New Zealand's main Alpine Fault extends.

The risk of liquefaction in the Canterbury region was known prior to the earthquakes and had been referenced in planning documents in the 1970s. Some general information on liquefaction was held in Council Land Information Memoranda based on research work undertaken in the 1990s. However, an investigation completed in August 2011 (the Canterbury Fact Finding Project) found that "information on liquefaction and lateral spreading hazards was nonexistent in the zoning and consenting decision-making processes" for some of the most badly affected areas, particularly the eastern suburbs of the city.[3] While engineering professionals and scientists were aware of the potential for widespread liquefaction, the consent authorities and the general public did not understand the implications of liquefaction for land use planning. Many properties with the highest market value in Christchurch were located in what proved to be high-hazard locations in an extreme seismic event—on cliff tops later subject to cliff collapse and adjacent to streams subject to liquefaction.

Although the seismic design for buildings and infrastructure had been routine for decades, and liquefaction was a well-known hazard in Christchurch, the intensity and duration of the Canterbury earthquake sequence and the level of ground damage was not something Canterbury region residents had anticipated. Following the Canterbury earthquakes, it was evident that New Zealand's land use decision making legislation (the Resource Management Act) needed to better recognize and provide for hazard management. Land use decisions had allowed subdivisions in Christchurch without adequate mitigation measures. For instance, the Bexley subdivision was located in a wetland area and in a high-hazard flood zone. These types of decisions show that local-level subdivision consent decisions can have national implications: the Bexley subdivision suffered significant earthquake damage and required government buyout of the properties. Work is now under way to reform the Resource Management Act to strengthen hazard provisions by an explicit addition of risk management as a matter of national importance in the Act. Other reforms include providing national guidance on hazards management and a National Policy Statement to give better national direction.

2. ADDRESSING DISASTER RISK AS PART OF LAND USE PLANNING

Key lessons from the Canterbury region earthquake sequence are currently guiding land use planning processes in New Zealand and include a combination of approaches to address risk—risk avoidance, risk reduction, risk transfer, and risk acceptance.

2 Christchurch Earthquake Recovery Authority cited in Statistics New Zealand. 2013. New Zealand Official Yearbook 2012 – People – Regional Experiences – Canterbury's Earthquake Recovery Progresses. http://www.stats.govt.nz/browse_for_stats/snapshots-of-nz/yearbook/people/region/cera.aspx

3 Hill Young Cooper and Resource Management Group Limited. 2011. *Canterbury Fact Finding Project.* August. p. 5.

Identifying "safe" areas for growth and areas to avoid in strategic plans: Take a long-term view and identify "safe land" strategies for growth and avoidance of highest-hazard areas in strategic plans. In New Zealand, areas where development should be avoided include locations near active faults, land subject to mass movement, land with unacceptable slope stability issues or potential for rock roll, coastal erosion areas, and areas prone to frequent flooding. Longer-term planning that incorporates disaster risk is especially important to protect critical infrastructure and public facilities. Policies and rules of all planning documents should be analyzed to determine the projected long-term impacts of sea-level rise and climate change, and adaptations should be developed where necessary.

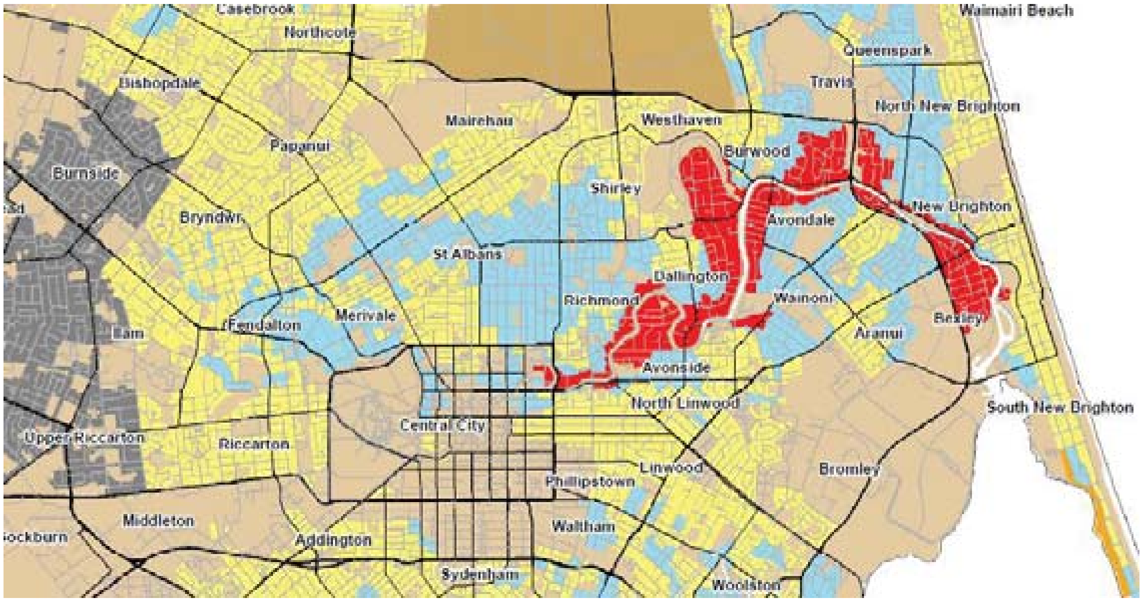
Using land zoning and property acquisition to avoid and/or retreat from high-hazard areas: The Canterbury Earthquake Recovery Authority (set up by the Government of New Zealand to provide governance for earthquake recovery) used a risk-based approach to divide the land in greater Christchurch into zones according to its suitability for rebuilding following the earthquake effects, particularly liquefaction and lateral spreading. Green zone land was generally considered suitable for residential construction, although houses in some areas needed more robust foundations or site-specific foundation design. Land not considered suitable for rebuilding at the present time or where there were risks to life was "red zoned" as shown on the map (see following page). These areas were subject to area-wide hazards and the risks could not be sufficiently reduced by individual homeowners.

Around 51,000 residential properties affected by the Canterbury region earthquakes experienced liquefaction-related damage. A total of 170,000 residential properties experienced some damage in the earthquakes. The government made an offer to buy out properties in the worst-affected areas (those in the "red zones"). The "red-zoning" was a voluntary process in which the government made an offer to purchase people's properties. Around 8,000 homes had to be "red-zoned" where the land was so badly damaged that it was unlikely it could be economically rebuilt on for a prolonged period; or in Port Hills where there was a life risk posed by rock roll or cliff collapse. A very small number of people chose not to move and to remain living in the "red zones." However, the cost to the Christchurch City Council of continuing to provide infrastructure services in these locations is not sustainable ($36,000 per property per year).[4] In the future, residents who remain in the "red zone" might have to become self-sufficient (e.g., install septic tanks and water tanks) if infrastructure services are decommissioned—a decision which the council has yet to take.

Future options for the "red zone" land put forward by the community so far, and subject to future investigation, have included recreational development (sports grounds and a lake for water sports), an urban farm, natural reserves, and possibly some private redevelopment to recoup costs. Much of the "red zone" land will remain subject to flooding, which affects future use. The "red-zoning" was a retrospective planning tool. Urban planners should, as best as possible (based on current knowledge of seismicity, ground conditions, and the state of the practice science), be identifying potential high-hazard areas before an event. If so, these could have been mapped, and the risk of the hazard communicated to communities, decision makers, and developers. New Zealand also needs to look more closely at what other risk reduction tools could be used to avoid and/or retreat from high-hazard areas and to better map out such potential areas.

[4] T. Law and C. Meier. 2015. Red Zone Stayers Relieved City Council Delaying Decision on Services. *The Press.* 27 August. http://www.stuff.co.nz/the-press/news/71485392/Council-to-consult-on-Christchurchs-red-zone-infrastructure

Map showing Canterbury Earthquake Recovery Authority – "Red Zone"



Note: Residential property on the flat land was "red zoned."

Source: Department of Building and Housing (now Ministry of Business, Innovation and Employment). 2012. DBH Residential Foundation Technical Categories. March.

Developing risk reduction policies and rules in planning documents: Assess the policies and rules in territorial plans to factor in disaster risk reduction, both for new and existing development. This can include locational controls, such as controls on subdivision density and the levels of geotechnical investigation required; appropriate development controls for high-hazards areas; and identification of emergency response areas (e.g., tsunami evacuation zones). It can also include development controls for buildings, such as requiring earthquake-strengthening of certain classes of buildings, requiring raised floor levels in flood hazard zones, and specifying the type of materials for buildings on more vulnerable land. Urban planners could be provided with examples of development or plan change consent conditions that could reduce disaster risk. All of these tools are being used in the Canterbury region. Urban planners have needed to work with engineers, scientists, and hazard specialists to formulate these controls.

A specific toolbox for risk-based land use planning for hazards has been developed by GNS Science.[5] This toolbox offers a new approach focusing on the consequences of hazards, rather than the hazards themselves. It provides techniques and options for councils to look at multiple hazard risks within council jurisdictions and with external stakeholders. Some councils around New Zealand are using this approach in their land use planning documents.

Identifying locations where greater levels of geotechnical investigation are needed: Where land might be subject to hazards, such as liquefaction, it is important that the appropriate level of geotechnical investigation is undertaken and appropriate foundation

5 GNS Science. 2013. A Toolbox for Risk Based Land Use Planning for Natural Hazards. http://www.gns.cri.nz/Home/RBP/Risk-based-planning/A-toolbox (last updated 26 Sep 2013).

solutions are adopted. In the Canterbury region, the Ministry of Business, Innovation and Employment (MBIE) (the New Zealand agency responsible for building controls) developed a post-disaster risk reduction tool to map the Canterbury Earthquake Recovery Authority identified green zone into three technical categories (TC1, TC2, and TC3). This work was principally undertaken by MBIE engineers and its collaborative Engineering Advisory Group of geotechnical and structural engineers. Urban planners were not directly involved in the technical category development process.

The categories provide a guide to the level of site investigation required and help in determing the most appropriate foundation systems, as well as indicating how land might perform in future earthquakes. This system allowed the repair and rebuild of earthquake-damaged homes to progress as quickly as possible (e.g., it allowed 80% of the lower-risk and therefore TC1 and TC2 properties to be repaired without the need for deep geotechnical investigations and site-specific foundation design). TC3 sites were those where moderate to significant liquefaction was possible in future large earthquakes. These areas required site-specific geotechnical investigation and specific engineering design of foundations. The technical categories did not necessarily represent the hazard on the site but gave a representation of ground conditions expected on an area-wide basis.

At a later stage, the Christchurch City Council adopted a liquefaction assessment line in its District Plan, dividing the city into two liquefaction assessment areas. The areas determined the differing levels of site investigation required for future development. Urban planners required the input of expert geotechnical engineers to develop the rules and policies around liquefaction because of the technical complexity of the issue.

Work is now under way on a national building guidance project to develop a land use planning framework for areas vulnerable to liquefaction across the country that will assist local authorities to identify other high-hazard areas where urban development or intensification will require a management approach.

Adopting building foundation solutions appropriate to site conditions (below-ground): The MBIE residential guidance document *Repairing and Rebuilding Houses Affected by the Canterbury Earthquakes* delivered foundation solutions that were developed for varying degrees of liquefaction susceptibility following the Canterbury region earthquakes.[6] The guidance also provides carefully optimized and scientifically tested ground improvement solutions to remediate residential land subject to a greater degree of liquefaction and/or lateral spread so that houses can be rebuilt on that land.

Promoting building design appropriate to site conditions (above-ground): The MBIE residential guidance provides design solutions to assist in making houses more resilient when they are built or rebuilt on land that has the potential to liquefy, for example by using more lightweight cladding, removing chimneys, and building "re-levellable" foundation systems. In the Canterbury region, building design regulations were put in place to raise floor levels in flood-prone areas. This tool can be especially useful in countries where sea-level rise is likely or areas are prone to flooding or tsunamis.

Implementing disaster risk reduction to obtain continued insurance provision: New Zealand has the benefit of extensive commercial and residential insurance coverage and this influenced the earthquake response. In 2015, 5 years after the Canterbury earthquakes, the earthquake insurance legislation (EQC Act) is being reviewed. Property owners in Christchurch areas that

[6] MBIE. 2012. *Repairing and Rebuilding Houses Affected by the Canterbury Earthquakes.* http://www.dbh.govt.nz/guidance-on-repairs-after-earthquake

flooded frequently after the earthquake faced flood excess payments of up to $10,000 on their insurance policies. This sent a signal about what may happen in future if adaptation measures are not taken in high-risk areas.[7] Where high-hazard areas are identified and documented on maps, developers may have difficulty getting insurance or loans for developments, and banks may not lend on assets in high-risk areas.

Many more areas will become vulnerable, high-hazard locations as sea-level rise and climate change impact large coastal cities. If disaster risk reduction is implemented, higher levels of insurance can be maintained, which has societal benefits because policy costs to individuals can be kept lower.

3. LESSONS LEARNED

The lessons from the Canterbury region earthquakes have highlighted the following roles and requirements among urban planners:

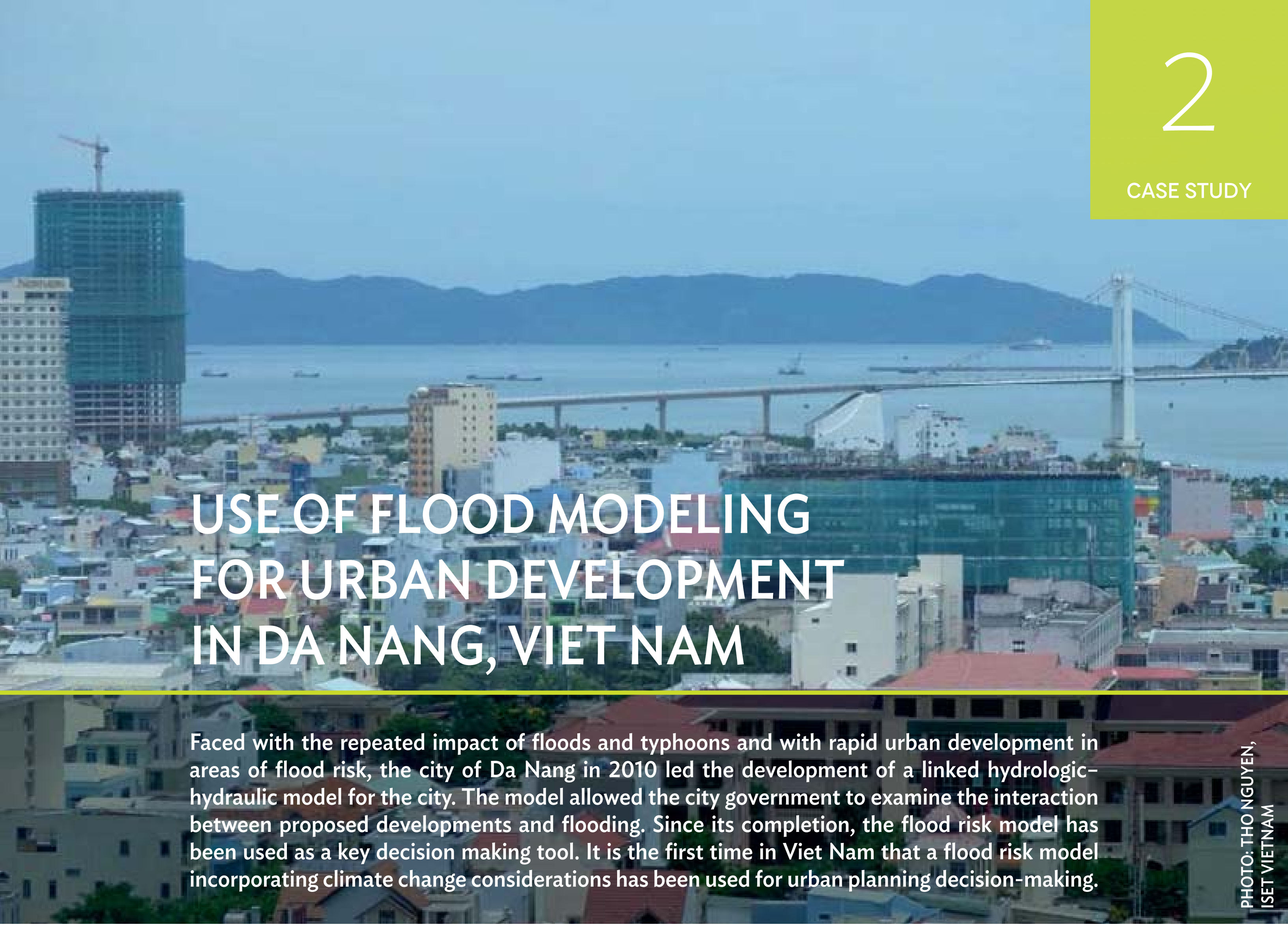
- **Develop urban planners to be effective leaders.** Urban planners need to work well with decision makers and demonstrate leadership so they can be visionaries for their cities, and support and influence courageous land use decisions to reduce disaster risks.

- **Strengthen relationships with other stakeholders.** Urban planners need to develop trusted relationships with engineers, architects, scientists, politicians, and, most of all, their local community, and maintain those relationships.

- **Better understand land conditions.** There is a need for urban planners to better understand the geotechnical conditions of a site and to work more closely with geotechnical engineers in land development decision-making. Most guidance for developing housing relates to above-ground information—there needs to be a better linkage of above-ground with below-ground knowledge. Urban planners need to work closely with building designers, building consenting staff, and structural engineers to understand what measures might need to be incorporated for disaster risk reduction in the building design and in the foundation design to achieve a more resilient building outcome.

- **"Sell" the concept of resilience to private sector developers and decision makers.** Urban planners need to work with private sector developers and public decision makers to "sell" the concept of resilience and get them to understand that a small investment in resilience planning in the design and location of a development will pay dividends in the longer term, with buildings or infrastructure that are more resilient to a disaster event. To do this, urban planners should work with developers to quantify the benefits of resilience. Economists can assist with cost–benefit analyses to provide this information.

[7] Insurance Council of New Zealand. 2014. *Protecting New Zealand from Natural Hazards.* October. Wellington, New Zealand.



2

CASE STUDY

USE OF FLOOD MODELING FOR URBAN DEVELOPMENT IN DA NANG, VIET NAM

Faced with the repeated impact of floods and typhoons and with rapid urban development in areas of flood risk, the city of Da Nang in 2010 led the development of a linked hydrologic–hydraulic model for the city. The model allowed the city government to examine the interaction between proposed developments and flooding. Since its completion, the flood risk model has been used as a key decision making tool. It is the first time in Viet Nam that a flood risk model incorporating climate change considerations has been used for urban planning decision-making.

PHOTO: THO NGUYEN, ISET VIETNAM

1. CONTEXT

The city of Da Nang in Viet Nam is susceptible to regular flooding from intense rainfall events associated with tropical depressions and typhoons. High tides and storm surge often worsen flooding. During the last 20 years, substantial flood damage has occurred in 1999, 2006, 2007, and 2009. Historically, the majority of flooding was concentrated in the northern part of the city center along the Cu De River and in the southern floodplain that lies between the Cam Le and Qua Giang rivers. Flooding is at its worst in low-lying areas bordered by new development or elevated embankment roads. Roadways often function as unintentional dams, blocking floodwaters and increasing floodwater depth and inundation duration.

In 2005, when the development of the southern floodplain was first approved, Da Nang had no way to quantitatively evaluate the potential impact of urban development on floodwater flow.
To address this, in 2010, the Da Nang Department of Construction (DOC) with support from the Rockefeller Foundation initiated the development of a flood risk model for the city. The objective was to construct a linked hydrologic–hydraulic model that takes into consideration potential impacts of flooding and urban development. This linked model would allow the DOC to examine the interaction between proposed development plans and flooding, both currently and under the influence of increased sea levels from climate change.

A project management board was established under the leadership of the DOC, with technical support from the Institute for Social and Environmental Transition, and membership from the Da Nang Climate Change Coordination Office and Da Nang Department of Foreign Affairs. The Da Nang University of Technology and the Southern Institute of Water Resources Research were technical partners for the project. Other city departments, including the Department of Transportation, Department of Agriculture and Rural Development, the City Committee for Flood and Storm Control, and the Da Nang Urban Planning Institute attended the consultation and dissemination workshops.

The project management board implemented the following tasks:

- Worked with Da Nang University of Technology to develop the hydrology and urban development simulation model. The Da Nang University of Technology was selected because of its technical expertise in the hydrology systems of the Vu Gia–Thu Bon river basin and the city of Da Nang. As a local institution, it had advantages in coordinating with other agencies and ensuring the technology is transferred to relevant user departments at the end of the project.

- Worked with the Southern Institute of Water Resources Research, a national institute for water resources management with extensive experience in modeling applications for planning, as a technical partner to provide support and guidance to the risk modeling team at the Da Nang University of Technology and review the product developed.

- Worked with ARUP International Development on the concept design to reduce the flood risk in the southern part of the city. ARUP International Development provided technical input on international best practices regarding risk-sensitive planning and infrastructure solutions.

- Organized a series of consultation meetings, training workshops, and dissemination meetings with experts in urban planning, water resources management, meteorology, and hydrology from technical agencies such as the Da Nang Department of Agriculture and Rural Development, Da Nang Union of Science and Technology Associations, Central and Central Highlands Institute for Water Resource Research, Cities Alliance, and ARUP International Development. This process was of great value to the success of the project. It helped improve the quality of products by updating them, and making them realistic, and consistent with future urban plans of Da Nang.

2. USE OF FLOOD RISK MODEL FOR DECISION MAKING

The DOC's involvement in developing the model has already changed its approach to infrastructure planning and led to modifications in a previously approved design of a new bridge in Cam Le, where they convinced local authorities to extend the span and raise the approaches, at extra cost, in consideration of higher future water levels. Other infrastructure plans are being revisited with the intent of departing from historical standard off-the-shelf designs to more contextual risk-based designs. This is a significant change as a result of applying the flood risk models. Based on the analysis of the model, the DOC developed the following set of recommendations for the city's planning to reduce flood risks:

- Conduct surveys and analyses to identify areas affected and/or not affected by floods, and adjust land use plans accordingly. Special care to be given to low-lying areas along the Yen, Tuy Loan, Qua Giang, Cam Le, and Cu De rivers.

- Investigate further expansion of the southern floodway area, considering structural solutions, such as embankments and buffer zones to function as natural riverine reserves, and urban green belts to reduce water levels and the speed of flood flow.

- In new development areas, provide recommendations for elevation levels, appropriate drainage solutions, and embankments.
- Investigate the expansion of the urban lake system to reduce pressure on the existing drainage system and minimize urban flooding.
- Investigate structural solutions for existing settlements in low-lying floodplain areas, such as flood shelters, pumping stations for flood control, and flood protection dikes.
- Invest in a flood early warning system for the city.
- Communicate and build awareness among local communities on how to build resilience to floods.
- Develop house designs suitable for existing settlements in floodplain areas, provide training, and encourage people to use designs appropriate to their location.

Results from the flood risk model provide an important basis for the establishment, evaluation, and approval of urban spatial plans and urban infrastructure plans. This includes plans for transportation, water supply, stormwater drainage, wastewater drainage, green areas, and lighting systems. It is the first time in Viet Nam that a flood risk model which includes climate change considerations has been used for urban planning-related decisions. To institutionalize the use of the model, the DOC also developed guidelines to use the models and flood maps for urban planning purposes.

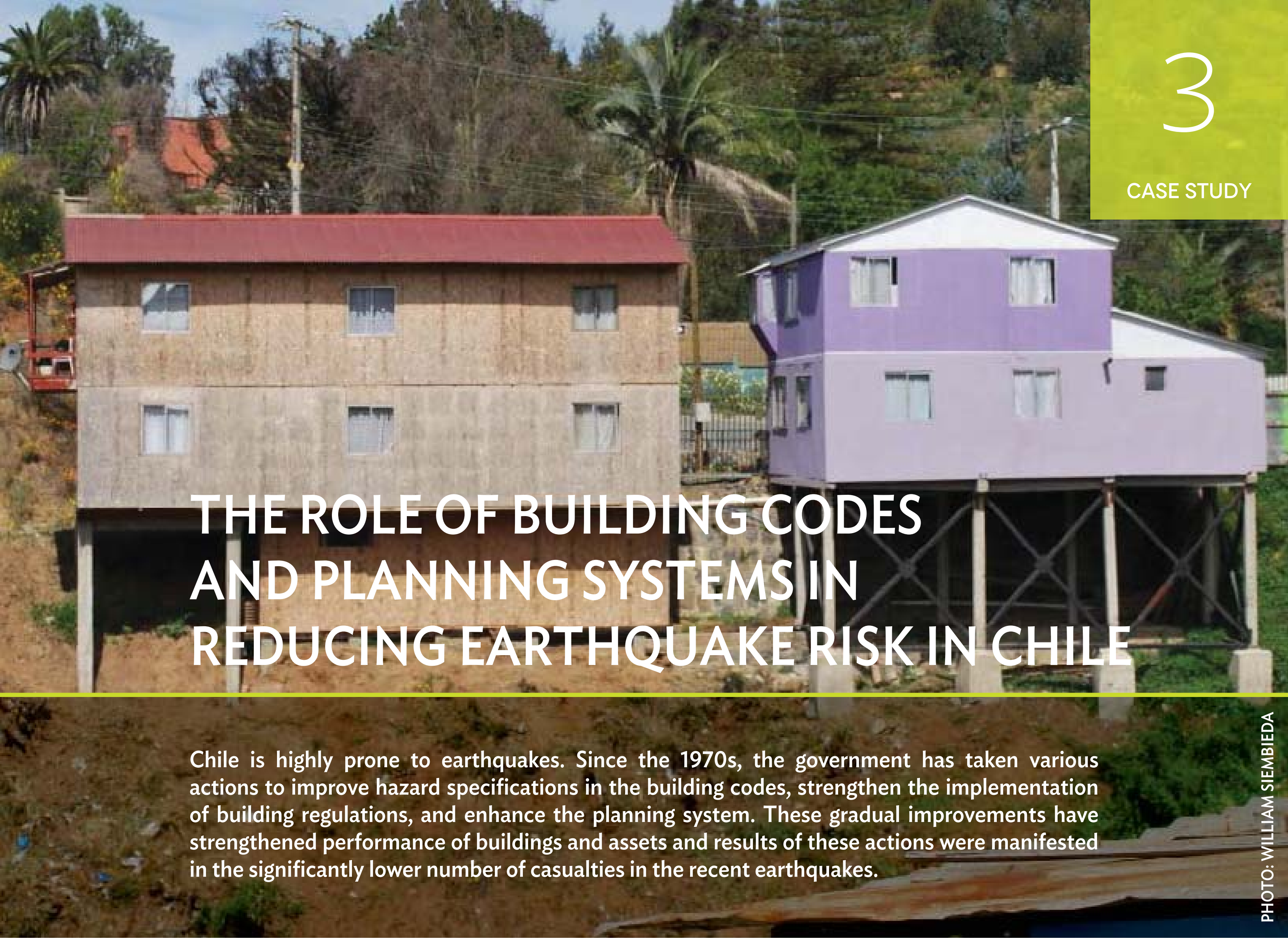
3. LESSONS LEARNED

The selection of the right partners with suitable skills sets, networking capabilities, relevant mandate, and commitment was critical for the success of the project. The collaboration between Da Nang University of Technology and Southern Institute of Water Resources Research to undertake the flood risk modeling work was a good lesson to address the complex issues that required both local expertise and practical application of the models.

There are very few decision support tools for urban planners who want to integrate disaster and climate change risk considerations into development and infrastructure decisions; and city leaders are reluctant to make significant investments without convincing evidence that the initial expense will have long-term benefits. This model is an exception. It can provide crucial evidence to improve policy decisions and build urban disaster resilience. In addition, the rigorous, multidisciplinary research on which the model was based was combined with a process of shared learning and open dialogue with the broader community. The active engagement with the community is expected to improve decision making on multiple levels.

As a result of this flood risk modeling, city leaders are now aware of floodways and have strong opinions about how to address flooding. Leadership is becoming more cautious about approving developments along the floodplain and is now more likely to request setbacks for floodwaters. The People's Committee requested that the DOC pay careful attention to the floodway when developing the southern area of the city. As a result, the DOC worked with the Da Nang Urban Planning Institute to adjust the development plan. This included working toward widening the floodways and maintaining and improving existing low-lying rural areas for flood drainage, and adjusting land use plans in riverine areas to adapt to and minimize future urban floods. On 4 December 2013, the Prime Minister approved the modifications to Da Nang's city development plan.

However, to promote and achieve these potential policy changes, more effort is needed, either through formal channels or through the power of mass media. In particular, there are still important questions about how the private sector, particularly land developers who play a crucial role in changing the nature of risk, will engage with this new tool. The DOC has proposed that all new residential developments be approved only after an impact assessment using the tool. There are additional challenges in maintaining and updating the model, recognizing that urban development is very dynamic. Elevations and construction details change very quickly. Climate science is also evolving and offers new insights over time; hence, there is a need to periodically review and update key parameters in the flood risk model. This is of concern to the DOC, because it will need financial support either from the government or other sources to keep the model updated. This is particularly a concern now because Da Nang is facing major fiscal problems as a result of slowdown in the manufacturing and real estate sectors, with a resulting reduction in local government revenues. However, the economic crisis may offer an opportunity for rethinking plans and development projects that previously could not have been stopped due to speculative pressure and urgency of construction cost inflation.



3

CASE STUDY

THE ROLE OF BUILDING CODES AND PLANNING SYSTEMS IN REDUCING EARTHQUAKE RISK IN CHILE

Chile is highly prone to earthquakes. Since the 1970s, the government has taken various actions to improve hazard specifications in the building codes, strengthen the implementation of building regulations, and enhance the planning system. These gradual improvements have strengthened performance of buildings and assets and results of these actions were manifested in the significantly lower number of casualties in the recent earthquakes.

PHOTO: WILLIAM SIEMBIEDA

1. CONTEXT

Because of its geology, Chile experiences a wide range of hazards. In particular, it is a seismically active country. Since 1900, there have been 27 earthquakes of a magnitude greater than 7.0 on the Richter scale, with 10 of these exceeding 8.0. The world's highest recorded event (9.5 on the moment magnitude scale, or Mw), occurred in Valdivia in 1960, when more than 10,000 people lost their lives. In 2010, 150 people were killed in the 8.8 Mw earthquake in the Maule region, and 6 lives were lost during the 8.2 Mw Iquique earthquake in 2014. More recently, large seismic events occurred in 2015, when Illapel experienced an 8.3 Mw earthquake, causing the loss of 11 lives, and Pisagua experienced an 8.1 Mw earthquake, killing five citizens. While earthquakes continue in Chile, the loss of life is declining due to better construction of buildings and evacuation processes. In fact, during the last 25 years, Chile has built over 10,000 buildings over six stories high, of which only 3.5 per thousand have suffered severe structural damage from seismic activity. In the 2010 Maule earthquake that impacted 70% of the country's population, it is important to note that only 30 deaths occurred in modern constructed buildings, and in the 2014 Iquique earthquake, no structural damage occurred to newly constructed tall buildings, although damage did occur in older buildings built as social housing.

Chile has more than 100 years of government involvement in housing development for its residents. In part, this explains its ability to address building codes, land use planning, and building safety issues. Government involvement in housing began in 1906 when the Councils of Work Housing were created, focusing on worker housing in the largest cities of the country. Also in 1906 after the 8.2 Mw earthquake in Valparaiso, the Government of Chile contracted the services of the French seismologist Ferand Montessus to direct the Institute of Seismology, which was officially established in 1908. While these two historical moments were seemingly separate, they served as the foundation for national government involvement in the planning and construction of buildings and cities.

In 1928, after the government began its involvement in housing and the Institute of Seismology was established, the country experienced the Talca earthquake. This earthquake led to Chile's first national city evacuation law. This law required cities of 20,000 or more to have a city evacuation plan in response to hazard events. It was a precursor to the 1931 version of the General Law of Urban Development and Construction, which was enacted to manage urban planning. It contains the principles, attributes, and responsibilities governing the institutions and professionals involved in planning and construction. All building codes, ordinances, and regulations are referenced in this law. Chilean urban planners, engineers, architects, and builders refer to the most current version of the general law and the associated ordinances for guidance. Local governments also use the law's ordinances. About 30 years after the General Law was enacted, the Ministry of Housing and Urban Development was created in 1965 to manage and direct housing policy and assist in the administration of urban planning functions outlined in the General Law of Urban Development and Construction. This structure established a centralized planning system, with the Ministry of Housing and Urban Development assigned the role of central agency for urban planning across the country. The ministry's strategic objectives are to promote integration and equity in cities through the application of regulatory instruments and the promotion of urban investments.

2. STRENGTHENING BUILDING CONTROL AND PLANNING SYSTEM

SEISMIC CODE

Chile's main building code was developed in the 1970s. The current seismic code (Calculo Antisismico de Edificios) was first adopted in 1972. The country is divided into three seismic zones, and the Chilean buildings codes are very specific. The highest seismic zone, Zone 3, is mainly along the coastal region of the country. Zone 2 is generally further inland from the western coast, and Zone 1 is even further inland to the eastern Andes Mountains. The capital city of Santiago is in Zone 2, for example. The code has been revised several times, mostly in response to an earthquake or other major hazard event.

After the 2010 Maule earthquake, changes were made to the seismic code sections that went into effect in 2015. These changes include

- Chilean Norm (NCh) 337: 2015 Seismic design of nonstructural components and systems—sets minimum seismic design criteria for nonstructural components that are permanently fixed to buildings.
- NCh 3363: 2015 Structural design for buildings in areas at risk of flooding by tsunami or seiche—defines the minimum requirements for the structural design of buildings constructed in areas at risk of flooding tsunami or seiche.
- NCh 3359: 2015 Requirements for strategic and community service buildings—defines those buildings considered to be functionally strategic and establishes the minimum levels of service that must be maintained during the post-earthquake emergency period.
- NCh 3365: 2015 Requirements for equipment of vertical transport—defines requirements for vertical transport, including elevators and lifts.

- NCh 433: 2015 Requirements regarding site soil—defines four site-soil profile types and requires accounting for site-soil amplification effects in the design process; level of drilling depth by soil type is also specified in this section.

- Due to their importance, various government buildings and critical infrastructure are held to higher design standards. This has been the case since 1996 when NCh 433 required multiplying the design spectrum by 1.2 for such buildings. Minor modifications to NCh 433 were made in 2011.

The performance of modern buildings in the 2010 Maule earthquake resulted in the increased use of seismic performance systems (seismic isolation, energy dissipation, and tuned mass dampers).[1] More than 80 large projects built since 2010 have used such systems. Between 2010 and 2015, 12 new hospitals with seismic isolation have been constructed, implementing a policy of less horizontal evacuation (taking people away from hospitals) and more vertical evacuation (moving people to safer places within the hospital). Hospitals need to be more self-sufficient when vertical evacuation is the preferred policy.

The country's Institute of Construction regularly reviews codes and proposes modifications to the Chilean president. The institute is composed of 25 public and private members including the Construction Industries Association, the Architects Association, the Ministry of Public Works, the Ministry of Housing and Urban Development, the Engineers Association, the Association of Civil Engineering Contractors, the University of Chile, and the Pontifica Catholic University. All changes to code flow through the institute, and when approved are entered into the National Institute for Codes. Once adopted, the national ministries use the code in their own design and construction works prior to and in recovery from a disaster event.

BUILDING PERMITS

In all areas of Chile, a building permit is required before construction can begin. The building permit requires that an independent structural and seismic reviewer must approve the plans. This process provides a built-in "peer review" of design work and establishes a "checks and balances" procedure useful for safe construction. In addition, a set of drawings must be submitted to the building department of the municipality where the site is located. The law and specifications require that public projects have an additional, external independent construction inspection. Then, after construction is finished, the municipality has the responsibility to conduct another inspection of the building and provide final approval.

Building owners provide the municipality with an as-built set of architectural and structural drawings signed by the various design professionals involved in a project: these documents show all the modifications that were made during construction. This "construction book" documents all of the names of the people in charge of the construction project who have legal and civil responsibility for the construction. All levels of responsibility become transparent by creating such a book, especially because all building documents become public record.

[1] Examples of the seismic protection systems suite of approaches include:

- Seismic isolation: Hospital Militar de Santiago. 5-story reinforced concrete (RC) frame building that has 164 seismic isolators; construction finished in 2007 and it is located in La Reina, Santiago.
- Tuned mass dampers (TMDs): Edificio Parque Araucano. 22-story building with a core of RC walls, perimeter RC frames, and two pendulum TMDs; construction finished in 2006 and it is located in Las Condes, Santiago.
- Energy dissipation: Titanium La Portada office building. 52-story building with a core of RC walls, perimeter RC frames, and 45 metallic dampers; construction finished in 2010 and it is located in Vitacura, Santiago.

Building developers have 10 years of legal responsibility for any damage to structural elements of the buildings and 5 years for nonstructural elements. This clarity in responsibility for proper design and construction provides the motivation for making buildings that are "life safe" at a minimum.

The 2010 earthquake and tsunami caused housing damage in hundreds of cities and towns, and the national recovery scheme called for rebuilding on owner's sites as much as possible. The national housing ministry established strict norms related to housing size, materials, and thermal levels that needed to be met by the private sector contractors working at the local level. All the housing plans were certified before being offered to the public. This relieved local city governments of this review task, although local governments did certify that the actual land plots were located in nonrisk zones.

PLANNING SYSTEM

The General Law of Urban Development and Construction sets out three tiers of regulatory plans—at the regional, intercommunal, and municipal levels. Sectional plans for subareas of the city are also allowed. This hierarchical planning system is believed to provide consistency of practice throughout Chile—from regional to the neighborhood level. For example, the district master plan (article 42) consists of (i) an explanatory report which contains the socioeconomic background of the area; information relating to population growth, industrial development, and other technical background details that form the basis of the proposals; and the objectives, goals, and priorities of the basic works planned; (ii) a feasibility study to extend or provide potable water and sewerage infrastructure in relation to the projected urban growth; (iii) a local ordinance that will contain the relevant regulations; and (iv) plans that graphically express provisions on land use, zoning, road relations, urban fringe, urban development priority areas, and so on. Areas prone to natural hazards are also identified in this document.

While changes to the building codes flow through the Institute of Construction, changes to the planning system require adjustments to the General Law of Urban Development and Construction through support from the Housing and Urban Development Ministry. The 2010 Maule earthquake called into question the current instruments used for territorial planning that addressed disaster risk and how risk mapping was utilized at the municipal level. In response to that earthquake, the general law was amended in 2011 to simplify reconstruction in disaster-declared areas. The new changes included separating areas of risk from natural areas into smaller area plans. Disaster risk areas may be overlaid on top of other zones or may be stand-alone. Disaster risk reduction measures can also be suggested. Creating these area plans requires detailed risk assessments and risk maps to be produced by qualified professionals. These areas must be included in the main text of the zone's regulatory plan, and such inclusion should result in a required public notice of disaster risk areas.

Changes in the planning regime are also called for in areas subject to high flood, tsunamis, and volcanic activity. Throughout the country, areas impacted by a disaster, such as flash floods and mudslides (e.g., in the Atacama region), will require taking into consideration the risk area conditions existing before the event and addressing them as part of any reconstruction plans made. Changes would likely limit construction unless risk reduction measures are included and require such tools as evacuation plans for buildings where more than 50 people reside. Examples of addressing high-risk areas include the government acquiring houses in high-risk tsunami zones to create new "protection buffers" that protect residential areas inland from the sea or waterway. Such projects have been undertaken in the town of Dichato, in the Bio-Bio Region, and the city of Constitución in the Maule Region. The buffers are used for parks, expanded roadways, or part of a tsunami mitigation zone. Chilean law allows the government to acquire lands for such public purposes, as long as proper compensation is paid to the property owners (land and structure).

3. LESSONS LEARNED

In the last 40 years, gradual changes in Chile's building performance against major earthquakes—greater utilization of seismic protection systems in buildings, improved tsunami protection, and improvement in evacuation procedures and modeling—has resulted in lowered loss of life. Still, more was needed, so in 2012 the central government funded the National Research Center for Integrated Natural Disasters Management (CIGIDEN), which is a university consortium focused on applied hazard reduction science in the Chilean context. This is yielding results in applied research building networks with government agencies, such as the National Office of Emergency of the Interior Ministry (ONEMI) that operates the national system of civil protection, and with international assistance agencies.

The country continues to examine its critical infrastructure so it can function with reduced impact and greater continuity of all services after a disaster. Major toll roads, as well as utility and communications systems are private concessions with strict requirements for the operators to have in place sufficient insurance to quickly rebuild and improve their services in the event of a disaster. Such arrangements serve Chile well in terms of financing rapid infrastructure recovery. Its multiple stakeholder system for building technical inputs works well, as does its system of building design checks and balances. The engineering, construction, architecture, and planning communities can make their voices heard. Civil society, however, is not well represented in any formal way, and more attention is needed in ways to obtain and utilize citizen involvement. Chile is making changes in risk assessment tools, risk mapping, its own version of the United States HAZUS damage assessment model. The relevant ministries are trying to integrate these tools into the fabric of municipal planning through training and inclusion of local stakeholders. The challenges for Chile are to strengthen the capacity for local governments to integrate disaster risk considerations with their regional and local plans in ways that permit adjustments in the local context, while continuing to receive support from the central government ministries.

4

CASE STUDY

PHOTO: EBRU GENCER

REDUCING DISASTER RISK IN URBAN AREAS THROUGH URBAN REDEVELOPMENT, ISTANBUL, TURKEY

Since the devastating 1999 Marmara earthquakes, Istanbul has strengthened legal, institutional, and regulatory measures to reduce earthquake risk. In particular, it has adopted urban redevelopment as a tool for reducing earthquake risk of individual buildings and large areas.

1. CONTEXT

Istanbul is a sprawling megacity and considered the financial and cultural capital of Turkey. Since the 1980s, Istanbul has seen a dramatic increase in its population, as the population increased from about 4.75 million in 1980 to 13.9 million in 2013,[1] and projected to become 16.6 million by 2023.[2] Particularly in the late 1980s and 1990s, much of the incoming population, which consisted of either unemployed or temporary or low-skilled workers, accessed an informal and speculative real estate market.[3] Gecekondus,[4] which had originated as temporary shelters for the newcomers, developed into informal neighborhoods, and soon new peripheral municipalities arose in the outskirts of Istanbul.[5]

1 Based on 1980 and 2012 official Census results; data from the Turkish Statistical Institute. http://www.turkstat.gov.tr/

2 Based on projections for 2013; data from the Turkish Statistical Institute. http://www.turkstat.gov.tr/PreTabloArama.do

3 E. Gencer. 2013. *The Interplay between Urban Development, Vulnerability, and Risk Management: A Case Study of the Istanbul Metropolitan Area.* Heidelberg, Germany: Springer. p. 73.

4 *Gecekondu*, a Turkish word born in the 1940s, translates into "built overnight," and describes the illegally constructed squatter buildings. According to its official description in 1966, *gecekondus* are "dwellings erected, on the land and lots, which do not belong to the builder, without the consent of the owner, and without observing the laws and regulations concerning construction and building." (K. Karpat. 1976. The Gecekondu: Rural Migration and Urbanization. Cambridge, UK: Cambridge University Press. p. 16; cited in footnote 3, p. 60.)

5 Footnote 3. p. 72.

According to a study of the Istanbul Provincial Directorate, in 1992, 850,000 (42.5%) buildings in Istanbul Province had permits, 750,000 buildings were regularized by amnesties (37.5%), and 400,000 (20%) buildings were illegal.[6] Indeed, the city had expanded so much in the 1980s that a 1989 study of the 1980 master plan revealed that the plan and the existing situation no longer matched.[7] This situation led to the establishment of a Master Planning Office and to the development of the 1/50,000 scaled Istanbul Area Sub-Region Master Plan, based on the principles of the 1980 plan.

The 1994 master plan analysis involved a series of geophysical studies and the plan report explained that "in Istanbul, the possibility of a damaging earthquake" was quite high.[8] The plan also proposed for the first time to "identify priorities in critical areas due to Istanbul's earthquake risk, and develop alternative mass housing projects for squatters in residential development areas."[9] In addition to these proposals, the Metropolitan Municipality established the Directorate of Earthquake and Ground Research in 1996.

However, these developments were too late for the informally urbanized city and surrounding urban areas. On 17 August 1999, an earthquake of 7.4 magnitude (Mw) struck Golcuk, south of Izmit, an industrial city located on the eastern border of Istanbul province. Shortly after, on 12 November 1999, another 7.2 Mw earthquake occurred in the same region, with its epicenter in the town of Duzce, located 200 kilometers east of Istanbul. These two earthquakes, known as the Marmara earthquakes, resulted in the deaths of approximately 18,000 people and injury to 50,000 people. Additionally, "more than 300,000 housing units and 46,000 business premises were damaged and 320,000 people lost their jobs."[10] The total economic loss was estimated to be around $16 billion,[11] equivalent to 7% of Turkey's gross domestic product at the time. The immense losses resulting from the Marmara earthquakes led to changes in urban planning and development policy and regulatory system in Turkey.

POLICY AND REGULATORY SYSTEM FOR URBAN REDEVELOPMENT IN TURKEY

Following the Marmara earthquakes, a probabilistic hazard assessment was undertaken in 2000 and a deterministic hazard assessment was undertaken in 2002, both of which indicated the high possibility of an earthquake in the Marmara Sea. This heightened awareness led the Istanbul Metropolitan Municipality to organize a consortium of four universities to prepare the Istanbul Earthquake Master Plan (IEMP). The IEMP proposed the use of urban

6 M. Sonmez. 1996. Istanbul'un iki yuzu: 1980'den 2000'e degisim [Two faces of Istanbul: transformation from 1980 to 2000]. Arkadas, Ankara, p. 140; K. Mortan, ed. 2000. Istanbul bir sosyo-ekonomik degerlendirme [Istanbul: a socio-economic evaluation]. T.C. Istanbul Valiligi, Istanbul, p. 49; cited in footnote 3, p. 72.

7 M. Tapan. 1998. Istanbul'un kentsel planlamasinin tarihsel gelisimi ve planlama eylemleri [Planning actions and the historical development of Istanbul's urban planning]. 75 yilda degisen kent ve mimarlik [The transforming city and architecture in 75 years]. Turkiye Is Bankasi and Tarih Vakfi, Istanbul. p. 88; cited in footnote 3, p. 74.

8 Turkiye Cumhuriyeti Istanbul Buyuksehir Belediyesi (TCIBB). 1995. 1/50.000 olcekli Istanbul Metropolitan alan alt bolge nazim plan raporu [1/50.000 scaled Istanbul metropolitan area sub-region master plan report]. TCIBB, Planlama ve Imar Daire Baskanligi, Sehir Planlama Mudurlugu, Istanbul. p. 52; cited in footnote 3, p. 76.

9 Footnote 8, p. 329; cited in footnote 3, p. 76.

10 A. Bibbee, R. Gonenc, S. Jacobs, J. Konvitz, and R. Price. 2000. Economic Effects of the 1999 Turkish Earthquakes: An Interim Report. *Economics Department Working Paper* No. 247, Organisation for Economic Co-operation and Development (OECD). p. 1; cited in footnote 3. p. 47.

11 Based on estimations in M. Erdik. 2001. Report on the 1999 Kocaeli and Duzce Earthquakes. Bosphorus University, Department of Earthquake Engineering, Istanbul.

redevelopment as a tool for reducing disaster risk in urban areas and recommended the development of a regulatory system for its application. The IEMP was deemed a milestone in gaining consensus on the importance of earthquake risk reduction and a strategy for disaster risk management was developed by the universities enrolled within the IEMP. Based on the proposed strategies, the Istanbul Metropolitan Municipality undertook detailed microzonation studies in 2004–2010, the results of which were used as the basic parameters in a land use planning process. In addition, a microzonation approach was adopted by the central government as a requirement in the preparation of all land use plans in Turkey.

In Turkey, urban development is regulated by the Land Development Planning and Control Law (Law No. 3194) (1985) and the Spatial Planning Bylaw (1984; 2014), which are implemented by local authorities. In 2002, when the IEMP was under preparation, various articles of these laws addressed urban redevelopment. For instance, article 18 of the Land Development Law allowed the planning authority to redevelop (with some limitations) areas that included irregular or illegal housing. In addition, the Spatial Planning Bylaw included different articles that addressed disaster risk reduction. However, none of these articles adequately allowed the implementation of major redevelopment projects such as those proposed by the IEMP, necessitating new legislation.

Law on Survival of Dilapidated Historical and Cultural Immovable Assets through Active Use and their Preservation through Renewal (Law No. 5366) (2005) that defined approaches for the redevelopment of preservation areas (both historical and natural assets). This law provided authority to the Mass Housing Development Administration (TOKI) and the Privatization Administration (OIB) to cooperate in the implementation phase. Further, with the amendment of article 4 of the Mass Housing Law (Law No. 5162) in 2004 and 2008, TOKI gained major authority to develop implementation plans for squatter redevelopment areas.

In 2005, another new piece of legislation in the context of urban redevelopment was included under article 73 of the Local Authorities Law (Law No. 5393), which granted authority to local governments to implement urban redevelopment (or "urban transformation" as used alternatively) projects. Accordingly, municipalities could determine urban redevelopment areas (minimum 5 hectares) for the purposes of urban renewal, earthquake risk reduction, and/or protection of historical or cultural urban fabric. In the article, municipalities required a majority vote in municipal councils to determine these areas. However, in 2010, the Law Regarding Revision of the Law on Local Authorities (Law No. 5998) revised the article, providing local governments with further authority for urban redevelopment, primarily allowing them to determine such areas without the full majority of the councils, thus eliminating the need for consensus in such decisions. In addition, with this revision, metropolitan municipalities acquired the authority to determine urban redevelopment areas (up to 500 hectares) without the need to seek the opinion of its district municipalities, which are lower-tier local authorities in metropolitan areas. However, according to the Law Regarding Revision of the Law on Local Authorities, the district municipalities are not able to determine an urban redevelopment area without the consent of metropolitan municipalities, giving metropolitan municipalities the power to undertake all scales of development plans, construction license, and any other relevant development authority within the urban redevelopment areas, reducing the powers of local district municipalities.[12] This is a particularly

[12] Y. Bektas. 2014. Bir Kentlesme Stratejisi Olarak Yasanin Kentsel Mekani Donusturmedeki Etkisi: Ankara Ornegi [The Effect of Law in the Transformation of the Urban Space as an Urbanization Strategy: The Case of Ankara]. *Planlama* (3), pp. 157–172. Ankara: T.M.M.O.B. Sehir Plancilari Odasi Yayini. p. 160.

important development in the metropolitan municipalities of Turkey such as in Istanbul, where both the metropolitan municipality and local municipality administrations are elected officials who can be from different political parties, thus possibly creating challenges in planning and development.

These laws and articles related to urban redevelopment were further amplified by the 2012 Law Regarding Redevelopment of Areas Prone to Disaster Risks (Law No. 6306) and its 2013 implementation bylaw. The aim of this law is to determine the procedures and principles regarding the rehabilitation, clearance, and renovation of urban areas and buildings prone to disaster. It specifies urban redevelopment for disaster risk reduction in three different contexts: (i) the rebuilding of individual buildings that are deemed at-risk; (ii) the development of reserve areas (as new transitional and residential areas); and (iii) the redevelopment of large urban areas at risk. The law grants major authority for urban redevelopment to the Ministry of Environment and Urbanisation. Accordingly, the ministry has the authority to declare mass housing areas, transfer ownership and development rights to another area, transfer rights for a real estate development, authorize new construction, and apportion ownership rights. According to the law, district municipalities and metropolitan municipalities can implement urban redevelopment activities, with the approval of the Ministry of Environment and Urbanisation.

2. THE APPLICATION OF URBAN REDEVELOPMENT AS A TOOL TO REDUCE EARTHQUAKE RISK

The IEMP team proposed two plans to integrate risk reduction into physical planning activities: (i) an Earthquake Mitigation Plan (EMP) as a framework to coordinate all risk reduction measures "to enhance safety and total quality of life in the City"[13] and (ii) a Strategic Plan for Disaster Mitigation (SPDM) to identify problems and potentials of the Istanbul Metropolitan Area and to develop a "road map" with strategies, planning instruments, and priorities.[14]

The SPDM proposed a vision for a decentralization plan incorporating regional growth based on the high-risk areas for the city and identification of suitable disaster risk reduction strategies for its urbanized settlement areas. In such areas, the SPDM identified priority working areas based on the legal status of their development, urban functions, population densities, and hazard assessment. Furthermore, in these priority areas, the SPDM suggested the development of microlevel implementation plans to undertake urban redevelopment for risk reduction.[15]

In order to implement the proposals of the SPDM, the Istanbul Metropolitan Municipality established the Urban Transformation Directorate under its Department of Earthquake Risk Management and Urban Development. The initial idea behind the "urban transformation" projects was to follow up on a pilot seismic risk assessment

[13] N.Z. Gulersoy, M. Balamir, R. Bademli, H. Turkoglu, A. Ozsoy, Y. Unal, G. Erkut, H. Eyidogan, A. Tezer, R. Yigiter, B. Onem, K.Y. Arslanli, H. Cicek, G. Simsek, B. Arslan, M. Burnaz, M. Senol, A. Taylan, B. Ozdemir, B. Sari, and U. Akin. 2003. The earthquake mitigation plan for Istanbul (EMPI). Boğaziçi University, Istanbul Technical University, Middle East Technical University, and Yildiz Technical University: *Istanbul icin Deprem Master Plani* [Earthquake Master Plan for Istanbul]. pp. 262–272. Istanbul Metropolitan Municipality, Geotechnical and Earthquake Investigation Department, Planning and Construction Directorate, p. 262; cited in footnote 3, pp. 92–94.

[14] A. Okten, B. Sengezer, I. Dincer, G. Batuk, E. Koc, A. Gul, Y. Evren, E. Seckin, T. Cekic, and O. Emem. 2003. Yerlesim Calismalari [Settlement Studies]. In footnote 14, pp. 195–214; cited in footnote 3, p. 94.

[15] Footnote 15, pp. 200–201; cited in footnote 3, pp. 95–96.

project in a priority area, building mass housing projects for about 3,000 buildings that were assessed as high risk and to extend such assessments to nine other districts.[16] Soon after, the concept of "urban transformation" was extended to large-scale commercial and residential developments, and the Istanbul Metropolitan Municipality established the Istanbul Metropolitan Planning and Design Center under Bogazici Insaat Musavirlik A.S. (BIMTAS) in 2006, a consultancy unit, working for the municipality, to undertake the design of such projects. In the end, however, implementation never worked out as planned and currently BIMTAS and the Istanbul Metropolitan Planning and Design Center no longer have the previously assumed authority on urban redevelopment. Hence, neither the previous legislation nor the establishment of special units was able to provide a solid basis for urban redevelopment in Istanbul.

As mentioned, the latest and relatively most comprehensive approach is the Law Regarding Redevelopment of Areas Prone to Disaster Risks, which provides the basis for most of the current urban redevelopment activities. Therefore, the following section will explore this law in its two main areas: (i) buildings that are deemed at-risk (building based reconstruction); and (ii) the redevelopment of large urban areas at risk (area-based reconstruction). The third area—the development of reserve areas—is briefly discussed under "area-based reconstruction."

BUILDING-BASED RECONSTRUCTION

The rebuilding of individual buildings deemed at-risk, or building-based reconstruction (BBR), is the most commonly used urban redevelopment strategy in Istanbul. Since the 1999 earthquakes, and particularly after the passing of the Law Regarding Redevelopment of Areas Prone to Disaster Risks, thousands of buildings in Istanbul have been rebuilt using this strategy. The first step of the BBR process is to gain collective demand by the residents of the building to undertake a risk assessment. Organizations and institutions certified by the Ministry of Environment and Urbanisation undertake the risk assessment and produce a report. The parameter of risk is to determine the fragility of the building components and whether the building can withstand a potential earthquake. The specifications for a building to be determined at-risk are for it to have a status between "safety of life" and the "precollapse stage."[17] The cost of building assessments is covered by the building owners and a copy of the risk report is sent to the ministry's local office for its approval. Once the report is approved, the property owners or tenants are provided a minimum 60 days to finalize the demolition of their buildings. If the building is not demolished in time, an additional time not less than 30 days is provided. If the demolition still has not occurred by the end of that period, the public authorities demolish the building and the cost is paid by the residents.

In most cases, the property owners stay in touch with contractors throughout the whole process (even before the approval of the risk report, because most of the time residents are certain that their building will be deemed as at-risk) and usually come to an agreement with the contractors during the period between the development of the risk report and the demolition phase. At least two-thirds of the building residents have to agree to the agreement between the property owners and the contractors. In contrast, prior to the law

[16] Turkiye Cumhuriyeti Istanbul Buyuksehir Belediyesi (T.C.I.B.B.). 2007. Zeytinburnu'ndaki "deprem donusum" calismalari 10 ilcede surecek. [The "earthquake transformation" projects in Zeytiburnu will continue in 10 districts]. http://www.ibb.gov.tr; cited in footnote 3, p. 97.

[17] Ministry of Environment and Urbanisation. 2013. Riskli Binalarin Tespit Edilmesi Hakkinda Esaslar [Principles on Identification of Buildings as Risky]. http://www.csb.gov.tr/db/altyapi/editordosya/Gun%201_Ders%202_RiskliBinaTespitEsaslari(3).pdf (in Turkish).

and the revisions to the Flat Ownership Law in 2012, all residents of an apartment building needed to approve rebuilding or retrofitting activities.

In most cases, contractors then increase the number of stories of the new building to recover reconstruction costs. Most apartment buildings built prior to the 1980s had only 5 or 6 stories, but under existing development laws contractors can usually build up to 10–12-story buildings, providing additional new apartments that they can sell. This approach also allows for density increase in the city. During the rebuilding phase, the tenants can apply for rental assistance either from the contractor or from the government for up to 18 months. However, the subsidy provided by the government is not deemed to be adequate by many urban residents.

It can be argued that rebuilding "a single building cannot be successful on lots with attached houses, or in lots where the required distance between buildings is insufficient, putting the risk of each building on its neighbor."[18] However, in a field survey measuring Turkish homeowners' willingness-to-pay for earthquake measures, it was found that "the role of group dynamics, trust and fairness" played a significant role in earthquake risk reduction investment of Istanbul residents, and that the existence of a prior retrofitting of a neighborhood building has a positive effect on its neighbors.[19] Likewise, the current situation shows that residents are increasingly willing to take a BBR approach as they observe successful applications in their neighbors' buildings.

AREA-BASED REDEVELOPMENT

Compared to BBR, area-based redevelopment (ABR) is a much more complex process because it involves the redevelopment of an area at risk and may include hundreds of buildings with thousands of dwellers. The first step in ABR is to determine the risk. This step is undertaken by the authorized public entities. The areas are categorized as at-risk based on the vulnerability of their geological conditions, by the state of the buildings, or both.

In Istanbul, all district municipalities and the Ministry of Environment and Urbanisation are authorized to determine these areas at-risk. After an area is determined as at-risk and the terms of redevelopment are agreed upon, demolition and reconstruction start. The main parameters of the terms of agreement are the duration of redevelopment, location and quality of transitional houses, level of rental assistance, and the level of profit demanded by the residents. In addition to rental assistance to move to new areas during the redevelopment phase, residents in ABR areas can also access "interest support" for purchase of TOKI-built mass housing at other locations, if it is part of their agreement.

The terms of agreement between residents, the local government, and the contractor are the key to the successful implementation of the ABR process, which is usually the phase where the ABR process becomes stagnant. In Istanbul, 40 locations, corresponding to around 1,100 hectares, have been declared as at-risk and suitable for ABR.[20] However, full implementation has not been

[18] T. Uyaroglu. 2005. Olası Marmara Depremine Iliskin. [About Potential Marmara Earthquake]. *Yapi* (*Istanbul*), 288, pp. 26–27; cited in footnote 3, p. 91.

[19] A. Onculer. 2002. Turkish Homeowner's Willingness to Pay for Earthquake Mitigation Measures. Paper presented at IIASA-DPRI meeting on Integrated Disaster Risk Management. Laxenburg, Austria; cited in footnote 3. p. 91.

[20] Ministry of Environment and Urbanization. http://www.csb.gov.tr/iller/istanbulakdm/index.php?Sayfa=sayfa&Tur=webmenu&Id=10108 (in Turkish, accessed 30 October 2015).

initiated other than in a few specific cases because the ABR process is too complex and requires a consortium between a large number of stakeholders—civil society, the public sector, and contractors. ABR projects also need to align with other existing laws and regulations, such as the laws related to historic preservation.

The third section in the Law Regarding Redevelopment of Areas Prone to Disaster Risks allows for "reserve areas" to be declared by the Ministry of Environment and Urbanisation in accordance with standard norms of science and art, and constitute a healthy and safe living environment and to be used for the purposes specified in the law. Accordingly, reserve areas can be used as transitional and new residential areas which can comprise housing and workplaces for those residing in risky buildings in or outside of risky areas. In addition, it is possible to develop any type of building and application in these areas and allow their sale to those not living in risky buildings in and outside of risky areas as well to bring in income. In Istanbul, reserve areas have been declared, but transitional houses to support the redevelopment process for ABR have not been constructed, increasing the implementation period of ABR.

3. LESSONS LEARNED

Since the devastating 1999 Marmara earthquakes, and following legal and institutional changes, Istanbul has experienced major urban redevelopment fueled by demand from residents, the private sector, and directly from the central government. In most cases, the process of urban redevelopment under the relevant legislation is carried out using the BBR approach, since it is easier and allows homeowners to rebuild their houses based on current building standards. Not only does BBR allow for an earthquake-resilient urban fabric, but it also improves physical living conditions (e.g., heating, energy efficiency, and infrastructure) for urban residents by transforming unsafe structures into ones that are up to current building and construction standards.

While ABR is a more comprehensive approach to urban risk reduction, it requires a high level of coordination between various stakeholders—urban residents, the public sector (municipalities and/or ministry), and contractors. In ABR, it is essential to generate an efficient level of communication among stakeholders and transparency of the procedure. In most cases, the failure to achieve these has created misunderstandings and slowed the ABR process. In this regard, urban planners play an important role, not just in using conventional spatial planning instruments and providing the most sustainable land use, but also in creating cohesion between these parties. In addition to these basic needs for an efficient ABR, urban planners must also be aware of the unique characteristics of the city, such as its historic and cultural properties and environmental values.

Although ABR is potentially a comprehensive solution to reduce disaster risks in urban areas, it is complicated in that it takes into account various components of social life—housing, work–housing relationship, social facilities, and many others—while involving all stakeholders in the process. At the moment, due to the short period of time that this process has been implemented in the cities of Turkey, there is insufficient data to indicate how this process can be improved. However, the current practice already signals problems and indicates that ABR needs to be a more community-driven and participatory process. If a top–down approach is used in this process, not only will the reasoning behind this approach be questioned, but also the problems in implementation. In this respect, urban planners' roles in the urban redevelopment process need to evolve to a proficiency that includes arbitration between parties so that a sustainable and resilient city can be achieved.

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Reducing Disaster Risk by Managing Urban Land Use
Guidance Notes for Planners

This document provides guidance for urban planners on how to use land use management-related tools they have at their disposal—land use planning, development control instruments, greenfield development, and urban redevelopment—to reduce disaster risk and contribute to strengthening urban resilience and sustainable urban development. The guidance provided in the document is further illustrated through case studies showing examples where urban land use management-related tools have been adopted to reduce disaster risk. It is hoped that this document will support urban planners as a professional group to step up and embrace disaster risk reduction.

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