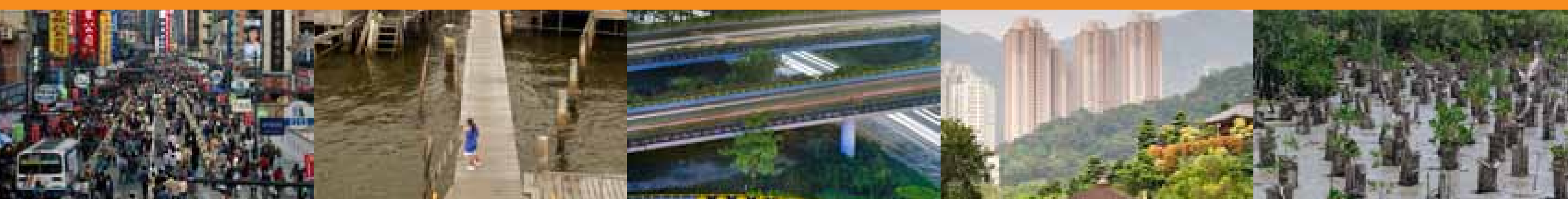
Building Urban Resilience



MANAGING THE RISKS OF DISASTERS IN EAST ASIA AND THE PACIFIC

Principles, Tools and Practice

THE WORLD BANK

Australian AID

Building Urban Resilience: Principles, Tools and Practice

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The International Bank for Reconstruction and Development

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About Building Urban Resilience in East Asia

Building Urban Resilience in East Asia is a World Bank program, which aims to increase the resilience of cities to disasters and climate change impacts by using a risk-based approach in public investment decision-making process. The objective of the initiative is to demonstrate a scalable methodology and practical tools for risk assessment, which can be used for city-level investment decisions.

Working closely with the stakeholders involved in land-use planning and infrastructure development, Phase I of this program identifies the key challenges facing urban decision-makers in terms of risk from natural disasters and climate change, and offers a set of open source risk assessment tools that can be used by city-level institutions, private investors, communities and planners of infrastructure services. Phase II of the program focuses on the exploration different investment options, management plans and capacity building.

Building Urban Resilience in East Asia is part of a broader effort of the World Bank to incentivize governments to effectively use risk information. The Open Data for Resilience Initiative (OpenDRI) aims to reduce the impact of disasters by empowering decision-makers with better information and the tools to support their responsibilities. "InaSAFE" (Indonesia Scenario Assessment for Emergencies) is one of those tools, developed through a partnership with the Indonesian National Disaster Management Agency (BNPB), the Australia Indonesia Facility for Disaster Reduction (AIFDR), and the Global Facility for Disaster Reduction and Recovery (GFDRR) Labs team.

Getting started – how to use this Handbook

This report is divided into three major sections designed to give urban planners and practitioners an intuitive and easy way to build elements of resilience into their urban governance and city planning.

Chapter 1

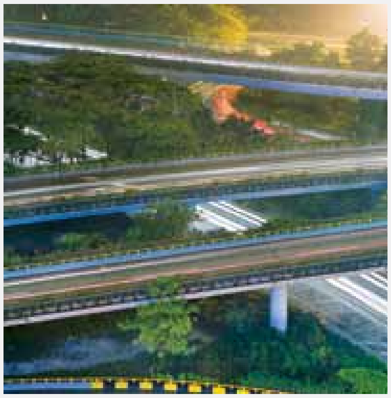
Principles of Urban Resilience

Presents key guiding principles for resilient cities in the context of today's urban development; risk, uncertainty and complexity; disaster risk management; social resilience; land use planning; urban ecosystems; urban upgrading; and incorporating resilience into the project cycle.

Chapter 2

Tools for Building Resilience

Focuses on the most common and effective tools and methodologies available and steps in using them. These tools include: risk assessment; risk-based land use planning; urban ecosystem management; urban upgrading; community and stakeholder participation; disaster management systems; data gathering, analysis and application; and risk financing and transfer approaches.



Chapter 3

The Practice of Urban Resilience

Provides guidance in identifying, planning and implementing urban investment projects, focusing on three major sectors. Water supply and wastewater systems details the importance of water and sanitation systems, including resilience to flooding – an increasing challenge to cities around the world. Energy and communications focuses on the national and sub-national energy systems. Transportation Systems discusses road, rail, air transportation, and how to enhance disaster resilience in these systems.

The Handbook includes case studies and tables providing good practice examples and further details. Each Chapter lists the most important resources and a detailed reference list is provided at the end of the Handbook. The Annexes provide general disaster definitions and classifications; a checklist for infrastructure owners and operators; a comparison of spatial plans for urban infrastructure; and data collection guidelines.

Foreword

In the context of the demographic, urbanization and climatic trends, policy-makers in East Asia are facing many difficult decisions over medium and long-term investments in public infrastructure and urban management.

Recent tragic events in the region, including the Great East Japan Earthquake and Tsunami, widespread flooding in Thailand, and the tropical storm Washi in the Philippines remind us of the devastation, economic damage and loss of human life that result from disasters. They add a sense of urgency to the challenge of preparing for and managing disaster, and carry important lessons to urban disaster risk management practitioners.

There are concrete ways to improve the decision-making process to guide cities towards the aspired benefits, and this report guides its readers in finding ways to avoid the mistakes of the past and build resilience into urban management, critical infrastructure investments, disaster and climate risk mitigation measures, stretching across sectors and jurisdiction and reaching all the way to the communities and the most vulnerable.

First, there are principles that can guide decision-makers when deciding over public finances. One of these is investing in quality risk data and tools that facilitate the use of data across sectors and jurisdictions. Cities that are better able to define and communicate their risks are better at preparing for and managing the impacts of natural disasters in a changing climate.

Second, there are concrete tools that can support the preparation and implementation of decisions. For example, integrating risk-based approaches into urban governance and planning processes can help national and city level stakeholders make complex decisions in a smarter, forward-looking and more sustainable manner resulting in increased resilience.

Finally, key economic sectors – including water, energy and transport systems – deserve particular attention. They are not only vital for cities and communities to be able to deal with a disaster and recover quickly, but they are also the sectors where careful investments – those that pay attention to the principles and make full use of the tools available – can make a real difference in people's lives.

The Building Urban Resilience initiative encourages cities to adopt and invest in risk-based approaches and make better use of the technologies and tools available to manage disaster risks. This report is an example of the commitment of the World Bank and AusAID to support cities in the East Asia region to be better prepared for the development challenges of both today and tomorrow.

John Roome, Director
Sustainable Development East Asia and the Pacific
The World Bank

Busy street in Shanghai, China. Photo: Goodshot

Executive Summary

This Handbook is a resource for enhancing disaster resilience in urban areas. It summarizes the guiding principles, tools and practice in key economic sectors that can facilitate the implementation of resilience concepts into decisions over infrastructure investments and general urban management as integral elements of reducing disaster and climate risks.

Resilience is the ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner.[1] Resilience in the context of cities translates into a new paradigm for urbanization and influences the way we understand and manage urban hazards, as well as urban planning in general. It provides a conceptual framework with practical rules of thumb that can guide stakeholders' decisions to incorporate the management of disasters and climate risks into urban investments. In practice, *operationalizing resilience* is a challenging process.[2] To facilitate this process, this book provides guidance on how to build urban resilience, primarily into critical infrastructure and the social realm, by reviewing available methodologies, tools and resources.

Focus on Cities

In the next decades, the major driver of the increasing damages and losses from disasters will be the growth of people and assets in harm's way, especially in urban areas.[3] Cities are the quintessential complex adaptive systems.[4] By 2050, the UN expects 80% of world's population to live in urban areas.[5] For the East Asia region, the urban population is expected to double between 1994 and 2025.[6] Often located along the coastline, in flood plains, or along seismic rifts, with their concentration of assets and people, cities are vulnerable to disasters. The combination of rapid and unplanned urbanization, which takes place on marginal lands and hazardous areas in combination with poorly constructed settlements and degraded ecosystems, puts more people and more assets into harm's way.

Rapidly growing peri-urban, small and middle-sized cities are particularly at risk. Often lacking financial resources, infrastructure, services and the capacity to manage the increase in urban population, their exposure is increasing and will translate into heavy loss of life and property in case of climate and disaster events, unless proactive measures are mainstreamed into urban governance and planning processes.

East Asia and the Pacific, along with South Asia, are particularly vulnerable to natural disasters. Globally, Asia-Pacific is the worst affected region in terms of economic impact and size of population involved. In the past year, the earthquake and tsunami in Japan, large-scale floods in Thailand, and the tropical storm in the Philippines are tragic reminders of the devastation, economic and social damages, and loss of human life caused by disasters, carrying important lessons to urban disaster risk management practitioners.

Risk and Uncertainty

Urbanization, environmental degradation, climate change, and development-related processes and planning, shape and configure hazards. The complexity of systems and uncertainty related to the impact of development and climate change affect the way we understand and manage risks when we build and develop our cities. Conceptually, we have to accept that our underlying assumptions could be wrong and the risks of disasters cannot be eliminated completely. This has two implications for cities. First, rather than focusing on "optimal engineering design", cities ought to adopt a robust approach to uncertainty and unknown risks using a balance of ecosystem measures and land use options, which incorporate a greater degree of flexibility into designs of engineered measures, and takes into account potential weak spots and failure. Urban planners must understand and incorporate natural ecosystem services into urban infrastructure and resilience projects. This approach will help cities avoid being "locked in" financing large-scale investments that might prove obsolete with change in future risks. Second, the recognition of residual risks implies that cities have to continue improving the quality of risk communication, early warning systems, emergency contingency, evacuation and recovery planning.

The nature of disaster and climate risk is highly uncertain. While long-term trends in normalized losses have not been attributed to natural or anthropogenic climate change, climate change adds an additional layer of risk and uncertainty.[7]Climate change can have a compounding effect on existing flood risk, for example, sea level rise, changing rainfall patterns, and an increase in storm surges.

The urban environment changes by design, in terms of physical and nonphysical characteristics. Development-related processes, including planning and management of urban growth and settlements, environmental and ecosystem degradation, and poverty, affect cities' risk profiles already today, with serious consequences. For instance, city decision-makers must consider a range of time horizons from annual budgeting priorities extending to 20-30 years for spatial plans and approximately 50 years for infrastructure design. Urban planning methods may support this longer term view of a city's needs, however, the output of the planning process may often be incomplete or inconsistent, and can rapidly become outdated and limited in its utility to guide the city to a more resilient future.

Facing these challenges, there is critical demand for a flexible and dynamic approach to building resilience, which goes beyond risk mitigation measures.

Building Urban Resilience - Principles, tools and practice

Building resilience in cities relies on making investment decisions that prioritize spending for activities offering alternatives which perform well under different scenarios. In managing risks today and planning for the future, a balance must be struck between, on the one hand, common sense approaches that minimize impacts through better urban management and maintenance of existing mitigation measures and, on the other hand, far-sighted approaches. Long-term views anticipate, defend and build resilience against future hazards by investing in new infrastructure or by altering the urban landscape. The balance will be different for each urban settlement at risk. The overall goal is a preferred strategy under which flexible or so-called "low-regret" measures can be cost effective even in the case of uncertain risks.[8]

Taking into account future risks and uncertainties, resilience relies on redundancy. Cities face difficult decisions over scarce resources and investments, striving for efficiency. The quest for efficiency often results in a game of trade-offs between resilience and redundancy.[9] Resilience does not strive for efficiency but for 'ways to build into near-term investments and choices, an appropriate consideration of long-term trends and worst-case scenarios.[10]

All governments have an obligation to protect their citizens, so that resilience can be seen as a public good[11] dependent on public funding. For city and municipal governments, this implies: planning development; providing safe and affordable infrastructure and services; regulating building design and construction; regulating hazardous activities; influencing land availability and construction requirements; encouraging and supporting household and community actions towards risk reduction; and finally, providing adequate disaster early warning, preparedness and response systems. Fulfilling these roles can reduce risk levels for populations and economies.

The disaster risk management framework, consisting of mitigation, preparedness, disaster, response, recovery and reconstruction phases, offers practical opportunities for enhancing resilience. Risk is the uncertainty of loss, and loss is the convolution of hazard, assets, and the vulnerability of these assets to hazards. Risk can be reduced by several approaches focusing on the: i) location; ii) structure; iii) operational aspects; and iv) risk financing and transfer options. Government and donor-led projects should identify and implement a balanced combination of these approaches, to reduce risk and enhance resiliency.

Urban infrastructure - water, sanitation, energy, communications and transportation systems - is critically important for emergency response and the quick recovery of the community and its economy. Vulnerable to a wide range of natural hazards, there are opportunities for enhancing resilience of critical systems. Residual risks have to be managed in a way that is both flexible and robust. Traditional cost-benefit analysis does not work well when dealing with catastrophic tail risk. Critical systems therefore need to be designed in a way that they fail "gracefully", striving for a robust design that builds on investments in risk information, strategic communication, cross-sectoral coordination, and a well-planned response and recovery strategy.

Social resilience is the capacity of a community or society to cope with, and adapt to, disturbances or changes. It includes the ability of communities and broader society to absorb disturbances, to self-organize or adjust to existing and new stresses, and to build and increase their capacity for learning and adaptation. A resilient community is able to respond to changes or stress in a positive way, and to maintain its core functions as a community despite those stresses. Policy-makers should strive to create an enabling environment for communities to be able to participate and make decisions. This increases collective resilience and facilitates public authorities in their dual role of creating and disseminating risk information.

Risk-based land use planning identifies the safest areas to prioritize immediate investments in urban development and infrastructure projects. Land use plans influence the location, type, design, quality and timing of development. Mainstreaming land use planning in infrastructure projects reduces episodic and everyday risk in rapidly growing urban centers prevalent in hazard-prone areas. While land use planning informs urban spatial development plans, comprehensive risk reduction requires appropriate social and economic policies and programs that will increase the capacity of the urban population to adapt to risks.

Combined with land use planning, ecosystems management approaches for resilience in urban areas make use of the existing natural landscape and can significantly decrease the cost of urban infrastructure projects. Ecosystem management requires an understanding of ecosystem services and the local urban environment. Methodological tools can help to integrate ecology into urban resilience. There are a number of ecosystem management strategies that are relevant to urban resilience and, more broadly, to disaster risk reduction, including: watershed management (e.g. coastal zone management); urban landscape design; green and blue infrastructure; and environmental buffers.

Urban upgrading prioritizes infrastructure, housing, livelihoods and social networks for the most vulnerable households living in slum settlements. The majority of slum settlements are located on relatively inexpensive yet hazard-prone sites. Over-crowded living conditions in poorly built structures, lack of basic services and secure tenure along with socio-spatial exclusion, make the urban poor vulnerable to disaster risks. However, variations in slum conditions create different degrees of risk. Strategic urban upgrading can manage risks by: i) regulating slum development in hazard-prone areas through planned resettlement and building codes, ii) reducing losses by prioritizing critical infrastructure, escape routes and community refuges in slums, and iii) promoting safe and socio-economically viable low-income neighborhoods in accordance with a citywide plan.

In reaching decisions on the appropriate prioritization of resilience efforts, an understanding of both current and future risks is needed. Risk information serves as a basis for prioritizing different risk reduction measures. Indicators and visualization tools can highlight trade-offs between various policy options and in this way guide investment and development decisions. Risk assessments are important disaster and climate risk management tools for identifying and quantifying the potential impacts, and prioritizing mitigation measures. Geographic Information Systems (GIS) are instrumental in identifying assets at risk. Sharing hazard and risk information plays a critical role to assess potential hazards, and identify vulnerabilities of different urban communities and sectors. Building on this, innovative approaches to managing capital and risk, including risk financing and transfer mechanisms, strengthen fiscal resilience and improve the utilization of public and private capital.

Emergency and disaster planning is crucial to urban disaster resiliency. Risk can never be eliminated in full. Emergency response, continuity and recovery planning, are ways to buffer the impact, aiding the overall reconstruction and recovery process in the aftermath of a disaster. Investments in early warning systems are amongst the most cost-effective measures that any country can undertake. An integrated warning system consists of scientifically designed and located detection sensors, a data analysis and warning decision-making facility, the warning message, a dissemination capacity, and a public educated to understand the message and take the appropriate actions.

Financial approaches to urban disaster resilience aim to reduce the negative impacts of disasters on individuals and communities, the private sector, and public entities. They allow for an increase in the financial response capacity in the aftermath of disasters, and reduce the economic and fiscal burden of disasters by transferring excess losses to the private capital and insurance markets. While the primary clients of disaster risk financing frameworks have traditionally been national governments, cities and local governments can also strengthen their resilience through principles and instruments that are widely applicable.

Looking forward

Take the rapid expansion of urban built up areas as an opportunity to develop and manage new settlements in a way that they incorporate resilience at the outset into regular urban planning. The aftermath of a natural disaster often provides an opening for decision-makers to push through with *corrective* and *preventive* actions. Resilience goes beyond risk migration measures. Resilience increases preparedness *and* the capacity to respond to a disaster *and* swiftly recover from its impacts. It has to be part of everyday urban development, medium-and long-term investment and planning, urban governance and hazard management. This report makes recommendations on how to enhance resilience, particularly in critical infrastructure and the social realm.

Invest in sustainable risk information systems and analytical tools, which allow for systemic and evidence-based understanding and communication of risk. Quantifying the impacts of planned or proposed investments is a critical step to reduce risk.

Integrate risk assessment and cost-benefit analysis within a dynamic decision-making process for the purpose of informing resilient urban investments. This requires developing: i) technical tools to perform risk assessment and cost-benefit analyses; ii) institutional arrangements for adopting these analyses in decision-making; iii) political will to adopt institutional tools for risk assessment; and iv) the capacity of all stakeholders to be able to access and make use of the risk information and tools.

To make necessary budgetary and investment decisions, decision-makers seek consistent and quantitative tools to evaluate public investments. Integrating risk-based methods into cost-benefit approaches enables the consideration of the probable impacts of climate change and disasters by quantifying the economic consequences of these events. **These tools include:**

- Risk Assessment,
- Risk-Based Land Use Planning,
- Urban Ecosystem Management,
- Urban Upgrading,
- Community and Stakeholder Participation,
- Disaster Management Systems,
- Data Gathering, Analysis and Application,
- Risk Financing and Transfer Approaches.

List of Acronyms and Abbreviations

ACCCRN	Asian Cities Climate Change Resilience Network
AIFDR	Australia-Indonesia Facility for Disaster Reduction
AKOM	Disaster Management Centre of Istanbul City
BNPB	Indonesia's National Disaster Management Agency
BRACE	The Building the Resilience and Awareness of Metro Manila Communities to Natural Disaster and Climate Change Impacts
CAEP	City-Assisted Evacuation Plan
CAS	Country Assistance Strategy
CAT DDO	Catastrophe Deferred Draw Down Option
CBDRM	Community based disaster risk management
CCA	Climate Change Adaptation
CDD	Social Fund/Community-Driven Development
CDMP	Comprehensive Disaster Management Programme
CDP	Community Development Plans
CIESIN	Center for International Earth Science Information Network
CPS	Country Partnership Strategy
CSO	Civil Society Organizations
DEM	Digital Elevation Model
DPL	Development Policy Loan
DRFI	Disaster Risk Financing and Insurance
DRM	Disaster Risk Management
DRR	Disaster Risk Reduction
EEWS	Earthquake Early Warning Systems
EMPI	Earthquake Mitigation Plan for Istanbul
EOC	Emergency Operations Centers
FEWS	Famine Early Warning Systems
GFDRR	Global Facility for Disaster Reduction and Recovery
GHG	Green House Gas
GIS	Geographic Information System
GLTN	Global Land Tools Network
GUO	Global Urban Observatory
HABISP	Information system for social housing in the city of São Paulo
HOT	Humanitarian OpenStreetMap Team
IDRM	Integrated Disaster Risk Management
IIED	International Institute for Environment and Development
IRM	Immediate Response Mechanism
ITC	International Institute for Geoinformation Science & Earth Observation
JFPR	Japan Fund for Poverty Reduction
LDCF	Least Developed Countries Fund
LNG	Liquid Natural Gas
LRAP	Local Resilience Action Plans

MIS	Management Information Systems
MOU	Memorandum of Understanding
NGO	Non-Governmental Organization
OCHA	Office for the Coordination of Humanitarian Affairs
PAD	Project Appraisal Document
PAS 200	Publically Available Specification in Crisis Management
PCN	Project Concept Note
PCRAFI	Pacific Catastrophe Risk Assessment and Financing Initiative
PDNA	Post-Disaster Needs Analysis
PDO	Objective Development Objective
PDO	Project Development Indicator
PID	Project Information Document
RRTI	Regional Risk Transfer Initiative
SCBA	Socioeconomic Cost Benefit Analysis
SDI	Shack/Slum Dwellers International
UNEP	United Nations Environment Programme
UrEDAS	Urgent Earthquake Detection and Alarm System
VCA	Vulnerability and Capacity Assessment
VTC	Volunteer Technical Communities
WBI	World Bank Institute
WFP	World Food Programme
WRI	World Resources Institute

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Resilience is the ability of a system, community or society exposed to hazards to resist, absorb, accommodate 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.

Chapter 1
Principles of Urban Resilience

Key Points

- ***Resilience*** *is the ability of a system, community or society exposed to hazards to resist, absorb, accommodate and recover from the effects of a hazard in a timely and efficient manner.*
- ***Residual risk and uncertainty*** *have to be managed in a way that is both flexible and robust, including design solutions that build on investments in risk information, strategic communication, cross-sectoral coordination, as well as well-planned response and recovery strategy.*
- ***The urban poor*** *are particularly vulnerable to climate change and natural hazard impacts due to the location of the homes and livelihoods, and the lack of reliable basic services.*
- ***Disaster risk management framework,*** *consisting of mitigation, preparedness, disaster, response, recovery and reconstruction phases, offers practical opportunities for enhancing resilience in each phase.*
- ***Risk mitigation*** *is part of the resilience approach. With the overall aim of increasing preparedness and the capacity to respond to a disaster and swiftly recover from its impacts, resilience goes beyond mere mitigation measures.*
- ***Risk can be reduced*** *by several approaches focusing on the: i) location; ii) structure; iii) operational aspects; and iv) risk financing and transfer options.*
- ***Social resilience*** *is the capacity of individuals within a community or society to cope with, and adapt to, disturbances or changes.*
- ***Land use planning and ecosystem management*** *are relatively low-cost `no-regrets' approaches to manage disaster risks effectively, especially for small and medium urban centers that lack resources and capacity.*
- ***Urban infrastructure*** *is critically important for emergency response and the quick recovery of the community and its economy. The design of critical systems needs to prepare for its failure through redundant and back-up measures, and preparing for failure in a way that is least damaging to the society.*
- ***Risk information*** *serves as a basis for prioritizing different risk reduction measures. Sharing hazard and risk information with key stakeholders plays a critical role in managing risk facing urban communities and sectors.*
- ***Creating an enabling environment*** *for communities to participate and make decisions based on adequate risk information and tools, fosters the collective resilience of an urban system.*

Key Resources

Section	Resource
1.1 Urban Disaster Resilience	***Natural Hazards, Unnatural Disaster; The Economics of Effective Prevention.*** *World Bank, 2010.*
1.2 Risk, Uncertainty and Complexity	***Density & Disasters: Economics of Urban Hazard Risk.*** *World Bank, 2009.*
1.3 Disaster Risk Management and Opportunities for Resilience	***Improving the Assessment of Disaster Risks to Strengthen Financial Resilience: A Special Joint G20 Publication by the Government of Mexico and the World Bank.*** *World Bank, 2012.*
	Hyogo Framework for Action 2005-2015: Building Resilience of Nations and Communities to Disasters. UNISDR, 2006.
1.4 Social Resilience	***Climate Resilience and Social Change: Operational Toolkit.*** *World Bank, 2011.*
1.5 Land Use Planning	***The Role of Land-use planning in Flood Management: A Tool for Integrated Flood Management.*** *APFM Technical Document No. 12, Flood Management Tools Series, WMO, 2008.*
1.6 Urban Ecosystems	***NYC Green Infrastructure Plan.*** *New York City Department of Environmental Protection, 2010.*
1.7 Urban Upgrading	***Climate Change, Disaster Risk, and the Urban Poor: Cities Building Resilience for a Changing World.*** *The World Bank Urban Development Series. World Bank, 2012.*
1.8 Incorporating Resilience into the Project Cycle	***Abhas Jha, Henrike, Brecht 'Building Urban Resilience in East Asia'*** *An Eye on East Asia and Pacific, Issue 8. World Bank, 2011.*

1.1 URBAN DISASTER RESILIENCE

Resilience is the ability of a system, community or society exposed to hazards to resist, absorb, accommodate 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.[12] A resilient community is one that can absorb disturbances, change, reorganize and then still retain the same basic structures and provide the same services.[13] As a concept, *resilience* can be specifically applied to any community and any type of disturbance: natural, man-made, or a combination of the two. Disaster resilience can be seen as a public good that builds an appropriate amount of redundancy into urban systems and encourages communities to plan for dealing with disruptions.

In practice, finding ways to operationalize resilience poses a challenge.[14] Addressing disaster risk in the context of resilience encourages urban planners to look at the many impacts of disasters and build the long term capacity of communities to both adapt and cope with uncertain risks. The goal is for communities to be prepared for an earthquake as much as they are prepared for a drought or flooding. By breaking down urban resilience into its four components, *economic, institutional, infrastructural and social*, underlying issues can be addressed and a broader capacity can be developed. While this report addresses all components of disaster resilience, the focus rests on critical infrastructure and social aspects.

Components of Urban Disaster Resilience

Infrastructural | **Institutional** | **Economic** | **Social**

- **Social resilience** refers to the demographic profile of a community including by sex, age, ethnicity, disability, socio-economic status and other key groupings, as well as a community's social capital. Social capital, although it is difficult to quantify, refers to a sense of community, the ability of groups of citizens to adapt, and a sense of attachment to a place.[15]

- **Infrastructural resilience** refers to the vulnerability of built structures including property, buildings and transportation systems. It also refers to sheltering capacity, health care facilities, the vulnerability of buildings to hazards, critical infrastructure, and the availability of roads for evacuations and post-disaster supply lines. Infrastructural resilience also refers to a community's capacity for response and recovery.

- **Economic resilience** refers to a measure of a community's economic diversity as well as to the overall employment, number of businesses, and their ability to function following a disaster.

- **Institutional resilience** refers to the governmental and non-governmental systems that administer a community.

The following sections of **Chapter 1** set the context for integrating resilience into urban areas, and summarize the key guiding principles. Techniques and tools that serve as ways to build and enhance resilience are discussed in **Chapter 2**.

1.2 RISK, UNCERTAINTY AND COMPLEXITY

Drivers of risks, including rapid urbanization, environmental degradation, climate change impacts, and development-related processes, shape and configure hazards. The shift of human population from rural to urban areas is largely driven by economic opportunity. Uncontrolled development often takes place in high-risk areas, such as hillside slopes, floodplains, or on subsiding land, most often putting the poor and the vulnerable into hazardous areas. In extreme cases, vulnerable populations, living in slum settlements, tend to trade-off the value of environmental and disaster safety for living in close proximity to economic opportunities offered by the urban environment.[16]

Uncertainty is the essential element of any disaster, referring to the disaster impacts that cannot be quantified or are completely unknown. In order to cope with uncertainty, cities have to adopt a robust approach to decision-making. This means taking into account potential weak spots and system failures, and adapting to a wider range of futures rather than focusing on optimal design solutions.

Climate change adds an additional layer of uncertainty. The 2012 Special Report of the Intergovernmental Panel on Climate Change (IPCC) on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation indicates that 'long-term trends in normalized losses have not been attributed to natural or anthropogenic climate change.'[17] In the foreseeable future, population and asset growth in hazardous areas will be, by far, the biggest driver of fatalities and damages from extreme weather events.

Urban infrastructure refers to key systems and services, which are critically important for emergency response and the quick recovery of the community and its economy. The design of these systems, including water, sanitation, energy, communications and transportation, needs to prepare for its failure, finding ways to both operate through redundant and back-up measures, as well as ways to fail or shut-down "gracefully" or in a way that is least damaging to the society. Traditional cost-benefit analysis, for instance, does not work well when dealing with catastrophic tail risk. A different approach is needed, which focuses on robust design and builds on investments in risk information, strategic communication, cross-sectoral cooperation, and well-planned response.

FIGURE 1 Illustration of cascading failures: Balboa Boulevard, 17 January 1994 Northridge earthquake (Los Angeles, USA)

Source: NISEE, 1994.

The ability to be flexible and adaptable to known and unknown disturbances is an important characteristic of a resilient system. In planning for disasters, there is always an element of uncertainty that requires additional preparation and redundancy in the system design. Enhancing resilience relies on having appropriate redundancy and flexibility to continue providing for essential needs given existing and future risk and uncertainty. Poor practices in urban planning often set the minimum critical needs as the appropriate objectives of any project. However, given the level of uncertainty linked to disasters, these approaches tend often to fail to meet those critical needs, whereas resilience approaches go beyond minimum critical needs.

The need for redundancy and alternatives increases with the size and complexity of an urban area. The complexity of urban infrastructure increases exponentially as urban areas expand in population and density. As an urban area increases in size, the available transportation will quickly reach capacity and cannot address the basic needs of the community. Following a disaster, this can lead to cascading failures or collocation failures.

- *Cascading failures* occur in a series in which specific system components overload and fail. Major electrical blackouts are typical of this type of failure. Disasters can cause several components to fail simultaneously, thus triggering the *cascade*. Cascading failures can also jump from one system to another – failure of the electrical grid can result in major traffic disruptions, and lack of communications, further compounding the disaster.
- *Collocation failures* occur when a catastrophic failure of one of the lifelines, such as a water main, then undermines or otherwise affects neighboring utilities, such as gas mains, power cables, or road infrastructure.

Resilience is a forward-looking approach that goes beyond risk mitigation and seeks to enhance capacity. Due to land use pressures, these types of complex failures are difficult to mitigate. Redundancy planning and designing for failure during the early stages of development of an urban region is the ideal solution, but can be difficult to achieve in practice. Introducing resilience approaches can be perceived as reducing the efficiency of urban systems and increasing costs. Helping communities to understand the long term cost savings of resilience is central to addressing issues of risk and uncertainty. **Box 1** describes steps in enhancing resilience for the water, food and transport sectors.

1.3 DISASTER RISK MANAGEMENT AND OPPORTUNITIES FOR RESILIENCE

All governments have an obligation to protect their citizens. As local governments are the first institutional levels to respond to disasters, they have a particular obligation to reduce disaster risk and build resilience within their communities.[18] For city and municipal governments, this includes: guiding where development takes place; providing safe and affordable infrastructure and services; regulating building design and construction; regulating hazardous activities that can produce disasters; influencing land availability and what can be built on it; encouraging and supporting household/community action that reduces risk; and providing adequate disaster early warning, preparedness and response systems. When urban governments fulfill these key roles, the levels of risk for their populations and economies are much reduced, and urbanization is associated with much lower risks.[19]

Public institutions are accountable to manage and communicate risk. Creating and enforcing the accountability of city and municipal governments to effectively manage and communicate risk can be challenging. Managing and reducing risk requires a

Box 1 Examples of enhancing resilience in an urban region

1. **Identify and prioritize the most important needs** for the urban region, the sector or the system you're concerned with. For example:

- ***Potable water*** might be the most crucial need following a disaster. Food is generally a lower priority, although still crucial for selected populations, especially the elderly, children, pregnant women, and the sick.
- ***For the food sector***, refrigeration may be a critical need – inventory sufficient for days or even weeks for a region can be lost within a day or so without power. Again, understanding the need for relatively modest but highly reliable electric power at major warehouses is a key step towards enhanced resiliency.
- ***For the highway department****,* there may be a few critical links (e.g. key bridges, mountain passes) whose failure will result in major disruption. Understanding where these links are, and why they're so important and perhaps vulnerable is a valuable first step towards enhanced resiliency

2. **Identify ways to enhance meeting these needs**. To the maximum extent feasible, reducing vulnerabilities by strengthening, relocating or developing redundant key assets is highly desirable. Resources are scarce so that vulnerabilities typically can only be reduced *as low as reasonably possible* (the "ALARP" principle). Even so, uncertainty exists so that resiliency can be enhanced by alternatives approaches in parallel, such as:

- ***Potable water****:* educate people about the need and how to conserve water, and ways to purify questionable water; and identify technologies, stockpile equipment and develop plans for portable water purification and distribution.
- ***Refrigerated food***: identify major warehouses and help them to review and upgrade their backup power generators and fuel supplies; have emergency plans for replenishing their fuel quickly following a disaster.
- ***Highway department***: identify alternative routes or ways to re-establish the disrupted link. For example, when the Bay Bridge was damaged and out of service for 30 days in the 1989 Loma Prieta Earthquake, temporary ferry service was established for commuters to get to work.

longer-term perspective that stretches beyond elected terms. Authorities must balance a multiplicity of competing economic, political and social interests, for example, whether to protect the mangroves that buffer storm surges or allow industrial development in coastal areas, whether to try to control population movements to high-risk sites or to direct the incentives and infrastructure investments which would guide population movements towards safer sites.[20] Some decisions and resources also are beyond their control at regional or national levels, or beyond their jurisdiction or sector.

A combination of measures is needed to ensure the accountability of government to its citizens for their safety, namely:

- The development and enforcement of a legal and institutional framework - including performance frameworks - for disaster and climate-related risk management in cooperation with civil society, the private sector and regional/national government.
- Promotion of the meaningful participation of community and other interest groups in the design, delivery and monitoring of disaster and climate-related risk management including the use of tools such as social audits. **Box 2** provides an example from the Philippines.
- Clear delineation of the roles and responsibilities of all levels of government and civil society

Box 2 Increasing accountability in the Philippines

The Mindanao Summit on DRR and Geo-Hazard Awareness in Cagayan do Oro City, called by two Philippines Government senators following a devastating tropical storm in this city and nearby areas, brought together a broad range of government and civil society stakeholders to discuss how to reduce disaster risks. A number of specific legislative, communication, planning and response priorities for disaster risk reduction were identified for Mindanao. This included the creation of a disaster response and accountability rating system for Local Government Units.

Source: Mindanao Declaration on Disaster Risk Reduction Priorities. 19 February 2012. Cagayan de Oro: Mindanao Summit on DRR and Geo-Hazard Awareness, February 19-20.

actors for disaster and climate-related risk management.

The disaster risk management framework offers many opportunities for enhancing resilience. Disaster risk management (DRM) stretches across different sectors and relies on coordination among actors. Measures should be guided by the principles set by the Hyogo Framework for Action (HFA) adopted by 168 countries. A comprehensive DRM strategy is based on the following five pillars: i) risk identification, assessment, and monitoring; ii) risk reduction through prevention and mitigation measures; iii) disaster risk financing and insurance; (d) emergency preparedness; and (e) post-disaster response, recovery, and reconstruction that reduces risk from future events.[21]

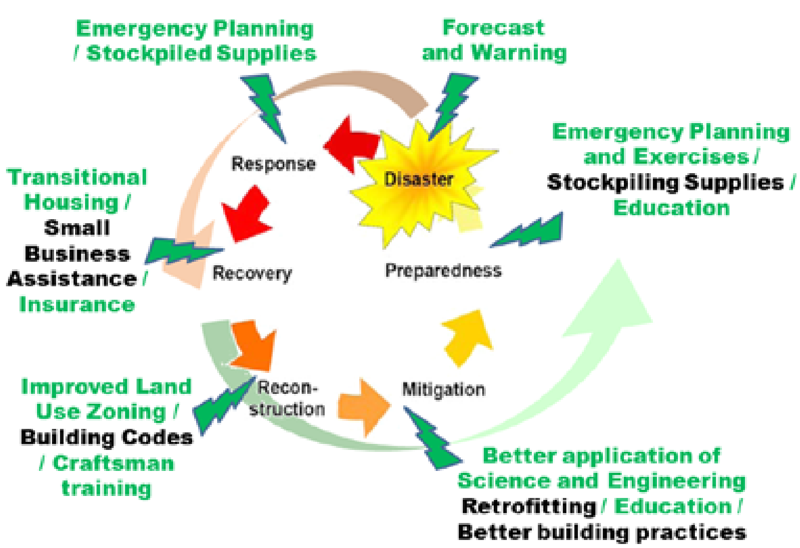
From the perspective of urban planning, decision-makers face a trade-off between adequate preparedness versus potential future costs associated with the necessary response, recovery and reconstruction following a disaster. The aftermath of a natural disaster often provides an opportunity for decision-makers to take corrective and preventive actions. A World Bank report on the economics of natural disasters presents empirical evidence for preventive measures that can have large future returns.[22] Throughout this Handbook, the resilience tools and sectoral practice are geared toward the long-term mitigation and planning component of the disaster cycle, depicted in **Figure 2**.

Analyzing disasters through the lens of the disaster cycle identifies opportunities for mitigation to break the chain of causation and make impactful change to disaster resilience. Using the framework of the disaster cycle, one has to bear in mind that the cycle is only a schematic representation of phases, which in reality take place in parallel. While disaster risk mitigation is part of the resilience approach, with the overall aim of increasing preparedness and the capacity to respond to a disaster and swiftly recover from its impacts, resilience goes beyond mere mitigation measures.

The ***Mitigation Phase***, strengthening community ties, social organizations and the economic base enhance resilience. The lessons of the previous disasters must be utilized so that present and future development and growth of the urban region occurs in a sustainable manner.

The ***Preparedness Phase*** focuses on preparing for the next disaster. Typical preparedness activities include disaster and evacuation planning, training

FIGURE 2 The Disaster Cycle traditionally includes six phases



Box 3 The Great California ShakeOut

In November 2008, the largest earthquake drill in U.S. history up until that time took place, involving 5.3 million participants. The drill, which was organized by the Earthquake Country Alliance, took place in homes, businesses, schools, places of worship and communities across California and featured week-long events to connect Southern California communities with preparedness resources and provide residents with the information and knowledge to prepare, respond and recover in the event of a disaster. The drill is now an annual event – in 2009 it attracted 6.9 million participants, and in 2011 more than 8.6 million Californians plus an additional 800,000 people in Oregon, Nevada, Idaho, Guam, and British Columbia. Encouraged by live drill broadcasts on more than 55 California radio and television stations, participants simultaneously practiced the "Drop, Cover and Hold On" drill recommended by experts as essential for avoiding injury and even death in the event of a major earthquake.

Source: http://www.shakeout.org/.

and exercises and stockpiling of supplies. **Box 3** provides an example of an earthquake drills, regularly conducted in California.

In the ***Disaster Phase***, warnings and evacuation can help to reduce losses and prepare the community to respond more quickly. Warnings not only allow shelter seeking for personal safety but, if the warning period allows, also permit quick movement of valuable goods, foodstuffs, animals and vehicles to safer locations.

The ***Response Phase*** lasts hours to weeks depending on the scale and type of disasters and capacity of the affected areas. This phase focuses on the people affected through rescue operations, public health precautions, shelter and food distribution. Intervention is made only to prevent additional major destruction – containing fires and hazardous materials releases, emergency repairs to certain infrastructure to prevent further failures, and restoration of crucial services such as emergency communications.

The ***Recovery Phase*** typically lasts weeks to months, depending on the size and scale of the disaster. During this phase, social and economic functions are restored, using temporary measures if required. Communities are moved out of temporary structures and shifted into semi-permanent housing, schools are reopened and community organization is restored. At this point, both critical and non-critical infrastructure is rebuilt so the economy can begin to function again.

The ***Reconstruction Phase*** fully restores what was lost, to the extent possible, and typically takes months to years. The transition from emergency responders to normal government agencies occurs early in this period. In most disasters, residential housing reconstruction is a key issue for addressing the long term needs of the community. Central decision-making tends to remain in place in order to return permanent infrastructure and economic sectors, but residential housing presents a number of complexities including resettlement in hazard-free zones, payment for private reconstruction and construction standards. Introducing new building technologies under the pressure to rebuild quickly makes *building back better* more difficult. In extraordinary cases, a special government agency may be created. The creation of the Queensland Reconstruction Authority, described in **Box 4**, is one such agency.

Disaster Risk Information for Resilience

Sharing data and creating open systems promotes transparency and accountability, and ensures that a wide range of actors is able to enhance resilience. The World Bank recognizes that transparency and accountability are essential to the development process and central to achieving the Bank's mission to alleviate poverty. As a knowledge institution, the World Bank has a mandate to share its information freely and openly.

Box 4 Queensland Reconstruction Authority - A designated authority for reconstruction

In Queensland after the 2010/2011 floods, the Queensland Reconstruction Authority (QldRA) was formed for the time period of 2 years. The QldRA's mission is to reconnect, rebuild and improve Queensland communities and its economy. The Authority has been vested with the power and authority to take charge of the reconstruction process and facilitate effective interaction between the concerned line departments at the Queensland State and local levels, in coordination with the concerned local councils. This approach ensures that reconstruction will continue to be a part of normal government businesses for the line department concerned. In working with local governments, the QldRA also takes the approach of supporting local Councils in pushing forward their local recovery and development agenda under the framework of broader reconstruction policy, especially with regards to disaster mitigation and reconnecting the community, and rebuilding the local economy. This approach does not only build the ownership of the local Councils and their constituents, but it will also empower them to undertake future planning and investment decisions that incorporate resilience.

Source: Queensland Recovery and Reconstruction in the Aftermath of the 2010/2011 Flood Events and Cyclone Yasi, World Bank / Queensland Reconstruction Authority, 2012, Washington DC, (pdf). More information about the Authority: http://www.qldreconstruction.org.au/.

Risk information serves as a basis for prioritizing different risk reduction measures. Indicators and visualization tools can highlight trade-offs between various policy options and guide investment and development decisions. The Open Data for Resilience Initiative (OpenDRI), led by the Global Facility for Disaster Reduction and Recovery in partnership with the World Bank and other development institutions, aims to reduce the impact of disasters by empowering decision-makers with better information and the tools to support their decisions. **Figure 3** illustrates the virtuous cycle of improving risk information for better decision-making.

FIGURE 3 Open data for resilience cycle

Smarter management of information within the city's institutions can greatly enhance decision-making capacity and therefore lead to greater resilience. There is a critical need for systems at the city level to manage and share geospatial data and information associated with technical disaster and climate risk studies. The key objective of data sharing is to promote the open and efficient exchange of information between government stakeholders. The OpenDRI approach promotes the development of tools to assist in the task of sharing data and enabling resilient decision-making.

A core task of the urban public sector is the collection of information that is relevant to urban planning and management. This includes producing credible information on hazard risk and making it easily available to all stakeholders.[23] Full openness of data also has many benefits; however, this can be seen as an ongoing process developed through an evolving discussion between government stakeholders and their constituents. Opening access to information allows a broader set of stakeholders, academic institutions, individual citizens, and the private sector, to incorporate risk reduction elements in their decision-making. This increases the collective resilience of the city and enables the city authorities in their dual role of creating and then disseminating risk information.

Further Reading

Using High Resolution Satellite Data for Identification of Urban Natural Risk (Deichmann, et al., 2011).

Disaster Risk Mitigation as an Element of Resilience

Risk is the combination of the probability of an event and its negative consequences, or in other words, the uncertainty of loss or damage in a given period of time. Disaster risk is a function of hazard[24], exposure and vulnerability. While some perceive vulnerability as the opposite of resilience,[25] the following distinction can be made: whereas resilience refers to the capacity of systems in absorbing, buffering and recovering from shocks, vulnerability refers to the susceptibility of people and assets to suffering damage or losses due to certain conditions, such as poor living conditions. Vulnerability is linked to exposure, as the location of people or economic assets creates conditions for vulnerability factors, such as the quality of housing standards, to play a role. **Figure 4** depicts the elements of risk calculation.

Mitigation of disaster impacts can be accomplished by means of the following risk reduction approaches focusing on the location, structure, operational capacity, and financial strength and exposure, illustrated in **Figure 5**.

- **Locational** approaches avoid hazards through land use planning or resettlement.
- **Structural** approaches increase resistance to the hazard-proofing buildings, retrofitting, and improving building codes.
- **Operational** approaches focus on contingency and emergency planning, including provision of temporary evacuation.
- **Fiscal** approaches include risk financing and transfer mechanisms, including, contingent financing, budget relief, and other instruments and services to share or transfer financial exposure through public or private entities.

Chapter 2 provides further information about tools to increase resilience. **Chapter 3** focuses on how to use these tools in key sectors.

Locational mitigation

Locational mitigation involves physically avoiding all or some of the impacts of natural hazards. Natural hazards occur in a geographically defined manner: when their location can be defined, population and assets can be guided to safer areas where disaster impacts are lower or non-existent. **Land use planning and ecosystem management** are relatively low-cost approaches that manage disaster risks effectively, especially for small and medium urban centers that lack resources and capacity. The most common modality for the locational approach is **hazard mapping for land use planning**. Mapping of hazards is a major task, which requires a significant investment of scarce resources. International organizations or national geologic agencies can assist in the process and facilitate local capacity development.

Hazard maps can take as many forms, depending on hazard definition, for instance as unique multi-hazard maps for a given locality. Flood hazard maps are the most common hazard maps, but more recently mapping of earthquake faults, seismic liquefaction zones, landslide potential, tsunami inundation zones, cyclone storm surge zones and volcanic hazards has begun in many countries. Hazard maps need to be created and actively utilized in urban areas. Development projects should assist hazard identification and mapping as part of the project technical work, taking into consideration existing land use policies. Maps need to be widely disseminated, and land use policies need to be developed and implemented.

FIGURE 4 Key elements of risk calculation

Risk = Hazard x Exposure x Vulnerability

FIGURE 5 Key elements of risk reduction

Locational | Structural | Operational | Fiscal

Another modality of the locational approach is **building redundancy**. Key infrastructure projects should consider the enhanced reliability benefit of redundant facilities within complex systems, such as two water tanks or water treatment plants (at different sites), rather than one large tank or treatment plant. Having excess water or power capacity is not wasteful if it increases the reliability of those systems – the costs of outages are far greater than a modest investment at the time of construction. Redundancy is most effective when geographically dispersed.

Structural mitigation

Addressing mitigation from a structural perspective deals with the physical impacts of natural hazards. Natural hazards are physical phenomena whose forces and energy can to some extent be physically managed. Traditional structural mitigation has involved resisting forces, such as earthquakes, in buildings via structural **bracing, frames or shear walls**. More recently, reducing forces rather than resisting forces has emerged as a viable alternative. Earthquake forces are reduced via the technique of **base isolation** by placing the structure on a series of flexible foundations (e.g. rubber pads), which isolate the building from the ground motions beneath the pads. Another technique for reducing forces is the use of **enhanced structural damping**, analogous to shock absorbers in an automobile. By damping the building's displacements (caused by the ground motions) to acceptable levels, damage is avoided. Structural approaches are not limited to earthquake or wind mitigation. Flood mitigation has traditionally been accomplished by building levees and floodwalls, which hold back or resist the floodwaters and are clearly a structural approach. **Flood-proofing** of buildings, and elevating buildings above the flood plain, check dams, holding ponds, bypasses and wetland buffers are structural approaches to reducing flood impacts rather than resisting them.

Structural approaches are most effective when they are addressed during the initial design and construction using a thoughtful combination of local building practices, including land use regulations and building codes that address modern design technologies. When the original design does not address hazard risk, **retrofitting** can be seen as one of the options for structural mitigation, albeit it can expensive. Given time and resource limitations of replacing existing building stock with new structures which adequately address hazards, cities often chose to invest in retrofitting of critical public infrastructures such as schools, hospital, fire stations, etc. In the long-term, structural mitigation is achieved most effectively by working with urban building authorities to develop the capacity to understanding risks and incorporate this knowledge into urban infrastructure through building codes and land use regulations.

Operational mitigation

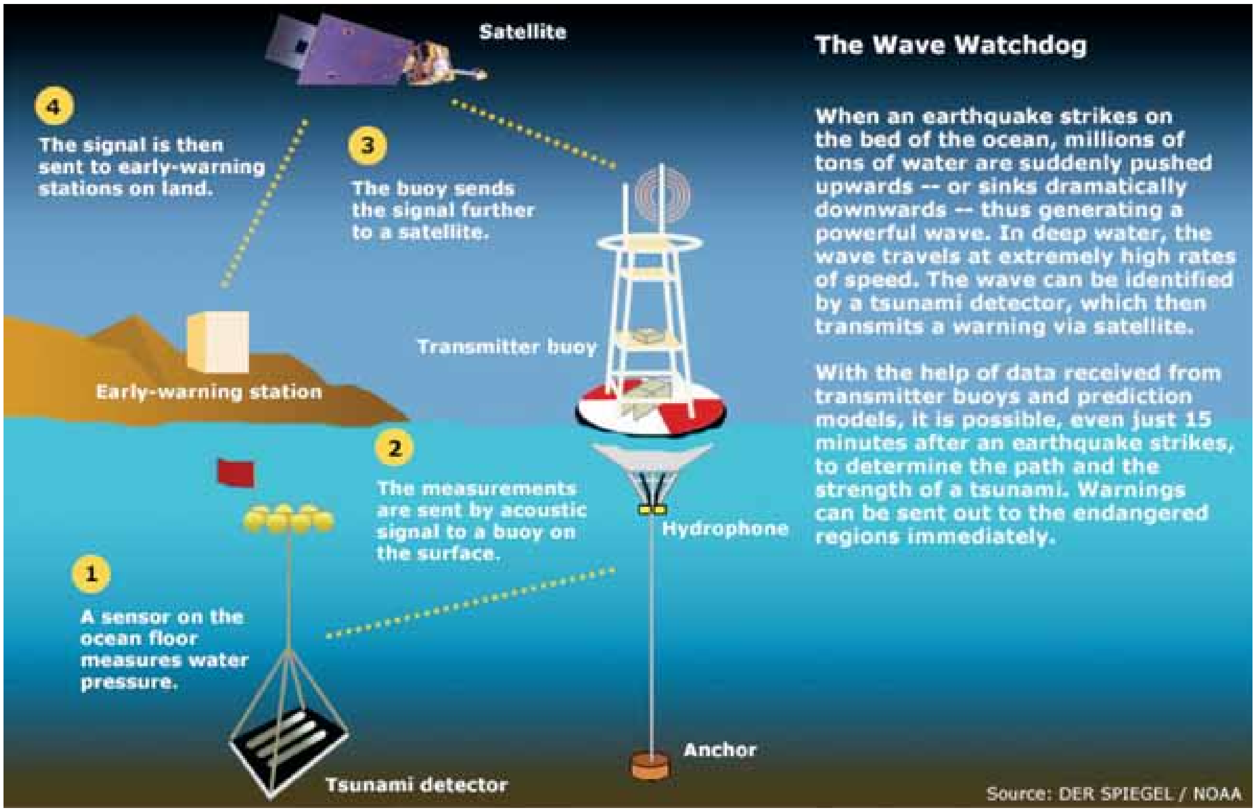
Operational mitigation looks to employ temporary measures to reduce impacts of specific disasters, rather than employing permanent structural or locational mitigation. Because natural hazards cannot be prevented, it is usually not possible to foresee or eliminate the potential for all damage. Operational capability must be provided for responding to disasters.

The most common modalities for operational mitigation are **emergency plans and disaster management systems**, which typically have the following elements:

- Defining critical functions with the goal of maintaining their continuity;
- Assigning responsibility for specific actions at projected times and places where capabilities are exceeded;
- Defining lines of authority and relationships;
- Showing how actions will be coordinated;
- Describing how people and property will be protected;
- Identifying resources for response and recovery operations;
- Addressing mitigation concerns during response and recovery activities.

Given that risks cannot be eliminated entirely and failures cannot be prevented, investing in emergency planning, early warning systems and response capacity cannot be neglected.

FIGURE 6 Illustration of tsunami early warning system



Investments in the **early warning systems** are among the most cost-effective measures that any country can undertake. Weather services significantly support efforts to reduce disaster risks, to alleviate poverty, to enhance food security and protect health. Early warning systems have been increasingly operational in parts of the world for tropical cyclones, flash floods, volcanoes and tsunamis since the mid-20th century. **Figure 6** provides an illustration for an early warning system. Authorities need to focus on training of personnel, supporting emergency planning and exercises of the plans, enhancement of emergency communications and improving emergency response and logistical capabilities of all stakeholders involved. Often coordinated by a dedicated emergency operations center, these measures should be, and are best, undertaken on a routine basis so that preparedness prior to the disaster can be increased.

Fiscal mitigation

Disasters place significant fiscal burden on governments, businesses, households and individuals. They are considered a contingent liability as direct and indirect impacts of disasters can have adverse impacts on the economic development of countries and communities.[26] In the aftermath of a disaster, quick access and ability to disburse funding to the affected communities is of vital importance. In the immediate aftermath and early recovery phases, ex-ante financing mechanisms including budget reserve, contingent credit lines, and transfer mechanisms, including catastrophic risk insurance, risk pools, weather derivates, catastrophe bonds, and others, can be used. For the recovery and reconstruction phases, governments typically mobilize funds through deficit-spending, tax increase, spending cuts, and loans.

Financial approaches to urban resilience can spread disaster risk across an urban area and soften the impact of a disaster. Policy-makers should strive to develop a comprehensive framework for dealing with disaster risk, addressing high-impact low-probability events, as well as medium-low impact high-frequency events. The choice of financial instruments corresponds to the specific phases of disaster - relief, recovery, and reconstruction. Socio-economic situation and products available on the national and international markets also shape the selection of appropriate (mix of) risk instruments. While traditionally the primary client of disaster risk financing frameworks are national governments, cities and local governments can also strengthen their resilience through principles and instruments that are widely applicable.

Chapter 2 provides for further information on disaster risk financing and insurance.

1.4 SOCIAL RESILIENCE

Social resilience refers to the capacity of a community or society to cope with, and adapt to, disturbances or changes. It includes the ability of communities to self-organize, to adjust to stresses, and to increase their capacity for learning and adaptation. A resilient community is able to respond to changes or stress in a positive way, and maintain its core functions as a community despite stresses. People affected by disasters are often the first responders during an emergency and the most critical partners in reconstruction. Any attempt in building resilience has to consider social aspects, utilizing local knowledge and networks for managing and reducing risk.

Efforts to quantify social resilience and develop a methodology to relatively score the overall resilience of countries tend to break social resilience into two separate component forms.[27] The first component explains the amount of participation and engagement of communities and the second component explains the demographic distribution of the entire society. The first component will include indicators such as political engagement and participation in elections, while the second component will include demographic indicators like sex and age distribution, socio-economic status, ethnicity, disability and other key social groupings. For the purpose of this Handbook, these two components have been combined to create a common group that explains traditional social development themes and goals. **Table 1** lists some of the key challenges in integrating social resilience into urban projects. A more comprehensive description can be found in **Chapter 2** 'Community and Stakeholder Engagement'.

Overall, the most cost-effective, useful and sustainable urban investments in building social resilience have been found to meet everyday basic development or poverty reduction needs while simultaneously reducing vulnerability to disasters.[28] The urban poor are particularly vulnerable to climate change and natural hazards as a result of their locations within cities, and the lack of reliable basic services.[29] Cooperative and collaborative approaches between local governments and citizens have been found to substantially reduce the costs of risk reduction, ensure local acceptance and build social capital.[30] The benefits can extend to overall improvements in urban governance, infrastructure and services.

At urban levels of government, social resilience is well-suited to be integrated into the existing

TABLE 1 Challenges in integrating social resilience

Stakeholder/Community participation	Vulnerable and marginalized populations
■ Limited awareness of the impact of disaster risk and climate change	■ Competing priorities
■ No priority for disaster risk reduction and climate change adaptation	■ Lack of legitimacy and trust
■ Lack of political will within local government units	■ No history of collective organization
■ Vested political or commercial interests	■ Discrimination within communities
■ Weak coordination between local government units, CSOs and private stakeholders	■ Gender inequality
■ Limited availability of resources	
■ No support for participatory decision making and local resilience planning	

project cycle because of the parallels with existing social development goals. In order to maximize the chances of successful and sustainable outcomes of investments in building resilience, urban planners must understand the relationships and institutions that protect against and encourage adaptation to the shocks and hazards an urban area will face.

Government and donor-financed projects can support effective participation and contribute to building social resilience both at the neighborhood and municipal levels. Projects should promote and enhance community and stakeholder participation to the extent possible, regardless of whether the proposed urban investment focuses on the community or government level. While challenges still exist to effectively include stakeholders at the community level, there are a number of strategies that have been developed and implemented. The sections below summarize how a focus on social resilience will produce better results, lower costs and improve the livelihoods of poor and vulnerable populations. **Box 5** provides an example of a participatory process in Mozambique.

Better Results

Enhancing the social resilience of urban areas contributes to the achievement of urban development goals. It has been shown in numerous studies and development programs that the incorporation of a focus on social development produces better results that are more sustainable. In 2005, the World Bank reviewed 2,507 projects in nine thematic portfolios and found a strong positive association between social development themes and project success. Projects that addressed at least one social development theme were rated three to four percent higher on outcome, sustainability, and institutional development impact than the overall average of Bank projects for a 30-year period. Projects that addressed multiple social development themes concurrently performed even better on the same three ratings. The study also highlighted the use of sub-national institutions as key to long-term sustainability, noting the role of local government and community institutions.[31]

Box 5 Combining resources to reduce flood impacts

In Quelimane City, Mozambique, local communities partnered with the City Council and several international organizations (Cities Alliance, World Bank, DANIDA, UNICEF, WaterAid) to work on upgrading for communities particularly affected by cyclical floods as a result of a high water table and heavy rains. The city and communities worked together on developing a participatory urban development strategy for informal neighborhoods, where around 80 percent of the population lived. This included a special focus on water and sanitation conditions.

The participatory planning process utilized led to joint actions and contributions to improve conditions in the densely populated peri-urban slum belts of the city. The City Council gave an in-kind contribution of US$100,000 by providing office space, equipment, a meeting room, technical/administrative staff, and vehicles. The community provided an in-kind contribution of US$150,000 through provision of subsidized labor, conducting awareness campaigns, forming operational management teams, and reducing their plot size or, in extreme cases, moving to another area due to improvement works. UN-HABITAT, the World Bank, DANIDA, UNICEF, and WaterAid contributed a total of US$440,000 in cash and in-kind. Other in-kind contributions totaling US$30,000 were secured from a state water supply institution and a private-sector firm which made its trucks available on weekends in exchange for paying only for the fuel and driver.

The results achieved through these combined contributions included: a city council better equipped and capacitated to work with informal settlements; the construction of two community centers, cleaning of 10 km of drainage channels with one km paved, widening and improvement of 20 km of unpaved roads, installation of ten new water points installed in the most densely populated areas, and building of 20 rainwater collection systems and four public lavatories - all of this mainly through planned labor-intensive activities; greater government and community awareness of water, sanitation and drainage maintenance issues; and improved planning for sanitation and expansion of the water supply network to the densely populated peri-urban slum belts.

Source: World Bank, 2011, pp 20-21 and UN-HABITAT (website): 'Improving Water and Sanitation in Quelimane City.'

Collaborating on project planning, design and implementation with a diverse group of stakeholders develops more options and creates a better platform for decision-making. International experience also has shown the importance of including local government units, civil society organizations (CSOs) and the local private sector in efforts to increase the resilience of cities to the impacts of natural hazards and climate change. While local communities will often already have grassroots adaptation strategies, local government units and local organizations may not implement urban resilience strategies in a broader context. Interventions aimed at strengthening physical infrastructure, service delivery, or government capacity for disaster risk reduction and climate change adaptation have the biggest impact when implemented in partnership with communities.[32]

Without government support, there are limitations to what household and community action can do to reduce disaster risk. Much of what is needed to reduce risk in low-income urban communities depends on the financing or provision of infrastructure that residents cannot provide alone, such as road networks and a full range of health care services. The scale and range of what CSOs can achieve are significantly increased when they can work with government agencies.[33]

When local communities and businesses are not consulted and are not involved in urban investment projects, efforts to build resilience can become fragmented and even counter-productive. In extreme cases, poor planning and communication have even led to popular protests and riots as was seen with the privatization of many urban water systems in the 1990s.[34]

Lower Costs

There is considerable evidence for the cost-effectiveness of investing in strengthening social resilience. If communities and local businesses see the potential benefits of a project, they are more likely to support it and enter into cost-sharing arrangements. A study on community-based and community-driven development, found such projects generally had better outcome ratings than non- community-based and community-driven projects and helped lower the cost to government of delivering infrastructure.[35] This is an especially important consideration for local government units with limited financial and management capacities.

There are also significant potential benefits from combining investments in physical infrastructure with those aimed at building household and community resilience. A 2008 cost-benefit study of flood and drought risk reduction in urban and rural locations in India, Nepal and Pakistan, found approaches that included a people-centered resilience-driven flood risk reduction approach had cost-benefit ratios that ranged from 2 to 2.5 under both current and future climate change scenarios.[36] The study concluded that the most economically effective risk reduction strategies were to increase the resiliency of livelihoods, housing and other infrastructure at the household and community level.[37]

Improved Outreach to the Poor and Vulnerable

Urban infrastructure projects improve the livelihood of poor and vulnerable populations by strengthening the key relationship between at-risk populations and government stakeholders. Poor and vulnerable populations are the most at-risk for the impact of disasters and climate change. The creation of opportunities for communities, local businesses and CSOs to engage with local government can contribute to better-informed and more appropriate policy decisions. Communities and other stakeholders are engaged in their own governance, they have a greater capacity to shape mitigation and adaptation measures to the shocks, whether from natural hazards or other causes. Conversely, people without the ability to engage in governance are more likely to be negatively impacted by forces outside their control.[38]

The disproportionately high adverse impacts of disasters on women are well documented. Gender analysis of all proposed urban interventions is essential in order to assess the different impacts of activities on men and women, and to identify specific actions to promote the full and active participation of both genders in project decision-making and their equal access to project benefits. Gender-sensitive programming recognizes the conditions that allow women, men, boys and girls to fully contribute to building resilience to disasters and climate change, thereby benefitting both households and the entire community.

Further Reading

Climate Change, Disaster Risk, and the Urban Poor (World Bank, 2012).

Making Women's Voices Count: Integrating Gender Issues in DRM – set of Guidance Notes (World Bank, 2011).

Climate Change, Disaster Risk, and the Urban Poor: Cities Building Resilience for a Changing World, The World Bank Urban Development Series (World Bank, 2012).

1.5 LAND USE PLANNING

Risk-based land use planning identifies the safest areas to prioritize immediate investments in urban development and infrastructure projects. Land use plans influence the location, type, design, quality and timing of development. Mainstreaming risk-based land use planning in infrastructure projects reduces risk in rapidly urbanizing urban centers that are prevalent in hazard-prone areas and expose a high concentration of population and economic assets to risk. Risk-based land use plans must inform all infrastructure projects.

Historically, urban centers have been located in naturally hazardous zones. Urban centers have developed at sites of agricultural surplus such as fertile volcanic soils or along major trade and transportation routes such as coasts and river systems that are prone to flooding and coastal erosion[39]; major urban centers are located on seismic faults. Close to 650 million people in dense urban centers of East and South Asia, Central America and Western and South America are exposed to geo-physical and to hydro-meteorological hazards.[40] High urban densities of population and economic assets increase losses during catastrophic events. Climate change is said to exacerbate these risks while also creating new risk in zones considered otherwise safe.

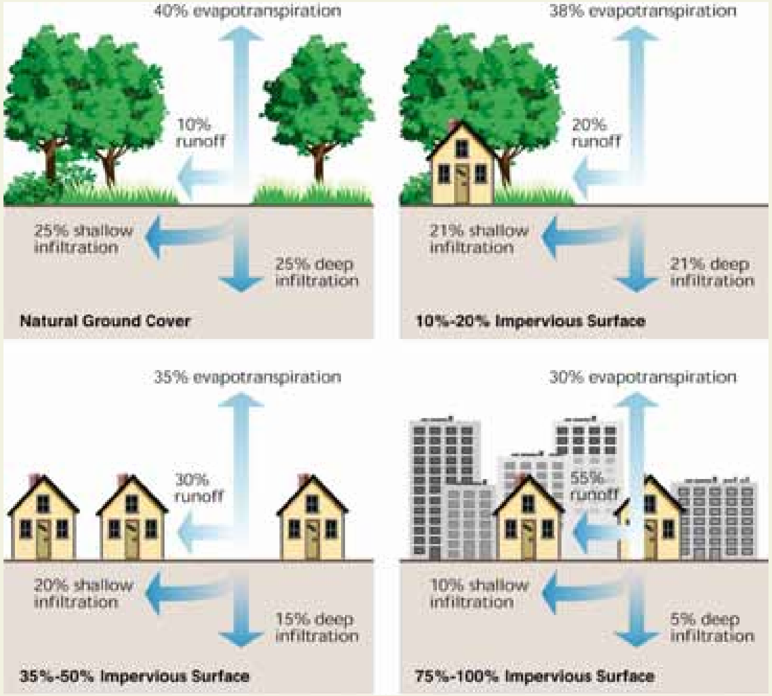
Land use planning efforts have not responded to rapid urban growth and spatial expansion that is exposing more people and economic assets to disaster risks. More than half the global population now lives in urban centers; small and medium urban centers in low and middle-income countries are growing fastest.[41] While urban population is expected to double by 2025, urban land is expected to triple during the same time.[42] Land use planning spatially directs projected growth by allocating zones for specific land uses that meet the stated socio-economic goals of the community. In practice however, typically long planning cycles in low-middle income countries do not garner political support; land use plans are prepared by technical experts without effective community consultation; land use plans are rarely implemented since most municipalities have limited technical capacity and resources to invest in land and infrastructure. Consequently, land use plans follow rapid urban growth rather than direct it; unplanned developments are common, often as informal settlements on hazard-prone sites, and increase hazard risk. For example, unplanned land development can increase flood risk by increasing impervious surfaces and consequent water runoff (see **Box 6**), apart from extending habitation outside existing flood defenses.[43] Additionally, increase in urban energy consumption and urban heat island effect associated with spatial expansion contribute to climate change.

Land development based on notions of safety from episodic risks that are promised by large engineering works can accentuate disaster risks. Traditionally, land development ignores the hazard characteristics of land and assumes that large engineering works will ensure safety to future residents. Since urban land values are high, it is common for hazard-prone sites such as floodplains, wetlands, steep slopes and seismic fault lines to be developed. For example, in the American city of New Orleans, which has been historically susceptible to floods and hurricanes, $200 billion is losses from Hurricane Katrina, is largely attributed to urban expansion on former wetlands that were deemed safe through the construction of levees; in fact failure of levees has contributed to about a third of all flood disasters in the US.[44]

Risk-based land use planning can reduce both episodic and everyday risks. While risks from catastrophic events such as earthquakes and volcano eruptions may not be predictable, relatively small and frequent events that cause localized damage and few

Box 6 Urbanization and flood risk

Urban expansion, particularly in flood-prone areas, alters the path of natural watercourses, increases impermeable surfaces that reduce rainwater infiltration and increase overland flows beyond the capacity of drainage systems causing flood risk. Poor sanitation and solid waste management in most cities in developing countries exacerbate health risks in the event of floods.



Source: World Bank 2011.

injuries and deaths at a time constitute a considerable share of hazard risks.[45] Analysis of detailed records of 126 thousand hazard events in Latin America showed that 99% of reported events accounted for 51.3% of housing damage.[46] Small hazards can turn into disasters if many people occupy hazard-prone areas, critical infrastructure is inadequate and emergency response is inadequate. While it is important to plan large structural measures for risk from catastrophic events, locating development safely through land use planning can reduce risks from episodic as well as the high incidence of everyday events; a study of National Flood Insurance Program claims and payments in the US showed that state governments that adopted comprehensive planning requirements reduced losses from flooding.[47]

The Hyogo Framework for Action (HFA) for disaster resilience emphasizes the incorporation of risk reduction in urban planning. Priority Area 4 identifies the need for risk-based land use planning and building codes in urban infrastructure projects to reduce underlying risk factors.

Further Reading

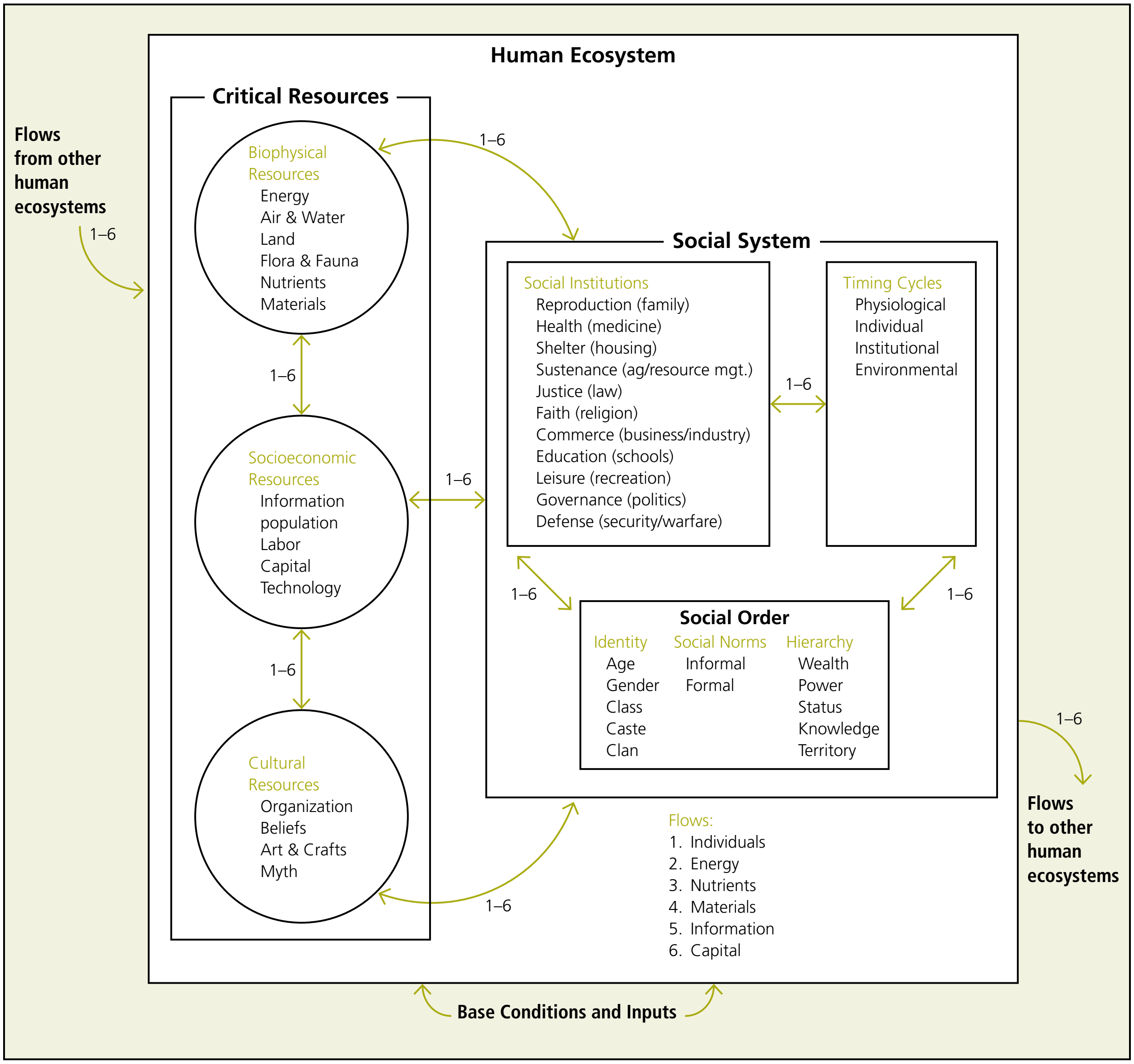
Cities and Flooding. A Guide to Integrated Urban Flood Risk Management for the 21st Century (World Bank, 2012).

The Role of Land-use planning in Flood Management: A Tool for Integrated Flood Management (WMO, 2008).

1.6 URBAN ECOSYSTEMS

From an ecological perspective, an urban area is its own fully functioning ecosystem. An ecosystem is defined as a biological community of

FIGURE 7 Diagram depicting the human ecosystem



Source: Machlis, et al. (2005), The Structure of Human Ecosystems, V.05.02.

interacting organisms and their physical environment, a concept that can easily be applied to an urban area. The major difference between our traditional understanding of ecosystems and one that includes urban areas is that the physical environment in cities includes both natural and human-made elements. These elements are affected by natural environment, as well as culture, personal behavior, politics, economics and social organization. The urban ecosystem contains both individual and nested systems from three spheres: the natural environment, built environment and socio-economic environment. **Figure 7** illustrates these spheres and their relationships.

Urban planners must understand and incorporate natural ecosystem services into urban infrastructure and resilience projects. Urban ecosystems are intertwined systems of natural and manmade services. It can be difficult to understand how new infrastructure will impact natural systems. Urban planners should work with local stakeholders and experts to attempt to understand positive externalities, like ecosystem services, that may not be fully understood. The goal is not to stop new infrastructure projects, but to ensure that the complexity of an urban ecosystem is integrated into government and donor-supported projects.

In order to develop policies and programs that build resiliency and promote sustainable development, each system requires dynamic balancing and integration. Issues like biological diversity, water filtration, soil depletion, and deforestation must be integrated with issues such as sewerage, water supply, transportation, social/political institutions, and norms and values. This means that urban ecosystem management is multidisciplinary in nature and requires a composite of social, environmental, economic and decision-making tools and institutions that are flexible and can adapt to changes in one or more systems. An integrated urban ecosystem approach includes generating information for policy makers such that trade–offs and synergies between various options (in terms of social, economic and ecological values) that can be addressed at various spatial, temporal, and management scales.[48]

Pro-poor and Community-focused Ecosystem Management

Structural and institutional problems force the poor to draw upon the natural resources within and around cities. These problems include inadequate governance structures, land tenure arrangements, and lack of access to financial resources. Much of the urban poor live in informal settlements which are often located in less desirable and consequently more hazardous locations such as steep slopes, river basins or exposed coastal areas. They uncover and degrade the landscape in search of space for living, bio-fuels for cooking or sale, and water for their daily needs.[49] The lack of resources put into public health care systems further adds to their difficulties; expenditures in this area for low–income countries averages one per cent of gross domestic product (GDP), compared to six per cent of GDP in high–income countries.[50]

In order to be successful and equitable, ecosystem management must be linked to broader poverty reduction agendas. Urban infrastructure projects must address the trade-offs between conservation, livelihoods and equitable distribution of resources. Historically, there has been a tension between conservation models that create protected areas that are perceived as inaccessible to communities. Often, the models are implemented at the expense of the poor and marginalized residents, or users of resources from these areas. Social, economic and environmental development programs have become impediments to sustainable development because there is no balance between the needs to protect ecosystem services and the desire to use resources to address needs of the community. Communities must be enabled to identify and negotiate their own options, and to increase their flexibility to cope with unexpected change.[51]

Community-centered approaches to ecosystem management recognize that human impact and activities are a necessary element of an urban area. Initiatives that focus on achieving environmental protection as well as allowing humans to benefit from natural resources are considered more sustainable.

Issues of Governance

The political economy of land use and ownership, often marked by vested interests, creates tension between the economic, commercial, environmental protection and social equity objectives of land use planning. In all land systems, some actors stand to benefit from extending control over land and natural resources, often to the detriment of poor and vulnerable groups. As such, mechanisms to address vulnerability and promote disaster resilience can be perceived as threatening by government agencies or vested interests from the professional, commercial or other sectors.[52] All levels of government need to balance these competing interests and ensure that ecosystem management planning be informed by socio-economic, political and stakeholder analyses. **Figure 8** illustrates involved sectors.

In recent years, a number of governments and international agencies have adopted a land governance approach to urban policy development and planning. Land governance refers to the process by which decisions are made regarding the access to and use of land and how conflicting interests for land are reconciled. A land governance approach to urban

FIGURE 8 Competing interests in land use

Source: D Campbell, 1999 in GLTN, Good Land Governance Policy Paper.

planning focuses on the institutions and different stakeholders that affect land use patterns. This information is combined with risk analysis and land use planning to inform a broader strategy for urban ecosystem management. Risk, land use and community stakeholder participation are discussed in **Chapter 2**.

1.7 URBAN UPGRADING

Urban upgrading prioritizes infrastructure, housing, livelihoods and social networks for the most vulnerable households living in slum settlements. Strategic urban upgrading can manage disaster risks by: i) regulating slum development in hazard-prone areas, ii) reducing losses by planning evacuation routes and community refuges, and iii) promoting safe and socio-economically viable low-income neighborhoods in accordance with a citywide plan.

In rapidly growing cities, inadequate planning for low-income households creates slum conditions that transfer a disproportionate burden of disaster risk to the poor. Most slum settlements are not planned, slum structures are not durable, and are located on relatively inexpensive but hazard-prone sites. The urban poor have limited choices in residential location. They live in areas they can afford - close to their place of work and where they have kinship ties – that is mostly in slums[53] which have the worst environmental conditions in a city. Housing that is affordable is usually on sites considered uninhabitable by planning standards and therefore secure against immediate eviction. Unsafe sites occupied by slum residents, such as flood prone, steep slopes or landfills, close proximity to toxic urban/ industrial wastes, rail corridors and electric lines, expose them to disaster risks. Houses that are over-crowded, in poor structural condition and located in dense, irregular layouts that lack basic services[54] cause greater losses in disasters. Insecure tenure, coupled with socio-spatial exclusion reduces their access to receive information and financial assistance to cope with disasters.[55] Urban centers themselves contribute to climate change by generating significant GHG[56] emissions during economic activities, transportation and energy consumed by buildings[57]; paradoxically, the urban poor who consume minimum urban resources and contribute the least to global warming bear the maximum brunt of the hazards.

The benefits of urban economic densities outweigh the exposure of large numbers of urban poor to disaster risks.[58] The rural poor move to urban centers in large numbers for high-wage livelihoods.[59] Migrants find accommodation in slum pockets, reinforcing the formation and persistence of slums; a third to a half of the urban population in low-middle income countries lives in slums[60]. Slums are formed as a result of the city's inability to provide affordable housing for migrants seeking better economic opportunities. Colonial legacies of land use and housing regulations in most cities in developing countries have been inappropriate; chronic lack of housing development finance (public and private) skews urban land markets and drives up the price of housing. Density regulations, such as low

FAR[61], and minimum development and housing standards that are expensive, restrict the supply of land and housing for low-income households.[62] Consequently, chronic housing scarcities have provided opportunities for entrepreneurs to collude with real-estate developers, politicians, as well as local government officials to profit from selling a `notion' of security against immediate eviction to the urban poor at considerable cost by `allowing' them to squat on or develop land illegally on vacant urban sites, albeit hazardous and un-serviced. In some cities in developing countries, a significant proportion of the population lives in slums: in Mumbai (India) 60% of the population is said to live in slums that occupy only 8% of its land area.[63]

For the urban poor, everyday hazards attributed to climate change can turn into high impact disasters.[64] In slums, the absence of drainage infrastructure may turn heavy rainfall into a disastrous flood. For example, in six cities in Bangladesh, more than 50% of slum clusters were typically flooded as a result of moderate-heavy rainfall in the monsoon season.[65] Destruction or damage to infrastructure can lead to water scarcity, contamination and spread of vector-borne diseases. Lack of access roads can prevent relief efforts from reaching the affected households. Lack of income and lack of access to safe housing with adequate water supply, sanitation, health care and education affects the capacity of slum residents to recover.[66] **Table 2** lists some of the key implications of urban poverty on every-day and disaster risk.

Variations in slum conditions create different degrees of risk. Environmental conditions in slums vary. Some slums are located on hazard-prone sites and lack basic services, others are planned but lack secure tenure. Slums are formed in specific city locations as a consequence of deterioration of existing neighborhoods[67], squatting[68], unplanned development of urban villages[69], or illegal sub-division of vacant sites[70]. Slum locations dictate access to and type of livelihoods, urban land values, tenure status, housing conditions, mobility, social capital, as well as access to basic services, all of which influence the vulnerability of the urban poor to disasters.

Mainstreaming risk reduction for the urban poor should be a priority in all urban infrastructure

TABLE 2 Urban poverty, everyday hazards and disaster risks

Aspect of urban poverty	Implications for everyday risk	Implications for disaster risk
Inadequate and often unstable income: deprivation of basic necessities; indebtedness.	Very limited capacity to pay for housing; living in slums with very high environmental health risk.	Location on hazard-prone sites; lack of infrastructure and services increases disaster risks.
Inadequate limited safety net: property, skills, savings, social networks to ensure basic survival, access to housing and healthcare during periods of no income	Very limited capacity to cope with financial and health stresses or shocks in everyday life	Very limited capacity to recover from disaster events: food and water, homes and livelihoods; lack of documentation can exclude from post-disaster support; no insurance.
Poor housing quality: made with temporary materials, often insecure, overcrowded housing located on dangerous sites	High risk levels from physical accidents, fires, extreme weather and infectious diseases.	At risk from storms/high winds, earthquakes, landslides, floods, fires and disease transmission which may cause epidemics.
Inadequate infrastructure: water supply, sanitation, drainage, roads, footpaths, etc.	High levels of risk from contaminated water, flooding from lack of drainage.	Lack of protection from flooding; lack of roads, footpaths and drains inhibit evacuation
Inadequate basic services: schools, vocational training, health-care, emergency services, public transport, communications and police	Unnecessarily high health burden from diseases and injuries because of lack of healthcare and emergency response.	Lack of healthcare and emergency services that provide rapid response to disaster
Limited negotiation in public projects	Inappropriate development investments	Little support for low-income groups to rebuild back better.

Source: Adapted from IFRC 2010.

investments. Due to their informal status, households in informal settlements are generally excluded from public investments in essential infrastructure.[71] Given the large numbers of the urban poor, the need for urban upgrading can be overwhelming and far exceed the capacity of the local government to undertake comprehensive measures. Comprehensive urban upgrading prioritizes slum upgrading to reduce existing disaster risks along with increasing the overall supply of affordable housing to prevent the formation of new slums and new risks through incentives for private sector and community engagement. The Mayor's Task Force on Climate Change, Disaster Risk and the Urban Poor launched at COP 15[72], urges a focus on the disaster risks for the urban poor and provides a forum for policy development and strategic investments.

Further Reading

Climate Change, Disaster Risk, and the Urban Poor: Cities Building Resilience for a Changing World (World Bank, 2012).

1.8 INCORPORATING RESILIENCE INTO THE PROJECT CYCLE

It is crucial to place resilience at the core of project planning, particularly in regions of rapid development. The focus of this Handbook is early incorporation of resilience into urban investment projects. All projects go through a cycle – the terminology for the different parts of the cycle vary with the organization, but in essence most organizations use variations on the same core phases in the process. The World Bank's project cycle is depicted in **Figure 9**, as an example of the core process; and **Table 3** gives examples of how resilience can be incorporated into the project at each phase in the World Bank project cycle.

The overall goal of project interventions is to reduce poverty and increase welfare; sustainably manage the environment and natural resources; reduce disaster risk and improve recovery management. The Philippines offers an example of a Country Assistance Strategy (CAS) that includes key elements addressing disaster and climate risk reduction needs. **Box 7** provides details.

FIGURE 9 World Bank project cycle

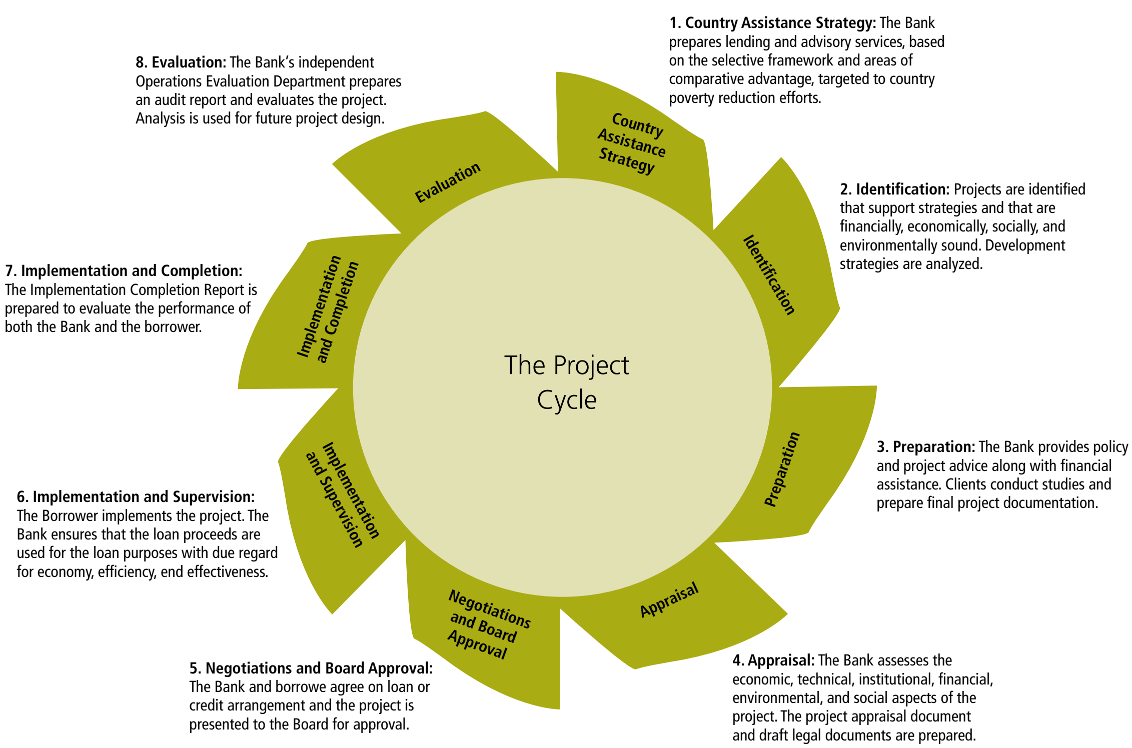


TABLE 3 Opportunities for enhancing resilience within the World Bank project cycle

Project cycle	Opportunities for enhancing resilience
Country Assistance Strategy (CAS) or Country Partnership Strategy (CPS)	The CAS/CPS is the "master plan" under which individual projects are formulated, each individual project contributing to the goals of the master plan over a given time frame, normally 3-4 years. Because the CAS is the foundation on which everything else is built, it offers powerful opportunities for enhancing resilience, including for example: A CAS/CPS policy statement should be made that places a high value on resilience. The policy statement should stress redundancy, avoidance of collocation and performance- or risk-based design for physical projects. In the social realm, a key element of the CAS/CPS should be education and development of human capital based on stressing resilience, decentralized decision-making and adaptive management. A National Disaster Risk Assessment should be developed during this stage, in support of and as one of the fundamental criteria guiding the CAS. CAS should reflect the social and economic impacts of potential disasters on a country.
Identification	The Project Identification phase of the cycle conceives of specific projects in support of the master plan. Using the social and economic impacts as presented in the national risk assessment, this phase can identify specific disaster-related infrastructure or other projects that can readily reduce disaster risk. Examples include flood, storm and tsunami warning and planning, flood levees and earthquake strengthening of existing buildings and infrastructure. In addition to disaster-specific projects, the CAS/CPS policy should be implemented in this phase to require *all* projects to employ performance- or risk-based design / mitigation against disaster risk.
Preparation	Performs the studies and ground work that leads to development of the specific Project Concept Note, Terms of Reference, Performance Objectives and other documents for the project. In this phase, projects that are disaster-specific (e.g., flood levees) should be designed so as to assure the project will adequately reduce disaster potential. Projects that are not disaster-centered (e.g., construction of a highway, or a regional health program should enhance disaster resilience in two separate ways: (a) they should consider if the project might serve a secondary disaster reduction role (e.g., can the highway also serve as a flood levee, or will it be useful for evacuation purposes; can the regional health program include some elements of disaster medicine), and (b) they should consider the impacts disasters might have on the project – will it be destroyed? – and what cost-effective measures can be incorporated into the project to reduce this risk. Examples include exceeding minimum code requirements for earthquake design, elevating buildings for flood, or simply placing electrical and other equipment on second or higher floor of a building, to avoid flood damage. For economic resilience measures in project design, there are possibilities to include contingent emergency components that are in accordance with Operational Policy 8.0 Operation Rapid Response to Crises and Emergencies.
Appraisal	Reviews the prepared project to assure it is consistent with the CAS/CPS and is cost-beneficial for the country. In order to enhance resilience, in this phase projects should be evaluated in light of– *has the project considered disaster resilience? Is it vulnerable to disasters and, if so, are the mitigation measures sufficient and cost-effective?*
Negotiations and Board Approval	An audit and confirmation of previous phases of the project cycle and a similar line of inquiry from the Appraisal phase
Implementation and Supervision	Project performance documents should contain specific provisions to assure mitigation and resilience-enhancing measures are effectively implemented. Project design requirements should be based on detailed project-specific analysis for disaster effects.
Implementation and Completion	Did the project consider disaster resilience, and how was it enhanced? Was the project vulnerable to disasters and, if so, were the mitigation measures sufficient, cost-effective and implemented?
Monitoring and Evaluation	Did the project consider disasters and enhance resilience? Were disaster mitigation measures sufficient, cost-effective and implemented? Is there a program to maintain resilience and mitigation measures?

Box 7 Country assistance strategy in the Philippines

One of the four strategic objectives of reduced vulnerabilities with goals to: reduce poverty and increase welfare, particularly in rural areas**;** sustainably manage the environment and natural resources**;** reduce disaster risk and improve recovery management. The results area 4.2 Disaster risk management and climate change has the following outcomes:

Outcome 1: Disaster- and climate change-related risks reduced. The Philippines is extremely vulnerable to natural disasters due to a high incidence of severe weather conditions—especially floods, typhoons, and drought—and a large number of earthquakes and active volcanoes. This inherently high disaster risk is likely to be exacerbated by the effects of global climate change. The resultant human and economic costs of disasters are significant, with estimates suggesting 0.5 percent of GDP lost annually due to natural disasters. The country has begun to develop more in-depth strategies for disaster risk management and climate change adaptation to address the dimensions of: (i) strengthening preparedness and adaptation at the local level with a focus on improving planning and capacity, knowledge and understanding of measures to reduce disaster risk, including adaptation to climate variability; (ii) reducing vulnerability of farmers to crop risk through support for innovative solutions such as weather risk insurance schemes for assisting small farmers to cope with the economic losses stemming from disasters; and, (iii) improving disaster risk financing strategy at national and local level through support for identification of appropriate instruments and establishment of new financing windows for preparedness, response and recovery. Bank support for these initiatives is through the Global Facility for Disaster Reduction and Recovery (GFDRR) technical assistance to enhance the development of disaster risk management and climate change strategies; new financing instruments, such as a CAT-DDO; and GEF grant-funded activities, including a possible Climate Change Adaptation project, which would integrate climate risk management into national and local development planning in agriculture and natural resource management and would demonstrate cost effective adaptation measures to strengthen the resilience of investments, initially in those sectors. These measures may be expanded to other vulnerable sectors or regions such as in coastal areas, where an integrated coastal zone management approach could contribute to reducing vulnerability to natural disasters and other hazards while promoting sustainable livelihoods and poverty reduction.

Outcome 2: Greenhouse gas emissions reduced through expansion of mitigation programs in key sectors and LGUs. While the Philippines is a minor emitter of greenhouse gases, it is committed to continue to pursue cost-effective solutions for reducing emissions. The emergence of new mitigation financing instruments—particularly the Carbon Partnership Facility and the Clean Technology Fund—opens up the potential for developing broader mitigation programs in areas such as renewable energy, reducing air and water pollution, and solid waste management. Building on the experience and successes of ongoing mitigation projects in the Philippines supported by the Bank, such as geothermal and wind projects and wastewater treatment projects which already commit to an emission reduction of about 2 Mt CO2e, opportunities will be pursued in the power, transport and waste management sectors. In cooperation with other development partners, the World Bank will assist the Philippines in mobilizing existing and future sources of international financing assistance.

Source: Country Assistance Strategy for the Republic of the Philippines for the period FY 2010-2012.

Indicators for Monitoring and Evaluation

Although there have been recently a number high-profile indicator efforts that explain various components of disaster resilience, the most consistent and effective indicators are produced from within urban infrastructure projects. The majority of disaster resilience indicator efforts has ignored urban areas and has instead focused either on country-level resilience or very small areas. There are a few indexes that have been created, namely the *Social Vulnerability Index* and the *Resilience Capacity Index*. Both indexes have only been applied in the United States, but have been successful at monitoring disaster resilience, which can help to understand what indicators might be helpful when monitoring and evaluating urban infrastructure projects. ***Individual indicators can be helpful for monitoring and evaluation, but cannot be relied on to sufficiently monitor or evaluate projects that enhance urban resilience***. Single indicators will be unable to describe the different components of urban resilience but they may be able to help to understand the state of urban resilience in a given area. Indicators like the *Sheltering Capacity* or *Number of Hospital Beds* in an urban area will greatly help to evaluate how a community will respond

TABLE 4 Disaster resilience indicators

Social resilience	Economic resilience	Institutional resilience	Infrastructure resilience	Community capital
Age Education Equity Transportation Access Communication Capacity Language Competency Special Needs Health Coverage	Housing Capital Employment Income and Equality Single Sector Employment Business Size Health Access	Mitigation Flood Coverage Municipal Services Political Fragmentation Previous Disaster Exp. Mitigation and Social	Housing Type Shelter Capacity Medical Capacity Access/Evacuation Housing Age Sheltering Needs Recovery	Place Attachment Political Engagement Social Capital - Religion Civic Involvement Advocacy Innovation

Source: Cutter 2010.

following a disaster, but they cannot be the single indicator that is used to evaluate the success of a project. For this reason, it is suggested that urban planners develop practical, local indicators that are appropriate for the specific urban infrastructure project. ***When developing indicators for urban resilience, urban planners should rely on the risk assessment and risk-based land use plan.*** Frequently, a risk assessment and spatial plan will provide helpful data to plan for monitoring and evaluating the resilience of an urban area. Most of this data will be hazard specific, which will only address a small bit of urban resilience. Urban planners should look to create multi-hazard indicators or develop a number of indicators geared toward a market basket of hazards, so as to make sure the indicators will explain resilience well. **Table 4** provides a list of indicators geared toward larger issues of resilience. In all likelihood, not all of these indicators will be collected when implementing an urban infrastructure project, but it is important to encourage better data collection in urban areas. **Table 5** provides select examples of World Bank projects including resilience components.

Concluding Remarks

The rapid expansion of urban built up areas provides an opportunity to develop and manage new settlements in such a way that they incorporate resilience at the outset into regular urban planning. The aftermath of a natural disaster often provides an opportunity for decision-makers to push through with corrective and preventive actions. Resilience goes beyond risk migration measures. Resilience increases preparedness and the capacity to respond to a disaster and swiftly recover from its impacts. It has to be part of everyday urban development, medium- and long-term investment and planning, urban governance and hazard management. This report makes recommendations on how to enhance resilience, particularly in critical infrastructure and the social realm.

To make necessary budgetary and investment decisions, decision-makers seek consistent and quantitative tools to evaluate public investments. Integrating risk-based methods into cost-benefit approaches enables the consideration of the impacts of climate change and disasters by means of quantifying the economic consequences of these events. These tools, described in **Chapter 2** include: risk assessment; risk-based land use planning; urban ecosystem management; urban upgrading; community and stakeholder participation; disaster management systems; data gathering, analysis and application; and risk financing and transfer approaches.

TABLE 5 Select World Bank projects with resilience components

Country	Project	Project Development Objective (PDO)	PDO / Results indicators
Indonesia	Third National Program for Community Empowerment in Urban Areas III (P118113)	The overall objective is to assist the Government of Indonesia to ensure that the urban poor benefit from improved socio-economic and local governance conditions. One of the actions to achieve this objective will be to increase the awareness of disaster risk mitigation and mainstreaming of measures for resilience.	■ Improved access to infrastructure, economic and social services in at least 80% kelurahans (wards) in 2013 ■ Min 80% satisfaction levels from beneficiaries regarding improved services and local level governance: ■ Infrastructure built is 20% less expensive than that built by non community based approaches in 80% of participating kelurahans ■ Min 90% of complaints are resolved (Percentage): 98.00 as of 30-Nov-2011 ■ Number of people in urban areas provided with access to all-season roads within a 500 meter range under the project **Intermediate Results Indicators** ■ Min. 40% participation rate of poorest and vulnerable community members in planning and decision making meetings (Percentage): 54.00 as of 30-Nov-2011 ■ Min. 40% participation rate of women in planning and decision making meetings (Percentage): 48.00 as of 30-Nov-2011 ■ Min. 30% of the adult population voting in BKM elections at the neighborhood level (Percentage): 32.00 as of 30-Nov-2011 ■ BKMs formed in minimum of 90% of kelurahans (Percentage): 100.00 as of 30-Nov-2011 ■ Min 90% of kelurahans with Community Development Plans (CDPs) completed and ratified (Percentage): 100.00 as of 30-Nov-2011
Democratic Republic of Timor-Leste	Road Climate Resilience Project (P125032)	The project will deliver sustainable climate resilient road infrastructure on the Dili-Ainaro corridor.	■ Improvement in climate resilience of the Dili-Ainaro corridor. 20.00 as of 31-Jan-2012 ■ Increase in traffic on Dili-Ainaro corridor (Percentage): 10.00 as of 31-Jan-2012 ■ Reduction in the number of incidents requiring emergency repairs on the Dili-Ainaro corridor. ■ Roads in good and fair condition as a share of total classified roads : 8.00 as of 31-Jan-2012 **Intermediate Results Indicators** ■ Improvement in road condition in the Dili-Ainaro corridor measured by reduced road roughness (Number): 11.00 as of 31-Jan-2012 ■ number of linear kilometers of road sections with new or improved drainage on the Dili-Ainaro corridor ■ Number of locations with improved slope protection on the Dili-Ainaro corridor ■ Dili-Ainaro corridor is adequately maintained ■ Percentage of national roads in Aileu and Ainaro Districts covered by multiyear performance-based maintenance and first-line emergency response contracts.

Continues

TABLE 5 Select World Bank projects with resilience components

Country	Project	Project Development Objective (PDO)	PDO / Results indicators
Nepal	Modernization of Rani Jamara Kulariya Irrigation Scheme Phase 1 – (P118179)	The project development objective of the Modernization of Rani Jamara and Kulariya Irrigation Scheme – Phase 1 is to improve irrigation water delivery to, and management in, the command area. The objective will be achieved through improving the performance of the irrigation systems and strengthening community-based irrigation management. These activities are essentially about building resilience through more efficient water delivery and management against water induced hazards such as droughts, floods, and changes in water availability during the agricultural seasons.	**PDO Indicators** ■ Resources generated by water users for the operation and maintenance of the modernized irrigation systems (measured in percentage of required resources). ■ Irrigation service delivery by service providers (WUAs) assessed as satisfactory by water users (measured in percentage of water users). ■ Increase in irrigated crop yields of main crops rice, wheat, and maize in about 40% of the command area, at the head of the canal systems. (Metric ton) ■ Number of female and male water users (defined as member of the WUA) provided with improved water delivery services. ■ Maize (Metric ton) **Intermediate Results Indicators** ■ Completed Structures. ■ Number of Executive Committee meetings and General Assembly meetings held per WUA (Annual, not cumulative). ■ No of WUA members trained (annual). ■ Agriculture Service Center and Agriculture Contact Points active and providing advisory services. ■ Number of farmer field schools and demonstrations implemented (annual).
Kiribati	Kiribati Adaptation Phase III (LDCF) (P112615)	To improve the resilience of Kiribati to the impacts of climate change on freshwater supply and coastal infrastructure	**Intermediate Results Indicators** ■ Number of groundwater abstraction systems installed and operating in North Tarawa. 1.00 as of 12-Dec-2011 ■ Reduction in total volume of non-revenue water lost through leaks and wastage in zones treated for leakage reduction in South Tarawa (Percentage) ■ The frequency of water supply of households has increased from an average 1-2 hours per day to 3-4 hours per day in areas treated for leakage/waste reduction. (Hours): 1.00 as of 12-Dec-2011 ■ National Key Performance Indicators on Climate Change Adaptation and Disaster Risk Management are developed, applied and reported. ■ Functional plans (under the Disaster Management Plan) relevant to public health and potable water are established and operational.

Continues

TABLE 5 Select World Bank projects with resilience components

Country	Project	Project Development Objective (PDO)	PDO / Results indicators
Colombia	First Programmatic Fiscal Sustainability and Growth Resilience Development Policy Loan (P123267)	Enhanced fiscal sustainability and strengthened resilience of economic growth. The programmatic DPL operation supports the long-term Country Partnership Strategy (CPS) outcome of improved fiscal, financial, and social risk management under the 'inclusive growth with enhanced productivity' CPS theme.	**Results indicators** ■ Central Government non-oil, tax revenue as share of GDP (Percentage): 13.70 as of 31-Dec-2011 ■ The Central Government overall fiscal deficit. (Percentage): 2.90 as of 31-Dec-2011 ■ Publication of an annual evaluation report detailing the implementation of the medium-term debt management strategy. ■ Reimbursements to health insurance companies from FOSYGA for medical services (procedures and medicines) outside the Mandatory Benefit Package of the contributive regime (recurrent expenditure). COP 2,103 billion as of 31-Dec-2011 ■ Number of financial instruments implemented to mitigate national disaster risks.
Solomon Islands	Increasing Resilience To Climate Change And Natural Hazards (P112613)	(under preparation)	
PNG	Building a More Disaster and Climate Resilient Transport Sector (P129322)	The main objective of the Project is to improve the resilience of PNG to the impact of natural disasters and climate change in the transport sector. This objective will be achieved through building capacity for hazard risk assessment affecting the transport sector to minimize disruption of services and improve transport access.	Provisional indicators: (a) a system of disaster risk assessment is in place (b) km of roads and bridges analyzed for disaster risks

Source: World Bank (2012).

Chapter 2
Tools for Building Urban Resilience

Key Points

- ***Risk assessment*** *is a technical tool for quantifying the possible impacts of disaster and climate events in terms of the spatial distribution of damage and loss and the probability or likelihood of the events occurring.*
- ***The socioeconomic cost-benefit analysis*** *is a method to assess a broader range of positive and negative impacts of an investment to the public and the city government's key stakeholders.*
- ***Risk-based land use planning*** *identifies the safest areas to prioritize investments in urban development and infrastructure projects.*
- ***Urban upgrading*** *prioritizes infrastructure for the most vulnerable populations living in slum settlements.*
- ***Ecosystems management*** *approaches for resilience in urban areas make use of existing natural infrastructure and can significantly decrease the cost of urban infrastructure projects.*
- ***Participation of communities and stakeholders*** *into urban infrastructure projects, including private sector partnerships offers effective ways to build social resilience.*
- ***Geographic Information System (GIS)*** *software and tools are instrumental in creating and analyzing geospatial data, including hazard and exposure maps, as part of a risk assessment.*
- ***The recognition of residual risk*** *also implies that cities have to continue improving the quality of risk communication, early warning systems, emergency contingency, evacuation and recovery planning.*
- ***Disaster management frameworks*** *are an extension of local networks, national systems and even international regional disaster networks. The key is to create systems that are complementary and encourage collaboration between different levels of authority.*
- ***Investments in the early warning systems*** *are amongst the most cost-effective measures that any country can undertake.*
- ***Financial approaches*** *to urban resilience can spread disaster risk and soften the impact of a disaster.*

Key Resources

Section		Resource
2.1	Risk Assessment	***Tools for Building Urban Resilience: Integrating Risk Information into Investment Decisions. Pilot Cities Report – Jakarta and Can Tho***. *World Bank, 2012.*
2.2	Risk-Based Land Use Planning	***Safer Homes, Stronger Communities: A Handbook for Reconstruction after Natural Disasters, Chapter 5***. *World Bank, 2010.*
2.3	Urban Ecosystem Management	***Cost-Effective Green Opportunities to Protect and Improve Upper Neuse Watershed Health – A Survey of the Literature for Beneficiaries***. *World Resources Institute, 2011.*
2.3	Urban Upgrading	***Approaches to Urban Slums: Adaptive and Proactive Strategies.*** *The World Bank Institute, 2009.*
2.4	Community and Stakeholder Participation	***Cities and Climate Change Initiative Discussion Paper, No 1, Participatory Climate Change Assessments: A toolkit based on the Experience of Sorsogon City, Philippines.*** *UN-HABITAT, 2010.*
2.5	Disaster Management Systems	***Disaster Risk Management Systems Analysis***. *FAO, 2008.*
2.6	Data Gathering, Analysis and Application	***Using High Resolution Data for Identification of Urban Natural Disaster Risk***. *World Bank, 2012.*
2.7	Risk Financing and Transfer Approaches	***Cummins, J David and Olivier Mahul. Catastrophe Risk Financing in Developing Countries: Principles for Public Intervention – Overview.*** *World Bank, 2008.*

2.1 RISK ASSESSMENT

Institutional

Economic

Key Points

- Risk assessment is a technical tool for quantifying the probability and consequences of disaster and climate events.
- Risk assessment is the primary tool for all urban infrastructure projects.
- A risk assessment is ideally implemented in the identification or preparation phase of the project cycle.
- Risk assessments include core components: hazard, exposure, and vulnerability.

Summary

The objective of a risk assessment is to provide a quantitative measure of the possible impacts due to natural hazards. The results of a risk assessment can be used to enhance resilience to disasters and climate change by informing the selection and design of infrastructure and other urban investments. To make necessary budgetary and investment decisions, decision-makers seek consistent and quantitative tools to evaluate public investments. Integrating risk-based methods into cost-benefit approaches enables the consideration of the impacts of climate change and disasters by means of quantifying the economic consequences of these events. It is widely accepted that such cost-benefit evaluations, when they are consistently used in connection with a standardized project evaluation method, can be used to stimulate efficient and effective public investments.

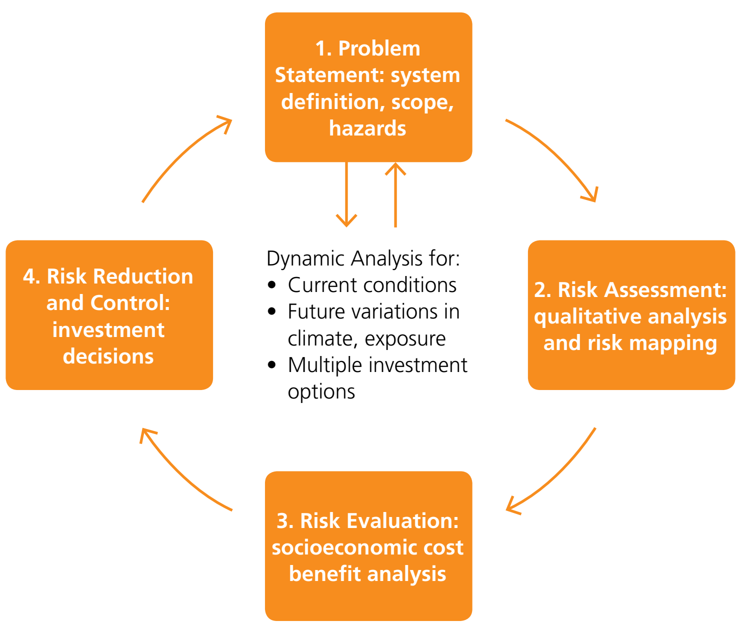
Risk assessment provides the factual basis for integrating disaster risk reduction into urban infrastructure projects. A risk assessment should always be part of a larger planning process, which will help form a basic understanding of risk for communities, property owners, urban planners and different levels of government. Depending on the situation, a risk assessment can be used as a tool to build social resilience, and can greatly add to the quality of the assessment. In all cases, risk assessments cannot be implemented without inputs from communities and stakeholders in order to define each of the elements within a risk assessment.

Risk Assessment and Investment Decisions

Risk assessment is the primary tool for any urban infrastructure project. It should ideally be implemented in the identification or preparation stage of every urban project. The design of a risk assessment is to give an overall sense of expected loss to specific or multiple hazards over a particular period of time.[73] Traditionally, loss refers to human lives and their welfare, which includes infrastructure and economy, but has expanded over the years to include socioeconomic and institutional indicators as well.

Technical risk information created during the assessment and evaluation stages provides the basis for risk reduction measures. Figure 10 indicates the elements of a dynamic decision-making process, which integrates risk assessment and cost-benefit analyses. The process is begins with a problem statement specific to the investment decision, and the

FIGURE 10 Dynamic decision-making process



proposed cycle repeats for consideration of variations in conditions such as climate change scenarios, growth in exposure, and investment options. When investment measures or actions reduce the probability or consequences of a disaster, the relative change in risk can be evaluated by comparing the difference in expected value of the impact. This process is the application of a risk assessment as part of a cost-benefit analysis.

Methodology

There are several methods for assessing risk in a given area. The preferred method should be well understood and repeatable. The four core elements of any risk assessment methodology must include: *hazard identification, exposure analysis, vulnerability analysis and risk analysis*. Urban planners must be careful to understand the quality of a risk assessment, which is dependent on the availability of data, the interaction of multiple hazards, the complex effects of disasters and the ability to involve experts in the process. As with all urban investment projects, community participation in risk assessment is critical to understanding practical effects of disasters. In sum, community representatives have to be part of the risk assessment process at all stages. Community risk mapping is an invaluable tool for community participation and grounds the risk analysis in actual versus assumed or projected risk data. **Section 2.5** provides details on community and stakeholder participation is discussed in detail.

Hazard Identification

In urban resilience terms, hazards are defined as disturbances to urban areas that threaten human life and habitation. Disturbances refer to natural disasters, like earthquakes and flooding but also include a broader set of events that are a result of human acts of omission or commission.[74] This component of a risk assessment includes the collection and analysis of underlying hazard data to produce a probabilistic event set and to define the localized/downscaled physical hazard conditions (such as elevation, soil type, and bathymetry).

With low frequency, rare events such as earthquakes, it is particularly important to engage in a robust probabilistic analysis of the hazard. This will yield a characterization of the hazard that extends beyond the limited or incomplete historical record of observed events. **Probabilistic hazard models** allow for the quantification of the impacts of climate change on disaster occurrence. Historical event catalogues are still important in the hazard modeling process as the source of validation benchmarks. The most valuable validation data are hazard empirical measurements or observation points from historical events, which can be used to test downscaling algorithms used to produce event footprints.

The resolution of hazard analysis will determine the fitness-of-use of the overall risk assessment output. If only course resolution hazard information is available, then the stakeholders and other users of the risk assessment should be educated about the limitations. Key outputs from a hazard analysis are a probabilistic event catalogue defining the frequency and severity of possible events in addition to multiple geospatial datasets defining local site conditions impacting the event footprints.

Hazard mapping is the most common form of identification and is recommended for urban investment projects. It is an easy and intuitive way to identify areas at risk to disasters. Identification of hazards should include the frequency, duration, area extent speed of onset spatial dispersion and temporal spacing. The possibility of secondary hazards should always be understood as well. Multiple hazards should be treated separately and identified through parallel processes. **Box 8** gives an example of city-wide community risk-mapping exercise in Uganda.

Exposure Analysis

Exposure analysis is intended to connect identified hazards with the elements at risk, which in urban infrastructure projects generally refer to human populations and infrastructure. The standard definition of exposure is the collection of assets (such as buildings, infrastructure, crops, and populations) within proximity of a given hazard and can expect to sustain loss or damage during a disaster event. For the purpose of this discussion, we focus on examples of buildings and structures as specific types of exposure.

Box 8 Community-based mapping at the citywide level

The Government of Uganda, Cities Alliance and Shack Slum Dwellers International (SDI) are currently engaged in a partnership program that targets transformation of urban slums in five secondary cities of Uganda (Ninja, Arua, Kabale, Mbale and Mbarara). The program aims to reach an estimated 200,000 slum families, including the registration of all informal settlement in these cities.

Within this broader context, UN-Habitat's Global Land Tools Network (GLTN) and a Social Tenure Domain Model (STDM) platform is being tested in Uganda in 2011, entailing citywide enumeration and mapping exercises. This follows on from a study by the developers of STDM of the enumeration experiences of slum dwellers' federations in Mumbai (India), Nairobi (Kenya) and Kisumu (Uganda) and the coding of the results onto an open source Quantum GIS program. The STDM uses GIS and Microsoft Excel to capture enumeration and mapping information at household level, one base lower than plot level cadastre-type information.

Uganda has a complex urban land tenure system. For instance, in the Kisenyi slum in Kampala, the Kabaka - constitutional king of the Buganda kingdom - owns the land. Over time, landowners have received land grants at the king's pleasure. In turn, they have parceled the land and made leases to structure owners who have built a sprawl of 35,000 shacks and rent them every month to the city's urban poor.

SDI's Ugandan affiliate, the Uganda Slum Dwellers Federation, and its support NGO, Actogether, aims to use the citywide enumerations and mapping exercises to determine the usage and investment patterns within such informal settlements. In the longer run, this work has potential implications for the transformation of the land information system in Uganda, as title deeds could conceivably be supplemented by user deeds. The ultimate success of the pilot will depend on persuading Uganda's Ministry of Lands of its use value.

Source: J Makau, SDI Secretariat in 'Solving the land information gap through GIS,' February 2011.

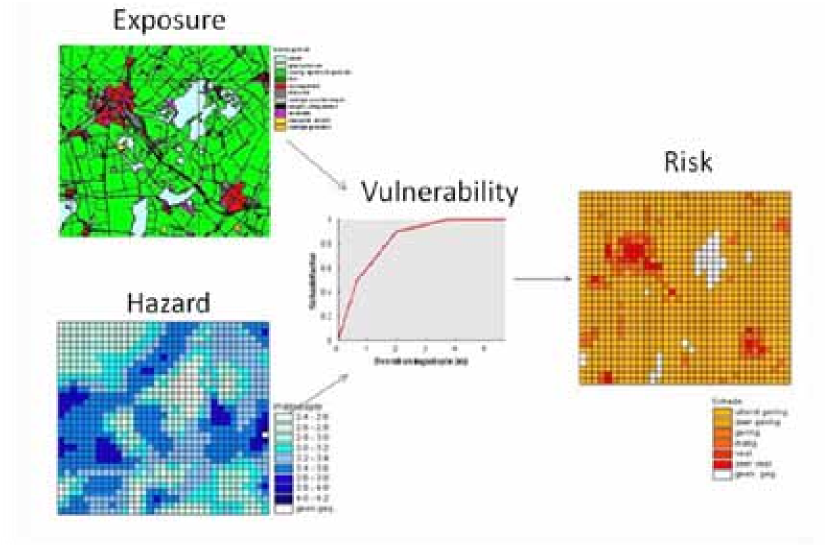
Exposure is characterized by a combination of physical characteristics (i.e. masonry apartment building with four stories), monetary value (either cost required to replace the structure or its actual market value), and spatial location (street address, latitude longitude coordinate). The detail and accuracy of the exposure data has a critical impact on the risk assessment output: location of exposure determines the type and intensity of hazard it will experience, physical characteristics influence the vulnerability and therefore the damage to the exposure, and finally monetary value coupled with the measure of damage estimate the expected losses that a community would incur during recovery.

Understanding the application for the risk assessment is important for exposure development. For example, the resources and tools required to assess exposure will change based on the geographic scope of the assessment: global, regional, national, municipal or site-specific. Large scale assessments, such as those conducted at national level or higher, often include aggregated exposure data determined by top-down estimation of count of structures/population and assignment of typical characteristics. These aggregate methods contrast with building-specific exposure, wherein data is collected about individual structures and their exact locations are determined.

Vulnerability Analysis

This analysis quantifies the susceptibility of exposed populations and their assets to different levels of hazard intensity. Vulnerability analysis measures degree of susceptibility and indicates the elements at risk that can be addressed. Vulnerability differentiates the risk between asset types identifying structures and populations that are more or less susceptible to damage during an event. It is important to recognize that vulnerability relationships should be defined to reflect the unique characteristics of the area being assessed. Vulnerability analysis must include estimates of human casualties based on distribution of population, damage, loss of assets and capacity analysis. [75] Historical data on disaster loss is vital to understand how specific disasters impact populations and infrastructure. In many cases, necessary data may not exist; however, there are engineering-based analytical models that estimate impacts of disasters.

FIGURE 11 Risk analysis calculation



Risk Analysis

This analysis combines hazard, exposure and vulnerability analysis and provides a spatial assessment of risk based on hazards, vulnerable populations and the ability of the community to cope with disasters. Risk analysis provides the basis for determining the acceptable level of risk and related land use planning interventions. It also provides data for calculating the benefit costs of various interventions.[76] The analytical steps shown in **Figure 11** indicate the flow of information from the hazard and exposure components to the vulnerability function which yields estimated damage as a measure of risk. Visualization of risk assessment results through risk maps is very useful in the decision-making process as well as in communicating the risks to various stakeholders.

Risk analysis must include estimates of loss of human life as well as direct and indirect economic loss. These direct losses are more straightforward to evaluate with the standard relationships between the severity hazard event, location of the damage assets, and occurrence of damage of certain severity, as described by the preceding methodology. However, there are consequences of disaster events that are more challenging to quantify, and can significantly contribute to the overall risk that an urban infrastructure investment seeks to mitigate. The information in **Table 6** provides examples of these general categories of disaster impacts within a matrix for Impact Type (Direct or Indirect) and Asset Type (Economic or Non-Economic).

Probabilistic risk modeling, initially developed by the insurance industry, can help decision-makers when dealing with uncertainty over current and future risks. In urban areas, probabilistic risk assessments can guide urban planning, ensuring that buildings, schools, hospitals and other assets are located in safe areas. CAPRA, is an example of a probabilistic risk assessment initiative, which provides a risk calculation platform integrating exposure databases, physical vulnerability functions and hazard assessments in a probabilistic methodology (see **Box 9**).

The outputs of probabilistic risk assessments can have many policy applications[77], for instance:

- Territorial planning to identify, for example, flood plains or geographic damage scenarios from earthquakes or tsunamis;
- Infrastructure risk assessment for an assessment of expected damage from specific hazard scenarios;
- Cost benefit analysis for mitigation measures;
- Preparedness measures for support of emergency and contingency planning for different crisis scenarios;
- Insurance premium calculations for provision of

TABLE 6 Types of disaster impacts

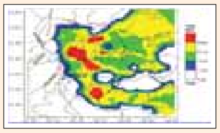
	Economic	Non-Economic
Direct	■ Residences, commercial, industrial buildings ■ Vehicles, stock and supply, other non-structural property ■ Agriculture, livestock ■ Infrastructure and other public facilities ■ Utilities and communication ■ Business interruption (inside flooded area) ■ Evacuation and rescue operations ■ Clean up costs	■ Population (casualties, psychological cost of displacement) ■ Environmental ■ Historical and cultural
Indirect	■ Business interruption/supply chain disruption to industry outside flooded area ■ Substitution of production outside flooded area ■ Extended temporary housing or permanent relocation of evacuees	■ Societal disruption ■ Damage to government capacity

Box 9 CAPRA: Probabilistic Risk Assessment Initiative

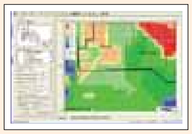
A free, modular, open-source, and multi-hazard tool for risk assessment, CAPRA provides a risk calculation platform integrating exposure databases, physical vulnerability functions and hazard assessments in a probabilistic methodology. CAPRA evaluates risk in terms of physical damage and direct economic and human losses in standard risk metrics (AAL, PML) to visualize hazards and risk in geographical information system (GIS).

Building on—and strengthening—existing initiatives, CAPRA was developed by Latin American experts with the support of the Central American Coordination Centre for Disaster Prevention (CEPREDENAC), the World Bank, the Inter-American Development Bank (IDB) and the International Strategy of United Nations for Disaster Reduction (UN-ISDR), in partnership with Central American governments Risk assessment and visualization tools such as CAPRA can enable many applications

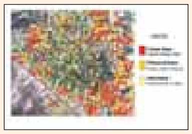
Territorial Planning



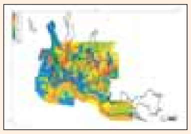
Infrastructure Risk Assessment



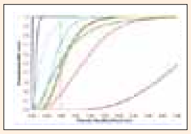
Cost Benefit Analysis



Preparedness Measures



Insurance Premium Calculations



Source: World Bank, 2012. Further information: http://www.ecapra.org/.

accurate information about annual expected loss and probable maximum loss for a specific area.

Cost-Benefit Analysis

When a risk assessment is used to quantify the added value of a project or measure, it can become part of the cost-benefit analysis. In the cost-benefit analysis, a range of impacts beyond direct damage, are assessed including costs for mitigation measures and emergency aid and the relative decrease in damages due to these measures. Because the impact of a project is often wider than just the damage avoided, a socioeconomic cost-benefit analysis is often used.

The socioeconomic cost-benefit analysis (SCBA) is a method to assess a broader range of positive and negative impacts of an investment (project) to the public and the city government's key stakeholders. In socioeconomic cost-benefit analyses, financial impacts, environmental impacts, and social impacts are considered (see **Table 7**). All these impacts are expressed in monetary terms. The advantage is that all impacts can be added so that it becomes clear if an investment has a positive or negative balance.

TABLE 7 Summary of socioeconomic cost-benefit analysis

	Socioeconomic
Goal of analysis; which question does it answer?	What is the welfare change for society due to a project?
Perspective (target group)	All actors of a society, e.g. a geographical region like a country, province or city
Type of impacts	Socioeconomic impacts: human welfare in terms of: ■ Market internal and market external; ■ Directly and indirectly linked to the project;
Time span	Depends on the when possible an infinite time span is used ■ Impacts later in time count less than impacts early in time due to discounting
Reference situation/ base line	The current situation plus autonomous developments

The outcome of the cost-benefit analysis is usually expressed as the net present value or internal rate of return. When the balance of a project is positive, the investment is socioeconomically sound. In this way, socioeconomic cost-benefit analysis can be used to enhance a sustainable economic development, as it reveals the relationship between market and socioeconomic impacts. Because in SCBA all impacts of a planned project are, in general, expressed in monetary terms, it resembles a financial cost-benefit analysis. The main difference between the SCBA and the standard CBA is the inclusion of both market and non-market welfare impacts.

As an illustration, the most common criteria used in evaluation of flood risk measurements through a cost-benefit analysis are provided in the list below.

- **Economic benefits**, including direct damage reduction related to damages to property, industry, agriculture, etc., and indirect damage reduction related to loss of business, evacuation costs, disruption of society.
- **Social benefits** related to reductions in the affected area in terms of assets, people, vulnerable points (hospitals, police station, power plants); psychological damage, loss of life.
- **Environmental benefits** related to water quality improvement, biodiversity.
- **Costs for construction, operation and maintenance**.

In ex-ante decision-making, direct economic damage is usually valued with replacement costing and productivity costing methods. For intangible damage the monetization is slightly more complicated since market prices are not always available. Several options are available to estimate the economic value of flood risk reduction:[78]

- **Damage Cost Avoided:** The economic value of flood damage is estimated by the costs of measures to prevent flooding.
- **Averting Behavior Method**: The economic value of flood damage is estimated by the costs to avoid actual damage and unwanted effects.
- **Replacement Costs**: The economic value of flood damage is estimated by the costs to repair or compensate for flood damage.
- **Productivity Costs:** The economic value of flood damage is estimated by the costs of the loss of production of commercially marketed goods.
- **Conditional Valuation Method**: The economic value of flood damage is estimated by creating a hypothetical market in which people are enabled to price flood damage.

From the decision-making perspective, investments can be evaluated based on efficiency, effectiveness, and relative priority:

- **Efficiency**: Is a project efficient in terms of achieving more benefits than costs, as compared to other proposed projects under consideration for the same public financing?
- **Effectiveness**: Is a proposed project the best way to reach the specified goal, or are there other options less expensive with the same result?
- **Priority**: If a project is efficient and effective? What's the best time for project implementation?

Concluding Remarks

There are many different methodologies for effecting a risk assessment, and while attempts have been made to create one comprehensive risk assessment tool, the debate about the most appropriate methodology is ongoing. Most important is to select a risk assessment methodology which can work now as well as in the future, so that urban planners can understand how risk is changing over time in a given area. Risk assessments provide the foundational data sets for understanding and enhancing urban resilience. The four core elements of risk assessment are widely accepted, even though methodologies differ, and should always be utilized when quantifying risk. **Box 10** illustrated flood risk assessment conducted in Dhaka.

Box 10 Flood risk assessment for mitigation planning in Dhaka City, Bangladesh

Background: Dhaka is located on low lying land at the confluence of two major river systems, Brahmaputra and Meghna and is subject to periodic flooding. Even in a normal flooding event, the death toll and the amount of economic loss is very significant leaving heavy burden on national budget needing international support. Because of Bangladesh's low elevation, between 30 and 70 percent of urbanized and agricultural areas are generally inundated during part of the monsoon season; May to August. In addition to the normal annual flooding, there have been 5 extremely serious floods in 1974, 1984, 1987, 1988 and 1998. The flood in 1974 caused widespread famine. The flood in 1998 is considered to have been the most devastating flood in recorded history. Two thirds of the country was inundated and more than 30 million urban and rural people have been directly affected. Millions were displaced from their homes and lost their earning opportunities. While employment opportunities in the rural areas are virtually scarce in the aftermath of a disaster, rural people move to urban areas for jobs and shelter. Thus natural disasters in Bangladesh have directly linked with the high rate of urbanization.

Further, water retention ponds/lakes that are naturally emerged with time are vanishing due to land filling for urbanization. Also, the city's population is increasing steadily forcing to identify more lands for housing and industries contributing to fast urbanization. Internal water logging due to poor drainage compounds the flooding impacts.

Objectives: Flood vulnerability map using remote sensing and GIS technologies; use of remote sensing to provide timely and low cost information on floods and land use status and GIS for managing information for land management and flood mitigation.

Actions:

- Land Cover Map was generated using satellite data; major land cover classes were used and they were verified with selected urban maps of the area for accuracy
- Flood Area Map was generated using data on flood during a normal flood event; a Digital Elevation Model (DEM) was used to further clarify flooded and non-flooded areas where there was ambiguity in interpreting satellite data; optical sensor images were used to identify water features not affected due to rainfall.
- Land Cover Map was combined with population data to produce a population distribution map according to land use types. Since the population information was available at district level, a finer spatial distribution was achieved by incorporating land use categories with population sub-districts.
- Flood Risk Map was produced by overlay analysis of flood areas and population distribution map by land use type showing population at risk during a normal flood event. This represents the number of people at risk during a flooding season.
- This map was compared with the Dhaka City Master Plan to evaluate the adequacy of the plan for flood mitigation.

Source: World Bank Institute, 2009.

2.2 RISK-BASED LAND USE PLANNING

Infrastructural | Institutional | Economic

Key Points

- Risk-based land use planning is a non-structural approach that identifies the safest locations and regulations for guiding urban development.
- Risk-based land use plans must inform all urban infrastructure projects.
- Mainstreaming land use planning in infrastructure projects reduces episodic and everyday risk in rapidly urbanizing cities and towns that are prevalent in hazard-prone areas and expose a high concentration of economic assets and population, especially the poor.
- Land use plans control development in hazard-prone zones, facilitate rescue operations and provide for emergency refuges.
- Land use plans are implemented using a combination of regulations and incentives for private sector and community engagement. Implementation of land use plans is challenged by lack of institutional coordination and municipal capacity.
- Risk-based land use planning should be incorporated in all phases of the urban project cycle.

Summary

Risk-based land use planning identifies the safest areas to prioritize investments in urban development and infrastructure projects. Land use plans influence the location, type, design, quality and timing of development. Risk-based land use planning aims to: i) identify and mitigate the root cause of disaster risks embedded in existing land development practices through regulated use of land in hazard-prone areas and building codes, ii) reduce losses by facilitating faster response through provision of open spaces and well planned road network for rescue operations, and iii) promote controlled urban growth without generating new risks, `building back better' through rebuilding and upgrading infrastructure using hazard-resistant construction in accordance with a comprehensive plan. This section discusses the importance of mainstreaming effective land use planning in cities to reduce disaster risk, implementation challenges and how project managers can incorporate risk-based land use planning into projects.

Mainstreaming Risk-based Land use Planning

Risk-based land use planning manages exposure to existing disaster risks in urban centers as well as reduces new risks created by rapid and haphazard urban growth prevalent in cities in low-middle income countries. The Hyogo Framework for Action (Priority 4) emphasizes the incorporation of land use planning and regulations to reduce underlying risk factors. Since then modest progress has been made on planning regulations in some countries; an Earthquake and Megacities Initiative focuses on risk-sensitive urban redevelopment planning with Makati (Philippines) as a pilot.[79] Even so, risk reduction through land use planning and building codes has not been as effective in comparison to advances in national legislation, risk assessments and preparedness and must inform all urban infrastructure projects.[80]

Implementation Challenges

Despite evident benefits, risk based land use planning is not widely adopted. Although nearly all countries committed to the Hyogo Framework for Action (HFA) in the Asia-Pacific region have developed land use guidelines and building codes for risk reduction, mechanisms for enforcement of regulations are lacking.[81] In the United States, fewer than half of the states require local governments to prepare comprehensive plans, and less than ten states incorporated risk resilience; although some local governments have adopted building or zoning regulations to minimize flood losses, building code violations have contributed heavily to losses.[82] Key concerns in this respect include: i) capacity development and resource constraints at the sub-national level; ii) national institutional structures put in place are not connected to local and community processes; and iii) administrative devolution for risk reduction in some countries is not backed by financial delegation.[83]

Multi-jurisdictional coordination is necessary for the benefit of all settlements in a risk-shed. Implementation of risk-based land use planning crucially depends upon: i) institutional coordination between various sector specific agencies engaged with land management as well as multi-jurisdictional cooperation when risks extend beyond urban limits, and ii) institutional capacity for good urban management, risk assessment, finance for implementation and ensure compliance to plans. In order for risk-based land use planning to be effective, different agencies concerned with land development, including roads and transportation, communication and utilities, housing, should share information and work in a coordinated fashion using an urban information management system that can ensure accountability to residents. Risk-based land use planning can encompass a region beyond the urban jurisdiction since risks can be generated up-stream; for example, floods in a basin can be the result of land use practices on the hillsides.

Integrating Risk-based Land use planning into the Project Cycle

Appreciation of risk based land use planning enables project managers to review and inform local government proposals for infrastructure investment guided by the spatial distribution of risk. The process for risk-based land use planning must be incorporated in all stages of the project cycle (see **Table 8**).

1. Project Identification

Effective risk-based land use planning will be feasible if the local political environment and land use planning culture are favorable and if time and resources are available. In many cities, land use plans are poorly prepared and may not be updated regularly. It is necessary to sensitize politicians and administrators of

TABLE 8 Risk-based land use planning in urban infrastructure projects

Stage of project cycle	Incorporating risk-based land use planning
Identification	Feasibility assessment and scope definition for incorporating risk concerns in the local land use planning environment Stakeholder perceptions to spatial distribution of risk
Preparation/Appraisal	Preparing a risk-based land use management strategy Stakeholder appraisal to ensure `buy-in’ for major strategies such as resettlement and retrofitting of existing structures
Implementation	Institutional strengthening and capacity building for land use planning Communication of land use plan intent and implications
Monitoring	Indicators for risk reduction through land use planning Institutional capacity and community participation in monitoring risk reduction through land use planning

Box 11 Checklist for feasibility assessment and scope definition

- ✓ Is there political support for risk-based land use planning? Is it possible to demonstrate short-term gains and garner political support?
- ✓ Is the local risk concentrated or dispersed? What resources are available to scale down national risk assessments or to perform local risk assessment?
- ✓ Is there enabling legislation and existing comprehensive plan that can incorporate risk-reduction measures in infrastructure projects? If not, is it more feasible to prepare a hazard or site specific plan?
- ✓ Does the planning institution have well trained technical personnel, finances and capacity to work with the community?

the possibilities of risk reduction through land use planning. Land use planning is typically a slow process that has limited political support since it can outlive political careers. Political support is usually strong in the aftermath of a major disaster, for example, risk reduction was incorporated in post earthquake reconstruction in Bhutan 2009.[84] Risk-based land use planning must be an integral part of a post-disaster reconstruction plan and during updating an existing land use plan. Many cities have Local Resilience Action Plans (LRAPs) that can give due emphasis on risk reduction through land use planning. Ongoing development programs such as transportation networks, water supply, housing developments, commercial centers and community amenities can offer co-benefits with risk reduction through appropriate land use planning measures. For example, the Myanmar Action Plan on risk reduction requires a disaster impact study as part of the planning and approval process of development programs.[85]

The scope of the risk-based land use planning activities needs to be defined based on distribution of local risk, institutional capacity and community priorities. Lack of local risk information is frequently stated as a reason to forgo planning. The availability of risk data, spatial distribution of risk, time and skilled personnel can limit the scope of a risk-based land use plan. While citywide comprehensive plans are desirable, where time or finances are scarce, a site specific or hazard specific land use plan can be effective in reducing the major risks. Planning processes assume the existence of a supporting legal and institutional framework and professional capacity. Small urban centers typically lack financial and technical capability to undertake preventive measures. Institutional capacity must exist to disseminate risk information, communicate with local stakeholder groups, revise and update land management strategies and recommending updates to existing development regulations. **Box 11** summarizes some of the key questions when preparing a feasibility assessment and defining the scope. Institutional audit is necessary to identify all local city agencies involved with land development, their roles and gaps. Community perceptions of risk, goals of urban space and capacity to accommodate new risk-based guidelines can affect compliance of the municipal plan. For details on stakeholder consultations, please refer to **Section 2.5.**

When initiatives start small and are consistent with local policies, opportunities for incremental improvements that are consistent with the capacities of under-resourced local governments, there is greater possibility of success.[86]

2. Project Preparation/ Appraisal

A risk-based land use plan is prepared by incorporating local risk-assessment within a spatial development plan to delineate: i) no—build zones, ii) zones for risk-sensitive development and retrofitting guidelines, and iii) safe zones for future development. However, spatial development plans alone do not work when municipalities lack funds, and the institutional capacity and coordination for land development are weak. Spatial plans need to be supported by land use implementation tools according to institutional capacity within a risk-based land use management framework. Stakeholder appraisal is required to gather feedback and recommendations to ensure `buy-in' to new efforts in planning; for details on stakeholder consultations, you may refer to **Section 2.5.**

Preparing a Risk-based Land use Management Strategy

Step 1: Conduct local risk assessment

Step 2: Prepare a risk-based land use plan

Step 3: Analyze cost-benefits of land use implementation tools

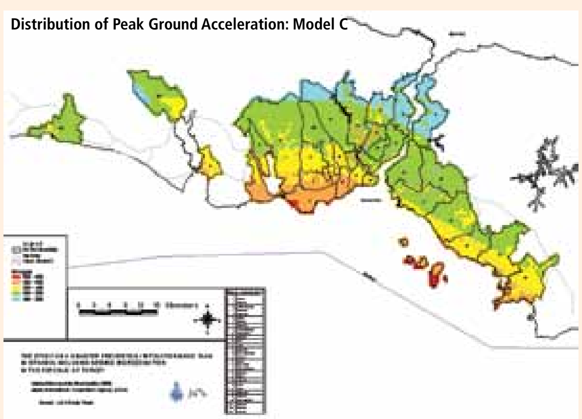
Step 4: Find the right mix of regulations and incentives

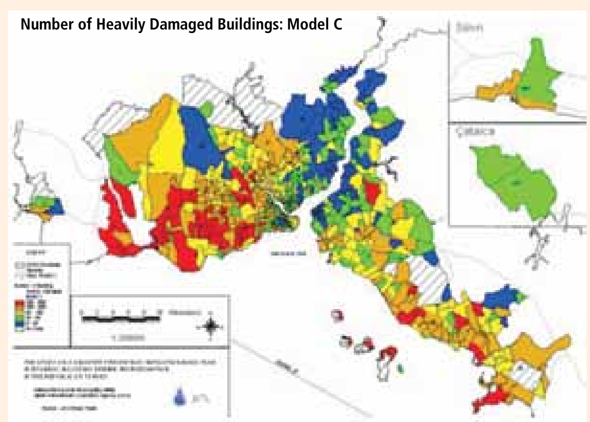
Step 1: Local Risk Assessment. Risk assessment is used to inform spatial development plans such as the comprehensive land use plan, a hazard specific plan or a site-specific multi-hazard plan. Risk assessment gives information on which parts of the city are potentially affected; for example, whether it is a coastal area with tourist facilities or residential communities in peri-urban areas. The outcome of risk assessment is a defined set of risk-based (micro) zones with varying characteristics. Planners can determine which neighborhood has the highest overall long-term risk from a specific hazard or a combination of hazards and establish spatial planning standards, zoning regulations and building codes based on an acceptable level of risk (see also **Box 12**). A detailed time-dependent assessment may be needed to justify differential zoning regulations and ensure social equity.[87] For more information, you may refer to **Section 2.1 on Risk Assessment**.

***Step 2: Risk-based Land use Plan**:* A spatial plan is prepared based on project scope. Incorporating risk reduction into a comprehensive plan is effective where such a plan already has standing as a policy guide. A spatial plan can be in the form of a land

Box 12 Istanbul earthquake risk reduction plan

A rapidly growing historic, commercial and cultural center, Istanbul is located close to the North Anatolian Fault Zone and has survived 120 earthquakes during the last 2000 years. Earthquake risk is increasing due to deterioration of old buildings and poor quality of construction. Probabilistic risk assessment revealed that in the event of a major earthquake, the city would not be able to respond to emergency needs since it has 30% of hospitals in the highly vulnerable south-western part of the city. A study of 1278 buildings in different locations showed that the average concrete quality was below the 1998 Seismic Code requirements for new buildings.





Scenario Analysis: distribution of peak ground acceleration and number of heavily damaged buildings

The Istanbul Metropolitan Municipality (IMM) considers two parallel risk reduction approaches:

- A Strategic Plan for Disaster Mitigation in Istanbul that suggests measures at three levels: Macro (national, regional; and metropolitan master plans), mezzo (urban redevelopment projects) and micro (urban redevelopment ignition areas, local development areas and land readjustment areas).
- Earthquake Mitigation Plan for Istanbul (EMPI) consisting of a city contingency plan and local action plan in high-risk areas.

Source: Istanbul Metropolitan Municipality - Disaster Coordination Center, WBI 2009.

classification plan, a future land use plan, a verbal policy plan, a land use management plan or a mix of all these elements; for a comparison of spatial plans, refer to **Annex 3** or UN-HABITAT's 2009 *Planning Sustainable Cities.* Since a comprehensive plan is a common planning tool, planners are familiar with its utility, procedures and limitations. However, being comprehensive, such plans tend to be time-consuming and detailed, making the planning process tedious and costly and this difficult to update after a disaster and anticipate demand for land and changes in land use in rapidly urbanizing areas. When there is no existing comprehensive plan, or it is weak or out of date, a specialized risk reduction plan is appropriate. This could be in the form of general policy guidelines or a specific program that address specific hazard prone areas, such as, flood plains, or take a more community-wide approach. However, stand-alone risk management plans are less effective than adapting existing development mechanisms to reduce risks.[88] Site-specific risk reduction plans are appropriate and efficient where there are no existing broad policies or plans or if the risks in a particular location require special attention. Care must be taken that site-specific measures do not create new risks or transfer existing ones to other areas.

Step 3: Land use implementation tools for risk reduction include planned resettlement, hazard zoning, managing urban form and densities, ecosystem management, critical infrastructure planning and road network planning. For successful implementation, a set of compatible regulatory and incentive based implementation tools needs to be identified.

Planned Resettlement eliminates exposure to risks and reduces costs of emergency response and rehabilitation. Where risk mitigation is not possible, such as, in seismic areas with highly liquefiable soil, areas of volcanic flow, hurricane/ flood/ landslide prone areas, resettlement becomes the only option.[89] More often than not, it is the low-income families that occupy hazard-prone sites and need resettlement. For more details on resettlement of slums, **see Section 2.4 on Urban Upgrading.** Resettlement is often not planned and focuses on housing provision alone; relocated families often move back to earlier location where they had strong economic or social ties. Planned resettlement should include relocation of housing as well as rehabilitation of livelihoods, social networks and access to public services (see also **Box 13**). In Bogota, Colombia, emergency relief was used in 1997 to resettle 100 households of an informal

Box 13 Checklist for a successful relocation

Planned resettlement or relocation is a sensitive program that must be carefully implemented so residents are fully involved in the process and decision to relocate. Here are some key points to keep in mind when implementing a relocation program.

- ✓ Affected communities participate in critical relocation and implementation decisions (site selection, identification of basic needs, settlement planning, housing designs and implementation).
- ✓ Livelihoods are not site-specific and so not disrupted.
- ✓ Water, public transport, health services, markets and schools are accessible and affordable.
- ✓ People are able to bring with them items of high emotional, spiritual or cultural value.
- ✓ People belonging to the same community are resettled together to a new site.
- ✓ Emotional, spiritual and cultural attachment to the old site is not excessively high.
- ✓ Housing designs, settlement layouts, natural habitat and community facilities conform to a community's way of life.
- ✓ Social, environmental and hazard risk assessments confirm that risk cannot be mitigated in the old location, while the community can be assured of the suitability of the relocation site.
- ✓ Communication with target groups is frequent and transparent, and mechanisms to resolve grievances are effective.
- ✓ Relocation and assistance to mitigate its economic impacts are adequately funded over a reasonable period of time.

Source: World Bank, Safer Homes, Stronger Communities: A Handbook for Reconstruction after Natural Disasters 2010, p 80.

settlement located in a seismic high-risk and environmentally sensitive micro-watershed zone; however some households returned to the area. In 2005, an integrated rehabilitation, reconstruction and sustainable development plan included establishing hazard buffer and no-build zone, socio-economic studies to identify potential impacts of displacement (loss of housing, social networks and livelihoods), community engagement for risk awareness and resettlement process and post-resettlement assistance for education and health care; however implementation was challenged by vested interests, lack of legal tools, fear of relocation; inter-institutional and inter-sectoral interventions were key to resolving these issues.[90]

Further Reading

Populations at Risk of Disaster, A Resettlement Guide (GFDRR, 2011).

World Bank Resettlement Handbook (World Bank, forthcoming).

Hazard zoning enables local authorities to demarcate hazard-prone areas such as coastal and seismic zones, regulate land use or prevent development in these areas, demarcate safe land for infrastructure for future expansion, set development regulations (specific rules about location, bulk, height, shape and use of structures in each zone), and set building codes (design, constructions specifications) to withstand risk; examples include flood-zone regulations, setbacks from faults, steep slopes and coastal erosion areas, development standards for wetlands, dunes and hill sides. For hazard zoning to be successful in areas where such zones are already settled, they must be accompanied by planned resettlement of families located in no-build zones identified and programs to increase the supply of housing in the city as a whole (see **Box 14** for examples).

Risk-based development regulations and building codes can apply for new construction as well as retrofitting of existing development when resettlement is not feasible. Chennai Corporation is carrying out vulnerability analysis of 65,000 buildings of over one storey across the city and recommending approriate retrofitting measures[91]. Development regulations and building codes should incorporate climatic settlement planning and design principles to mitigate fuel and energy consumption that is said to contribute to climate change. The IPCC identifies energy efficiency in buildings as a cost-effective instrument for reducing GHG emissions among all energy consuming sectors; India is implementing its Energy Conservation Building Code for large commercial buildings with large measures to ensure compliance capacity[92]. Although a powerful tool, zoning ordinances are difficult to implement if institutions are weak, technical capacity is limited and lack political support; in Nepal – only 4 out of 58 municipalities are implementing provsions contained in the seismic code[93].

The use of incentives to promote risk-based building codes needs to be encouraged; in Japan, fiscal incentives have been used to promote retrofitting of old buildings in congested urban areas[94].

Further Reading

Sustainable Reconstruction in Urban Areas: A Handbook (IFRC, 2012).

Urban form and densities can be managed for risk resilience; for example, to zone safe land for urban expansion, redevelop city center and increase overall supply of housing to control unplanned expansion, facilitate a multi-nucleated urban with multiple Community-based Developments that enable faster recovery in the event one economic center is destroyed during a disaster event, and encourage development along safely sited transit corridors using development incentives. Open space planning can facilitate emergency response and relief operations by functioning as temporary shelter sites and medical field stations during a disaster event apart from environmental and recreational benefits (see **Box 15**).

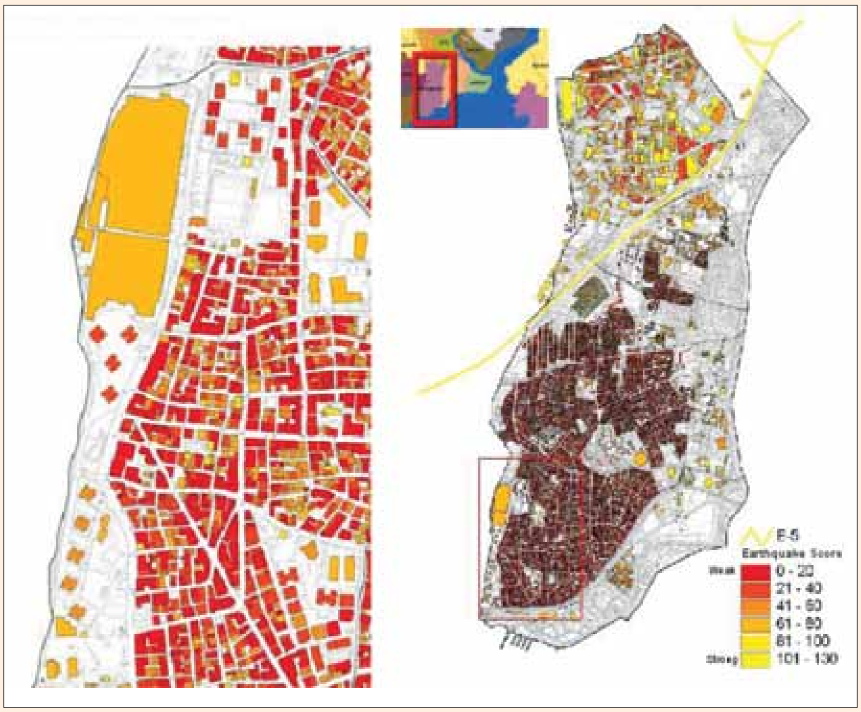
Ecosystem Management through spatial plans, that protect and improve the connectivity of green spaces and reduce impervious surfaces, can effectively reduce disaster risk apart from improving the overall urban environment. For example, protecting wetlands with zoning regulations and demarcating environmental buffer zones produces environmental and health benefits in urban areas while reducing flood impacts.[95] You may refer to **Section 2.3** for more information on ecosystem management.

Critical infrastructure located strategically through land use planning can facilitate quick response and rescue efforts. For example, zoning can locate community amenities such as hospitals and schools at

Box 14 Hazard zoning

In Metro Manila, Philippines, fault zoning in the City of Muntinlupa included demarcation of danger and no-build zones along 10 km. zone, tax relief, relocation and financial assistance to affected residents. However, land surveys conducted by the Zoning Administration Office would usually be unwelcome, notices to vacate danger zones would fall on deaf ears; informal settlements continued to thrive. The government did not acquire land for relocation nor provide sufficient assistance for resettlement.

In Istanbul, the Metropolitan municipality launched a micro-zonation project in the high-risk south-western part; detailed information on local ground conditions were used to establish appropriate design parameters and building codes for construction.Scenario Analysis: distribution of peak ground acceleration and number of heavily damaged buildings



Distribution of vulnerable buildings in Sumer neighborhood; Distribution of earthquake weakness scores through the Zeytinbumu District

Source: Istanbul Metropolitan Municipality - Disaster Coordination Center, WBI,2009.

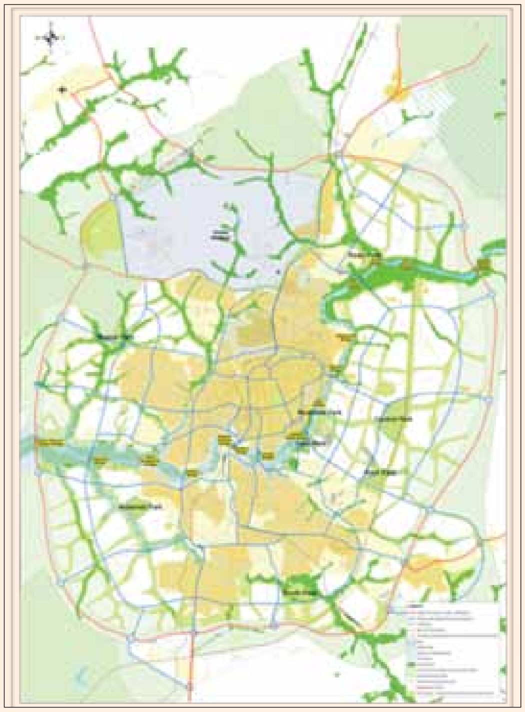
multiple locations in the city in close proximity to all neighborhoods rather than in a central location that can be destroyed in the event of a disaster. Building codes for design of critical facilities should be based on a higher threshold of acceptable risk. You may refer to **Section 2.4** for a more information on upgrading critical urban infrastructure. ***Road networks*** that provide quick access to facilitate search and rescue operations and function as evacuation routes in hazard prone areas can reduce the impact of disasters significantly (see **Box 16**).

Step 4: Combining regulations and incentives is effective to implement risk-based land use plan. It is common for municipalities to favor one land use tool that has gained political acceptance at a given time; often such tools end up negating the gains from another. It is important to appreciate that there is no `magic bullet'; risk reduction will be achieved by using a `basket of tools' that are compatible and do not work at cross purposes; for example, if coastal zone regulations are imposed without land acquisition for resettlement in keeping with a comprehensive plan,

Box 15 Spatial development framework for risk reduction, Kaduna, Nigeria

A Spatial Development Framework was evolved from analysis of natural assets and risk associated with River Kaduna that is subject to major periodic flooding. The plan encourages an efficient urban form by promoting development along corridors of new planned infrastructure while preventing development in the flood plain by zoning riverside areas for agricultural and amenity use and zoning multiple tributaries and streams that serve as natural drainage channels for the city as green corridors to accommodate phased expansion of the city. Investment in infrastructure is limited to short-term demand in accordance to the overall planning vision; this protects investment on redundant infrastructure that may be subject to later hazards.

Source: Max Lock Consultancy Nigeria, 2010.



Box 16 Master plan for risk reduction, Constitución, Chile

Following the earthquake and tsunami of 2010, the Government of Chile used the master plan for recovery and reconstruction efforts as an opportunity to incorporate risk assessment and mitigation in future planning of coastal settlements. The master plan includes a system of streets for evacuation perpendicular to the sea and river on both sides of the settlement allowing access to a safe point at 35m height above sea level on the seacoast side and 10 m above sea level on the rover edge side. These corridors have been designed as pedestrian routes that end up at meeting points in safe areas planned as community open spaces.

Source: Costa n.d.

it is more than likely that residents will not move, or may move to other locations that are also hazard-prone (see also **Box 17**).

For implementing risk based land use plans, regulations alone do not work; regulations need to be balanced with incentives. The choice of tools will depend upon the institutional capacity, availability of risk information, socio-economic cost-benefits to community, compatibility with existing land use policies and practice and cultural orientation to risk. Evaluation of cost-benefits of reducing risks requires comprehensive probablistic assessments that are not available in most countries. It may be cost-effective to concentrate on retrofitting the most vulnerable and critical facilities rather than spread investments to protect many risk-prone assets. In Mexico, the benefit-cost ratio for retrofitting the most vulnerable 20% of risk-prone public buildings was considered appropriate.[96]

3. Implementation

Institutional capacity must exist to disseminate risk information, communicate with local stakeholder groups, revise and update management strategies and recommending updates to existing regulations. Establishing institutional and legislative enabling

Box 17 Checklist for land use risk management strategy

- ✓ Should risk concerns be incorporated in a comprehensive plan, site-specific plan or a hazard-specific land use plan?
- ✓ Is there a need for a hazard specific regional plan that needs cooperation between multiple jurisdictions?
- ✓ Is there adequate information and resources available to conduct cost-benefit analysis of land use tools?
- ✓ Which land use tools are appropriate given the spatial distribution of risk, existing urban form, availability of open space, condition of infrastructure, existing regulations and the socio-economic conditions of the community?
- ✓ Which regulations and incentives can support the enforcement of the risk reduction plan? What is the right balance?

Box 18 Institutional capacity for risk reduction

The Earthquake Mitigation Plan for Istanbul evaluates current legal structures, institutional responsibilities and financial schemes necessary for implementation. It stresses that risk management mostly relates to legal, social and political issues. It includes assessment of seismic vulnerability of existing building stock, developing seismic retrofitting methods and identifying technical, social, administrative, legal and financial measure needed for implementation. The Disaster Management Centre of Istanbul City, known as AKOM, was built and furnished with the necessary equipment to collect, process and disseminate disaster information.

In Kaduna, Nigeria, the Spatial Development Framework is based on a land use survey of the entire urbanized area and sample household survey; the data along with satellite imagery, topographical and hazard data is stored in linked databases that will be an operational Geo Data Infrastructure for urban management

Source: Istanbul Metropolitan Municipality - Disaster Coordination Center and Max Lock Consultancy Nigeria, 2010.

frameworks for coordinating land use planning measures is the fore-most step (see **Box 18**).

Sectoral coordination is needed between agencies such as those concerned with environmental protection, land cadastres, public works, transportation, water and sanitation, housing and cultural heritage. Institutional partnerships between different city agencies and need for capacity building need to be identified to address redundancies and gaps identified earlier. How can the efforts of various sector-based municipal agencies be coordinated? Many cities opt to set up a separate DRM nodal institution to facilitate such coordination.

Multi-stakeholder cooperation through incentives for private sector and community engagement are critical for successful compliance with the risk based land use plan. In Philippines, the private sector plays a significant role in resource mobilization to support risk reduction and reconstruction efforts.[97] A communication strategy needs to be developed to ensure that the plan intent and implications reached all stakeholders. A list of stakeholders involved is provided in **Table 9**.

It may be necessary to develop training for technical staff to prepare a land use plan based on risk assessment as well as recruit technical experts. The UNISDR Education and Training Institute for Urban Risk Reduction established in 2009 targets professional planners apart from city managers and local DRR offficials; the Asia Regional task Force on Urban Risks Reduction aims to strenthen networks of urban planners, architects and engineers to ensure that risk reduction is incorporated in urban development planning.[98]

TABLE 9 Actors and roles in risk-based planning process

Level of government	Roles
Central or national government	■ Invoke federal/national law, only where the situation warrants. ■ Mobilize the relevant government agencies to undertake, commission, and supervise planning. ■ Provide funding or support for accessing international funding. ■ Provide specialized technical expertise if required. ■ Ensure public investments conform to plans and codes.
State or provincial government	■ Provide legal mandate for the plans. ■ Create the policy environment in which the plans are prepared. ■ Mobilize the relevant government agencies, including regional entities, to guide and support the planning process. ■ Provide technical expertise as required. ■ Provide funding or support for accessing funding. ■ If regional planning is required, carry out the planning process.
Local government	■ Carry out the planning process at the local level. ■ Create structures to enable meaningful community participation. ■ Be committed to implementing plans prepared with community participation. ■ Approve plans and establish the regulatory framework for implementation. ■ Carry out communications campaigns and training programs to ensure compliance with plans and codes. ■ Review and approve building plans, enforce building codes and land use regulations, carry out inspection, and administer sanctions.
Community **(affected people as well as larger community)**	■ Participate in the land use, physical, and strategic planning processes. ■ Develop a collective vision for the future of the community. ■ Arrive at consensus on policy issues that cut across communities. ■ Where relevant, prepare community-level detailed plans in conformity with larger policies.
Project facilitators (planners, nongovernmental organizations [NGOs], and other intermediaries)	■ Interpret government policies to set out the agenda for planning. ■ Educate the community on planning imperatives and the policy framework. ■ Interpret technical information and offer viable choices to government and communities to enable informed decision-making. ■ Develop and carry out projects that comply with plans and codes.
Technical experts	■ Carry out technical investigations, data collection, and analysis to support planning. ■ Develop technical recommendations and options. ■ Assist with implementation of plans and codes.

Source: World Bank, 2010.

Monitoring

While effective monitoring is a desirable activity, municipalities usually do not have the capacity to enforce land use plans. Using an array of incentives can certainly promise better compliance but it is necessary to monitor the performance of a risk-based land use plan to make changes to the plan itself and to identify and address new risks that may develop over time. Is there capacity to monitor risk on a continuous basis? What resources are needed? Monitoring can be effective if municipalities can set an open reporting of land use programs and risks addressed; likewise a system of community report cards can be effective in ensuring that the land use measures are indeed implemented and that the community appreciates the risks that are being offset.

The HFA provides indicators for risk reduction at the national level, work on local levels is limited.[99] Metrics for risk-based land use planning can include for example, in the case of transportation infrastructure, possible criteria could include total vehicle hours travelled post and pre-earthquake (congestion); total vehicle kilometers travelled post and pre-earthquake (detour length); time delay between critical origin/destination pairs (e.g. from damaged areas to emergency hospitals) and restoration time, say 80% of pre-earthquake capacity; observed land use changes; percentage of households that continue to occupy resettlement area; observed building code violations, and others.

Concluding Remarks

The process of preparing a risk-based land use plan accomplishes many objectives:

- Communities have the opportunity to consider critical risk issues in a comprehensive and practical manner with respect to community goals and priorities;
- Highlighting potential damage if development is permitted in high-risk areas and provides the basis for related political and legal defense;
- Community, developers, property owners and elected officials are more aware of risks and what may be feasible to address them, especially for those at high risk;
- The plan is a reference for elected and appointed officials in decisions regarding ordinances, allocating finances for capital improvements or granting permits for new developments.

While risk-based land use planning can inform urban spatial development plans, comprehensive risk reduction requires appropriate social and economic policies and programs that increase the capacity of the urban population to adapt to disaster risks. For example, hazard maps can improve the quality of zoning but a good zoning map and related regulations may not be enforceable if the affected population cannot afford to retrofit or relocate according to the mapped disaster risks.

Further Reading

Safer Homes, Stronger Communities: A Handbook for Reconstructing after Natural Disasters (World Bank, 2010).

2.3 URBAN ECOSYSTEM MANAGEMENT

Infrastructural   Social

Key Points

- Ecosystem management approaches make use of natural infrastructure to decrease the cost of urban infrastructure projects.
- Ecosystem management requires an understanding of ecosystem services and local urban environments.
- Integrating ecosystem services into urban resilience requires urban planners to raise awareness of ecological approaches, generate knowledge, turn knowledge into action and effectively monitor and evaluate projects' implementation.

Summary

Ecosystems management approaches for resilience in urban areas make use of existing natural infrastructure and can significantly decrease the cost of urban infrastructure projects. This approach, discussed in **Chapter 1**, assumes that non-engineered infrastructure can be utilized to reduce cities' vulnerability to disasters. A holistic urban resilience program should, therefore, integrate ecosystem management within conventional, long-standing strategies for disaster reduction. There are a number of ecosystem management strategies that are relevant to urban resilience and, more broadly, disaster risk reduction:

- Watershed management (see **Box 22**);
- Coastal zone management;
- Urban landscape design;
- Green & Blue infrastructure (see **Box 21**);
- Environmental buffers (see **Box 19**).

Urban ecosystem management projects often incorporate a combination of available strategies and tools for disaster mitigation.

Ecosystem management requires an understanding of ecosystem services and the local urban environment, and there are methodological tools that can help to integrate ecology into urban resilience. This section will highlight how ecosystem management can be used as a strategy for contributing to urban resilience while, in many cases, providing large co-benefits such as assisting in poverty alleviation. These strategies should be well-planned, long-term and labor intensive interventions with continuous community involvement, rather than implementation of one-off construction projects. Healthy ecosystems highlight the synergies between disaster risk reduction and climate change adaptation. This section also presents a methodology for incorporating ecosystem management into urban infrastructure projects as a means for enhancing resilience.

Integrating ecosystem management into Risk-based Land Use Planning

Local jurisdictions should incorporate ecosystem management projects into their comprehensive development and land use plans, as part of their resilience interventions. Ecosystem approaches to disaster risk management need to consider spatial scales that are usually broader than individual municipalities. However, factors causing the decline of ecosystem services, such as rapid urban development and environmental degradation, occur at the local level and are often generated by

Box 19 Rehabilitation of the Maasin Watershed Reserve in the Philippines

The primary objective of the Maasin watershed rehabilitation was to regulate flow within the watershed and downstream urban areas like Iloilo City. Increasing the flow–regulation capacity of the watershed would prevent flooding during the rainy season and decrease water scarcity during the summer. Reforestation would also decrease surface runoff and soil erosion, while contributing to slope stability and decreasing the occurrence of mudslides.

Rehabilitation of the watershed to provide these ecosystem services involved:

- Improved management practices though agro-forestry. When the project began in 1986, farmers and occupants were hired as tree planters and trained to plant only particular species in between trees as a substitute for the rice, corn, tobacco and other crops that they had been planting.
- Reforestation for commercial plantations, with the fast-growing mahogany and gmelina species.
- Allowing natural regeneration and promoting other vegetative measures.

As the providers of the ecosystem services, the communities living within the watershed were trained in various technical and organizational aspects of forest management. Existing community organizations and residents were organized into the Maasin People's Organization Federation (KAPAWA). The organized communities were contracted to undertake comprehensive site development in the form of reforestation, assisted natural regeneration, timber stand improvement, and agroforestry. A total of 17 associated livelihood projects were also developed to benefit the residents of the watershed.

The Metro Iloilo Water District (MIWD) is a semi-private water utility that supplies water to Iloilo City, Maasin and three other towns, as well as to 2,900 hectares of irrigated land. It is considered to be the user of the ecosystem service of water production. Since 1998, MIWD has been paying one percent (1%) of its gross income for the utilization and extraction of water as mandated in the Philippines' Local Government Code (provides the legal basis for local governance of the country's natural resources, including watersheds). User fees are built into the water bills of MIWD customers, the beneficiaries of the service. Payment is distributed to the following government units where the natural resources are located, as provided for in the Allocation of Share section of the Code:

- Iloilo province (20%);
- Municipality of Maasin (45%) - goes to the general fund used in the acquisition of equipment for maintenance and protection of the watershed; and
- Barangays (35%) - distributed to 51 barangays comprising the municipality of Maasin.

The Tigum-Aganan Watershed Management Board is composed of representatives from the local governments of Iloilo City and 8 other towns, the irrigators' association, water district, business groups, non-government organizations, people's organizations, and academia. This institutional mechanism for watershed management galvanized efforts around the set of watershed management issues being faced by both the upstream and downstream stakeholders.

Results

The physical accomplishments of the project as of 2004 were:

- 30% of the Reserve still cultivated by upstream/upland farmers (agro-forestry);
- 40% of the area covered by stable tree plantations (mahogany, gmelina and other forest species);
- 20% covered by fruit trees;
- 10% old growth;
- 330 hectares of riverbank stabilized;
- 20,000 sq.m. of vegetative erosion control measures put in place.

Continues

Box 19 Rehabilitation of the Maasin Watershed Reserve in the Philippines (cont.)

Key implementation lessons

1. Increased institutional capacity is necessary to ensure the long-term integrated management of a watershed after external funding has been utilized. A cross-municipal mechanism that involves both upstream and downstream local governments is essential.
2. Community organization of the providers of the ecosystem services, as well as the existence of necessary legal provisions, are instrumental in supporting Payments for Ecosystem Services programs.
3. There is a need to raise awareness and willingness-to-pay for ecosystem services. Concerned local government units initiated an Information, Education and Communication campaign in print, radio, and television to generate public awareness and support for the program. This resulted in donations from civil society groups and engendered support for the cross-municipal Management Board.
4. Requiring downstream urban beneficiaries to pay for watershed services is good practice, and can generate funding to assist subsistence farmers and other landowners in upper watersheds to adopt more sustainable natural resource management practices and protect upland ecosystems. Although User fees were, in this case, associated with the provision of water supply, urban resilience co-benefits are also delivered by the arrangement.

TABLE 10 Implementing ecosystem management into land use planning

1. ***Conduct resource inventories and determine urban development impacts***: The basis for designing an ecosystem management project is a risk assessment of existing resilience issues, discussed in section 2.1. This assessment should include a determination of existing and potential ecosystem services that may mitigate risk. Identifying the extent and root causes of degradation of existing natural resources provides a baseline for projects that aim to restore ecosystem service provision.

   To identify new land for use as an environmental buffer, for example, planners must first identify the existing network of areas that may already provide the service, together with their ownership categories. This inventory can then be the basis for generating plans that incorporate green infrastructure projects.

2. ***Setting goals and objectives***: Goals and objectives articulate specific, measurable targets for the reduction of disaster risk, such as the percent reduction in surface runoff to reduce flooding. Measurable objectives ensure clear indicators of increased resilience. Goals should also be spatially specific so as to be more effectively integrated into land use plans.
3. ***Coordination***: Cooperation across municipalities, landowners, and other stakeholders is necessary to effectively integrate ecosystem management projects into the land use plans of different jurisdictions.

   Ecosystem management approaches for urban resilience are often implemented over watersheds that extend upstream of cities, across large wetland areas, beyond a single planning area, or across organizations. Poorly coordinated local land use decisions can have unintended negative impacts on urban resilience; collaboration across jurisdictional boundaries is thus a necessary component of many types of ecosystem management projects.

4. ***Implementation***: Successful ecosystem management approaches for disaster risk reduction depend on the ability of comprehensive plans to designate responsibility for implementation and enforce standards. There must also be a focus on monitoring ecological conditions so that a community project can be adapted to changing conditions.

   Land use plans are not only the documents in which ecosystem management projects are articulated, but they are the starting point for the ordinances, land development codes, and environmental policies that enable the projects.

local land use decisions. Incorporating ecosystem management projects into risk-based land use planning involves certain actions. These actions are summarized in **Table 10**. In general, risk-based land use plans should include clear and concise goals for the implementation of effective resilience programs.

During the project cycle, it is important to facilitate a proactive approach to ecosystem management within the land use plans, rather than to change policies after disasters have occurred or ecosystem integrity has been irreparably degraded by human impacts. Land use plans should provide a bottom-up, spatial perspective for protecting the regulatory functions and processes of ecological systems so that they can increase long-term urban resilience.

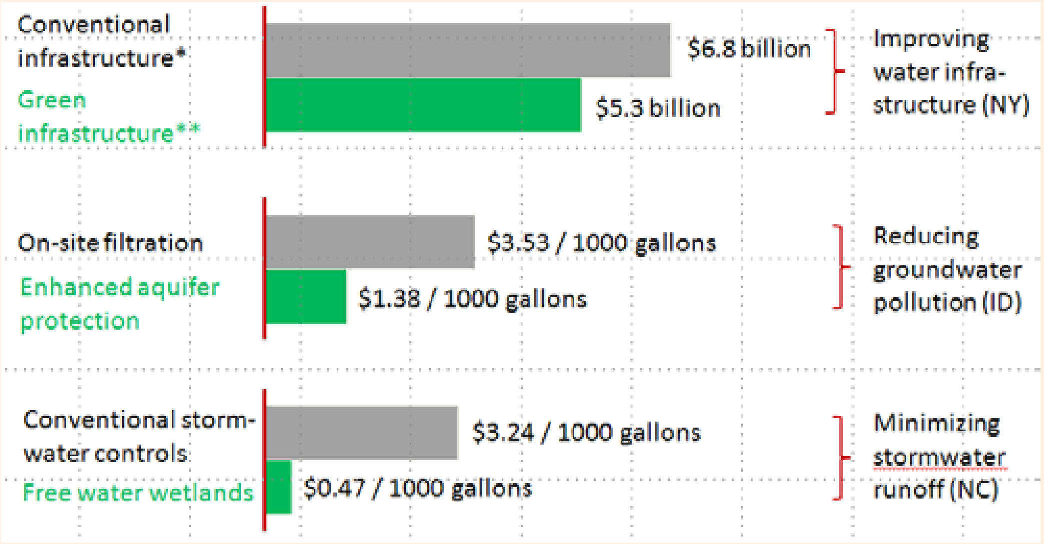
The inclusion of ecosystem resource inventories in local land use plans can assist communities in understanding which ecosystem services are available to provide urban resilience functions, and which are being degraded by poorly planned urban growth. Adaptive risk management needs to monitor the change of ecological conditions over time, and the impact of human activity on these resources. Based on the monitoring, municipalities can adjust the implementation and targets of ecosystem management projects.

Traditionally, the policies, tools, and implementation mechanisms of land use planning have tended to be regulatory rather than incentive-based. A shift in focus towards incentive-based tools can significantly contribute to more effective programs by taking into account the potential of stakeholder engagement, employment creation and community-based management opportunities, all of which are inherent in ecosystem management for urban resilience. **Incentives** encourage stakeholders to safeguard the integrity of ecosystem services voluntarily; for instance, *preferential tax treatments* can be granted in exchange for the provision of environmental buffers within a development. **Table 11** lists select ecosystem

Box 20 Comparing the costs of gray and green infrastructure

To facilitate the integration of green infrastructure in land use plans, a standardized method is necessary for evaluating the cost-effectiveness of green versus conventional "gray" infrastructure. The World Resources Institute (WRI) has developed a "Green-Gray Analysis" approach with the following results, showing that in many cases green infrastructure is more cost-effective.

Figure a: Examples of green vs. gray infrastructure costs

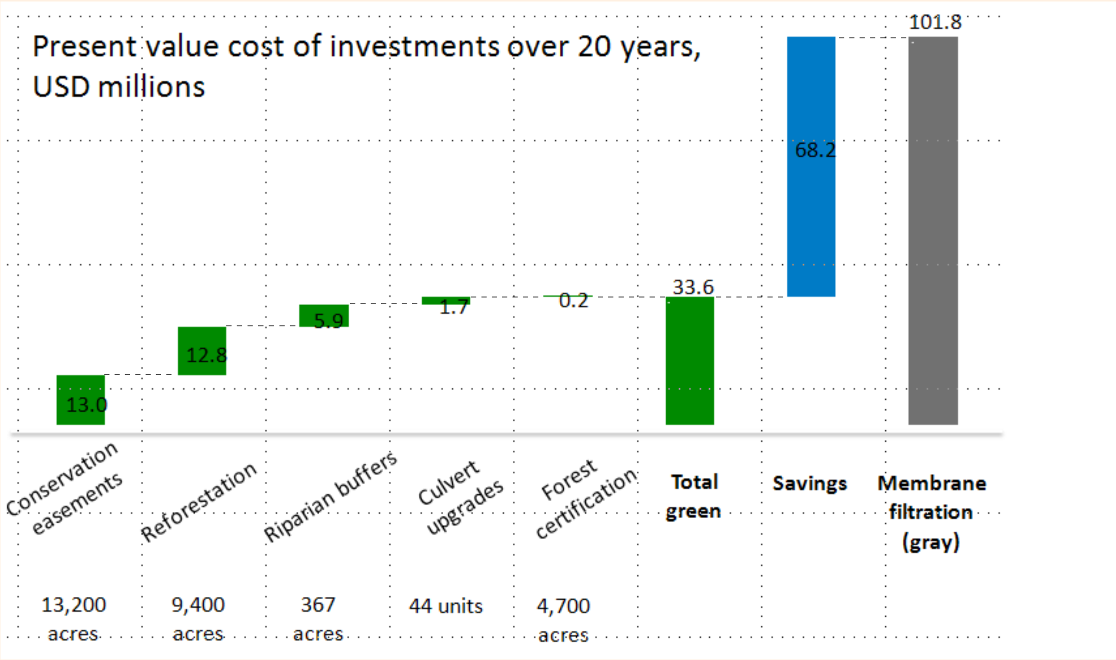


* Includes tunnels, diversion structures, and other approaches. ** Restored stream buffers, bioswales, green roofs, and other approaches. Source: PlaNYC 2011, BBC Research 2001, ACOE 2003.

Continues

Box 20 Comparing the costs of gray and green infrastructure (cont.)

Figure b: Green vs. gray infrastructure costs for securing clean drinking water (Portland, ME)



Green infrastructure alternatives include stream buffers, aquifer protection, bioswales, green roofs, reforestation, wetlands, mangrove coastal protection, and others. The costs associated with these options can be determined via on-site consultations, publicly available data, geospatial analysis and other methods. At present, WRI's Green-Gray Analysis is conservative, as it does not yet include estimates of the co-benefits of green infrastructure (e.g., increased carbon sequestration, recreation opportunities, and increased property values). Including these co-benefits would tip the scales even further towards choosing green alternatives.

Source: Talberth, John and Craig Hanson. Green vs. Gray Infrastructure: When Nature Is Better than Concrete. WRI Insights [online] insights.wri.org, June 19th 2012. Washington, D.C.: World Resources Institute.

management interventions. **Box 21** provides further information on one of these interventions – green and blue infrastructure.

Methodology for Ecosystem Management

The United Nations Environment Programme (UNEP) has taken steps to integrate ecosystem approaches to post-conflict environments, which requires a rapid assessment and implementation of ecosystem management. Overall, the goal is to establish an integrated approach to environmental sectors that deliver ecosystem services, identify ecosystems priorities and finance those priorities. This methodology should be incorporated into projects and implicitly requires that urban planners work with urban communities to develop these strategies together.

Step 1: Making the Case

- Conduct awareness-raising workshops on the concept of "place-based" ecosystem management and on ecosystem services, and the relationship between ecology and human well-being;

TABLE 11 Common ecosystem management interventions

Bio-retention	Nitrogen-Fixing Plants
Constructed Wetlands	Permeable Pavement
Coral/Shellfish Reef	Public Parks/Gardens
Coastal Wetlands	Rain Gardens
Repair/Protection	Retention Ponds
Flood Zone Restoration	Sand Dunes/Berms
Forest Repair/Protection	Tree Planting
Green Roofs	Vegetation Planting for Landslides
Mangroves	Watershed/Wetland Repair/Protection

Box 21 Green and blue infrastructure

The term green infrastructure generally refers to a network of green spaces providing various ecosystem services.[100] Urban forests, tree stands, and parks, for example, provide protection against landslides, erosion, floods, and drought. Forest restoration in cities' hinterlands also protects urban communities, their livelihoods, and economic infrastructure such as roads, ports, and hydroelectric dams. Blue infrastructure, on the other hand, refers to green spaces that include water for regulating hydrological flows.

In most urban areas around the world, rainwater flows into combined storm water/sewer drainage systems. Extreme precipitation events can exceed the capacity of these combined systems, leading to flooding, backed up sewage, and public health hazards. Green infrastructure is increasingly being utilized for storm water management, mimicking the natural infiltration and runoff reduction functions of natural ecosystems. Green roofs, bioswales, retention ponds, and permeable pavements are a few examples. When compared with rehabilitating or even replacing an entire network of combined storm water/sewer systems, green infrastructure is a cost-effective way to manage storm water.

This recognition of natural areas as functional infrastructure or environmental buffers necessitates their preservation and integration into comprehensive land use plans. This can be implemented via urban projects involving:

- Integrated watershed management, including management of upstream forests
- Management of natural freshwater wetlands
- The design of landscaping interventions and engineered measures to complement and emulate the resilience effects produced by existing ecosystems.

- Deliver accessible guides on the ecosystem approach for local government units, local communities and other stakeholders;
- Disseminate key messages as widely as possible, particularly regarding the important links between ecosystem services and human well-being, and the drivers of ecosystem degradation;
- Facilitate assessment of key ecosystem services that are linked to regional and national systems.

Step 2: Generating Knowledge

As noted earlier, ecosystem management is complex and requires a deep understanding of the local urban environment. In this Handbook, it is not possible to account for each specific situation but it is likely that any application of this methodology will require data collection and analysis. Please refer to **Section 2.7** for more information on gathering and understanding data. In order to generate information related to ecosystem services, it will be necessary to take the following actions:

- Establish networks for data and information exchange on ecosystem service;
- Facilitate or undertake ecosystem level assessments as needed;

- Identify relevant ecosystem services and their relation to human well-being;
- Identify the direct and indirect drivers of ecosystem change;
- Develop plausible scenarios based on the impacts of direct and indirect drivers;
- Build capacity to undertake economic valuation of ecosystem services.

Step 3: Turning Knowledge to Action

Careful planning and long-term approaches to ecosystem services are necessary because the natural services that are provided most likely have far reaching effects throughout the urban environment and beyond the boundaries. A comprehensive ecosystem management strategy must include local community participation as well as regional and national stakeholders who might benefit from downstream ecosystem services. Ecosystems management strategies should:

- Determine which services have priority;
- Develop effective intervention strategies;
- Ensure equitable access and use of ecosystem services by all stakeholders.

Step 4: Monitoring and Evaluation

To ensure the optimal delivery of ecosystem services:

- Offer technical support for the development and review of indicators of ecosystem service delivery;
- Facilitate review of the delivery of ecosystem services against established baselines;
- Facilitate and build capacity to develop and implement feedback mechanisms into steps 1-3 above.

Concluding Remarks

Ecosystem management approaches are gaining in popularity because they offer holistic and integrated approaches to issues that have been treated separately previously. The gains from utilizing, enhancing and repairing ecosystem services can be far greater than creating new infrastructure. Urban planners need to recognize the unintended impacts that altering natural ecosystems can have on an environment in and around an urban area. Ecosystem approaches are a key element of urban resilience, but they do require a nuanced understanding of the local environments. **Box 23** provides an example of London's greening efforts.

Box 22 Lake Matthews: Watershed for urban development

Developed in cooperation with representatives of the local county, the Flood Control and Conservation District, landowners, and a residential developer, the Metropolitan Water District developed a drainage management plan. This plan aims to mitigate the impacts that development of the surrounding watershed has on reservoir water quality. Although the Lake Matthews Watershed and Colorado River Basin are sparsely populated, they lie in the path of expanding growth. Urbanization of the watershed is expected to increase loadings of heavy metals, pathogens, sediments, oil, and grease.

The first phase of the drainage management plan focuses on the Lake Mathews reservoir. Lake Mathews is an 180,000 acre terminal reservoir for imported Colorado River water. The surrounding 39- square-mile watershed is drained by Cajalco Creek, which feeds into Lake Matthews. One key element of the Lake Matthews management strategy is to use a series of wetlands to help "cleanse" water from first-flush and nuisance flows as well as to provide wildlife habitat. Next, the water would flow into a constructed water quality pond to provide a first-flush diversion facility, and then into a sediment basin to capture bed load sediment before it enters Lake Matthews. Lastly, there are plans to construct a dam and detention basin designed to regulate 100-year peak flood flows from Cajalco Creek.

Source: US Environmental Protection Agency.

Box 23 London's Green Grid

Background: London has a wealth of green spaces and vegetation in its public parks, private gardens, woodlands, street trees, wetlands, and river and transport corridors. Improving the quality, quantity, connectivity and diversity of London's green spaces will increase the city's resilience and capacity to adapt to a changing climate.

Actions:

- As part of the wider regeneration of the East London sub-region, a 'Green Grid' is being delivered through a program of projects designed to connect, add to, and enhance the potential of existing green spaces to absorb and store water, cool the vicinity, and provide amenity space and diverse habitats for wildlife. More than £20 million-worth of projects have already been delivered. Planning guidance published by the Mayor of London enables implementation of the Green Grid through borough-level and sub-regional planning.
- A London-wide Green Grid is also planned.
- Property owners are beginning to make use of multiple opportunities for greening roofs and walls. These green areas perform a range of ecosystem services essential to quality of life in the city and ensure a high level of resilience, including:
  - Supporting biodiversity
  - Reducing flood risk by absorbing and temporarily retaining rainfall
  - Moderating the temperature by offsetting the urban heat island effect
  - Reducing energy demand by providing shade and reducing wind speeds
  - Helping to reduce noise and air pollution
  - Providing places for recreational and leisure activities that improve health.

Ecosystem Service	Green roofs/ walls	Street trees	Wetlands	River corridors	Woodlands	Grasslands
Reduce flood risk	✓✓	✓	✓✓✓	✓✓✓	✓✓	✓✓
Offset urban heat island	✓✓	✓✓	✓✓	✓✓	✓✓✓	✓
Reduce energy demand	✓ ✓	✓✓			✓	
Reduce noise/air pollution		✓✓			✓✓	
Support biodiversity	✓ ✓	✓	✓✓✓		✓✓✓	✓✓✓
Recreation/Leisure	✓		✓	✓✓	✓✓✓	✓✓✓

Source: London 2010.

2.4 URBAN UPGRADING

Institutional

Infrastructural

Key Points

- Urban upgrading prioritizes investments in infrastructure, housing, livelihoods and social networks for the urban poor in slums who are the most vulnerable.
- Inadequate planning for low-income households in rapidly growing cities creates slum conditions that transfer a disproportionate burden of disaster risk to the poor.
- Urban upgrading is usually sector-based and piecemeal; risk reduction is challenged by little documentation on slums apart from lack of institutional coordination and municipal finance.
- Comprehensive urban upgrading reduces existing risks through slum upgrading and prevents new slum formation and risks by increasing the overall supply of low-income housing through incentives for private sector and community engagement.
- Risk resilience through urban upgrading should be incorporated in all phases of the project cycle.

Summary

Urban upgrading prioritizes investments in infrastructure, housing, livelihoods and social networks for the urban poor in slums who are the most vulnerable. Strategic urban upgrading can manage risks by: i) regulating slum development in hazard-prone areas through planned resettlement and building codes, ii) reducing posses by prioritizing critical infrastructure, escape routes and community refuges in slums, and iii) promoting safe and socio-economically viable low-income neighborhoods in accordance with a citywide plan. This section discusses the need to mainstreaming urban upgrading for risk reduction in cities, challenges in implementation and how project managers can integrate risk reduction through urban upgrading in the project cycle.

Mainstreaming Urban Upgrading

The phenomenal growth of slums in recent decades exposes a greater concentration of the urban poor to disaster risks. However variations in slum conditions create different degrees of risk. Urban projects need to mainstream risk reduction through strategic urban upgrading. There are increasing examples of low-income communities negotiating safer and better located land, adapting rigid zoning and building standards to local needs, upgrading vulnerable settlements to reduce risks and participate in planning and budgeting.[101] Dar es Salaam, Jakarta, Mexico city and Sao Paulo, as examples, have all successfully addressed local risk through slum upgrading programs in addition to early warning systems and adaptation planning.[102]

Implementation Challenges

Building risk resilience for the urban poor is challenge since the notion that different communities face different degrees of vulnerability is generally not well understood. Although slums are growing faster than any other urban areas, most governments do not report on slum conditions and trends. Slums are invisible parts of the city – `zones of silence' in terms of public knowledge.[103] Since slum enumeration is not entirely reliable, it is difficult to estimate the scale and scope of the target population for slum upgrading projects.[104]

Urban upgrading programs are usually sector-based, piecemeal and politically driven around election cycles. Often there is little coordination among different agencies involved in sector-specific upgrading, such as provision of sanitation, organizing solid waste management etc. Central policies for slum upgrading often conflict with state priorities and local municipal capacities. For most municipalities that struggle with finances for urban services, programs for slum upgrading are not priority. Poor planning and even poorer implementation of slum upgrading programs at times results in sub-standard housing and poor environmental conditions that can create new disaster risks. For example, a plan for paving streets that does not take cognizance of existing drainage patterns and plinth levels of houses can create new flood risks. The impact of disasters is greater in urban centers where authorities are lax and have limited resources to ensure respect for building codes, basic services and social amenities.[105]

The central challenge in slum upgrading is that of scale – slum upgrading has benefitted only a small percentage of slum residents[106]; piecemeal upgrading in a handful of slums can create new risks in other parts of the city. It is necessary to look beyond neighborhoods to a citywide comprehensive approach that addresses the root causes of slum formation and increases the supply of low-income housing in the city. This requires reconciling land tenure issues and urban management for a multi-sector and citywide integrated approach that includes socio-economic development for slum residents such that they are able to afford the increased expenses[107] of formalized city services, once the slum is upgraded[108].

Integrating Risk Management through Urban Upgrading into the Project Cycle

An appreciation of the differential nature of disaster risks for the urban poor enables project managers to prioritize urban upgrading projects in local government proposals for infrastructure investment. Poverty reduction programs that aim to provide safe environmental conditions through improved housing structures and basic services contribute significantly to disaster risk reduction; such programs should identify risk management as a mandatory component in all stages of the project cycle (see **Table 12**).

Since the underlying causes for slum formation vary, slum conditions vary according to age and location; it is imperative to develop localized projects and avoid general strategies.[109] Urban upgrading programs have four objectives: i) to improve environmental and socio-economic conditions, ii) to ensure that the benefits reach the target population, iii) to build organizational and technical capacity among the slum households and community, and iv) be affordable to the local government and community.[110] Local governments need to work with informed and engaged communities in all stages of the project cycle. For more details on community engagement, see **Section 2.5.**

Project Identification

Defining the scale and scope of urban upgrading is necessary to identify priority sites for slum improvement and new developments for low-income housing. The total number of households,

TABLE 12 Risk Management approach in urban upgrading projects

Stage of project cycle	Incorporating risk management in urban upgrading
Identification	Defining scale and scope of slum upgrading / new low-income housing Political sensitization Stakeholder consultation to identify priority projects
Preparation/Appraisal	Risk assessment for the urban poor Preparing a strategic urban upgrading program Institutional audit and stakeholder appraisal to ensure `buy-in’
Implementation	Institutional strengthening and capacity building Communication of plan intent and implications
Monitoring, evaluation and knowledge-sharing	Monitoring indicators Institutional capacity and community participation in monitoring

geographical distribution, rate of growth, shortfall in low-income housing and the driving forces for slum formation determine institutional capacity required and time schedule. The severity of slum condition (exposure to disaster risk due to location characteristics, density, housing condition, tenure status and community readiness will determine the sector-specific interventions required. Tenure status can be complicated and affect the feasibility of undertaking upgrading; sites may have single or multiple or disputed ownership; occupied public lands are simpler to upgrade in comparison to private sites.[111]

It is important to sensitize city managers to appreciate the importance of risk reduction through urban upgrading. Municipalities tend to ignore the existence of slums and their contribution to the urban economy. Many governments pursue still slum demolition as part of city beautification plans; however, slum demolition merely relocates slums to other parts of the city. The political attitude to slums can determine the feasibility of urban upgrading. Political bias needs to be influenced to recognize the contribution of the informal economy to the urban economy: in the Latin America and Caribbean region, two out of three urban jobs were generated by the informal sector in the past decade.[112]

Project Preparation and Appraisal

It is necessary to conduct a risk assessment for the urban poor through surveys to determine infrastructure, environmental and socio-economic conditions and determine the level of services to be planned. Constraints on land ownership should be assessed to determine land acquisition needs and alternatives. A strategic urban upgrading program to manage risks will include reactive measures to mitigate existing risks, such as, planned resettlement, provision of secure tenure, improvements in housing and basic services and proactive measures to prevent new risks by increasing the overall supply of low-income housing. An institutional audit of all agencies engaged in urban upgrading projects will determine gaps and areas for strengthening. Community appraisal is essential to engage the interest and commitment of the community and ensure affordability of new risk reduction measures. In Rio de Janeiro (Brazil), the community was involved in the project preparation stage through workshops, door-to-door visits from community leaders and events in which the community debated and approved settlement development projects.[113]

Risk Assessment for Slums

Although significant progress has been made in urban risk assessments, they do not address vulnerabilities and capacities of people to risks adequately.[114] Risk assessment process for urban upgrading should identify the slum population, their location and assess sector specific risks (housing and tenure, basic services, critical infrastructure, transportation, social and economic vulnerabilities, community readiness, institutional capacity, access to data and finances) as well as citywide risk assessment for integration with comprehensive urban planning goals. For a methodology for citywide risk assessment, you may refer to **Section 2.1.** Both the complexity and the cost of a risk assessment must be considered when implementing an urban upgrading project.

However, risk assessment for informal settlements is a challenge since local governments have varied capacity for slum identification, most have none. Many local governments do not have mechanisms to systematically monitor urban growth, let alone informal growth. The UN-HABITAT Urban Indicators Programme, 2005, reported that 80 out of 120 cities do not have monitoring systems to track changes in the spatial dimension of the city; additionally different cities follow different standards and information, often influenced by ongoing politics.[115] Citywide statistics on urban poverty based on slum definition parameters used by the Global Urban Observatory (GUO) mask its heterogeneity; they do not differentiate between magnitude (percentage of slum dwellers) and severity (multitudes of deprivation)[116]; durability of housing is solely based on building materials; compliance with building standards, hazardous location, such as steep slopes, flood plains and toxic sites, and settlement characteristics, such as condition of roads, drainage, management of solid waste and air pollution are not considered[117].

For targeted risk reduction measures in urban upgrading, disaggregated information on poverty indicators at the sub-city level is needed. An initiative led by GUO, CIESIN and ITC[118] identified a set of methods using very high resolution (VHR) remote sensing with census data that includes exposure to natural hazards apart from building construction characteristics (size, materials, shape), roads, open space, access to social amenities, site conditions (location within urban area, slope, natural vegetation, hazards), and the slum formation process itself.[119] An increasing number of community based organizations and NGOs are using VHR for slum surveys.[120] In Pune (India), an NGO has successfully mapped slums using satellite imagery to plan for targeted provision of basic services (see **Box 24**). However, access to satellite imagery can be expensive.

Local governments need to work with national bodies, universities, research institutes as well as private firms to access the latest methods and techniques. In addition, data and technology should be simple enough for slum residents to use with minimum investment in training.[121] In Jakarta (Indonesia), disaster risk assessment for the poor found that data created by several agencies - multi and bi-lateral organizations, NGOs and private sector consultants - was either extremely scarce, inconsistent or very difficult to access as some agencies were reluctant to release information. Gaps in data included poverty maps, subsidence maps, socio-economic and housing data on the very poor, definitions of slums and urban settlements, information on land tenure, updated census data, census data on the very poor, immigration and emigration rates, plans for resettlement of vulnerable areas, financing and long term plans for flood protection.[122]

Box 24 Slum mapping in Pune & Sangli-Miraj-Kupwad, India

Shelter Associates, an NGO, is working with slum communities to use satellite imagery in combination with field surveys to negotiate for slum improvement. VHR images from Google Earth are used to digitize slum boundaries and attach information on households, dwellings and site characteristics from field surveys collected by slum residents. Settlements are mapped by professional agencies using plane table methods showing plot boundaries. Spatial and socio-economic data is entered into a GIS database and accessed by the community to prepare upgrading plans.

In Pune, satellite images were used to provide evidence that individual slums were not growing in size but that in-migration needed to be planned for and prevent formation of new slums. Shelter Associates collaborated with slum residents and compelled the local government to legitimize migrants and initiate city planning to improve slum settlements by widening roads and install flood protection and develop new infrastructure. The Pune slum census covered over 100,000 households on over 200 slum pockets scattered throughout the city. The residents gained skills on data collection, a better understanding of their collective community problem, and their opportunities to negotiate with the local government in the planning process.

In Sangli Miraj Kupwad, slum mapping by the community initiated a comprehensive approach to improve all slum pockets with the local administration and elected members. Many slums have been mapped and their improvement plans have been produced in a cost-effective manner.

For more details, see work of Shelter Associates at www.http://shelter-associates.org/

Source: Sliuzas, Mboup and Sherbinin, 2008b.

Further Reading:

CIESIN/Columbia University Global Slum Mapping (website).

Urban Upgrading Measures

Ineffective urban planning and governance along with lack of investment in infrastructure provision and little community engagement mark the difference between how the urban poor in countries exposed to the same hazards are affected.[123] Strategic urban up gradation measures used in combination can address multiple risk-reduction goals: i) regulate slum development in hazard-prone areas through planned resettlement and building codes, ii) reduce losses through community preparedness for emergency response and by prioritizing critical infrastructure, community refuges and escape routes in slums, and iii) promote safe and socio-economically viable low-income neighborhoods in accordance with a citywide plan. Urban upgrading measures for disaster risk reduction include planned resettlement, slum upgrading through secure tenure, appropriate development controls, basic services, pedestrian road networks and open space planning, critical community facilities, and comprehensive citywide urban upgrading that includes socio-economic development for slum residents.

Planned Resettlement

Planned resettlement of slum communities in hazard-prone sites may be the only option when slums are located on hazard-prone sites such as steep slopes, flood plains and toxic sites, albeit a politically sensitive approach. However, finding suitable sites is a challenge; in many cases, the resettlement sites have not been planned or have been planned without good access to employment opportunities.[124] Relocation of slum residents have generally been confounded since most households want to return to the same location because of reliable and known access to livelihoods and social networks.[125] In Sao Paulo (Brazil), the municipality uses mapping of precarious settlements to selectively relocate the least number of families from unsafe sites. For successful planned relocation of slums, community and private sector engagement are critical. For more details on planned resettlement, see **Sections 2.2 and 2.4**.

Tenure Security

Where environmental conditions may be reasonable, lack of secure tenure in slums is a threat to security of livelihoods; threat of forced evictions prevents households from investing in home upgrading, and consequently increase vulnerability to disaster risks. Several viable tenure systems can be established, such as, temporary occupation rights, lease agreements, community land trust, adverse possession rights and anti-eviction rights. In Dar es Salaam, the government is identifying all properties in informal settlements and issuing land/ property licenses or right of occupancy, which could be used as collateral.[126] Programs for tenure security can often exclude minority communities, new migrants, women, elderly and tenants; cooperative ownership is an effective arrangement to accommodate the lowest income households while discouraging premature sale of plots after gaining ownership or occupancy rights.

Appropriate Development Controls

Since squatters always live with the threat of eviction, structures are small and mostly made of temporary materials, especially, in new and very small slums. In Bangladesh, a census of slums in 6 cities showed that 56% of the structures were of very poor quality.[127] The collapse of one poorly constructed structure built on unstable soils can trigger the collapse of multiple houses like a pack of cards; collapse of structures can in turn threaten safety and damage infrastructure; accumulation of debris can block access to relief. For example, poorly constructed houses compounded the severity of the impacts of the Great Hanshim-Awaji Earthquake in Japan; rubble blocked transportation networks, obstructed firefighting and made recovery difficult.[128]

Risk-based development controls and building codes tend to be based on standards that are not realistic to non-engineered slum neighborhoods and make construction and retrofitting exceed the financial capacity of low-income families; inappropriate risk-resilient standards are often ignored.[129] For example, in Caracas, Venezuela, although various groups are working to repair and rebuild housing in safe locations, as a result of poor planning and seismic code enforcement in the Barrios that are constructed with unreinforced masonry, squatters returned to the highly vulnerable sites.[130] Disaster resilient building standards need to be affordable and flexible to allow incremental building. In Windhoek, Namibia, Standards and regulations for land and housing (plot size and infrastructure development) were revised to be more affordable and a community loan fund was set up for service improvements; about 1000 groups have taken advantage of this community finance.[131] Site and housing retrofitting should be accompanied by energy efficient and affordable building technologies that reduce GHG emissions. High density of slums can be used as an advantage to adopt climate change adaptation strategies that use energy efficiently. Dense low-income areas can be models of environmental efficiency since high densities combined with better management can reduce the cost of delivery.

Planning and building regulations that influence the overall housing stock, such as, plot size, road reservations, building setbacks, and FAR need to be reviewed to encourage private sector investment in low-income housing in safe parts of the city can increase supply of affordable housing; this must be accompanied by a corresponding increase in infrastructure capacity to prevent new risks. In China, at least 70% of the land to be used for construction of urban housing should be designated for low-rent units, and smaller units of less than 90 sq m. to providing adequate housing for the urban poor, against the backdrop of surging housing prices.[132] Supporting development regulations, such as mixed land use, can support safe conduct of informal economic activities common to slum dwellers. Streamlining administrative procedures that are complex, time consuming, expensive and discourage compliance can ensure better compliance to building safety requirements. Regulatory reform is considered as the single most effective tool for reducing future slums.[133]

Slum redevelopment that capturing rising urban land values for redistributive purposes and making urban land affordable to the poor involves review of site-specific development controls has been effective in some cities to provide durable housing for slum dwellers cross-subsidized with higher-income or commercial development on the same site to attract real estate developers to invest in such projects[134]. With additional density of development, it is important to ensure that there is adequate off-site infrastructure.

Basic Services

Enhancing sector-specific service provision can improve the environmental conditions and reduce vulnerability of slum residents to disaster risks; for example, the installation of drains that cope with heavy rainfall reduces the vulnerability of the urban poor to flood hazards. Provision of basic infrastructure is relatively simple and rapid to implement; it costs less and can be financed by tax and user charges.[135] Illegal sub-divisions in peri-urban areas are increasingly laid out systematically to accommodate installation of services at a later date.[136]

Box 25 Incentive-based regulations for Low-income housing, Jakarta, Indonesia

Major floods in 2007 in Jakarta prompted the Provincial government to plan for flood mitigation that included relocation of 350,000 people living along the river bank along with improving infrastructure, community preparedness and early warning systems. Out of an estimated 70,000 housing units, the Jakarta government was able to provide only 2,000 housing units per year under its own housing program; the government provides rental flats for low-income households and ownership flats for lower middle-income families (costing about $12-13,000 per unit of 36 sq. m). For many of the slums inhabitants who live on government land, re-housing was considered too expensive with negative impacts on their informal livelihood activities.

Under a presidential mass house-building initiative, Jakarta is working in partnership with 28 private developers through the Real Estate Indonesia Association in Jakarta to deliver up to 20,000 high-rise units in 250 blocks over a period of a few years. Developers rely on cross subsidizing low-income units with middle-income apartments; however, the loss of additional floor space increases the unit cost to $21,000. As a result, the developers are shifting the target market towards the middle-income market. The provincial government may withdraw legislation that requires commercial developers to contribute 20% of developable land available for low income housing. This rule has hitherto been circumvented by developers paying money in lieu into a central fund used to provide alternative low-cost accommodation in cheaper, more remote locations.

Source: Berita Indonesia 2009; Koran Jakarta 2011; Kristanti 2011; E and Maryadie 2011; Mirah Sakethi 2010; Sawarendro 2010.

Trunk infrastructure is expensive to provide. For risk resilience through infrastructure provision, the use of small-scale distributed green infrastructure in patches that can be connected to existing trunk infrastructure can ensure basic services to a large number of slum residents at relatively less cost. Small-scale distributed infrastructure takes less space, can be accommodated within irregular layouts and can function as neighborhood networks. Since they are designed to restore the eco-system services of the land that has been developed, they can potentially reduce the occurrence of climate change events.[137]

Pedestrian Road Networks & Open space Planning

Mobility of the urban poor determines their opportunities for livelihoods and integration into society. Mobility is affected by road safety, the existence of internal road networks in addition to proximity to major transportation networks. Poor and expensive public transportation networks to peri-urban slums limit opportunities to employment and marginalize integration with higher-income social groups. Haphazard layouts with inadequate open space in slums also create poorly ventilated conditions and increase ambient temperatures. Irregular layouts and narrow streets that were originally planned for pedestrian traffic limit the possible locations for water supply, sanitation services and solid waste collection. Irregular streets can impede relief efforts, especially in large slums; in Port au Prince, Haiti, where 70 % of population lives in slums, unplanned growth hindered immediate rescue efforts after the 2010 earthquake because there were no access roads between streets, just a patchwork of unmarked corridors.[138] Developing a pedestrian network and planning community open spaces in slums ensures access to livelihoods, escape routes and community refuges in hazardous areas.

Critical infrastructure

Slums usually lack adequate healthcare and educational facilities. The capacity of a slum community to reduce losses and recover quickly after a disaster will be greatly enhanced by provision of adequate critical amenities and retrofitting of existing ones according to hazard specific building codes.

Comprehensive Citywide Urban Upgrading

Scaling up strategic slum upgrading and planning for urban expansion by low-income families in a citywide urban upgrading program can be complex, time consuming and expensive; nevertheless it offers a disaster-risk proof approach. Urban upgrading involves physical upgrading through provision of tenure security and basic infrastructure and socio-economic development through health services, education, support for employment opportunities, and assistance to micro and small businesses and financial policies for cost allocation, cost recovery and affordability. For a realistic urban upgrading program, it is necessary to consider the level of services to be provide, building standards; land acquisition, infrastructure, employment generation and increasing incomes through training and supporting small business, micro-finance and loans for housing and building materials.[139] Sites for new housing development, especially in peri-urban areas, must be well connected to employment opportunities and social amenities. Comprehensive urban upgrading requires a legal, institutional and financial framework to supply land, buildings, services and credit. Demand for housing and land requires a land budget to acquire safe land, access to transportation and livelihoods. Common approaches to provision of low-income housing are `sites and services', land pooling and land readjustment.[140] `Sites and services' provides serviced sites for housing development; it has been successful in Lima (Peru). Land readjustment pools strategically located underutilized land and re-plots at higher densities; it is being used Indonesia, Malaysia, Nepal and Thailand.[141]

Low-income housing supply can be facilitated by supporting development finance in addition to the prevalent focus on consumer finance for low-cost housing loans.

Apart from conventional economic development programs targeted for poverty reduction, diversification of livelihoods for slum residents can be provided by direct engagement in disaster preparedness, early warning and emergency response, and urban up gradation projects themselves. In Accra (Ghana), street paving, sanitation and reliable electricity supply in the Suzame Magazine, an area known for informal employment in the automobile mechanical sector, boosted the local economic development; the area developed as a training zone for automobile mechanics; projects generated direct employment based on small-scale contracts.[142]

Box 26 Strategic urban up-gradation of precarious settlements, São Paulo, Brazil

In São Paulo, 32.27% of the population lives in precarious settlements. Gathering data about the residents of precarious settlements – *favelas*, informal subdivisions, slum tenements, hazardous areas, as well as, government housing projects, in a geo-referenced managerial information system, the Information System for Social Housing in the City of São Paulo (HABISP), made it possible to understand the characteristics of these settlements, classify them, set prioritization criteria for interventions. The HABISP identified settlements in the potable water reservoir areas that are most precarious.

Characterization of Precarious Settlements for Strategic Intervention

Types of information needed for the characterisation	Conditions unsuited for occupation	Characterisation
General desription Condition unsuited for occupation Legal Status Existing infrastructure Community organisation Existing programmes and projects	Occupation by approach ramps Occupation under bridges and/or viaducts Occupation in traffic circles or traffic islands Occupation on sanitary landfil or otehr dumps Occupation under high tension lines Occupation on unbuildable areas adn/or riverbeds Occupation in areas at risk of cave-ins or landslides Occupation in contamined areas Occupation in nonbuidable areas of the active highway system Occupation in nonbuildable areas of the active railway system	**Not upgradable settlement** ↑ **Total** **Parcial** ↓ **Upgradable settlement**

In the Breho Area, flood-prone area was upgraded with a minimum of 180 households estimated for relocation in resettlement housing and 308 redistributed.

Before upgrading

Upgrading Plan

After upgrading

Grotinho Risk Area: Flood prone area upgraded with relocation of a minimum of 182 families

Before upgrading

During upgrading

After upgrading

Source: (Diniz, 2010)

The HABISP allowed Housing Secretariat of the Municipality of Sao Paulo (SEHAB) to strategically develop multiple community specific program areas that included land tenure, slum up gradation, sanitation improvement in environmentally fragile water supply areas and regularization of informal land subdivisions. Technical criteria, based on indicators of infrastructure, health, social vulnerability and risk areas, were established to prioritize interventions under each program in order to allocate funds. New housing units that include social rental properties are built as part of the programs. A key feature has been the integration of public spaces. During 2005-2008, 2330 dwelling units were

Continues

Box 26 Strategic urban up-gradation of precarious settlements, São Paulo, Brazil

upgraded, 268 affordable rental units were constructed in addition to 2111 units built by COHAB. The partnership has survived different city government administrations and leadership changes within Cities Alliance and demonstrated the importance of long term planning

SEHAB has set up a managerial information system, the HABISP that provides data that is geo-referenced to cartographic and photographic databases that is easy for SEHAB personnel to use with user-friendly data design and data entry tools. Data entry was standardized and information merged from dispersed databases to view the extent of slums across the city. Structure boundaries were determined using aerial photography and field inspections of dwelling units in existing settlements. Data on water and sewer mains network was crosschecked against geo-referenced data to identify the extent of coverage in each settlement. It is now possible to identify the degree of environmental precariousness of each of the 103 sub-basins in the city's territory. Ongoing updating of the database automatically produces a new chart of precarious conditions allowing evaluating housing assistance in real time. All content is open to the public since March 2008 and can be monitored by civil society. For more information see www.habisp.inf.br.

Source: Cities Alliance, 2009.

Project Implementation

Conventionally cities treat urban upgrading as infrastructure provision in separate sectors for implementation by separate agencies. However, for comprehensive risk reduction, it is important to recognize that all infrastructure provision is implemented in the same space and should be coordinated in a citywide spatial plan that maps urban poverty; slum mapping enhances the capacity to upscale slum up gradation interventions. In Jakarta (Indonesia), despite its commitment to the Mayor's Taskforce on Climate Change, Disaster Risks and the Urban Poor, the approach of integrating projects and programs that increase resilience, improve spatial planning and decrease poverty in one systematized application is new for the government and requires institutional strengthening.[143] The institutional relationships between the local government, line agencies, financial institutions, collection agencies, maintenance organizations, the private sector and the civil society needs to be strengthened through partnerships based on relative advantages of scale and proximity. Developing capacity to work with communities for design and implementation of physical works and livelihood development for small businesses and residents is critical.[144]

Funding is required for risk assessments, urban infrastructure and basic services, capacity building. Cities currently rely on national and local tax revenues, the private sector, PPP, loans and concessional sources through multilateral development banks and donors. The financial structure for cost-recovery would depend upon available finance, effectiveness of local taxation, private sector and community engagement. In the Latin America and Caribbean region, most urban upgrading programs have successfully used cost-benefit analysis to determine finance requirements and allocation to the areas in most need[145].

Project Monitoring

Indicators to monitor risk reduction through urban upgrading can be linked to the MDGs. Several cities have successfully engaged the community in maintenance arrangements and monitoring of slum upgrading works. In Rio de Janeiro (Brazil), the responsibility for waste management was transferred to community associations; the associations were made responsible for contracting and managing the teams in charge of collecting waste; the municipal company provided training and supervised the service provision.[146]

Concluding Remarks

At its essence, urban upgrading is a tool for urban planners to prioritize risk resilience for the most vulnerable population. Apart from institutional strengthening and engaging the private sector and the community, the key to successfully implementing an urban upgrading program is to develop and maintain an open information system on slum conditions and upgrading programs.

Key Resource

Approaches to Urban Slums: Adaptive and Proactive Strategies. World Bank Institute, 2009 (website).

2.5 COMMUNITY AND STAKEHOLDER PARTICIPATION

Social | Institutional

Key Points

- The World Bank supports the effective participation of communities and other stakeholders in urban programming initiatives as a way of building social resilience which, in turn, contributes to strengthening overall urban resilience.
- Community driven programming is essential to implementing successful urban planning and infrastructure projects.
- Incorporating the participation of men and women at the neighborhood and municipal levels in urban programming initiatives is a priority.
- Multi-sector and multi-level partnerships with government and civil society, including community based organizations, private sector, academia, are an effective way to build social resilience, given the diverse range of contributing factors to disaster and climate-related risk.
- Participation by the men and women of communities and other stakeholder groups should be integrated into all phases of the project cycle.
- It is vital to ensure that vulnerable and marginalized populations are fully and meaningfully incorporated into community/stakeholder participation processes.

Summary

Limitations of local governments' capacity to address the disaster risk reduction and climate change adaptation needs of the urban poor has led to recognition of the importance of supporting direct action by low-income individuals, households and communities. This work has been particularly focused on initiatives to protect and increase or diversify their livelihoods assets and to build community-based disaster risk management capabilities. It includes developing the ability of local communities to make demands on local governments and, where possible, to work in partnership with them.

Urban investment planners can assist at-risk communities to protect and improve their asset base and build social capital. This can be achieved by incorporating actions into urban upgrading, resettlement or development projects that support household- and community-based responses. The **Table 13** provides an example of some of the types of asset-based activities that can be implemented in order to build resilience to extreme weather events. Specific sectoral level actions are identified in **Chapter 3**.

Community-Level Programming

Community-based disaster risk management *(CBDRM)* is a well-established methodology for building local resilience that has its roots in the good practices developed over several decades of community-focused development and poverty reduction programming. A holistic approach is taken to disaster risk management that recognizes the links between vulnerability, poverty, and socio-economic development. Thus, the programming developed can focus on various combinations of livelihoods, infrastructure and/or disaster preparedness activities (see also **Table**

Box 27 Scaling up and integrating CBDRM into local planning processes

The Comprehensive Disaster Management Programme (CDMP) is a whole-of-government strategy led by the Bangladesh Government's Ministry of Food and Disaster Management, and implemented by a range of government and private organizations. The community intervention part of the program aims to increase community resilience and strengthen local government capacity to manage risk reduction as part of their development responsibilities.

The program has developed and implemented a standardized community risk assessment tool, and helped develop local action plans for mainstreaming disaster risk reduction into the work of government authorities. Most importantly, the program provides a local funding structure to implement priority actions, motivating local authorities and communities to take part.

400 NGO staff members have been trained to carry out the community risk assessments. These are participatory processes that combine scientific data and predictions with discussion of local knowledge. The assessments are done from an all-hazards, all-risks and all-sectors perspective. As at 2010, assessments had been completed in 622 Union Parishads (a level of local government just below the sub-district) within 16 districts. Approximately 550 community risk reduction projects prioritized in the risk reduction action plans had been funded.

The World Bank's Local Government Support Program has begun to use risk reduction action plans developed under the CDMP to guide its development funding. The program is also training local officials to use this risk assessment guideline to assess vulnerabilities across all sectors, devise strategies to mitigate risk, and facilitate local mainstreaming of disaster risk reduction.

Source: UN-SDR/ITC/UNDP, 2010, pp 2-4.

13). The CBDRM approach seeks to understand and build on existing community coping/adaptation capacities, and in recent years, a number of organizations have incorporated a climate change focus into it (e.g. Red Cross/Red Crescent Climate Centre).

While a CBDRM approach may not be appropriate to all types of urban investment projects, key elements of it should be incorporated into most urban planning, upgrading and sectoral initiatives that are expected to bring changes to the lives and livelihoods of citizens. For example, the AusAID-supported disaster risk reduction and climate change adaptation program pilot Building the Resilience and Awareness of Metro Manila Communities to Natural Disaster and Climate Change Impacts (BRACE) in Metro Manila (the Philippines) incorporates a CBDRM component. The component has been designed to complement other components in housing and infrastructure, livelihoods, urban planning and scientific hazards analysis.[147]

Many of the World Bank's Social Fund/Community-Driven Development (CDD) projects and sub-projects have also been incorporating activities to build community resilience and local institutional capacity to mitigate the impacts of hazard events as one of the mutually reinforcing components of social protection in recent years. The managers of these Social Fund/CDD projects, in countries where they operate, will have invaluable local advice from their experiences of working with community and civil society organizations.

Scaling up: Because of the time and resources involved in undertaking CBDRM processes, as well as the expectations they can generate, replicating individual local initiatives at scale can be challenging. Related to this, international CBDRM experience has shown that poor communities are unlikely to have the means to reduce many facets of the risks they face in the absence of some form of incentive.[148] **Box 27** provides an example from Bangladesh.

Further Reading

Building Resilient Communities: Risk Management and Response to Natural Disasters through Social Funds and Community-Driven Development Operations (World Bank, 2009).

Government of Bangladesh Comprehensive Disaster Management Programme (website).

TABLE 13 Examples of asset-based actions to build resilience to extreme weather

Areas of intervention	Household and neighborhood	Municipal	Regional or national
Protection	Take household and community-based actions to improve housing and infrastructure. Conduct community-based negotiation for safer sites in locations that serve low-income households. Take community-based measures to build disaster-proof assets (such as savings) or protect assets (e.g. insurance).	Work with low-income communities to support slum and squatter upgrading, informed by hazard mapping and vulnerability analysis. Support increased supply and reduced costs of safe sites for housing.	Develop government frameworks to support household, neighborhood, and municipal action. Make risk-reducing investments and take actions that are needed beyond urban boundaries.
Pre-disaster damage limitation	Develop community-based disaster preparedness and response plans, including early warning systems that reach everyone, measures to protect houses, safe evacuation sites identified if needed and provisions to help those less able to move quickly.	Install early warning systems that reach and serve groups most at risk. Prepare safe sites with services, and organize transportation to safe sites. Protect evacuated areas from looting.	Establish national weather monitoring systems capable of providing early warning. Support community and municipal actions.
Immediate post-disaster response	Support immediate household and community responses to reduce risks in affected areas. Support the recovery of assets. Develop and implement responses.	Encourage and support active engagement of survivors in decisions and response. Draw on resources, skills and social capital of local communities. Rapidly restore infrastructure and services.	Fund and provide institutional support for household, community and municipal responses.
Rebuilding	Provide support for households and community organizations to get back to their homes and communities. Plan for rebuilding with greater resilience. Provide support for recovering the household and local economy.	Ensure reconstruction process supports household and community actions, including addressing priorities of women, children and youth. Build or rebuild infrastructure to more resilient standards.	Fund and provide institutional support for household, community and municipal action. Address deficiencies in regional infrastructure.

Source: C Moser and D Satterthwaite (2010) ‘Toward Pro-Poor Adaptation to Climate Change in the Urban Centers of Low- and Middle-Income Countries’ in R Mearns and A Norton, Eds, *Social Dimensions of Climate Change: Equity and Vulnerability in a Warming World*. Washington DC: IBRD/ The World Bank.

Community-Driven Approaches to Urban Development and Poverty Reduction

Urban investment planners can play a catalytic role in encouraging and supporting municipal disaster risk reduction and climate change activities. Urban investment projects can support NGOs and CSOs, particularly those formed by the urban poor to collaborate with local and national governments to undertake and/or scale up demand -driven pro-poor activities that build resilience. Many of these urban poverty reduction activities are already strongly linked to environmental hazards. Slum upgrading programs are a good example of initiatives that have addressed 'everyday' hazards and greatly reduced vulnerability of the urban poor.[149]

The International Institute for Environment and Development (IIED) has documented many of the innovative joint government-CSO urban resilience-building initiatives currently underway. These include many partnerships between local governments and federations formed by slum and shack dwellers. In some nations, these programs further receive considerable support from national government – as in the *Baan Mankong* (secure tenure) program in Thailand, supported by the Thai government's Community Organizations Development Institute. The Baan Mekong program is a relatively rare example of implementing such programs at scale without external finance.

Urban investment projects can assist local governments to develop a pro-poor policy environment and the skills to implement participatory approaches to project development and implementation.

Support to Public-Private Partnerships

Donor-assisted urban investment projects can support local governments to effectively engage local businesses to participate in project planning and implementation. The local business community, as well, must be stakeholders in building urban resilience.

Private sector actors can particularly contribute to building resilient economies, infrastructure and communities through active participation in activities such as:

- Assessments of hazard, risk and coping/adaptive capacity;
- Hazard and climate change awareness generation;
- Disaster preparedness training and drills;
- Improving the efficiency of logistics for rescue and relief operations;
- Provision of engineers, architects and building artisans trained in hazard-resilient construction;
- Development and application of cost-effective hazard-resistant technologies;
- Development of all-hazard warning and monitoring systems; and
- Development of risk financing, transfer and social safety net instruments.[150]

Local, and sometimes national, government support is key to enabling the private sector to do its part. In addition to the identification of resource sharing opportunities, the planners of urban projects can facilitate information exchange and dialogue between local government and private sector representatives about areas of potential risk and joint mutual interest to both parties and the options available for private sector participation to achieve shared objectives. If the government has a department promoting business and industry, it should be involved in this process.[151]

Further Reading

Building Resilience to Natural Disasters: A Framework for Private Sector Engagement (World Economic Forum/World Bank/ISDR, 2008)

*A Guide for Implementing the Hyogo Framework for Action by Local Stakeholder (*Asia Regional Task Force on Urban Risk Reduction/UN-ISDR/Kyoto University, 2010)

Possible Areas for Collaboration

Business and economic continuity: Small or local businesses need to identify ways to protect themselves from the effects of disasters. Local chambers of commerce and/or business associations can play a key role in educating business owners (formal and informal sector) about the risks from disaster and climate change. They can identify methods to better protect small businesses from these risks.

Built environment: Private sector involvement in the development and improvement of technical and legal procedures for the construction and maintenance of hazard-resilient infrastructure is critical to their acceptance and success. Outreach to small-scale local construction-related service providers can be particularly important, as much of the building work in informal settlements and urban slums often takes place outside of formal government regulatory systems. If settlement upgrades are planned, or resettlement, the impact on small businesses also should be fully assessed.

Disaster preparedness and early warning systems: The provision of urban lifeline utilities such as communications, energy, transport, water and wastewater systems are often contracted out to private sector firms. The public-private interdependencies must be understood and planned for in order to protect key productive enterprises. Local governments in at-risk locations may enter into a mutual aid agreement with such firms to formalize support that may be needed in the event of a disaster. The local and international private sector has also traditionally played an important role in post-disaster relief and recovery and should be involved in the formulation of local disaster risk management plans and hazard risk management systems.

Human and social capacity: Local NGO and CSO can also play an important role in supporting private sector firms to attain some of their corporate social responsibility goals including collaboration with finance and insurance companies on risk transfer mechanisms for poor urban communities.

Incorporation of Vulnerable and Marginalized Populations

It is essential at all levels of the project cycle that urban planners identify the poor and marginalized populations within an urban area, as they will experience the highest risk from future disasters. The urban poor, women, marginalized ethnicities are a few groups that tend to experience disaster risk to a greater degree than the rest of a population. While the benefits of coordination between these groups and different community stakeholders may be clear, there are many issues that well thought strategies.

Competing priorities: The residents of poor and/or informal settlements may feel there are few benefits for them of such partnerships. Survival needs and economic priorities often conflict with risk reduction and climate change adaptation objectives.

Legitimacy and trust: In urban contexts, another major obstacle can be the inability or unwillingness of local government units to work with the residents of informal settlements. Many regard informal settlement populations as problems rather than as key contributors to the urban economy.[152]

History of collective organization: Well-established neighborhoods usually have greater resilience, due to a dense fabric of social networks that is built up over time; these networks can even transcend socio-cultural differences within the community.

Discrimination within communities: Within any urban setting, there are likely to be groups who are marginalized or disadvantaged in some way. The disabled, elderly and the very poor—including tenants and informal settlers in urban settings—often represent the least resilient population within communities.

***Gender Equality**:* It is often mistakenly assumed that all members of a household experience disaster and climate-related risks in the same way and, hence, will benefit from the same resilience-building approaches and activities. As men and women have different roles and responsibilities in their households and communities, they face different forms of risk and vulnerability; they will also have different needs and perceptions of what is required to reduce risk. Power differentials, due to cultural and socio-political constructs of acceptable roles for men and women, can mute the voices of women in project planning processes.[153] Therefore, gender analysis of all proposed urban interventions is essential in order to assess and identify specific actions to promote the full and active participation of both genders in project decision-making and activities.

Integrating Community and Stakeholder Participation Into the Project Cycle

Projects should promote and enhance community/stakeholder participation to the extent possible, regardless of whether the proposed urban investment focuses on the community or municipal levels. A series of generic steps and actions to integrate community and stakeholder participation are outlined in **Table 14**.

Project Identification

For World Bank projects, the Project Concept Note (PCN) and Project Information Document (PID) should summarize the opportunities for, and likely risks associated with, community/stakeholder participation. The project options and scenarios developed should identify approaches or entry points to incorporate social resilience building, as well as the time and resources required for stakeholder engagement in developing the detailed design.

- Conduct initial preparatory work;
- Analyze socio-political context and identify advocates for change;
- Choose effective local partners and form effective partnerships;
- Educate key stakeholders (see **Box 28**);
- Form stakeholder working groups;
- Encourage sharing of risk information between stakeholders.

Analyze the socio-political context: An initial challenge in planning for the mainstreaming of resilience in urban investment projects can be a lack of awareness, interest and/or capacity for disaster risk reduction and climate change adaptation within city/municipal governments - let alone to utilize community-centered approaches to this work. The early stages of discussion of a potential urban investment project between the donor and the partner government may need to be preceded by, or to incorporate, activities with local

TABLE 14 Opportunities for community/stakeholder participation in urban investment projects

Stage of project cycle	Opportunities for community/stakeholder participation
Identification	Conduct initial preparatory work. Analyze social-political context for participatory approaches and building disaster/climate resilience. Choose effective partners at local, regional and national levels. Educate and build the support of key stakeholders. Form stakeholder working groups.
Preparation/Appraisal	Recruit technical experts in sociology and community development. Conduct risk, vulnerability and coping/adaptive capacity analysis VCA and participatory scenario development). Undertake multi-stakeholder planning. Develop community participation and communications strategy, including social and gender inclusiveness actions and performance indicators.
Implementation	Form neighborhood associations. Carry out resilience education with participating communities. Conduct local level VCAs or community hazard/spatial mapping and develop action plans (for CBDRM sub-projects).
Monitoring, evaluation and knowledge-sharing	Develop participatory community project monitoring and evaluation system. Develop community-centered complaints handling and grievance procedures. Support community level and local government peer-to-peer exchanges. Encourage sharing of risk information in sustainable ways.

Box 28 Multi-stakeholder collaboration in Indonesia

The Merapi Forum is a multi-stakeholder forum that jointly manages the risks and resources of Mt Merapi, an active volcano on the island of Java. The entire population of the four surrounding districts is vulnerable to the impact of Merapi's eruptions, with more than 320,000 people living in the most hazardous areas. The Forum targets stakeholders from three surrounding districts under the authority of Central Java Province and one under the Special Region of Yogyakarta Province. Membership includes: community groups; four district and two provincial governments; BPPTK (Office for the Study and Development of Volcanic Technology, National Ministry for Energy and Mineral Resources); universities; media; an NGO; the Indonesian Red Cross; and a number of donors.

The Forum was officially started in 2006, although groundwork for the collaboration stretched back several years before this. It was initiated by the local government authorities. The secretariat of the multi-stakeholder forum is hosted by BPPTK, the national institution that holds the highest authority over geological hazards. This has been an effective strategy because BPPTK is perceived as more or less free from vested interests and can be accepted by all local participants as a neutral arbiter. The initiative has substantially built the capacity of local communities and local governments through a range of practical joint activities on disaster risk reduction. This has included disaster simulations, contingency planning exercises and participatory risk mapping. It has fostered mutual understanding among the different stakeholders, establishing cross-border and cross-sector collaboration in risk reduction.

The participatory process gives space for the communities to take the lead in their areas of disaster risk reduction responsibility, and the local governments have appreciated their work. Ownership has been fostered among the stakeholders, particularly between community members directly facing the volcano's risks and the local governments. There has been substantial willingness among different stakeholders to contribute resources to the joint programs and activities, with practical support provided by central and provincial governments.

Source: UN-ISDR/ITP/UNDP, 2010, pp 28-29.

government partners to: raise awareness; build political support; and identify capacity gaps.

The first step in this process is to undertake a preliminary situation analysis of the socio-political and institutional context, in order to assess the opportunities (e.g. pre-existing consultative mechanisms, effective advocates for inclusive decision-making, potential project partners) and constraints (e.g. weak, disinterested or oppositional government; history of conflict) to effective stakeholder participation and/or disaster risk reduction and climate change adaptation. A stakeholder analysis should be conducted as a part of this process. The analysis should include the identification of supportive individuals in positions of influence who can act as 'champions' for disaster/climate resilience and/or a participatory decision-making process - an approach of proven effectiveness.[154] These can come from inside or outside of government. However, if such leadership is lacking, a champion may need to be cultivated.

Form effective partnerships: Experienced, locally respected and politically independent implementing partners can act as a bridge between communities and their government authorities. Some international NGOs have observed that there is usually not a large pool of existing CSOs or NGOs available in urban areas with a specific focus on, or competencies in, disaster risk reduction or climate change adaptation. Frequently, local partners are identified that have been involved in other areas of resilience-building support to local communities.[155] For example, many local government-community partnerships in Africa and Asia have been initiated through federations of slum dwellers.[156] Multi-level partnerships are also important for bringing communities together with their local, regional and national governments. For instance, advocacy by national level agencies has sometimes been a key factor in changing the attitudes and practices of local governments towards their citizens. National government disaster risk reduction and climate change adaptation policies, legislation and coordination mechanisms have further assisted with leveraging resources for local implementation.[157]

Educate and build the support of key stakeholders: The local champions and partner organizations can guide and support early work to sensitize the key stakeholders to disaster and climate change risks, e.g. through discussion, peer learning exchanges with other municipalities, and formal training. As local governments have to make decisions between many competing priorities, there is a natural tendency to priorities actions to address more immediate and visible risks over the avoidance of future negative outcomes. Therefore, it is usually preferable for awareness-raising activities to: a) draw from relevant real-life examples and evidence of the costs of inaction and b) link the benefits of potential courses of action to the achievement of broader urban development priorities.[158] The information should be adjusted to reflect the interests of different stakeholder groups, e.g. explaining to the housing authorities how consultation with women can result in safer and more practical housing and settlement designs.[159]

In some cases, building on the momentum created by a recent disaster event can be another effective entry point to engage local governments and communities with long-term resilience building efforts. For example, the Asian Cities Climate Change Resilience Network (ACCCRN) has found that cooperative action with diverse city actors in Surat, India was triggered by the memory of the 2006 floods and other disasters.[160]

Project Preparation/Appraisal

For World Bank-supported projects, the detailed design and Project Appraisal Document (PAD) should specify the nature and extent of social resilience and should serve as a foundational document during this stage. It may be necessary to consult with experts regarding community development in this stage.

Conduct risk, vulnerability and coping/adaptive capacity analysis: The Vulnerability and Capacity Assessment (VCA) methodology is popularly used in CBDRM projects to involve local government and business leaders and identify resource needs.[161] The analysis can be used as a basis for municipal planning for a wide range of resilience building measures, not only those related to disasters. In recent years, climate change and hazard trends have been increasingly incorporated into VCA methodologies. The World Bank has used 'participatory scenario development' to identify risk from future climate change, which can be adapted to VCA.

Multi-stakeholder planning: The collated technical and community data, including programming options should be analyzed and discussed a broad group of stakeholders. Public meetings and structured dialogues with the affected communities are effective methods. A good example of multi-stakeholder planning is explored in **Box 29**.

Community participation and communication strategy: The consultative processes should produce information about appropriate approaches to community/stakeholder participation and communication,

Box 29 Stakeholder participation in climate resilience awareness-raising and planning

The City of New York decided that multi-stakeholder, multi-level prioritization and decision making on urban development and climate change was essential to building policy and programming mixes that were robust enough to deal with most possible future scenarios and ensure that the policy choices did not have unacceptable consequences for stakeholders. In 2006, Mayor Michael R. Bloomberg created the Office of Long-Term Planning and Sustainability and charged it with developing a comprehensive sustainability plan for the City's future. The result of this effort, the 'PlaNYC,' was to prepare the city for one million more residents by 2030, strengthen the economy, combat climate change, and enhance the quality of life for all New Yorkers. As part of the office's mandate to address housing, transportation, and other infrastructure needs over the next 25 years, it coordinated the development of a climate adaptation strategy. A Climate Change Adaptation Task Force was convened to develop a coordinated plan for the city's critical infrastructure. t consisted of over 40 public and private sector stakeholders and was supported by a panel of scientists, academics, and private sector experts.

The planning office, in coordination with the relevant city departments, met with more than 100 advocacy organizations, conducted community meetings in each borough, and collected thousands of individual e-mails through its website. A "stakeholder interactive approach" was also developed by building contacts with national, regional and municipal agencies involved in urban planning, transport, environmental management, disaster response and other relevant areas. The citywide adaptation plan and broader comprehensive PlaNYC sustainability plan was released in 2007. The

Continues

Box 29 Stakeholder participation in climate resilience awareness-raising and planning

Plan brings together over 25 city agencies to work toward the vision of a greener, greater New York. It focuses on improvement of current buildings, building codes, and the strategic placement of public facilities, rather than guiding outward urban expansion. The PlaNYC also calls for a community-based approach to deal with the most vulnerable communities, and the city has been working on site-specific adaptation plans through a community planning process with stakeholder groups.

Significant progress has been reported towards the achievement of the PlaNYC's long-term goals. As at late 2011, hundreds of acres of new parkland have been built and existing parks improved. More than 64,000 units of housing have been created and improved, along with entire new neighborhoods with access to transit. The city government has also enacted ambitious laws to make existing buildings more energy-efficient and reduced greenhouse gas emissions 13 percent below 2005 levels. Overall, more than 97 percent of the 127 initiatives in PlaNYC were launched within one-year of its release and almost two-thirds of its 2009 milestones have been achieved or mostly achieved.

Sources: Rosenzweig and Solecki, 2009; World Bank, 2008, pp 67-68; World Bank, 2011, p 16; PlaNYC (website).

including social and gender inclusiveness considerations, to be applied during project implementation.

Implementation

Form neighborhood associations: Well-established urban neighborhoods in poor communities and/or informal settlements, along with their neighborhood associations, can be a good entry point for working with communities on building social resilience; this is especially the case where communities lack cohesiveness or trust of outsiders. Where such associations do not exist, they may need to be formed; sufficient time must be allowed to build their legitimacy and capacity. Some strategies for the effective use of neighborhood associations may include:

- Engaging a network of community promoters to deliver and reinforce project messages to new households in the community;
- Community led training of new committee members; and
- Continuing opportunities for peer learning and support.

Educational activities: Where disasters are not regularly recurring events or have not been previously experienced, building and maintaining community participation in projects can be challenging. Creative and innovative approaches to disaster/climate change risk education may be required, combined with 'hands on' demonstrations of cost-effective methods to reduce risk. For example, the city of St Louis in Senegal has set up climate change observation centers, put in place special training programs and enlisted teachers to act in a brigade for climate change.[162] Some examples of public awareness and social marketing tools that have been effectively employed include:[163]

- Commissioned scripts adapted for street performance, radio and TV;
- Curriculums developed for schools;
- Training of community members to conduct outreach to individual households; and
- Community events (e.g. dances, competitions, sports games, etc).

Further Reading

Safer Cities No 14, Public Awareness and Social Marketing: Experiences from the AUDMP (ADPC, 2005).

Box 30 Building earthquake risk awareness and safety in Nepal

Nepal has a long history of destructive earthquakes, with seismic studies suggesting major earthquakes occur around every 75 years. Since the last major earthquake of 1934, the risk for the Kathmandu valley has increased significantly due mainly to uncontrolled development, lack of incorporation of earthquake safety into construction, and lack of awareness among the general population and authorities. The Kathmandu Valley Earthquake Risk Management Project (KVERMP) aimed to address this situation, a challenging task as an earthquake had not occurred for many years.

The project used a variety of means to increase community and government understanding and action regarding earthquake risk. These included a symposium, awareness rally, art exhibition and competition, and the distribution of posters, booklets and leaflets. Much of this activity was centered on Nepal's annual earthquake safety day. Also, ten schools were surveyed for their ability to withstand earthquakes, with four selected for initial retrofitting. Consultations were undertaken with local stakeholders in each municipality. It was agreed the project would contribute technical assistance and training to local masons and carpenters on earthquake-resistant construction, while the communities would provide material and labor.

The "low-tech" approach adopted for school seismic safety screening and the use of simulations and loss estimates from the 1934 earthquake for educational activities had a significant impact on the community, without causing undue panic. Ordinary people started taking interest in earthquake issues and raising questions. In two wards of the Kathmandu municipality, residents took action on their own initiative to assess and to decrease the risk to their neighborhoods.

Source: Adapted from ADPC, 2004.

Box 31 Monitoring urban projects in Indonesia

The PNPM urban program in Indonesia won a World Bank innovation award in 2009 and has continued to set a high standard in community/stakeholder participation. Some of its 'community-friendly' features include:

- **Community Participatory Monitoring:** Community participatory monitoring involves community groups or members to monitor and oversee program activities. In addition to assessing progress and identifying ways to improve the program/project, these activities facilitate community learning
- **Information Accessibility and Transparency:** Project information must be available and accessible for community members to check and verify. Information regarding the project activities and budgets should be posted on information boards and project sites.
- **Open Public Meetings:** As a principle of community participation and transparency and accountability, all project meetings should be open to the public and community members should be allowed to participate and monitor proceedings. During project implementation, the projects should also hold accountability meetings to report upon project progress and finances.
- **Complaints Handling and Grievance Procedures:** The complaints handling process allows community members and the general public to channel complaints or inquiries via PO Box, SMS (since cell phones reach most urban areas) or communication with local government officials and facilitators. There are activities to strengthen community awareness strengthening about their rights and these mechanisms.
- **Management Information Systems (MIS) and Website-Project MIS:** The public website contains basic project information and updates, including on the status of complaints
- **NGO Monitoring:** Civil society groups/NGOs have been invited to independently monitor the program. These groups are seen as playing a critical role in ensuring that communities, especially marginalized groups, the poor, and women have the opportunity to participate in PNPM-Urban activities.

Source: World Bank PNPM - Urban Project Appraisal Document, 4 March, 2010.

Monitoring, Evaluation and Knowledge-Sharing

***Monitoring**:* There are many well-established methods of involving community groups or members in a participatory monitoring system, such as: public posting of project information and public meetings, establishment of complaints handling and grievance procedures, monitoring by CSOs and social audits. **Box 31** provides an example from Indonesia.

Evaluation: Where possible, representatives of community-based organizations, NGOs, CSOs and local businesses should be invited to play specific roles in any program/project evaluation.

Knowledge sharing: Developing a joint community of practice between different stakeholders can also be useful for building effective partnerships. As data is collected, it is important to encourage sharing risk information in sustainable ways.

Concluding Remarks

Community and stakeholder participation is the very center of development, and the reality is that programs like this are very difficult because communities and stakeholders will often have different priorities than urban planners. It can be easy to think that infrastructure development does not require community participation because infrastructure will be a universal good, but these types of programs are the actual connections between communities and governance structures. Establishing good governance takes generations and is the reason this Handbook takes a longer-term view of resilience. There is no minimum standard for community and stakeholder participation that can be met in an urban project; rather there should always be enough flexibility to do what is reasonable for a given context. The practical application of resilience theory is to always be building better systems so that communities are more equipped for the future.

2.6 DISASTER MANAGEMENT SYSTEMS

Infrastructure | Institutional | Economic

Key Points

- Provision of accurate and timely information to decision-makers and response units is crucial for saving lives and property.
- The recognition of residual risk implies that cities have to continue improving the quality of risk communication, early warning systems, emergency contingency, evacuation and recovery planning.
- Disaster management systems depend on effective distribution of roles and responsibilities, communication and collaboration between the government, local stakeholders and the affected community.

Summary

Disaster management systems are part of operational mitigation approach, which addresses preparedness and temporary measures to reduce the immediate impacts of disasters. While locational and structural approaches reduce the potential for damage, it is often not possible to foresee or eliminate the possibility a natural disaster will cause damage. Operational capability must be provided for responding to disasters. While technological advances have made it easier to prepare for and manage disasters, the focus of any disaster management system must be on effective collaboration and communication between government, local stakeholders and the community. Crowd-sourcing and modern applications, such as Twitter, have greatly enhanced the response capacity in urban areas; however the core of any disaster management system still requires that relevant actors to communicate and clearly delineate responsibilities prior to a disaster event. This type of collaboration requires day-to-day work and training.

Institutional and Legal Frameworks

Urban-focused disaster management frameworks should be seen as an extension of local networks, national systems and even international regional disaster networks. As complex systems exposed to the impacts of natural disasters, urban areas need to have in place an emergency response framework, which fits within the regional and national disaster management systems. The objective is to create systems that are complementary and encourage collaboration between different levels of authority and affected communities.

The effectiveness of disaster management systems depends on a legislative framework that delineates rules and responsibilities to prepare and respond to disasters. Responsibility for geographic and hazard related areas should be stated clearly and communicated across government, private sector, NGOs and civil society. An early entry point for cities is to undertake a full review of the existing capacity to prepare for and respond to natural disasters, which would allow urban planners to determine specific needs of the local government units and community stakeholders. Consultations will not only identify potential gaps but also helps stakeholders to understand their roles and ensures participation in the process.

Public Awareness

Understanding of natural and technological hazards and communication of relevant disaster information play vital role in emergency

management systems. Public authorities have a responsibility to protect their citizens and provide them with necessary risk information. Public awareness strategies and campaigns include production and dissemination of response information materials (e.g. hazard and evacuation maps,) through various delivery measures (radio, TV, press, public information centers, mailing lists). Age-differentiated student education in schools on natural hazards, prevention, preparedness, and response are effective mechanisms which can save many lives, as it has been seen in Japan in the aftermath of the Great East Japan Earthquake of 2011. Educational programs can have a broad focus or be tailored to regions or certain types of disasters. School curricula, educational materials, and teacher training can be developed to provide scientific understanding of natural hazards.

Local Resilience Action Plans (LRAPs)

Effective upstream planning for short and long term hazards offer urban planners a unique opportunity to rethink past development practices, improve the sustainability of human settlements and effectively prepare communities against threats and risks. Cities may consider developing a LRAP or a similar tool based on the potential impacts of climate change and natural disasters for areas determined to be highly vulnerable and where possible, for the entire city. The plan is a way of taking action to protect citizens, and assets, including city's historical and cultural heritage. The action plan would ideally be comprised of both hard (infrastructure and physical investments) and soft (governance, education and awareness) measures to reduce risk, and define institutional responsibilities and preferred sequencing for implementation. The National Association for Voluntary and Community Action (NAVCA) in the United Kingdom has published guidance notes on creating an LRAP on their website (www.navca.org.uk).

Emergency Response Planning

An emergency response plan should identify coordination patterns among stakeholders - both horizontally among local actors, and vertically with regional and national authorities. Typically, emergency response plans consist of operational and logistical components, including procedures for damage and needs assessment in the aftermath of a disaster. National response plans often include procedures on how to request international assistance, while local plans provide greater detail on evacuation and shelter plans. These plans should be developed through a process of stakeholder consultations (see **Box 32**) to ensure effective coordination during and in the aftermath of a disaster.

Emergency Operations Center

A key element of emergency response is the establishment of an emergency operations center (EOC). An EOC is where emergency services are coordinated. It is responsible for activating staff to respond to emergencies; requesting resources, such as

Box 32 Lincolnshire mapping of critical assets case study

During 2010, Lincolnshire's Critical Infrastructure and Essential Services Group held a series of workshops looking at Critical Infrastructure along its coastal strip. Local representatives and asset owners, including Anglian Water, CE Electric, British Telecom and five of the local drainage boards, attended these workshops. The results will feed into the local Multi-Agency Flood Plan community impact assessments.

During the workshops, organizations were asked to look at four issues: identifying assets; assessing their ability to continue to provide services during a flood; highlighting interdependencies between asset owners; and service restoration time frames. The workshops were an opportunity to review and update Lincolnshire's GIS system, which already contains sites including telephone exchanges, electricity sub stations, water and waste assets, together with vulnerable community assets such as blue light services, rest centers and schools. Key locations were highlighted in which the impact of community flooding would be significantly worsened by infrastructure failure.

Source: UK Cabinet Office (2011) Keeping the Country Running: Natural Hazards and Infrastructure. A Guide to Improving the Resilience of Critical Infrastructure and Essential Services.

equipment and teams; coordinating response and recovery activities; tracking resources; and collecting information from the field like damage and needs assessments. An emergency operations center is an important element in a country's disaster risk management framework. Its effective use relies on the country's legislative and institutional DRM platform, which clearly identifies stakeholders' responsibilities are institutionalizes coordination among them. **Box 32** provides an excellent example of stakeholder consultation process. In Turkey, the Bank projects have helped establish the national emergency operations center in Ankara, as well as the center for the Istanbul province with full technical information and communication capacities to manage emergencies and disasters.

Early Warning Systems

Monitoring, alert, and early warning systems communicate hazard forecasts to the public. An early warning system comprises a regularly tested process to receive data and disseminate warnings 24 hours a day, 7 days a week. It includes a back-up system to ensure communications in case the primary system fails. Communications to the public are hazard specific and contain clear emergency directions.

Alert and warning systems are designed for specific hazards, such as floods and strong winds. Flood, heavy rain, and strong wind warning systems combine meteorological data (rainfall, snowmelt, and storms) with water-level measurements on rivers and reservoirs to provide data for warnings of approaching floods and storms. The early warning system should establish data sharing and functional linkages between the hydromet service organizations and emergency response units (e.g., civil protection) and the authorities to allow sufficient time to inform the public of response measures, such as evacuations and launch rescue operations. In the area of flood early warning, trans-boundary cooperation among countries sharing river basins is particularly important.

Earthquakes have been the one major natural hazard that traditionally has not had a near real-time warning. Conceptually, instruments sited close to known earthquake faults can detect initial wave and send a radio or landline signal to a city a few seconds prior to the damaging ground motions. This basic concept underlies the recent development of Earthquake Early Warning Systems (EEWS) in Japan, Taiwan, Mexico and Turkey, which are excellent examples of warning systems. The Urgent Earthquake Detection and Alarm System (UrEDAS) used widely in the Japanese railway system since the 1980s. Mexico City established an EEWS in 1991 following the disastrous 1985 earthquake – as of May, 2005, the system had generated 57 warning signals with an average of 60 sec in advance of earthquake effects, with 11 of the warnings broadcast for public use.

Post Disaster Services

First response services include firefighting, medical, public safety, and search and rescue services. Typically fire-fighting services not only manage fires but also respond to vehicle accidents and hazardous material emergencies, such as explosions. Search and rescue, swift water rescue, and other specialized teams usually fall under civil protection or firefighting services. Provision of equipment and tools like personal protection equipment or emergency medical units can strengthen first response. Planning for the location of the emergency response equipment should consider accessibility and safety of storage. Continuous training and exercises strengthens first responders. Mass care is an essential element of emergency response, which includes temporary shelters and comfort stations to provide medical assistance, food, and water to the public. Effective public care considers provision of shelter services, proper sanitation, emergency power, safety of emergency supplies, and prevention of infectious outbreaks.

Training Exercises

Once plans are developed, relevant groups need training and exercising to determine gaps and shortfalls. National, regional, and local levels should conduct training and exercise programs to test coordination, response, and readiness, and to modify the emergency response plans, if needed.

Logistics

Logistics is the backbone of emergency response. It includes facility management, resource management, and transportation. Facility management

Box 33 Risk management and business continuity standards

ISO 31000:2009

ISO 31000 is intended to be a family of standards relating to risk management codified by the International Organization for Standardization. The purpose of ISO 31000:2009 is to provide principles and generic guidelines on risk management. ISO 31000 seeks to provide a universally recognized paradigm for practitioners and companies employing risk management processes to replace the myriad of existing standards, methodologies and paradigms that differed between industries, subject matters and regions. ISO 31000 includes three publications that can help organizations address risk in a standardized framework.

- ISO 31000: Principles and Guidelines on Implementation
- IEC 31010: Risk Management - Risk Assessment Techniques
- ISO/IEC 73: Risk Management – Vocabulary

Source: International Organization for Standardization (website).

British Standard 25999 for Business Continuity Management

In the UK, as part of the organizational resilience strategy, infrastructure owners and operators may aim, where proportionate, to maintain business continuity plans that meet the requirements of the British Standard 25999 for Business Continuity Management. This is a benchmark standard for corporate resilience and enables organizations to challenge business processes and decisions to improve their ability to manage disruption from natural hazards.

The UK Cabinet Office notes that "meeting the requirements of BS25999 certification may be disproportionate. For example, infrastructure owners may already be legally obligated to maintain high quality business continuity plans or, for smaller firms in particular, the cost may be too high. However, organizations may find it valuable to review BS 25999 to assess whether following the principles and process within the British standard would strengthen their current business continuity arrangements. Many small businesses may not find it cost-effective to comply fully with BS25999. But the government will encourage organizations to adopt and embed improved business continuity management within their operations."

In response to this, the UK Cabinet Office has sponsored the Development of a Publically Available Specification in Crisis Management (PAS 200). The premise for the PAS is that crisis management is much more than simply the ability to respond to crises when they occur."

Source: UK Cabinet Office (2011) Keeping the Country Running: Natural Hazards and Infrastructure. A Guide to Improving the Resilience of Critical Infrastructure and Essential Services.

encompasses the identification, acquisition, and set-up of response facilities, such as staging areas. Resource management is the identification, acquisition, storage, maintenance, distribution, accounting, and disposal of emergency resources. Transportation involves the movement of resources into the affected area. Logistics requires strong coordination across all emergency functions. **Box 33** provides examples of emergency standards for business and operators, highlighting the advantages as well as limitations. Effective use of standards relies on strong stakeholder coordination.

Communications

Delivery of accurate and timely information to decision-makers and response units is crucial for saving lives and property. Disasters cause damage to infrastructure and can immediately change the way that citizens communicate. It is the role of the disaster management system to prepare for these failures and ensure that affected communities receive necessary information. It is crucial to develop communication systems that have interoperability and coverage of both voice and data across emergency management agencies, such as fire brigades and medical units. Emergency management information systems collect, analyze, and share real time data between emergency management institutions and other public authorities at the national, regional, and local levels. The system should allow for two-way processing of information and support the daily operations of relevant agencies, extending information all the way to individual and family levels.

Crowd Sourcing, Social Media and New Technologies

Decentralized social systems have played an important role in recent natural disasters and disaster management systems should include them into their strategic communication. Essential information impacting victims of recovery needs to be given using multiple mediums and repeated a number of times to ensure that it has reached and been understood by your audience. Online information and social media conversations need to be a part of a mix of tools for recovery (see **Box 34**).

Retention of information can be challenging when communicating with population affected by disasters. Internet and cell phone network play an essential role because of the large population displacements occur during disaster recovery. Twitter and Ushahidi are social media tools that have been used in disasters. **Box 35** gives an example of how sharing was applied in the Horn of Africa crisis.

Twitter: Integration of this application into simple mobile phones has helped with near real-time hazard monitoring and post-disaster impact and assessments. While disaster management authorities can create user accounts where users can send direct messages, the likelihood is that users will control the way topics are presented. Communication strategies should include the capacity to monitor Twitter and transmit key information to first responders and other relevant authorities. Even though, there are still technical needs to improve the use of Twitter in disaster response, such as a robust way of semantic analysis related to the disaster, it can be used as a key tool to communicate directly with users who tweet from disaster areas and open dialogue between victims and responders.

Ushahidi is another crowd sourcing tool using Volunteer Technical Communities (VTC), implemented through the use of internet and mobile telephones. Ushahidi is a non-profit entity that works with local

Box 34 Uses of social media in disasters

People use social and online mediums to get information as it is happening – With the recent expansion of cell phone networks, mobile phones are often the major means of two-way communication available to people in disaster situations. While radio is a universal source of emergency information, the increasing use of smart phones means that those caught in these circumstances are searching the web, or using tools such as twitter to get location based information.

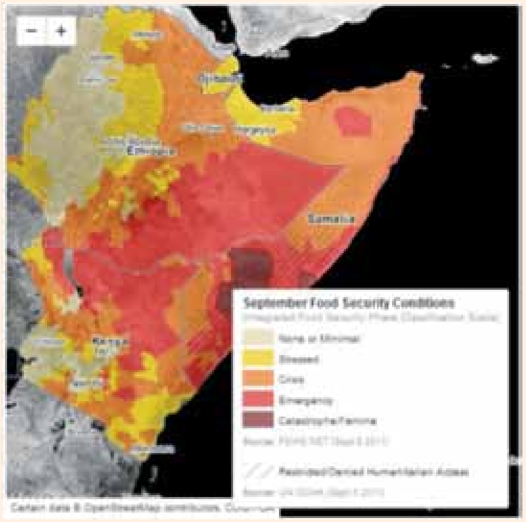
Social media users try to do their part by forwarding information – Disaster information is one of the most highly forwarded or re-tweeted information in social media. Many users, who are often removed from the situation at hand, lend their support by forwarding information to ensure it reaches as wide of an audience as possible. This has its advantages but also its dangers- as discussed below.

Incorrect information can spread like wildfire – Information on social media sites is placed on the good faith that the poster has the correct information at hand. In disaster situations, however, this good faith can sometimes be incorrect. This is not done through malicious intent by the poster, but can come about because emergency situations can often change faster than the speed of social media, or the heightened state of pressure present during a crisis can often lead to the misreading of a situation.

Social media can help monitor and address issues in disaster situations and recovery – The immediacy of social media makes it invaluable in the live monitoring of situations. Victims of natural disasters, often taken out of their comfort zones and regular modes of interaction with services, will often vent any frustrations through many outlets. Monitoring online mediums can help find issues that may not be being raised through offline means.

Source: D. Micallef, Social Media Today.

Box 35 Sharing data to rebuild a region



The crisis in the Horn is a deep reminder that development and humanitarian actors need to work closely and cooperate in monitoring and engaging early in slow-onset disasters.

The World Bank/GFDRR have recently developed the Horn of Africa Mapping Project - an initiative that aims at sharing all the data that has been collected by the various humanitarian and development agencies working on the Horn of Africa response. The Horn of Africa Mapping Project's objectives are:

- To systematize the collection of data by various organizations working in the Horn of Africa region into one open source mapping platform to support-decision making and build resilience in the region;
- To build capacity within the Horn of Africa region to host and share the data collected by these agencies on the mapping platform;
- To collect further critical data in the region;
- To create maps of the region to aid in planning and recovery;
- To develop tools that enable the offline usage and utilization of the data.

A data-sharing platform based on GeoNode has been established, hosted by a regional mapping agency in Nairobi and populated with data provided by teams at OCHA, WFP, FEWS, and GFDRR. Regular meetings are being held to continue and further institutionalize the partnership between assembled groups, jointly invest in developing offline and low-bandwidth tools to further the utility of the project, and a strong commitment to focus our efforts on supporting existing Bank programming in affected countries. The conversation will continue in the coming months as the teams collectively develop a joint work program for this initiative.

Source: http://horn.rcmrd.org.

governments to implement the tool on open source platforms, but it also can used and managed without local government. Ushahidi does require management in order to gather data from disaster zones, verify data, validate and transmit information to relevant authorities. Ushahidi helps disaster management systems to gather information from citizens in a near-real time, and have that information be displayed in maps. So far, implementations of Ushahidi have been primarily used for disaster assessments and impacts.

Further Reading

Volunteer Technology Communities: Open Development (World Bank/GFDRR Labs, 2011).

Concluding Remarks

Disaster response systems are central to mitigating the negative impacts of a disaster. The capacity to respond to disasters and quickly recover is a key element of resilience and operational mitigation. Given residual risk and future uncertainties, continuous investments in the institutional, operational, logistical and communication components of emergency and response systems are vital for any disaster risk management system.

2.7 DATA GATHERING, ANALYSIS AND APPLICATION

Institutional | Infrastructure | Economic

Key Points

- Data systems and risk analysis are vital for well-informed decision-making towards effective mitigation of disasters impacts.
- Urban planners should have a strategy that includes local government units, communities and stakeholders in the process of data gathering, analysis and management.
- Tools for creating, managing, and sharing GIS data are instrumental throughout all steps of a resilient disaster risk management.
- OpenStreetMap is an open project to map the world and it can fill data gaps to assist in response to disasters.
- GeoNode is an open-source platform for the analysis, management, and the web-based publication of geospatial data.

Summary

In reaching decisions on the appropriate prioritization of resilience efforts, a spatial and temporal understanding of risk is needed. Geographic Information System (GIS) tools are important for spatially understanding resilience in an urban area especially if operated in a dynamic and sustainable way. Risk data should be used to understand current states of resilience and set goals rather than be used as a predictive tool.[164]

Being able to quantify the impacts of planned or proposed investments as a means of risk reduction is a critical need. Sustainable risk information systems and analytical tools allow for systemic and evidence-based understanding and communication of risk. National, local and city level governments need to invest in geospatial risk information, as well as making risk information available in a sustainable and user-friendly format so that the whole community of relevant stakeholder can actively participate in disaster risk reduction and prevention. The provision of credible and reliable information, such as the geographic distribution of hazards and vulnerability of structures, can be seen as a public good and a critical element of urban hazard management policy.[165]

Data Gathering

Urban planners should view data gathering as a way to increase the capacity of institutions to build and maintain disaster related information and inform long-term decision-making. Data gathering could be at global or local level. Both are important in understanding resilience, even though, the information extracted depends on the scale. Global data provide an overall picture of resilience; local case studies provide a nuanced understanding of a given territory or local community, tend to explore resilience to single hazard, but gather very high level of data resolution. In all cases, the goal of data gathering is to encourage efforts to collect and maintain relevant data in a form that governments, international organizations and other stakeholders can easily access and use.

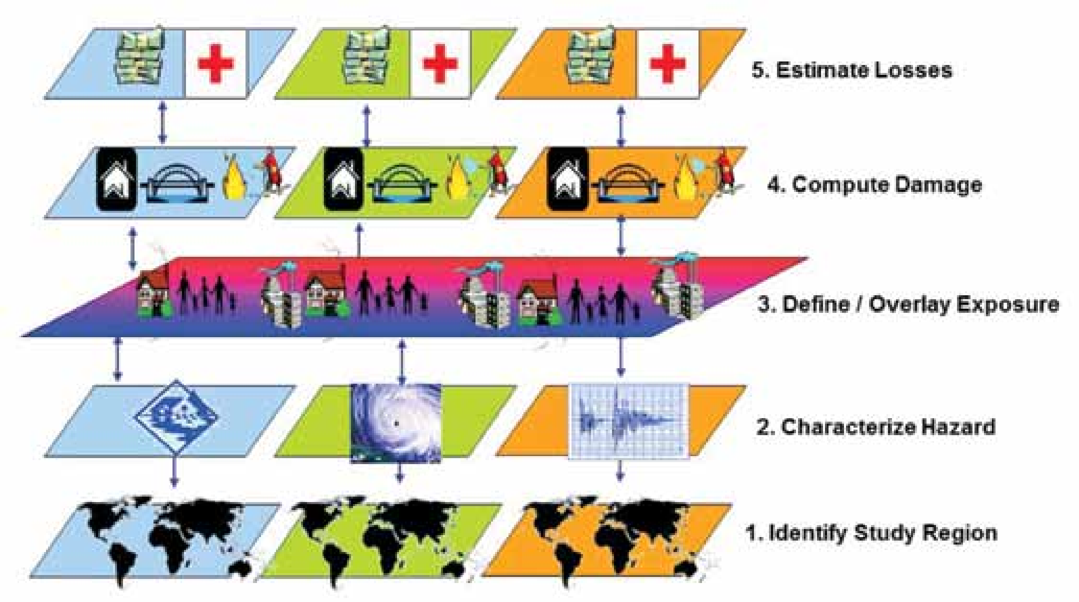
GIS Platforms and Tools

With the explosion of new technology, the integration of GIS in development projects has increased dramatically in recent years. GIS platforms and tools provide a sustainable and smart way of managing geospatial information. Geographic data permits the collection of local indicators, for instance population density or infrastructure locations, which can be understood, then utilized to build resilience in an urban area. Generally speaking, implementing projects and studies that gather localized data require a good deal of resources and are often not kept current because of funding issues. The HAZUS standard and software, created by the US Federal Emergency Management Agency, is a good example of a well-managed stand-alone database, although web-based applications and platforms are increasingly used. Details are provided in **Box 36**.

Box 36 Hazus

Hazus is a nationally applicable, standardized methodology and software application for the United States that containing models for estimating potential losses from earthquakes, floods, and hurricanes. Hazus uses Geographic Information Systems (GIS) technology to estimate physical, economic, and social impacts of disasters. Hazus graphically illustrates the limits of identified high-risk locations due to earthquake, hurricane, and floods. Users can then visualize the spatial relationships between populations and other more permanently fixed geographic assets or resources for the specific hazard being modeled. Potential loss estimates analyzed in Hazus include:

- Physical damage to residential and commercial buildings, schools, critical facilities, and infrastructure;
- Economic loss, including lost jobs, business interruptions, repair and reconstruction costs;
- Social impacts, including estimates of shelter requirements, displaced households, and population exposed to scenario floods, earthquakes, and hurricanes.



Source: http://www.fema.gov/plan/prevent/hazus/.

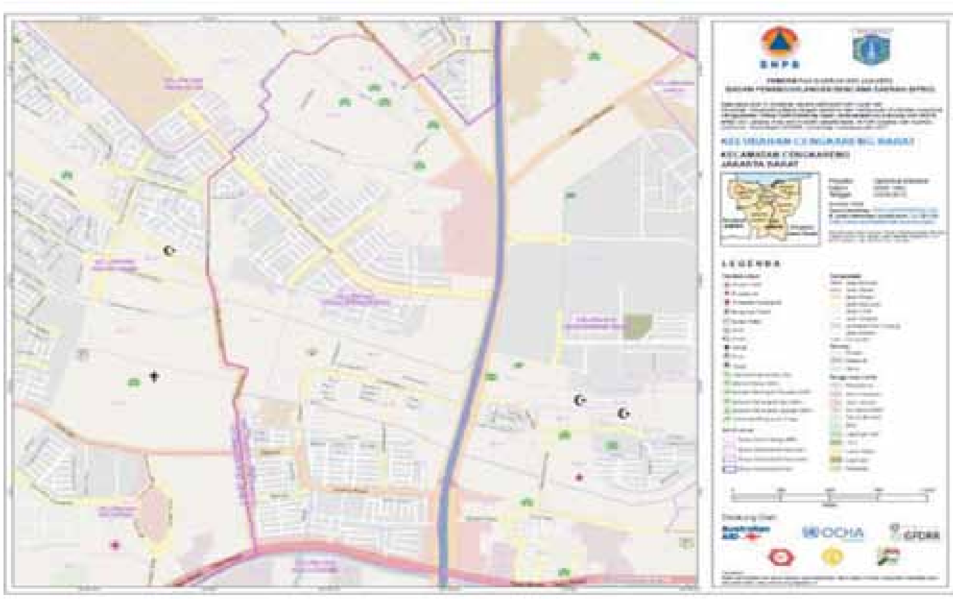
OpenStreetMap

OpenStreetMap is an innovative approach to collecting primary and field data, pre or pos-disaster. OpenStreetMap makes use of the 2.0 new technology and VTCs[166], and differs from more traditional methods. It is a web-based project that allows creating a free and open map of the entire world, built entirely by volunteers surveying with GPS, digitizing aerial imagery, and collecting and liberating existing public sources of geographic data. Information from OpenStreetMap can fill in base map data gaps to support disasters and crisis response. In the same way that the OpenStreetMap data bridges the missing information, the Humanitarian OpenStreetMap Team (HOT) acts as a bridge between the traditional Humanitarian Responders and the OpenStreetMap Community. HOT works both remotely and physically in countries to assist the collection and usage of geographic data, and to train communities in using OpenStreetMap tools.

The Community Mapping for Preparedness initiative in Indonesia started in 2011 through a partnership led by the Australia-Indonesia Facility for Disaster Reduction (AIFDR), Indonesia's National Disaster Management Agency (Badan Nasional Penanggulangan Bencana--BNPB), and the Humanitarian OpenStreetMap Team (HOT) with support from the World Bank/Global Facility for Disaster Reduction and Recovery (GFDRR). The main goal was to use OpenStreetMap tools to collect building level exposure data for risk assessment applications such as a Post-Disaster Needs Analysis (PDNA), or preparedness and contingency planning exercises. OpenStreetMap (OSM) offers several important features: open source tools for online or offline mapping, a common platform for uploading and hosting data with free and open access, and an active global community of users.

In a little over a year, more than 200,000 buildings was mapped and several new partners including five of Indonesia's largest universities, Local Government agencies, international development, and civil society organizations were trained and are using the platform in Jakarta. Most recently, the OSM tools were part of data preparedness and flood contingency planning activity led by the Province of Jakarta's disaster management agency. Teams of university students, government officials, community leaders, and technical experts mapped critical infrastructure and neighborhood boundaries across the entire city. This experience highlights the valued added by having a community mapping approach as part of a disaster risk reduction program. Figure 12 provides an example of maps produced by OpenStreetMap.

FIGURE 12 Illustration of OpenStreetMap



Data Analysis

It is important to be able to quantify the impacts of planned or proposed investments, as a means of risk reduction, but it is still critical to invest in the underlying science to produce robust hazard and risk. Having a flexible, dynamic, and simple tool such as InaSAFE to assist in such exercise is a step towards more resilient decisions. InaSAFE is a suite of tools that close the loop between sharing data and actionable information to support resilient decision-making. Since early 2011, InaSAFE has been under development in Indonesia through a partnership with the Indonesian National Disaster Management Agency (BNPB), the Australia-Indonesia Facility for Disaster Reduction (AIFDR), World Bank / GFDRR Labs, and the World Bank *Building Urban Resilience in East Asia Initiative*. InaSAFE is under continued, dynamic development through deep, technical engagement with key Government of Indonesia stakeholders.

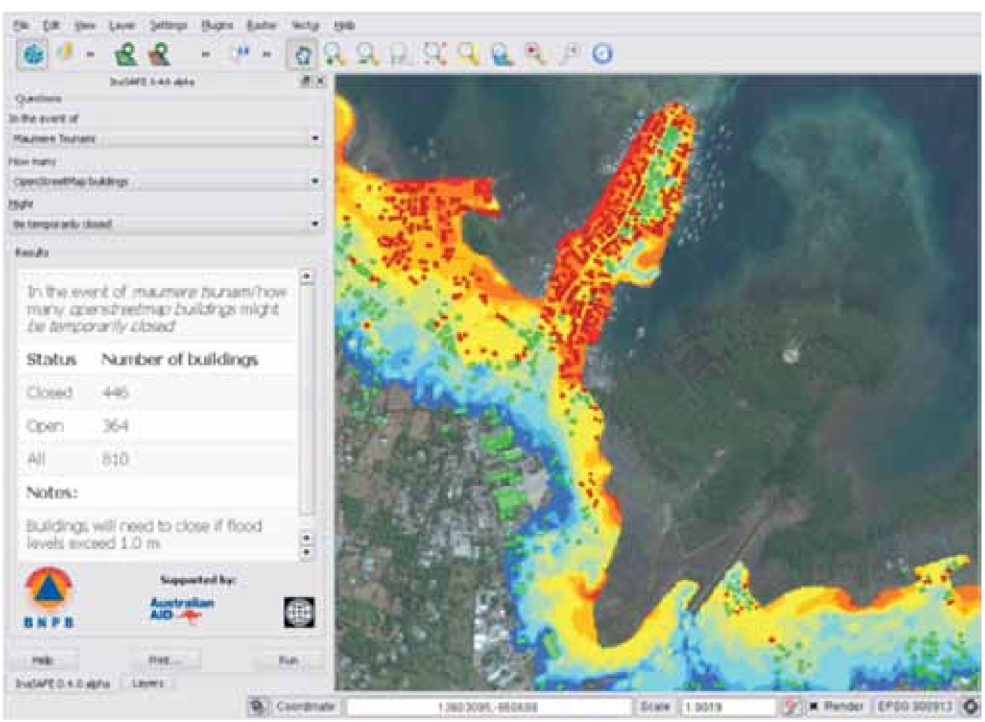
InaSAFE is designed to work as a web-based tool on top of the GeoNode open source geospatial data management platform or a desktop system using the QuantumGIS open source software. It combines the critical elements of GIS analysis with the ability to quantify impact metrics that can be used for informed decision-making. Through a pilot engagement in Jakarta, key stakeholders were exposed to beta functionality of InaSAFE and future work will further develop applications in infrastructure investment decisions **Figure 13** provides an example InaSAFE maps produced.

Further Reading

Tools for Building Urban Resilience: Integrating Risk Information into Investment Decisions. Pilot Cities Report – Jakarta and Can Tho (World Bank, 2012).

GeoNode is a web-based platform for the analysis, management, and publication of geospatial data. It brings together mature and stable open-source software projects under a consistent and easy-to-use interface allowing users, with little training, to quickly and easily share data and create interactive maps. A new approach to spatial data infrastructure focuses on users' needs and collaboration using simple web-based tools, allowing them to:

FIGURE 13 **Illustration of InaSAFE output**



- Edit metadata in the same place;
- Set up privacy controls to restrict access as needed;
- Download data in a variety of formats;
- Use data in the system to create maps; and
- Export maps to other web-applications or PDF format.

Box 37 provides a recent example of Geonode use in the Pacific region.

Box 37 The Pacific Risk Information System

Pacific Risk Information System is a web-based application using GeoNode platform to enhance management and sharing of geospatial data within the Pacific DRM community. The system enables the creation of a dynamic online community around risk data, by piloting the integration of social web features with geospatial data management. The system represents the first deployment of a web-based data sharing platform in combination with a risk assessment initiative of this scale.

Adequate preparedness based on credible information and risk assessments can substantially mitigate the devastation of natural disasters. The Pacific Risk Information System is part of the Pacific Catastrophe Risk Assessment and Financing Initiative (PCRAFI) - a joint program between the Secretariat of the Pacific Community (SPC/SOPAC), the World Bank, GFDRR Labs team, and the Asian Development Bank, with financial support from the Government of Japan. The key question at heart of the initiative was how to efficiently share terabytes of risk data compiled for 15 Pacific Island Countries with the region's DRM community to improve best practices.

The Pacific Risk Information System includes a regional geospatial database and country-specific catastrophe risk models. By drawing from one of the most comprehensive GIS data sets ever compiled for the Pacific, containing comprehensive data and information on population, land use and land cover, topography, bathymetry, soils and their engineering properties, assets including infrastructure and buildings, satellite images as well as historical catalogues and information on cyclones, earthquakes and tsunamis, risk models and risk profiles can be generated for the participating countries. The GIS database provides full coverage of the entire landmass of the select countries. Compiling the database involved intensive field visits to 11 countries to survey more than 80,000 buildings, digitizing from satellite imagery the footprints of 450,000 buildings, and inferring from satellite imagery 2,900,000 buildings and other assets. The participating countries are: Cook Islands, Federated States of Micronesia, Fiji, Kiribati, Palau, Papua New Guinea, Marshall Islands, Nauru, Niue, Samoa, Solomon Islands, Timor Leste, Tonga, Tuvalu, and Vanuatu.

Impact: Exposure, hazard, and risk maps produced as part of PCRAFI and accessible through this platform are powerful visual tools for informing decision-makers, facilitating communication and education on disaster risk management. Shared by all users, the risk information captured in the platform is the foundation for future steps of the PCRAFI, as well as any government and donor projects related to macro-economic planning and disaster risk financing; urban investments and infrastructure planning; and rapid post-disaster damage estimation.

Figure a: Field surveyed bridge in Fiji with photo validation

Figure b: Cyclone wind hazard map for the Solomon Islands

Source: Risk Information Systems (PaRIS): http://paris.sopac.org/.

Communicating Risk Information

Global approaches tend to quantify resilience against multiple hazard types and then develop an index that shows a country's relative resilience to other countries. While some of the data are gathered through remote sensing, a majority of the data comes from different country-based survey and censuses at national level, which often do not provide data resolution at the urban or sub-urban level. Indicators like GDP, population density or sheltering needs are not collected at a resolution that can be applied to a given urban area. While there have been efforts to collect data for urban areas, most notably the Resilience Capacity Index, they are not widely spread and have not been applied to the developing world. Examples of similar types of efforts include the UNDP's Disaster Risk Index, The Human Development Index, the Global Adaptation Index, among others. These types of data are helpful in the project identification and planning stages to give a relative sense of the resilience of an urban area and to identify other urban areas that have faced similar resilience issues.

Concluding Remarks

Quantifying the impacts of planned or proposed investments, in order to reduce risk, is a critical need. Having a flexible, dynamic, and simple tool such as InaSAFE to assist in this is a step towards more resilient decisions. It is still however imperative to invest in the underlying science to produce robust hazard and risk information that can then be integrated within a chosen decision support tool. Data systems and risk analysis ought to receive the attention of governments, donors, the private and civic sectors, as they are vital for well-informed decision-making towards effective mitigation of disasters impacts. It is important that urban planners have a clear strategy that includes local government units, communities and stakeholders in the process of data gathering, analysis and management. The end goal should be to have a governance system that sees the value of data and uses as they see fit.

Further Reading

Using High Resolution Data for Identification of Urban Natural Disaster Risk (World Bank 2012).

Volunteer Technology Communities: Open Development (World Bank/GFDRR Labs, 2011).

2.8 RISK FINANCING AND TRANSFER APPROACHES

Economic | Social

Key Points

- Financial resilience is a key component in a comprehensive disaster risk management strategy.
- Disaster risk financing and insurance instruments provide financial protection against impacts from natural disasters, but do not reduce the overall amount of damages and losses.
- According to the risk layering approach, risk retention, risk financing, and risk transfer instruments should be selected to cover disasters of different frequency and severity.
- Financial risk assessment and catastrophe risk modeling tools assist in assessing the economic and budgetary impact of disasters.
- The development of standardized exposure database of public and private assets at risk is particularly important for all fiscal risk management strategies including the development of private catastrophe risk insurance markets.

Summary

Financial approaches to urban disaster resilience aim to reduce the negative impacts of disasters on individuals, communities, private and public sectors. With high concentrations of people and assets, as well as their socio-economic, business and trade, political and institutional role, cities need to strengthen their financial resilience. In the aftermath of a disaster, financial strategies can help increase the financial response capacity of governments across all levels, while protecting their long-term fiscal balances. Provisions to ensure quick access and disbursement of funding for the repair and recovery process can help minimize the disruption caused by a disaster, and reduce the economic and fiscal burden by transferring losses through a range of mechanisms including private capital and insurance markets. In the continuous effort to develop a suite of instruments and services relevant for local governments and cities, there are lessons that can be learnt from the current disaster risk financing and insurance interventions available at the sovereign and national level. This section provides an overview of select risk financing and transfer mechanisms.

Box 38. Key terms

Risk Financing refers to the process of managing risk and the consequences of residual risk through products such as insurance contracts, catastrophe bonds, reinsurance, or options.

Risk Layering is the process of separating risk into tiers that allow for more efficient financing and management of risks.

Risk Pooling is the aggregation of individual risks to manage the consequences of independent risks.

Risk Retention refers to the process whereby a party retains the financial responsibility or loss in the event of a shock.

Risk Transfer is the process of shifting the burden of financial loss or responsibility or risk financing to another party, through insurance, reinsurance, legislation, or other means.

Source: Catastrophe Risk Financing in Developing Countries. Principles for Public Intervention. Cummins and Mahul, World Bank, 2009.

Cities and Risk Financing

With an increasing concentration of people and assets in high risk zones, cities are becoming more vulnerable.[167] The combination of rapid and unplanned urbanization, poorly constructed settlements and degraded ecosystems, often in already hazardous areas along the coastline, in flood plains, or along seismic rifts, puts at risk a growing number urban dwellers, businesses, public and private infrastructure, with serious implications for economic growth and sustainable development as well as regional and global trade patterns.

The development of disaster risk instruments for cities and local governments is challenging. Often, due to the localized nature of hazards in cities, such as flooding, limited scale for efficient risk pooling, and high vulnerability of its dwellers and assets, risk financing and transfer mechanisms unaffordable or unviable. In addition, cities and local governments face constraints because of limited financial resources, capacity or availability of risk information.

In overcoming these challenges, it is crucial to invest in the development of robust risk information which can inform disaster risk financing, and more broadly, disaster risk management, strategies; and to explore ways for cities and local governments to benefit from the current disaster risk financing and insurance mechanisms available on the market in developed and developing countries. Some institutions, including the Asian Development Bank (ADB), have recently started to target local and provincial governments to offer a suite of products which are more suited for the needs of urban areas. **Box 39** provides further information.

Risk Information

The development of risk financing and insurance strategy depends on the availability of robust data and models assessing the key elements of risk. Risk assessment provides detailed analysis of hazard, exposure, and vulnerability, feeding into urban development plans, investment strategies as well as financial mechanisms. Advances in risk mapping, hazard forecasting brings considerable benefits for all levels of government, local authorities, households and business. For instance, better flood risk information and forecasting allows for better flood risk prediction for public and individual assets, which helps with planning for and protecting against the risk of flooding.

Initially developed by the insurance industry, probabilistic risk modeling can help decision-makers when dealing with uncertainty over

Box 39. Financial instruments for cities and local provinces

The Asian Development Bank (ADB) is currently developing an Integrated Disaster Risk Management (IDRM) framework that incorporates elements of disaster risk reduction (DRR), climate change adaptation (CCA), and disaster risk financing (DRF). The purpose of the IDRM framework is to recognize linkages and synergies across many areas of DRM and to leverage these synergies to craft risk management solutions for member countries. ADB is paying particular attention to the disaster management needs of urban areas. A combination of factors, including urban migration, concentrated economic development, expanded infrastructure, and climate change, has given rise to the need to develop urban-specific IDRM strategies and instruments.

With the support of the Japan Fund for Poverty Reduction (JFPR), ADB has begun work with the governments of the Philippines, Indonesia, and Viet Nam to launch disaster finance programs for two cities in each country. The programs will start with urban risk profiling, which will support the development of city selection criteria through a collaborative process involving key government agencies and development partners. Following city selection, DRF options will be developed and tested through consultations and workshops to assess feasibility and market acceptance. DRF options may include disaster liquidity mechanisms, critical asset and infrastructure insurance, and social protection programs directed at households and small business involving micro-insurance or micro-finance. The three projects are scheduled for completion in 2014.

Source: World Bank/GFDRR, Advancing Disaster Risk Financing and Insurance in ASEAN Member States: Framework and Options for Implementation (2012).

Box 40. The Pacific Catastrophe Risk Assessment and Financing Initiative

The Pacific Catastrophe Risk Assessment and Financing Initiative (PCRAFI) is a joint initiative among the Secretariat of the Pacific Community SPC/SOPAC, the World Bank and the Asian Development Bank, with financial support from the government of Japan and GFDRR.

Detailed risk assessments were conducted for 15 nations in the Pacific region covering the entire landmass of Cook Islands, Federated States of Micronesia, Fiji, Kiribati, Marshall Islands, Nauru, Niue, Palau, Papua New Guinea, Samoa, Solomon Islands, Timor Leste, Tonga, Tuvalu and Vanuatu. Quantifying potential disaster losses from earthquakes, tsunamis and tropical cyclones, the GIS database includes the most comprehensive analysis of buildings, infrastructure and cash crop exposure ever conducted for the region.

The data, shared through the Pacific Risk Information System (PaRIS) forms base for future projects related to macroeconomic planning and disaster risk financing, mitigation investments, including urban land and infrastructure planning, and rapid post-disaster damage and loss estimation. Serving as a regional database for the risk information, PaRIS contains country-specific catastrophe risk models, offering technical tools for the development of affordable disaster risk financing and insurance solutions for the Pacific Island countries.

Source: World Bank, Pacific Islands: Disaster Risk Reduction and Financing in the Pacific, (web).

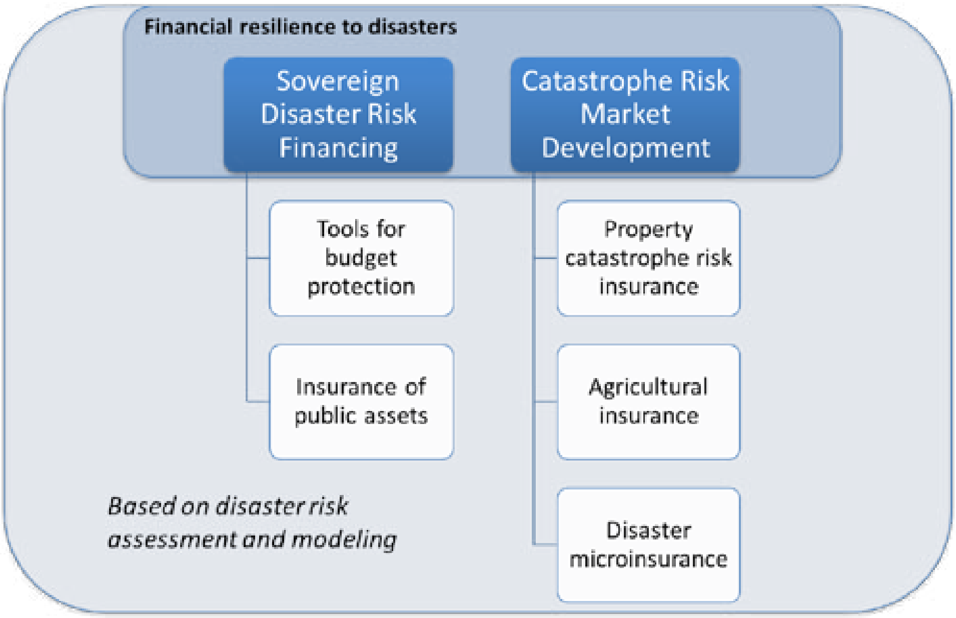
current and future risks. In urban areas, probabilistic risk assessments can guide urban planning, ensuring that buildings, schools, hospitals and other assets are located in safe areas. More recently, probabilistic risk models have also been coupled with climate change models to account for future changes in hazards and over time.[168] The outputs of probabilistic risk assessments have many uses, including insurance premium calculations for provision of accurate information about annual expected loss and probable maximum loss for a location. For example, the Government of Mexico developed the disaster risk assessment tool, R-FONDEN, to assess the contingent liability of the National Disaster Fund (FONDEN) with respect to natural disasters and to design its national disaster risk financing strategy implemented by FONDEN.[169] See **Box 41** for more information about FONDEN.

Investing in reliable risk information data, financial risk assessments and catastrophe risk modeling tools can help decision-makers assess the economic and budgetary impact of disasters. Standardized exposure database of public and private assets can assist in guiding fiscal risk management strategies including the development of private catastrophe risk insurance markets. The development of risk datasets can be an expensive process, especially for cities or small governmental entities. The Pacific Catastrophe Risk Assessment and Financing Initiative (PCRAFI) helps small islands countries in overcoming the burden of the initial investment and reap the benefits of sharing robust risk information among stakeholder for future projects and applications (see **Box 40** as well as **Chapter 2, section 2.7 on Risk Information**).

Disaster Risk Financing and Insurance

Risk financing plays an important role in a comprehensive disaster risk management strategy. This includes continuous effort in risk identification and assessment, emergency preparedness, risk reduction and mitigation measures, emergency and recovery planning, and institutional capacity building. The primary objective of World Bank's Disaster Risk Financing and Insurance (DRFI) program[170] is to increase financial resilience to disasters and to achieve increased financial resilience at the level of i) sovereign disaster risk financing to improve the government's financial response capacity while maintaining its long-term fiscal balance, and (ii) catastrophe risk market development to increase cover of residents, businesses, and agricultural producers (see **Figure 14**). This approach focuses primarily on interventions at sovereign and national level. While many of the general principles are widely applicable, more needs to be done to understand and develop appropriate interventions at the urban level.

FIGURE 14 World Bank disaster risk financing and insurance approach to building financial resilience at the sovereign/national level



Source: World Bank/GFDRR DRFI program, website (link), 2012.

Sovereign Disaster Risk financing

Sovereign disaster risk financing provides financial strategies to increase the financial response capacity of governments in the aftermath of natural disasters, while protecting their long-term fiscal balances. Delays in accessing and disbursing funding in the aftermath of a disaster can have serious socioeconomic consequences at both the macroeconomic and household levels.[171] The government has a variety of options for fiscal and market-based instruments to finance disasters that can be categorized as either ex-ante or ex-post. Figure 15 lists some of the most common sources of post-disaster funding, and indicates their use in the aftermath of a disaster.

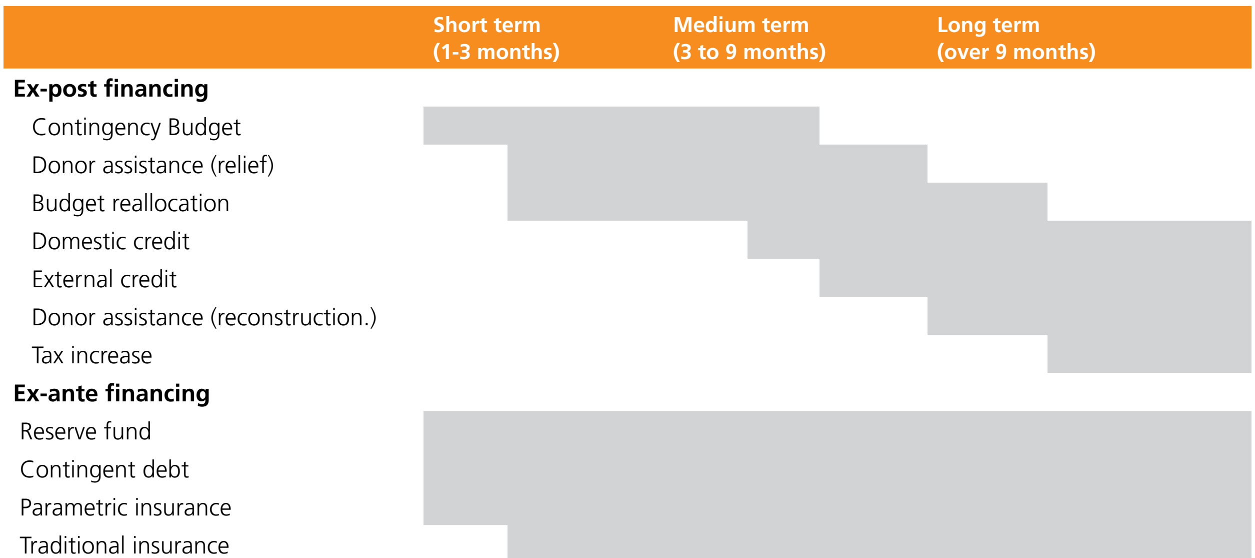
Ex-ante financing mechanisms can provide the government with immediate access to liquidity in the relief and early recovery phases. This includes budget reserve, contingent credit lines, and transfer mechanisms – such as catastrophic risk insurance, risk pools, weather derivates, catastrophe bonds, and others. Ex-post funding mechanisms include budget reallocation, domestic credit, external credit, tax increases and donor assistance. While post-disaster funding can be available, disbursements are not assured and may be donor dependent, which can have severe negative impacts following a large-scale disaster. For the recovery and reconstruction phases, governments typically mobilize funds through ex-post instruments, such as deficit spending, tax increases, spending cuts, and (recovery) loans.

Selecting Risk Financing and Transfer Options

The choice of financial instruments depends on the specific funding needs and time constraints linked to a disaster and the relevant phases of relief, recovery, and reconstruction. Once the needs and constraints are identified, appropriate ex-ante and ex-post instruments can be chosen. An optimal approach to financing disasters at the sovereign level generally combines ex-ante and ex-post instruments. The consequent development of a risk financing strategy is guided by the risk layering approach.

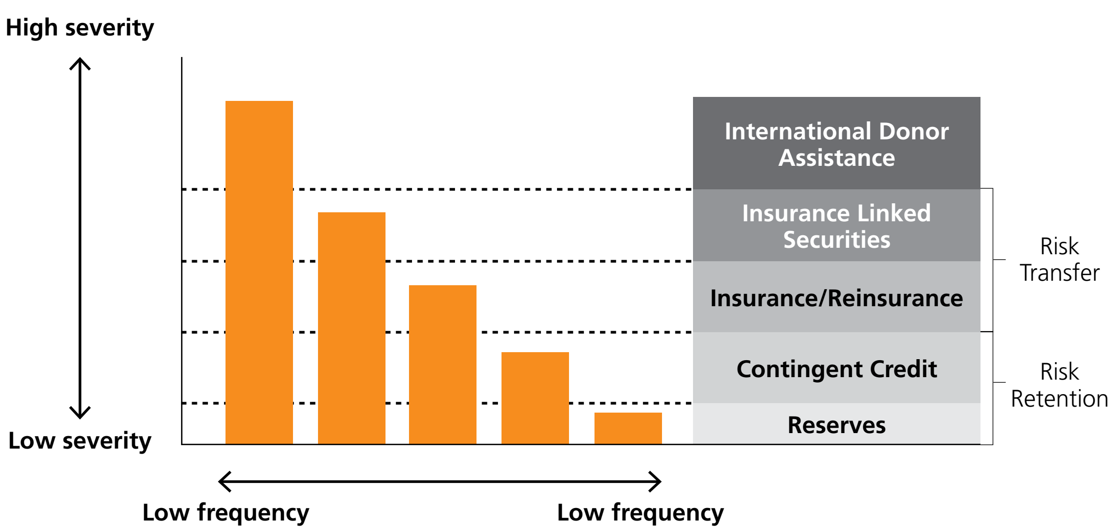
Risk layering is the process of separating risk into tiers that allow for more efficient financing and risk management.[172] The frequency and severity of disaster guide the selection of risk retention, risk pooling and financing, or risk transfer mechanisms. In accordance with the risk-layering approach, different layers of risk are addressed by different instruments. Typically, low severity and high frequency risks, such as annually occurring floods or drought, can be self-financed through annual budget (disaster) reserves. Medium severity and medium frequency risks are addressed through the use of contingent lines of credit. Low frequency and high severity risks, which cause extensive damage such as earthquakes or tsunamis, should be transferred to the risk market through catastrophic risk insurance, risk pools or catastrophe bonds. **Figure 16** lists some of the products available as part the layering approach to increasing its fiscal and economic resilience.

FIGURE 15 Sources of post-disaster funding



Source: Ghesquiere and Mahul, 2007.

FIGURE 16 Types of risk and possible sources of funding



Source: Cummins and Mahul, 2009.

A country's fiscal risk profile and socio-economic situation as well as the cost and availability of products on national and international markets shape the selection of appropriate (mix of) risk instruments. Liquidity situation, procedural arrangements on disbursement, reserve budget allocations, regulation on international donor assistance, and the borrowing capacity of the countries also influence the timing in accessing and disbursing funds and consequently the selection of instruments. The availability of instruments in local and international markets, as well as the client group (households, communities, businesses, national, regional or international entities) will determine the choice of risk financing tools. **Box 39** described Mexico's efforts in developing a comprehensive disaster risk financing strategy.

Risk Retention

For high frequency/ low severity events the risk of damages can be covered by retaining mechanisms including budget reserves, contingent financing, reserve funds, or pooled reserves. Budget mechanisms are the most cost-effective option for annual or highly recurrent events. However, there are often political and budget constraints to maintaining large disaster reserves. The World Bank provides support to its IBRD and IDA countries with ex-ante contingent credit, grant agreements, and emergency response mechanisms. An overview of select contingent and emergency and crisis response instruments currently available to IBRD and IDA countries is in the **Table 15**.

Contingent financing can take the form of self-standing contingent loans or ex-ante emergency components of standard investment operations. **Contingent components** as part of investment lending (IL) projects have been put in place for example in Bangladesh, Grenada, India, Indonesia, Lao PDR, St Vincent and the Grenadines.[173] In Lao PDR, following the following Typhoons Haima and Nok Ten in 2011, the contingent component was utilized to meet immediate emergency road repairs.[174] The Development Policy Loan (DPL) with a **Catastrophe Deferred Draw Down Option** (CAT DDO) is an example of a self-standing contingent financing provision budget support for IBRD countries. **Box 40** provides further information.

Emergency instruments, such as the **Immediate Response Mechanism** (IRM), or the **Crisis Response Window** (CRW) can provide beneficiaries with rapid

TABLE 15 Overview of World Bank contingent and emergency and crisis response instruments

Mechanism	Eligibility	Instrument	Comments
Contingent Emergency Response Components	IDA, IBRD	Investment Lending (IL), Development Policy Loan (DPL)	Preparation is done in advance through allocating a specific sum or a "zero" component into standard lending project. For IDA countries, ex ante funding of contingent components comes from a country's IDA allocation.
Catastrophe Deferred Draw Down Option	IBRD	DPL	Preparation done in advance, following standard DPL procedures. Access up to US$500 million or 0.25% of GDP whichever is less. Once request to drawn down CAT DDO funds following a disaster is received by IBRD, funds typically transferred within five business days.
Immediate Reponses Mechanism	All current IDA beneficiaries	IL	Allows for use of 5% (or $ US 5 million) undisbursed IL portfolio (re-structuring). Preparation work done in advance of crisis; approval within 1 week of borrower request; first disbursement possible within 1 week of approval.
Crisis Response Window	IDA only	IL, DPL	Provides limited additional finances. Average time from concept to approval 6.8 months; average time from approval to effectiveness 4.0 months.
Emergency Recovery Loans	IDA, IBRD	IL	Post-disaster lending instrument following standard procedures.

Source: Adopted from World Bank (2011) Proposal for an IDA Immediate Response Mechanism.

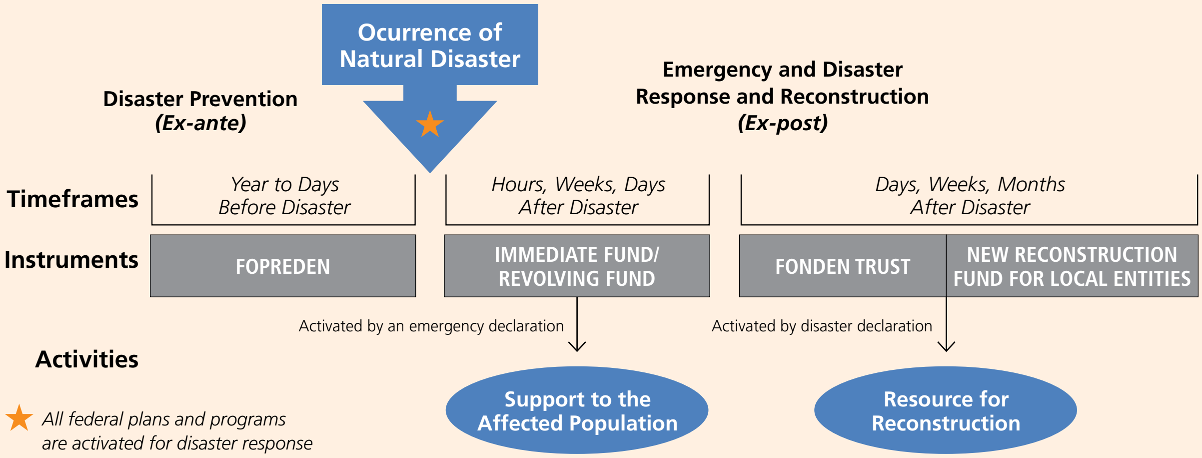
Box 41 Mexican Natural Disaster Fund (FONDEN)

To address its vulnerability to natural disasters, over the years, Mexico has developed a comprehensive financial protection strategy relying on risk retention and transfer mechanisms, including reserve funds, indemnity-based reinsurance, parametric insurance, and catastrophe bonds.

Founded in 1996, the **Fund for Natural Disasters** (FONDEN) was originally established as a budgetary tool through which federal funds were annually allocated for expenditure on post-disaster response. Since then, FONDEN has evolved significantly. In 1999, a catastrophe reserve fund -the FONDEN Trust Fund - was established to enable the accumulation of unspent portion of annual budgetary appropriation. In 2005, the Government of Mexico empowered FONDEN to develop a catastrophe risk financing strategy to leverage its resources, relying on a layered combination of risk retention and risk transfer instruments. In 2006, FONDEN issued the world's first government catastrophe bond, which was renewed in 2009. As of now, FONDEN consists of two complementary budget accounts, the FONDEN Program for Reconstruction and FOPREDEN Program for Prevention, and their respective financial accounts. Note that fiduciary responsibility for the financial accounts lies with BANOBRAS, Mexico's state-owned development bank.

- **The FONDEN Program for Reconstruction** is FONDEN's primary budget account.
- **The FOPREDEN Program for Prevention** supports disaster prevention by funding activities related to risk assessment, risk reduction, and capacity building on disaster prevention.
- **The FONDEN Trust** provides resources for the activities of the FONDEN Program, and acts as the contracting authority for risk transfer mechanisms, including insurance and cat bonds.

FIGURE **The Role of FONDEN's Instruments in Mexico's National System of Civil Protection**



Source: World Bank/GFDRR, Advancing Disaster Risk Financing and Insurance in ASEAN Member States: Framework and Options for Implementation (2012).

Using market- based risk transfer instruments: To manage the volatility of demand on its resources, FONDEN is allowed to transfer risks through insurance and other risk transfer mechanisms such as catastrophe bonds. However, FONDEN is not allowed to contract debt. FONDEN first transferred disaster risk to the international capital market in 2006 for US$160 million parametric catastrophe bond against earthquake risks in three zones for a three year duration. In addition, it secured US$290 million of parametric reinsurance coverage for the same three zones for three years, bringing its total protection to US$450 million. When this cat bond expired in 2009, FONDEN increased its cover by issuing a three-year, US$290 million multi-peril parametric catastrophe bond for earthquake and hurricane. Most recently, in 2011 and 2012, it secured a US$400 million excess-of-loss reinsurance cover for losses from damages to government assets and low-income housing exceeding US$1 billion over one fiscal year.

Source: FONDEN: Mexico's Natural Disaster Fund – A Review (2012).

Box 42 Development policy loan with a catastrophe deferred draw down option

Launched in 2008, the World Bank's Development Policy Loan (DPL) with catastrophe deferred draw down option (Cat DDO) offers immediate post-disaster liquidity to cover urgent financing needs in the aftermath of a national disaster while other resources, including national, bilateral aid, or reconstruction loans, are mobilized. The Cat DDO has a 'soft' trigger, as opposed to a parametric trigger; funds can be drawn down upon the occurrence of a natural disaster resulting in the declaration of a state of emergency. Borrowers are required to have an adequate integrated disaster risk management program in place, which is periodically reviewed by the World Bank.

Six countries in the Latin America and the Caribbean region have made use of this instrument. The Philippines was the first country in the East Asia Pacific region to sign a contingent credit (amounting to US$500 million) for natural disasters with the World Bank in mid-2011. This contingent credit was drawn down on December 29, 2011, following the devastating impacts of Tropical Storm Sendong (Washi).

Further information: World Bank/ GFDRR Disaster Risk Financing and Insurance (DRFI) Program (website).

or additional finances. Putting the IRM in place requires an operations manual and up-front agreements with countries on detailed implementation arrangements. The CRW provides limited additional post-disaster financing which can be accessed after severe exogenous shocks. Financing from the CRW can only be accessed after a severe exogenous shock. An **Emergency Recovery Loan** (ERL) is an ex-post mechanism to support economic and social recovery immediately after an extraordinary event that seriously disrupts a borrower's economy. They are also used to strengthen the management and implementation of reconstruction and recovery efforts, and to develop disaster-resilient technology and early warning systems to prevent or mitigate the impact of future emergencies.

Risk Transfer

When expected losses are beyond one's ability to self-finance, countries can opt for risk transfer mechanisms. These mechanisms transfer financial risk of disaster loss to a third party who provides coverage given certain disaster event. Risk transfer mechanisms allow for the mobilization of funds without additional post-disaster impact on budgets. The examples listed in below refer to risk transfer mechanisms developed for the use at the sovereign and national level.

Catastrophe Risk Insurance

Risk insurance in public and private sectors can help to reduce the contingent liability of governments and help increase the resilience of a society as a whole. [175] Traditional catastrophe risk insurance is indemnity-based: payouts are based on damages incurred by the insured, according to the terms of the policy. This type of catastrophe insurance is appropriate for governments concerned about incurring extreme aggregate or cumulative losses, but may not address immediate budgetary needs following catastrophic events and may be difficult in countries lacking insurance market infrastructure. For budget insurance, innovative parametric insurance products are increasingly being used by governments. Parametric insurance is a type of risk transfer where financial payouts are initiated according to a pre-determined indicator such as rainfall, soil moisture content or wind speed.

Insuring critical public infrastructure (hospitals, schools, bridges, etc.) can help reduce contingent liability of the state. Some countries require that public assets have property insurance coverage against natural disasters. This is the case in some Latin American countries, including Costa Rica, Mexico, and Colombia. In practice, most public assets to remaining under- or completely uninsured, in part due to limited resources and risk information.[176] In some countries, sub-national governments, including those of some cities, are proactively insuring their critical assets. In Indonesia, the municipality of Yogyakarta has insured its public assets since 2003, including government buildings, schools, hospitals, traditional market places, and motor vehicles. After a 2006 earthquake, the municipality received a payout of IDR3.4 billion, which represents 14 times the annual premium paid.

Catastrophe Risk Market Development

Private catastrophe insurance can help homeowners, small and medium enterprises, and governments shift the burden of disaster liability. In developing countries, private insurance markets are often under-developed, meaning that catastrophe losses are primarily borne by the population and the government. The development of these markets increases insurers' share in disaster losses. Particularly in middle-income countries, where asset bases at-risk are rapidly expanding, functioning catastrophe risk insurance markets play an important role in mitigating the financial and fiscal impacts of a disaster.[177]

Often, government intervention is required to support the development of catastrophe risk insurance markets. Governments can play an important role in supporting market growth. Governments can set an enabling legal and regulatory framework (see also **Box 44**). They can provide "risk market infrastructure," or public goods that contribute to market growth, such as product development, catastrophe risk assessment and pricing methodology, and underwriting and loss procedures. Investing in standardized exposure database of public and private assets at risk is particular important for the development of private catastrophe risk insurance markets.

Catastrophe Insurance Programs

In many countries, the government has gone further and engaged in public-private partnerships (PPPs) with the private sector to increase catastrophe insurance coverage.[178] Often, these PPPs take advantage of risk pooling to reduce costs and increase financial resilience to catastrophes. Although catastrophe insurance programs are most often found in high-income countries, in recent years, some middle-income countries, such as Turkey and Romania, have joined this list. The World Bank together with other international organizations works with low- and middle-income countries to develop property catastrophe insurance programs. The Turkish Catastrophe Insurance Pool (TCIP) is a public sector catastrophe insurance company – with distribution through Turkish insurers – with private sector reinsurance (see **Box 43**).[179]

At a city-level, for localized hazards, such as flooding, risk pooling might not be possible given the systemic nature of risk, making risk pooling unviable. Participation of city dwellers in a broader risk pooling mechanism (for instance on a regional scale, or including other hazards) which would spread the risk is one of the ways of addressing this issue. However, decision-makers are faced with the dilemma of supporting accumulation of assets in hazardous areas. This is an issue common to regional and national schemes (see **Box 45**). At the same time, insurance companies highlight that while some insurers are at an advantage of providing products to low risk customers, others have to offer cover many high risk properties. Some countries and insurance programs have put in place incentives for residents to take preparedness measures rewarded by lower insurance premiums.

Box 43 Turkish catastrophe insurance pool

The Turkish Catastrophe Insurance Pool (TCIP) was established in 2000 to overcome problems of market failure in Turkey, specifically the lack of local market earthquake capacity and low voluntary demand for earthquake insurance. The facility was developed by the Government of Turkey, in collaboration partner organizations including the World Bank, with the aim to establish a compulsory earthquake insurance scheme to increase uptake and to create a pool for earthquake risk that would build the capacity of the domestic insurance market to underwrite earthquake risk while isolating it from the risk of insolvency from an extreme event. Domestic insurers underwrite catastrophe risk but pass the risk onto the pool which is supported by risk capital from the international reinsurance community, the government, and donors. TCIP is a public sector insurance company that is managed on technical and commercial insurance principles. The TCIP purchases commercial reinsurance and the Government of Turkey acts as a catastrophe reinsurer of last resort for claims arising out of an earthquake with a return period of greater than 300 years.

Source: World Bank/GFDRR, Advancing Disaster Risk Financing and Insurance in ASEAN Member States: Framework and Options for Implementation (2012).

Box 44 Flood insurance in the United Kingdom

In the United Kingdom, privately provided insurance enables individuals to mitigate their flood risk. Unlike in the US, where flood insurance is sold as a separate policy, in the UK, flood cover is 'bundled' into standard insurance policies, available almost universally. As a result, the majority of people who insure their property against fire and theft are also insured against flooding with an estimated 95 percent of domestic buildings covered.

Through this agreement domestic flood risk is transferred to the private market. Commercial flood risk is also potentially insurable in the UK and public infrastructure can be insured or self-insured by local authorities and infrastructure companies. It leaves the central government supporting local authorities in the cost of emergency management, a fraction of the total costs from flood events. However, this system also leads to complacency and lack of preparedness among residents at risk of flood and can lead to lack of incentive for the government to invest fully in flood defence.

This agreement, which runs until June 2013, is based on a division of responsibility whereby the government primarily funds flood defenses and in return insurers agree to pick up the residual risk and provide insurance cover to most properties at flood risk. The Government and insurance industry are currently discussing a new agreement. The Government is for instance considering how the existing cross-subsidy that takes place within the insurance industry can be adjusted to make sure insurance prices remain affordable. The Government is also working with local authorities and other partners to look at the extent to which communities, through acting together, can help to manage the costs of flood insurance.

Source: Land et al, 2009 in World Bank (2012, p.340) Cities and Flooding: A Guide to Integrated Flood Risk Management for the 21st Century; and DEFRA 'Progress on affordable flood insurance' published 11 July 2012, link.

Box 45 The Southeast Europe and Caucasus catastrophe risk insurance facility

The Southeast Europe and Caucasus Catastrophe Risk Insurance Facility (SEEC CRIF) project is facilitating the development of national catastrophe and weather risk markets in the region through the design and introduction of innovative, low-cost insurance products, insurance business production technologies, regulatory reform, consumer education, and provision of reinsurance services. Under the project, a new platform to provide low-cost insurance service infrastructure, including access to web-based insurance production and claims settlement technologies was developed. The platform supports sales of complex catastrophe and weather risk insurance products. The facility will develop new, standardized weather risk insurance and reinsurance products; automate insurance underwriting, pricing, and claims settlement processes for such products; and increase public awareness of weather risk in participating countries.

Source: World Bank, 'Improving the Assessment of Disaster Risks to Strengthen Financial Resilience. Experience and Policy Lessons from the Work of the World Bank', 2012.

Regional insurance schemes can lower the cost of insurance by pooling risk. By entering regional insurance collective, insured parties pay an annual premium proportionate to overall risk exposure and receive compensation according to an agreed coverage contract. A portion of the pooled risk is retained through a joint reserve mechanism, which reduces the cost of insurance premiums. This can be particularly advantageous for smaller countries, who would otherwise face high premiums. The Caribbean Catastrophe Risk Insurance Facility (CCRIF) is an example of a successful regional catastrophe pool, which functions as a mutual insurance company controlled by participating governments. The facility was initially funded by participating countries and donor partners, including the World Bank. Since becoming operational in 2007, CCRIF has disbursed more than US$30 million to the participating Caribbean countries affected by natural disasters to help them finance their immediate post-disaster expenditures. CCRIF relies on a parametric trigger.

Alternative Risk Transfer

Alternative risk transfer (ART) refers to any non-traditional form of insurance risk transfer.[180] ART primarily takes the form of risk-linked securities that transfer catastrophe risk to the capital markets. A catastrophe (cat) bond is an ART instrument which transfers catastrophe risk to capital market investors. A "sponsor" transfers catastrophe risk to a Special Purpose Vehicle (SPV) through a reinsurance contract. The SPV acts as an intermediary with the capital markets and issues notes to investors; the terms of the notes mirror those of the reinsurance contract – in other words, investors will collect the premium paid by the sponsor, but they risk losing this premium and sometimes a portion or all of the funds that they have spent on the bond if a triggering catastrophe occurs. The SPV collects premium from the sponsor and manages the collateral account with investors' funds. If no triggering events occur during the life of the bond, then the SPV returns the principal to investors with the final interest payment. As mentioned above, if a triggering event occurs during the life of the bond, then some or all of the principal is transferred to the sponsor and payments to the investors cease.

Countries with developed risk financing strategy can make use of catastrophe bonds. In 2009, the Government of Mexico issued a multi-peril, multiyear catastrophe bond (US$290 million) under the World Bank sponsored MultiCat Program. The issuer is a Special Purpose Vehicle (SPV) that indirectly provides parametric insurance to the government's Natural Disaster Fund (FONDEN) against earthquake risk in three regions around Mexico City and against hurricanes on the Atlantic and Pacific coasts. The bond will repay the principal to investors unless an earthquake or hurricane triggers a transfer of the funds to the Mexican government.[181]

Further Reading:

- *Policy Options for Disaster Risk Financing and Transfer and Issues in Quantification of Disaster Losses and Exposures: An OECD Perspective in Improving the Assessment of Disaster Risks to Strengthen Financial Resilience (World Bank, 2012).*
- *Advancing Disaster Risk Financing and Insurance in ASEAN Member States: Framework and Options for Implementation (World Bank/GFDRR, 2012).*

Disaster Micro-Insurance

The poor generally have limited access to formal sources of credit, private insurance against risk or social insurance. Because of low or lacking income, unstable wages, or the inability to meet interest or premium payments, the poor often rely instead on mechanisms such as savings, informal insurance and reciprocal exchange arrangements like kinship ties, community self-help, and remittances. Many households will use harmful coping options, such as reducing consumption expenditures on food, health, and education, or will attempt to increase incomes by sending children to work. People in these situations are often forced to take out high-interest loans, default on existing loans, sell assets, or engage in low-risk, low-yield farming to lessen their exposure to extreme events.[182]

Micro-finance institutions (MFs) provide solid networks for delivering additional services to promote resilience and reduce vulnerability to disasters. In Bangladesh, El Salvador, India, and Nicaragua, MFIs have integrated loans for housing repair or reconstruction, in particular, into their portfolios for those in poor communities.[183]

Micro-insurance mechanisms are designed to facilitate access to disaster insurance products to protect the livelihood of the poor against extreme weather events. In recent years, a number micro-insurance schemes have been developed or extended to cover disaster risks. These mechanisms often promote disaster risk reduction in conjunction with social programs such as conditional cash transfer programs. There are also examples of bundling with savings programs, such as the Self-Employed Women's Association's (SEWA) micro-insurance program in India which allows its members to save for insurance through fixed deposits in savings accounts.[184] **Box 46** provides an example of a micro-insurance initiative launched in 2004 in India. Index based insurance is an approach that has been tested in a number of countries and has helped poor farmers manage weather-related risks and herders manage risks related to livestock losses.

International (re)insurers and brokers are also beginning to participate in the more developed micro-insurance markets.[185] This can facilitate the growth of supply of more sophisticated products. For example, in Indonesia, Allianz underwrites two group micro-insurance products that are distributed through microfinance institutions and community-based organizations. In the Philippines, Munich Re reinsures

Box 46 Insuring the poor against disasters

In 2004, the All India Disaster Mitigation Institute (AIDMI) and the ProVention Consortium introduced a micro-insurance project, Afat Vimo, under a Regional Risk Transfer Initiative (RRTI). RRTI partners included the Hazard Risk Management Unit of the World Bank and the IFRC. Afat Vimo aimed at converging micro-insurance, microcredit, and micro-mitigation for low-cost local risk transfer. It provides disaster insurance for the poor, insuring policyholders against 19 types of disasters (eg earthquake, cyclone, landslide, etc). Non-life damages to a policyholder's house, household assets, trade-stock, and losses of wages and livelihood were covered up to Rs. 75,000. The life insurance component paid out Rs. 20,000 in the case of death. The yearly premiums amount to Rs. 146 (roughly three days' wages).

The insurance product was unique, as it combined non-life and life insurance from different companies into one policy. AIDMI acted as an intermediary between the communities and the companies. It paid the policyholders' premiums upfront, to ensure immediate coverage - collecting payment later - and supported them with claims settlement and provided training in disaster preparedness and legal/procedural requirements. Within 20 months of its creation, Afat Vimo's membership increased by 675 percent, with renewal rates averaging around 88 percent, indicating the popularity of its unified policy design. Afat Vimo then faced the challenge of scaling up the operation and maintaining feasible operating and administrative costs.

Source: World Bank, 2009, p 82.

a parametric credit portfolio protection underwritten by the umbrella cooperative and licensed composite insurer Cooperative Life Insurance and Mutual Benefit Services (CLIMBS). Zurich Financial is underwriting property catastrophe micro-insurance for Holcim Ltd. that will be available for purchasers of Holcim construction materials or fertilizers.[186]

Women frequently face additional barriers to accessing credit or insurance due to higher poverty levels, eligibility criteria biased towards male heads of household, and lack of access to information about their options. Collateral can be a particular problem, as land or other assets are often legally in the name of the male head of household only. Being largely engaged in lower-paid occupations and in the informal sector, many poor women find it difficult to generate savings for self-investment in income-earning opportunities or to cover expenses in the event of a major shock. Female-headed households are also often risk-adverse to investment of their scarce resources for uncertain future benefits.

Social protection initiatives that support poor women to establish local savings groups have a demonstrated track record of helping women to improve their situation. Funding can also be channeled through microfinance institutions and savings societies to meet women's credit and insurance needs. Investment in informal insurance mechanisms, such as health associations and burial societies, further offer accessible options to protect women and their families from post-disaster impacts.

Further Reading

2009 Global Assessment Report – Practice Review on Innovations in Finance for Disaster Risk Management, (O'Donnell, I.,ProVention Consortium 2009).

How to Design and Implement Gender-sensitive Social Protection Programmes: Toolkit. (Overseas Development Institute, 2010).

Resilience, Equity, and Opportunity: The World Bank's Social Protection and Labor Strategy 2012–2022 (World Bank, 2012).

Concluding Remarks

Risk financing and transfer approaches provide tools and strategies for increasing resilience against the impact of disasters. They must be implemented as part of a comprehensive approach to disaster risk management. Investing in robust risk information on hazard, exposure and vulnerability is vital for the development and use of risk financing instruments. Current disaster risk financing and insurance mechanism provide a number of options for sovereign risk financing, small and medium sized business, as well as families and individuals. Developing a suite of instrument relevant for cities and local governments is an area where further research is needed.

Chapter 3
The Practice of Urban Resilience

Key Points

- ***Resilience can be built into all urban sectors****. Water supply and wastewater systems, energy and communications, and transportation systems deserve particular attention of urban planners and policy-makers as they are vital for the quick recovery of the community and its livelihoods.*
- ***An understanding of current and future risks and uncertainties, the possibility of failure as well as planning for failure in a way that causes the least damage possible*** *need to be considered as part of any measure taken within the built or natural environments.*
- ***Any measures must be aligned with building social and institutional resilience,*** *relying on stakeholder and community participation, good governance, livelihoods improvements, and sustainable development and planning.*
- ***The complexity of built and natural infrastructure*** *in an urban area will determine specific strategies and concrete steps in enhancing urban resilience.*
- ***The four essential strategies for building resilience in urban sectors*** *focus on the management of: locational, structural, operational and financial aspects of risk. These strategies do not preclude each other. Most successful strategies will rely on a mixture of them.*
- ***A locational approach is an effective long-term method*** *for addressing disaster risks, particularly suitable for new infrastructure development and planning.*
- ***Avoidance, relocation and redundancy*** *are options within the locational approach.*
- ***A structural approach is a medium-term method*** *for addressing risk and is most effective for existing infrastructure.*
- ***Green and "grey" infrastructure measures, and actions within the legislative and socio-cultural environment*** *can be taken as part of the structural approach.*
- ***Operational mitigation addresses the possibility of system failure and plans contingencies once failure has taken place****. Operational measures should always be considered even when locational, structural and fiscal measures have been implemented.*
- ***Disaster management and emergency response systems*** *with assigned responsibilities, clear procedures and regular trainings, end-to-end early warning systems, and damage assessments tools, form part of the operational approach.*
- ***A fiscal approach addresses both short- and long-term financial needs*** *of specific sectors.*

KEY RESOURCES

Section		Resource
3.1	Water Supply, Wastewater Systems and Flood Resilience	***Cities and Flooding: A Guide to Integrated Flood Risk Management for the 21st Century***. *World Bank, 2011.*
3.2	Energy and Communications	***Community Greening: How to Develop A Strategic Energy Plan***. *United States Department of Energy, 2009.*
3.3	Transportation Systems	***Effects of Catastrophic Events on Transportation System Management and Operations - Comparative Analysis***. *United States Department of Transportation, 2004.*
	All sections	***Keeping the Country Running: Natural Hazards and Infrastructure. A Guide to improving the resilience of critical infrastructure and essential services***. *UK Cabinet Office, 2011.*

3.1 WATER SUPPLY AND WASTEWATER SYSTEMS

Infrastructural

Social

Key Points

- Water supply and sanitation infrastructure ranges in complexity based on the size of the urban area and the population served.
- The location of buildings, transmission-distribution systems and storage facilities should avoid hazardous zones through risk assessment and risk-based land use planning.
- Redundancy, which creates multiple systems that provide the same service, is applied to water supply and wastewater treatment by creating secondary facilities, redundant transmission-distribution pipelines or multiple water storage facilities.
- A structural approach for increasing the resilience of water supply and wastewater systems will involve strengthening measures, building codes and maintenance works.
- Operational mitigation for water supply and wastewater facilities includes disaster management systems and alternative equipment (e.g. chlorine and iodine tablets; emergency water treatment generators; bottled water, etc.).

Summary

Water and wastewater systems are crucially important for public health and the quick recovery of the community and its economy. Reducing the potential for catastrophic failure of water supply and sanitation helps to make an urban community more resilient. The mitigation framework for risk reduction, discussed in **Chapter 1**, uses structural, locational, operational and fiscal approaches to address resilience. These approaches, further discussed in **Chapter 2** generally deal with the infrastructural, institutional, economic and financial components of resilience. The following sections give an overview of the water supply and sanitation systems and suggest concrete steps for enhancing resilience.

Urban infrastructure for water supply and sanitation ranges in complexity based on the size of the urban area and the population served. Most urban projects work with partially planned systems that provide adequate services to only a portion of the population, while the other portion of the population are use ad hoc systems that are not properly planned. Water supply and sanitation are vulnerable to a wide range of natural hazards, particularly flooding, but there are many opportunities for enhancing resilience. The goal for urban planners is to understand the full water supply and sanitation systems in an urban area and develop clear strategies to address deficiencies.

Overview of water supply and sanitation systems

Urban water supply systems range in complexity but they all have a source, transmission-distribution infrastructure and storage facilities, which should include the capacity to treat raw water, ending in the conveyance of purified water to a population. Complex water supply systems will have treatment facilities, often near a water source, which will convey the water under pipelines or aqueducts to individual homes. Simpler transmission-distribution systems may only include pipelines from individual wells. A majority of urban infrastructure projects will be a mix of both complex and simple transmission-distribution systems.

Sanitation systems, typically called wastewater systems, function in the reverse order from water supply, conveying wastewater from individual buildings through sewers to a sewage treatment plant. Wastewater can either have combined sewers, which include human waste as well as storm water run-off, or separated sewers. Combined sewers require greater resources in order to process and treat water, but are often still implemented in areas that do not process wastewater or because separated sewers are complex and resource intensive. Processing wastewater can involve primary, secondary and tertiary treatments. Depending on the quality of water treatment, the resulting treated water may be returned to rivers or oceans but away from human populations, as it will never be fit for human consumption.

Water Supply and Distribution

Sources for water can include single wells, aquifers, rivers or lakes. Transmission infrastructure will include the pipeline required to convey water as well as a mechanism to create pressure through gravity or hydraulic pressure. Storage facilities can be large municipal storage tanks, tanks providing for small communities, individual jugs or even the water source itself. There are many forms of water treatment, but chlorine is most prevalent in the developing world. Water can be purified at the source, in transmission or in storage facilities. Most urban water supply projects will be a combination of planned and unplanned systems, and it is critical to understand how both systems work practically throughout the urban areas.

When considering water supply, it is critical to understand long-term demand when evaluating the resilience of water supply. Projecting future water demand against total supply over a ten or twenty year period will give a more complete view of the actual capacity of a body of water or an underground aquifer to supply water to an expanding urban area. Larger urban areas may already have multiple sources of water supply, which is a form of resilience through appropriate redundancies, but sources must also be unified by an effective transmission-distribution system. Smaller and newer urban will most likely be exploiting surface water, but may not be accessing underground aquifers, which may be a way of building out multiple sources.

When dealing with transmission-distribution systems, it is critical to understand daily and monthly demand over an annual period, as the resilience of a system may change considerably over the course of a year. Urban transmission-distribution systems convey water through large transmission mains or aqueducts that spread out to smaller pipes and individual home. These transmission systems create pressure either through gravity, but where water sources are at lower elevations, hydraulic pressure may be used. Smaller urban areas generally have gravity fed transmission-distribution systems or rely on pumping through generators.

Increasing the capacity to store water is an important factor for resilient water supply systems, but the ability to keep water potable

must also be considered. Both storage and treatment facilities will depend entirely on the type of water source and transmission-distribution systems. In more complex water supply systems, large storage tanks of finished water can hold enough drinking water for the whole population for a week, but other simpler systems will convey water to local storage tanks that hold water for a few families. In general, treatment of water at the source is more efficient from a systems perspective, but the ability for that water to remain potable may be in doubt when considering the conveyance system and how the water will be stored. In many cases, it is more efficient to treat water once it has reached the storage facility. Raw water is generally treated with chlorinates which kill pathogens.

Wastewater Systems

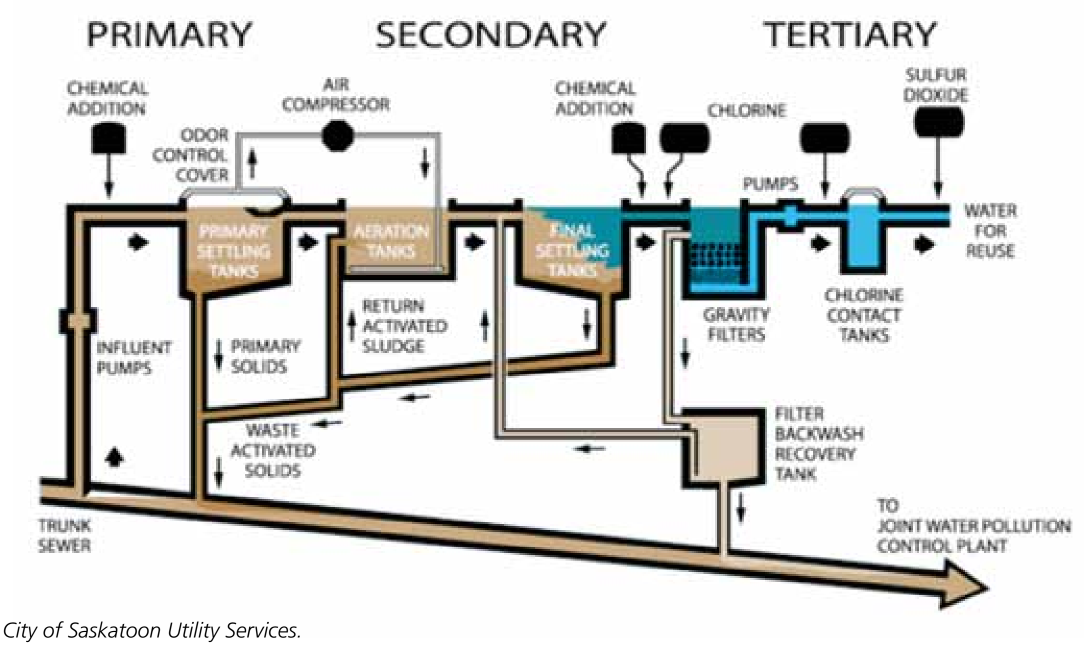
Developed urban areas have the capacity to remove or treat wastewater. In larger, more advance urban wastewater systems, wastewater is separated in two systems for household/industrial and water run-off, but the majority of wastewater systems still use combined sewer pipes. Older communities tend to have combined sewers and require more resources in order to treat wastewater and so often drain sewage directly into water sources or open drainage ditches. Ideally, separate wastewater systems should treat both household/industrial waste and runoff, but is not common in practice. Separate systems can lead runoff directly to outlets but channel sanitary waste to treatment plants. **Figure 17** illustrated a wastewater treatment process.

Wastewater treatment plants follow a multi-step process, including pre-treatment, primary, secondary and further tertiary treatment. Pre-treatment includes screening, grit and grease removal and primary treatment includes removal of heavier solids via settlement. Secondary treatment includes digestion of organic materials via water-borne micro-organisms, which is typically discharged into water sources. Tertiary treated water, which removes many remaining pollutants, also termed recycled or reclaimed water, is increasingly the trend, as it may be discharged, or used for irrigation of parks, agriculture or for industrial purposes. Where wastewater systems are more developed in urban areas, it is more common to find secondary treatments, but examples of tertiary treatment have been implemented. **Figure 18** describes a wastewater facility in California.

FIGURE 17 Wastewater treatment process

Source: New Mexico State University.

FIGURE 18 Wastewater treatment facility in Saskatoon, California



Source: City of Saskatoon Utility Services.

Enhancing Resilience of Water Supply and Sanitary Systems

Locational Mitigation

Avoidance represents the longest time horizon and requires and applies to water supply systems and wastewater treatment facilities that have not yet been built. Urban planners need to ensure the buildings, transmission-distribution systems and storage facilities have been located in areas that avoid hazardous zones through the use of **risk assessments** and **risk-based land use planning** (see Chapter 1, section 1.5, and Chapter 2, sections 2.1 and 2.2.). Avoidance may not be entirely appropriate when the nature of the hazard impacts an entire urban area or when the benefits of circumventing a hazardous zone are outweighed by the resources required. Box 45 describes the impact of Cyclone Sidr in Bangladesh on the water supply and sanitation facilities.

Relocation will follow the same methods as avoidance, but with an increased opportunity cost of installing new infrastructure to replace current systems (see also Chapter 1, section 1.7, and Chapter 2, section 2.3). **Redundancy**, which creates multiple systems that provide the same service, is applied to water supply and wastewater treatment by creating secondary facilities, redundant transmission-distribution pipelines or multiple water storage facilities. When building redundant systems, it is important to address demand following the failure of portions of the system to ensure there will be enough supply.

Structural Mitigation

Structural approaches, seek to prepare critical infrastructure for a wide range of potential hazards when locational approaches are not feasible. As with locational approaches, **risk assessments** and **risk-based land use planning** (see Chapter 2, sections 2.1 and 2.2.) will be the critical first step in understanding what types of hazards present risks and how critical infrastructure may be enhanced. A structural approach for increasing the resilience of water supply and wastewater systems will involve **strengthening measures** and **building codes**. This approach will be particularly effective for risk reduction from flooding, earthquakes, landslides

Box 47 Impact of cyclone Sidr on Bangladesh water supply and sanitation facilities

On 15 November 2007, Cyclone Sidr struck the southwest coast of Bangladesh with 240 kilometers per hour winds and a six-meter storm surge. Water supply and sanitation facilities were severely impacted with reported damage to 11,612 tube wells, 7,155 ponds and over 55,000 latrines. Damage for these totaled US$ 2.28 million. Human waste was generally not treated and waterborne disease was a major public health problem. Drinking water sources (tube wells and ponds) in many communities were contaminated by saline water and debris and power outages affected water supplies in areas with piped water. In addition, in many areas groundwater sources were contaminated by arsenic and salinity in shallow aquifers, and the lack of deep aquifers. The people of this area rely on pond water, and often use Pond Sand Filters. Damage to sanitation facilities and infrastructure was also significant in all the worst affected areas surveyed. Sanitation needs were significant for an estimated 1.3 million people. For some of the worst affected areas, physical damage to household latrines was fairly common, with one estimate putting the percentage of slab latrines damaged or destroyed as high as 70%.

Source: Cyclone Sidr in Bangladesh Damage, Loss, and Needs Assessment for Disaster Recovery and Reconstruction. 182pp. A Report Prepared by the Government of Bangladesh Assisted by the International Development Community with Financial Support from the European Commission, 2008.

and storms. **Figure 19** provides an example of mitigation infrastructure.

FIGURE 19 Example of structural measures against flooding

Communal toilets elevated against flooding, Cambodia; *Source: Charles Scawthorn*.

In the long run, water supply and wastewater treatment facilities can be strengthened by through **legislative action** to develop and implement **effective building codes** that address relevant disaster risk. In addition to addressing buildings, storage facilities, which can be very large, can also benefit from building codes. **Strengthening** can apply to the buildings, transmission-distribution system and the storage facilities. Strengthening buildings can be achieved through a structural analysis, which may suggest reinforcing retaining walls or creating floodwalls or berms around buildings (**Figure 20**). In extreme cases, portions of a building, or the entire building, can be elevated to be at a higher elevation than floodwaters.

FIGURE 20 Water treatment plant protected by berm walls in Blair, Nebraska

Source: Washington County Pilot-Tribune and Enterprise, 2011.

Transmission-distribution systems, whether above or belowground, can always be strengthened as well. Below ground pipes can be upgraded to withstand certain amount of earthquake shock as well as shifts as a result of a landslide. This includes a backbone system that replaces portions of the pipes with materials that are built to withstand certain forces. The cost of this option will depend heavily on the urban area. Aboveground aqueducts can be strengthened in the same way as building by **reinforcing** using buttresses. **Storage facilities** can be elevated off the ground to prevent intrusion by floodwater, but elevation can also present certain risk as a result of earthquakes. Reinforcing the tank may be a viable option. Box 47 describes the water supply improvement program in San Francisco.

Operational Mitigation

Operational mitigation addresses the possibility of system failure and plans contingencies once that failure has taken place. Operational mitigation for water supply and wastewater facilities includes disaster management systems and alternative equipment. These measures are particularly effective for flooding, earthquakes, storms and a majority of natural hazards. **Disaster management systems** can be crucial in the resilience of water supply and wastewater facilities (see Box 49). This type of planning can be a relatively cost effective way to prepare for disasters. Please refer to Chapter 2 for a description of how to implement disaster management systems.

In the case of a large disaster, water treatment and wastewater facilities will fail and **alternative equipment** will be necessary. In lieu of potable water, either treatment tablets or finished water must be delivered to populations. Both availability and logistical capacity will be required to meet the basic needs of the population, taking into consideration that:

- **Chlorine** and **iodine tablets** can kill pathogens, but **sediment filters** are also needed.

Box 48 San Francisco Water Supply Improvement Program

Built in the early to mid-1900s, by 2000 many parts of the San Francisco water supply system were nearing the end of their working life, with crucial portions crossing over or near to three major earthquake faults. In 2002, San Francisco launched the $4.6 billion Water Supply Improvement Program to repair, replace, and seismically upgrade the system's deteriorating pipelines, tunnels, reservoirs, pump stations, storage tanks, and dams. The program was funded by a bond measure in 2002 and includes more than 80 projects throughout the service area – from San Francisco to the Central Valley – to be completed by midyear 2016. WSIP is one of the largest water infrastructure programs in the USA, with the following objectives:

- Improve the system to provide high-quality water that reliably meets all current and foreseeable local, State, and Federal requirements.
- Reduce vulnerability of the water system to damage from earthquakes.
- Increase system reliability to deliver water by providing the redundancy needed to accommodate outages.
- Provide improvements related to water supply/drought protection.
- Enhance sustainability through improvements that optimize protection of the natural and human environment.

Source: www.sfwater.org.

Box 49 Resilience through mutual aid: water industry in the United Kingdom

"Under the Security and Emergency Measures Direction (1998) water companies are required to provide plans to ensure provision of the water supply. In 2004, the Water UK Council established a mutual aid protocol for all members to ensure delivery of water by companies during an emergency. The protocol includes agreements to share emergency equipment and support affected member company(s) during incidents. This enhances the resilience and contingency options available to the industry as a whole. This protocol was amended following the lessons the industry learned from the 2007 floods. Issues addressed include number and readiness of assets, technical compatibility of assets, means of managing and deploying staff and the resilience of the scheme to cater for simultaneous events."

Source: UK Cabinet Office, 2011, Keeping the Country Running: Natural Hazards and Infrastructure. A Guide to improving the resilience of critical infrastructure and essential services.

- **Emergency water treatment generators** have been successful following disasters, but require fuel sources and experts to repair them if they break down.

- **Bottled water** delivery has also been successful in specific disasters, but requires robust logistical capacity almost exclusive to militaries.

Operational measures should always be considered even when locational, structural and fiscal measures have been implemented. A successful combination will rely on a combination of different measures. **Box 50** provides a summary of measures aiming to enhance the flood-resilience of houses.

Concluding remarks

Water and wastewater systems are crucially important for public health and the quick recovery of the community and its economy. They are vulnerable to a wide range of natural hazards, particularly flooding, but there are many opportunities for enhancing resilience. Understanding, anticipating and preparing for disaster events is the essence of resiliency – if this done, losses are decreased and recovery hastened.

Box 50 Making human settlements more flood-resistant

House construction:

- Raising plinths and foundations.
- Combining a strong frame with lighter wall material that can be replaced after floods.
- Raising shelves to protect valuables.
- Using more-durable building materials that resist water damage.
- Planting water-resistant plants and trees to protect shelters from erosion.
- Establishing community committees to monitor construction quality and settlement planning.
- Doing community outreach to promote hazard-resistant design approaches in future building.

Settlement Planning:

- Prohibiting resettlement in the most hazardous areas, if possible.
- Improving access to safe land where feasible.
- Limiting obstruction of natural channels, using absorbent paving materials and roof catchments to reduce runoff designing drainage to minimize intensity of water flows.
- Raising and reinforcing access roads.
- Establishing community emergency shelters and evacuation routes.
- Setting up community early warning and monitoring systems to provide alerts of flood threats.

Source: Adapted from K Alam, M Herson and I O'Donnell, 2008, p. 11.

3.2 ENERGY AND COMMUNICATIONS

Infrastructural   Social

Key Points

- A combination of engineering, planning and emergency preparedness is required in order to enhance resilience in the energy and communication sectors.
- Avoidance by strategic location though the use of risk assessment and land use plans is needed when developing new energy or communications systems.
- Creating secondary conveyance systems of towers and cables can be a relatively low cost option when compared to interrupted services and necessary repair of downed lines.
- Structural mitigation may be a more practical form of resilience building with regards to energy systems, especially when there are locational constraints for generation facilities.
- Operational approaches to energy and communication systems include building reserve capacity, alternative equipment, understanding risks for critical infrastructure, and an emergency response system in place with effective training and procedures, as well as coordination among and participation of all the key stakeholders.

Summary

A combination of engineering, planning and emergency preparedness is required in order to strengthen resilience in the energy and communication sectors. A number of opportunities for enhancing resilience reside in reducing the initial loss, and the operational, structural, operational and fiscal mitigation framework is equally applicable for energy and communication systems (see **Chapter 1** and **Chapter 2** for core principles and tools). However, these systems can be quite vulnerable to particular hazards. Despite this, failures are inevitable, and local and emergency backup plans and equipment should be prepared in order to cope with loss of power and communications for several days. The following sections give an overview of energy and communication systems and suggest practical steps for enhancing resilience.

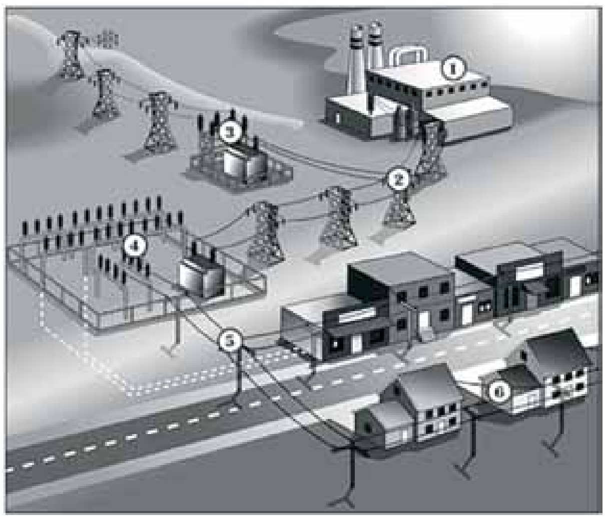
Energy and communications systems are crucially important for emergency response and the quick recovery of citizens and the economy. Energy in urban regions refers primarily to electric power, natural gas, or liquid fuels. The required infrastructure for each of these systems is essentially linear with regards to source, transmission, treatment and distribution. Communication systems are either uni- or multi-directional, but tend to be non-linear networks. Broadcast radio and television are examples of uni-directional transmission and the telephone and internet are examples of multi-directional systems. Multi-directional systems can be highly complex networks with as many 'sources' as 'receivers' and exponentially more paths.

Overview of Energy and Communications

Energy

Energy usage in developing cities is focused in the transportation sector, with buildings and industry lagging behind. Across the world, urban energy demand is predominantly coal, oil and gas. This demand is supplemented by nuclear, hydroelectric, biomass and other renewable sources.[187] Demand for electricity represents nearly 13% of that total energy demand.[188] While the overall energy budget is fairly consistent across all cities, the usage is considerably different in the developing world. Developed nations demand more energy for buildings and energy than for the transportation sector. **Figure 21** illustrates an electricity supply and distribution network.

FIGURE 21 Electricity supply and distribution network



Source: Black Hill Energy.

Liquid fuels for automobiles and other vehicles is produced at wells and conveyed by pipeline and/or ship to oil refineries. The refinery distils the raw petroleum into a variety of fuels, which are then piped or carried by rail or truck to urban distribution terminals, and finally to gasoline stations and other refueling depots.

Urban areas in the developing world primarily rely on fossil fuels, like coal, to generate electricity. Electric power systems are similar to water systems in that they are both source-transmission-distribution type networks. Electricity generation sources number from a few to a few dozen, and the distribution hubs within an urban area similarly number from a few to a few dozen, and is then conveyed to households and businesses. In urban areas with simpler systems, the generation sources can be more decentralized with private grids run off of gasoline generators or local coal markets that serve the community in a fairly resilient manner.[189]

Large-scale electricity generation begins with the transport of fuel to the power generation station. Fuel is stockpiled at the plant, and then ignited. Heat converts water to high-pressure steam, which then spins a turbine generator, which converts the energy into electric power. This power is transformed to high voltage in a substation and then transmitted to urban centers over Extra High Voltage (EHV) transmission lines, typically carried overhead on transmission towers. At other substations near the urban centers, the EHV is transformed to lower voltages for distribution with the urban region.

Electric power networks are relatively unique among infrastructure for a number of reasons. First, electricity is conveyed very quickly over power lines. Second, electric generators and substations have a fail-safe design that automatically disconnects the system if electric power fluctuations exceed relatively small tolerances. The resilience of these systems to handle internal shock is quite high. Electric grids are still susceptible to cascading failures when one failure will lead to multiple causing the system to shut down. The fail-safe protects the systems but also stops delivery of electricity very quickly, which can be very important following a natural disaster.

Communications Systems

Communication systems include radios, televisions, landlines, mobile phones and shortwave radios. Radio and television represent uni-directional communication, and the telephone, internet and shortwave radios represent multi-directional communication. Uni-directional systems are generally centralized in they can convey a single message from a source out to large audience; there is no mechanism to determine whether or not the message was received. Multi-directional systems provide clearer mechanisms to ensure receipt of a message, but are more decentralized.

One-way systems use transmitter at the source that sends out signals out over the air or via satellite. The television or radio then acts as the sole receiver of those signals and decodes the information into sound and video**.** Multi-directional systems use transmitters and receivers at both ends of the connection. In mobile phones, the call is sent from via radio waves to the nearest base station where it is transmitted via microwave or fiber optic to a central office, then is packet switched onward to the cell tower nearest the destination mobile phone, with the final link again by radio. Landline telephones function in a similar manner but will either rely on physical lines to complete the connection or will use satellite base stations to transfer the land line connection between locations.

The structure of the internet has grown rapidly over the last several decades, and is essentially a series of interconnected networks via internet service providers. Internet traffic is routed through this set of networks. Telephone voice calls may now be made directly over the internet using the voice over internet protocols (VoIP).

Enhancing Resilience of Energy and Communications systems

Energy Systems

Locational Mitigation

Electric energy generation and distribution systems are generally highly engineered and are usually built with hazard in mind, but **avoidance** by strategic location in **land use plans** may be needed as new systems are built (see also **Chapter 1**, section 1.5, and **Chapter 2**, sections 2.1 and 2.2). Depending on the type of energy source being used, it may be necessary to locate a generation station inside a hazardous zone. It will be more practical to focus on the transmission cables and towers to avoid landslide prone areas as well as areas that might experience high winds. **Electrical substations** should also be located at high elevations as they are very susceptible to flooding.

Relocation of generation stations or substations may be possible if new hazard risk is discovered, but the complexity of the infrastructure is such that it will be resource intensive. Again, transmission cables and towers should be considered if they are located in hazardous areas. Exceeding the demand for electricity through **redundancy** is an interesting form of locational mitigation because it does not require the abandoning existing infrastructure. Creating **secondary conveyance systems** of towers and cables can be a relatively low cost option when compared to interrupted services and necessary repair of downed lines.

Structural Mitigation

Structural mitigation may be a more practical form of resilience building with regards to energy systems, especially since there are constraints where generation facilities can be built. If a generation facility is built in a flood or earthquake zone, **strengthening** the area around the generation facility with berms and ensuring towers are supported in case of an earthquake could be very important. Much work has been done to develop seismically resistant substation equipment but substations continue to be one of the most seismically vulnerable links in the electric power grid. Electrical equipment is particularly vulnerable to water inundation and can cause catastrophic failure. In a similar manner, cables and towers falling in on the generation facility can cause damage that could shut down an electric grid for weeks following a disaster. Earthquakes can also cause secondary fires in generation facilities or as a result of fallen cables. Towers are particularly susceptible to high winds and ice storms. **Figure 22** gives an example of protective walls.

FIGURE 22 **Berm walls protecting an electricity plant**

Source: Power of Coal, 2011.

Operational Mitigation

Operational approaches to energy systems include building reserve capacity, alternative

equipment, understanding critical infrastructure and effective training and procedures. Urban disaster planning should always be prepared for the possibility of one or several major generating stations and/or transmission lines being simultaneously damaged by a natural hazard and losing function, perhaps leading to a cascading failure of the entire electrical grid, in either case resulting in partial or total loss of electric power for a region. Utilities operate with sufficient **reserve capacity** to cope with reasonably foreseeable sudden loss of supply, in order to preclude a cascading failure. **Spinning reserve** is immediately available additional capacity of the generators, in terms of rotational momentum of the generator and steam or hydro flow that can be quickly applied to the turbine. However, spinning reserve is expensive[190] and is normally kept as feasibly minimized as possible by operators. **Box 51** describes the 1998 and 2006 blackouts in Auckland, New Zealand.

Additionally, **alternative equipment** that includes a **quick-start capacity**, like hydroelectric power or gas, can provide an effective bridge while other utilities are being repaired. However, at peak consumption periods, these assets will typically already be on line, meaning the system will not have much excess capacity. When possible, it is also wise to build **reserves of alternative fuels**, like gas or petroleum, and then store them outside the urban area. It may also be possible to store fuel reserves specifically for emergency responders at local gas stations. Understanding critical infrastructure through effective **risk assessments** and **risk-based land use**

Box 51 Auckland blackouts – 1998 and 2006

The Auckland metro area is the largest urban area in New Zealand, with about 1.4 million residents (31% of the national population). In 1998 almost all of the downtown power was supplied electricity by via four power cables, two of them past their replacement date. One of the cables failed on 20 January and another on 9 February, increasing the load on and resulting in failure of the remaining two cables ten days later, leaving about 20 city blocks without power.

For the first few days few businesses could operate - some brought goods out onto the street to sell, but heavy rain in the first week made that impractical. Generators were brought in, which made the shopping district a very noisy place for customers. The event became an international media spectacle, with the story often giving the impression most of the city or even the entire island was without electricity. Ultimately, it took five weeks before an emergency overhead line was completed to restore the power supply, and for much of that time about 60,000 of the 74,000 people who worked in the area worked from home or from relocated offices in the suburbs. Some businesses relocated staff to other New Zealand cities, or even to Australia. The majority of the 6,000 apartment dwellers in the area had to find alternative accommodation. Temporary power was supplied for a while from large container ships at the port supplying power to the downtown grid. New power lines were strung along power poles alongside railway lines.

On 12 June 2006 power in Auckland was again interrupted at around 08:30 am due to a ground wire being dislodged in high winds and falling across a 220 kV line and the 110 bus bar below it, tripping both and disrupting many public services and businesses:

- Suburban commuter railway services were suspended.
- Over 300 groups of traffic lights were off.
- Some hospitals were closed and left only emergency services in operations.
- Radio station transmitters were taken offline for a period of time.
- Mobile phone and telephone service failures.
- People stuck in elevators in office buildings.
- End of semester exams due to be held that day at local universities were postponed.

Since the central business district was without power from the morning rush hours, business operations and traffic were disrupted severely. Many businesses sent their staff home.

Source: Ministerial Inquiry into the Auckland Power Supply Failure. Jun 21, 1998, New Zealand Herald.

planning will be very helpful to understand which sections of the urban area require energy in order to maintain basic services. Effective **training and procedures** that keeps system control equipment well maintained and operators well-trained, in the hope that system faults can be isolated in sufficient time to prevent dragging down the entire system. See **Chapter 2** for a description of how to implement disaster management systems.

Communications Systems

Locational Mitigation

Avoidance of hazardous zones in land use plans is important for transmitting and receiving towers for both types of communication as well as the switches that operate telephone systems. Depending on the type of hazard, this may mean towers should be placed either at high elevations to protect against flood damage, or at lower elevations to protect again high winds. As with most approaches, there are important trade-offs that the urban planner must weigh. Switches are particularly vulnerable to water inundation, and should always be placed at higher elevations. **Relocating** towers or switches once they are installed is also possible but it will be resource intensive. Creating **redundant** or alternate towers or a system of towers that serve multiple uses could be an effective and practical way to address disaster risk with locational mitigation.

Structural Mitigation

If a transmitting or receiving tower is located in a high wind, landslide prone or earthquake zone, **strengthening** the base structure with reinforcements is highly recommended. In a similar manner, a switch built at lower elevations and that is susceptible to water inundation should have berms built around it to protect against possible floodwater levels.

Operational Mitigation

Operational mitigation of communication systems requires urban planners to assume that communication systems will experience a catastrophic failure immediately following a disaster and that electric grid will not be operating. **Disaster management systems,** that assign the responsibility of different neighborhoods within an urban area, are essential. **Effective training** and **procedures** and **alternative equipment** are the most effective tools for this particular approach. **Box 52** discusses the relevance of social networks to disasters. Planning should stress low-tech solutions like motorcycles or bicycles with pre-arranged collection points for emergency responders so critical information can be conveyed quickly and effectively to the right people. **Alternative equipment** including shortwave radios and cell-on-wheels (COWS), which provide mobile service from a self-contained trailer, can allow emergency responders as well as the regular population to communicate across larger areas.

Concluding remarks

Modern societies are highly dependent on energy, particularly electric power, and have very low tolerance for loss of communications, so they are crucial for a resilient society. Energy systems are

Box 52 The relevance of social networks to disasters

Several studies investigating the use of Twitter and Sina-Weibo, another micro blogging site, following major earthquakes in Chile and China. Messages posted on Sina-Weibo were mainly categorized into five groups: opinion-related (33%), situation update (25%), general earthquake related (18%), emotion-related (16%), and action-related (4%). In another study, twitter responses were analyzed to determine the veracity of information that emerged on Twitter after the 2010 Chile earthquake.

The findings revealed that the propagation of tweets that correspond to rumors differs from tweets that spread factual news because rumors tend to be questioned and denied more than the news by the Twitter community. The conclusions that were drawn is that it is possible to detect the credibility of tweets, with 70% to 80% accuracy.

Source: Twitter for Crisis Communication: Lessons from Japan's Tsunami Disaster. Acar and Muraki, 2011.

relatively similar to water networks in the sense that they are linear infrastructure, which suggests that similar measures can be employed to enhance resilience. Communication systems are non-linear and present different issues. These systems can be quite vulnerable, so a combination of engineering, planning and emergency preparedness is required in order to achieve a reasonable degree of resilience. Failures to these types of infrastructure are inevitable following a natural disaster, and local and emergency backup plans and equipment should be prepared in order to cope with loss of power and communications for several days or a week. **Box 53** provides a good example of resilience efforts in the energy and communication sectors in the UK though the use of resilience standards.

Box 53 Resilience Standards for Communications and Energy Infrastructure in the United Kingdom

The UK Cabinet Office makes the following recommendations:

For mobile communications towers: "BS8100 provides a design standard for communications towers within the mobile and broadcast industry. Factors taken into account are the life-time of the structure, the geographic location i.e. vulnerability to hazards, and consideration of other infrastructure in the area. Hence, mobile communication towers are designed to withstand wind, debris and other natural hazards and as a result are rarely disrupted by the weather in the UK."

For electrical equipment: "Electrical equipment such as transformers and circuit breakers are vulnerable to temperature extremes, which can lead to power outages. The design standard IEC 61936-1:2010 provides common rules for the design and the erection of electrical power installations so as to provide safety and proper functioning for the use intended. IEC 61936-1 specifies a temperature range within which component parts of the electricity network should be designed to operate, for example outdoor components should function at ambient air temperatures of between -25oC and 40oC as calculated over a 24 hour period. Recorded extreme UK temperatures remain within this range, thus components designed to this standard would be expected to continue to operate during periods of extreme weather in the UK. In addition, critical circuits will have two levels of redundancy so that in the event of any minor faults the service will remain operational."

The UK energy sector under the direction of the Energy Networks Association (ENA) produced an Engineering Technical Report on Resilience of Flooding of Grid and Primary Substations (ETR 138). The electricity transmission and distribution industry has set out target levels (standards) of resilience for different assets within their sector, which includes a risk-based target of the 1 in 1000 (0.1%) annual probability flood for the highest priority assets within their Critical National Infrastructure. Other measures to improve resilience include the capacity to reconnect or provide an alternative energy supply to consumers.

Source: UK Cabinet Office, 2011, Keeping the Country Running: Natural Hazards and Infrastructure. A Guide to improving the resilience of critical infrastructure and essential services.Source: Twitter for Crisis Communication: Lessons from Japan's Tsunami Disaster. Acar and Muraki, 2011.

3.3 TRANSPORTATION SYSTEMS

Infrastructural Social

Key Points

- Risk assessments and risk-based land use planning aid urban planners in placing transportation systems into safe locations.
- The complexity of road transportations systems requires urban planners to focus on critical infrastructure that will be used for evacuation of affected population, transportation of emergency responders and of critical supplies.
- Resilient urban planning includes regular maintenance, strengthening and replacement on key road infrastructure including main thoroughfares, escape routes, bridges and tunnels.
- "Green" infrastructure offers a suitable alternative to "grey" infrastructure measures.
- Damage assessments assist cities in preparing for the failure of road networks.

Summary

To enhance resilience, urban planning needs to place transportation systems in safe locations and plan for the failure of those systems. Reducing the potential for catastrophic failure within the transportation system can be mitigated through structural, locational, operational and fiscal approaches to address resilience, discussed in **Chapter 1** and **Chapter 2**. The following sections provide an overview of the transportation system and make recommendation for concrete steps to enhance resilience in this sector.

All transportation systems have two fundamental dimensions – passenger, and freight, and both are essential for a resilient recovery. Transportation networks, which are almost exclusively non-linear, can make a significant impact immediately prior to and following a natural disaster. Emergency planners must pay special attention to transportation and take a multifaceted approach to building resilience. A single mitigation strategy will not be sufficient to allow critical goods and services to continue moving throughout an urban area after a disaster. Failure of road networks can have serious consequences for an urban area, and through impacts on supply chains, also for whole regions as well as global trade and commerce patterns.

Overview of Transportation systems

Road Transportation

Effective urban planning over a few generations can produce road networks that can withstand significant loads both in terms of heavy freight and density of vehicles. Road transportation networks provide both passenger and freight service simultaneously. In many countries, urban road networks are highly redundant and can be quickly reconfigured in the event of damage to a portion of the system. Planned road networks rely on a series of alternate routes that can effectively flow traffic around hazards, like flooding.

Urban expansion has put an enormous stress on the road systems, as communities expand without regard to urban planning. Ad hoc roads can quickly become major routes and divert traffic into bottlenecks. Moreover, many urban regions will have one or more critical bottlenecks, where a key bridge, tunnel or mountain pass constricts all or most traffic to a narrow and limited capacity section. These bottlenecks are typically the key vulnerabilities of the road network. Power supply outages can also severely disrupt traffic management but, in an emergency, that can be replaced with police on the street.

Rail Transportation

Rail systems are vital to most economies, since they move bulk commodities in quantities that are not otherwise feasibly moved on land. In most urban regions, commuter rail systems are also vital for most people. In both cases, the systems are much less interconnected than road systems, and are typically confined to a few rights of way. If these pathways are cut, rail systems will typically be severely curtailed if not fully interrupted. Urban areas present bottlenecks for rail lines as they pass through densely populated areas and intersect with road networks. These locations can cause multiple failures across different sectors, including energy and communication when they intersect in the same location. Railway systems are also vulnerable to disruptions in power supply, which may occur elsewhere in the overall network. This may or may not have been mitigated by having dedicated backup generators in place but these will also depend on fuel supply.

Air Transportation

Most urban regions may only have one or a few major air transport hubs; however they will also have a number of smaller airfields used by general aviation and the military that can be used as alternate sites. The key vulnerability of the air transportation system is the Air Traffic Control (ATC) system, which is a networked series of ground controllers that monitor and direct airplanes for safety. The ATC system in any region will consist of ground controllers who observe aircraft location and movement via radar, and hand-off aircraft to neighboring air traffic control centers as the aircraft move from one area of control to the next. The system is entirely reliant on electric power and communications. Airports, particularly at night, are very reliant on electric power, for runway and taxiway lighting as well as radar, communications and other needs, but often have their own backup power units.

Water Transportation

Water transportation almost exclusively addresses inland and ocean cargo. The only exception would be ferry services that bring people across bodies of water. Modern marine cargo facilities are typically highly concentrated, with all but the largest ports often having only one major container port, and a few oil and/or liquid natural gas (LNG) terminals.

Except for bulk goods such as oil, coal, wheat etc., most ocean cargo today is moved by large ocean-going container ships, which in most ports are confined to a relatively narrow dredged channel, to provide for the deep draft of large ships, via which they can reach ocean terminal piers and quays where the containers are loaded and unloaded. Landward of the piers or quays will be a large container yard and, often, warehouses, to store and handle the cargo. Some ports specialize in multi-modal operations, where containers are loaded directly from long dedicated trains to the ships. Inland marine (lakes and rivers) vessels are typically smaller ships and barges, which still account for an enormous amount of cargo.

Oil and LNG terminals will typically consist of a pier or dolphin (standalone offshore structure, floating or fixed) from which the liquid cargo is piped to onshore storage tanks. In the case of petroleum, a refinery is often located next to the terminal. Ocean and inland marine facilities are typically vulnerable to storm surge, flooding, earthquake shaking, tsunami and other disasters. As and where sea level rise occurs due to climate change, these types of infrastructure will have disproportionately increased vulnerability

Enhancing Resilience of Transportation Systems

Road Transportation

Locational Mitigation

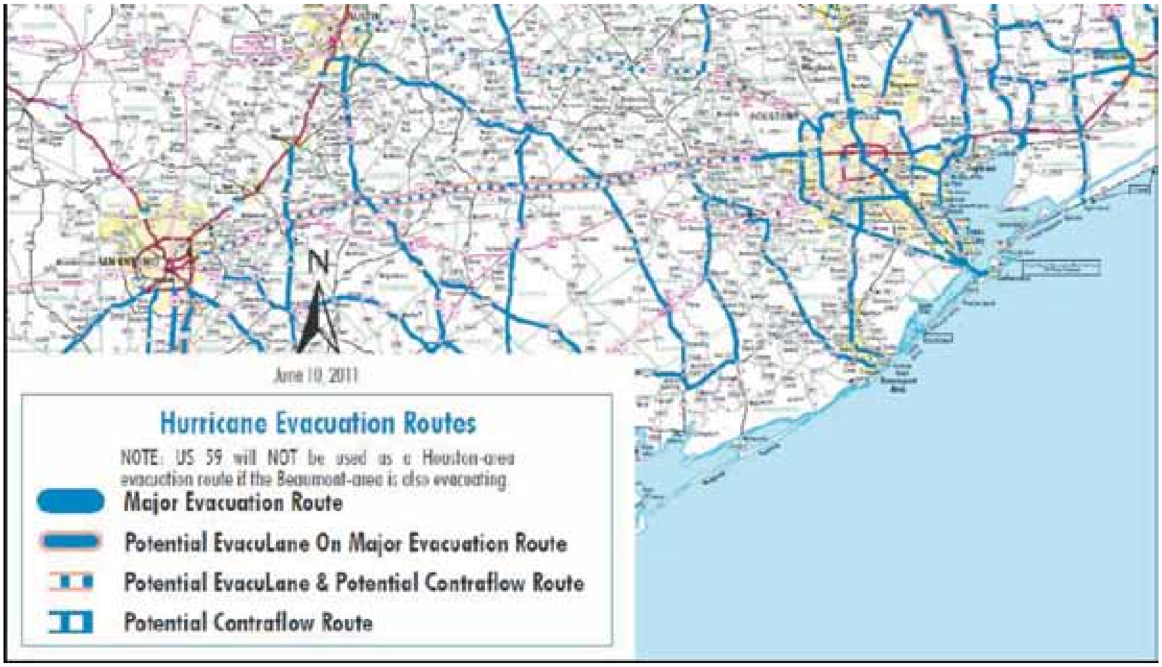
The complexity of road transportations systems requires that urban planners focus on critical infrastructure that will be used for evacuation of affected populations, transportation of emergency responders and of critical supplies (see **Figure 23**). When developing new road systems, **avoidance** of areas in lower elevations in land use plans will prevent roads from being inundated during floods. It is equally important to locate critical roads away from steep slopes to prevent roads from being swept away or over during a landslide. **Risk-based land use planning** and effective **zoning** regulations will assist in this process. See also **Chapter 1**, section 1.5, and **Chapter 2**, sections 2.1 and 2.2).

Although risk should be a priority, other objectives might compete in a rapidly expanding urban area. In addition to understanding risk from natural hazards, the number and location of bridges and tunnels on key infrastructure routes should be understood and addressed. Because communities in urban areas will be based around networks, a combined **redundancy** and **relocation** approach will most likely be required. Instead of removing unwanted infrastructure once new redundant roads are in place, older infrastructure will be de-prioritized in emergency planning.

Structural Mitigation

Resilient urban planning includes regular maintenance, strengthening and replacement on key road infrastructure including main thoroughfares, escape routes, bridges and tunnels. Roads can be strengthened using a variety of methods including buttressing underneath paved areas as well as building floodwalls or drainage ditches. It some areas it is common to place drainage ditches along the sides of roads as a means of wastewater and storm runoff control. Urban planners must be careful not to over stress systems that are already in place. Experts should inspect bridges and tunnels in order to understand the geological underpinnings of critical infrastructure relative to hazards. Additionally, widening roads above expected demand for roads is a way of creating safe and effective routes that can handle a mass evacuation. Planting trees along roads, creating bioswales, rain gardens and using porous pavement can all be effective ways to make use of **green infrastructure,** described in **Box 54**, as a means of strengthening road foundations and flood control. For more on ecosystem management and the use of green infrastructure, see also **Chapter 1, section 1.6 and Chapter 2, section 2.3**.

FIGURE 23 Hurricane evacuation routes in Texas, USA



Source: Department of Transportation, Texas.

Box 54 Green infrastructure and urban transportation systems

Surface transportation networks (roads, railways, sidewalks, parking lots, alleys and land-side port infrastructure) account for a significant amount of imperviousness in cities. This imperviousness increases surface runoff that, in turn, contributes to flood vulnerability. Green infrastructure can be a suitable approach to resilience because large amounts of funding are available from local transportation departments as well as private system operators. Funding is available for capital projects, as well as the repair, maintenance and improvement of transport systems. These funding sources can be leveraged to incorporate green infrastructure resilience measures into new projects, as well as in retrofits to large impervious areas.

Key considerations in the implementation of the green infrastructure approach in transportation projects are as follows:

- Resilient land transportation systems, by virtue of their broad spatial extent, should ideally be designed to avoid higher hazard areas, particularly at critical points like bridges and tunnels.
- The storage of rolling stock is generally less constrained by the actual alignment of the transportation network, and can be located in relatively lower-hazard sites.
- Vegetation and shading along the alignment of road and rail lines can decrease expansion and contraction caused by extreme temperatures. Fewer cyclic stresses result in slower deterioration and greater reliability of the transport infrastructure.
- Although informal settlements tend to be located on marginal lands, the transportation network needs to serve these areas as well, since evacuation routes should be available during emergencies or disasters. The co-benefits include improved access to markets and jobs for the informal settlers.
- Ideally, a process should be institutionalized to overlay various departments' project plans and scheduled capital improvement projects to identify how both public and private investments in green infrastructure can achieve co-benefits (storm water control, landslide mitigation, heat island reduction, etc.)
- Methods should be made available to determine what percentage of total project cost is represented by green infrastructure investments, and how this compares to traditional infrastructure. (e.g., green infrastructure can be used to reduce the concrete and asphalt needed for paving).

Operational Mitigation

Preparing for the failure of road networks requires the capacity to create reliable and meaningful **damage assessments**. The nature of disasters calls for both high and low tech solutions. Purchasing high-resolution imagery from satellites can give emergency managers easy and quick access to the state of road systems in a very large area, but they can be very expensive (see also **Chapter 2, section 2.7**). Decentralized assessments can be made by training individuals to be able to make quick damage assessments and deliver them to emergency planners. This requires more time, but less monetary investment. Once damage assessments are complete, there must be a way to effect critical repairs by clearing roads and replacing pavement or dirt where roads are impassable. High tech solutions involve keeping construction equipment on hand should a disaster occur. However this can often be accomplished with simpler traditional dirt and implements. It is vital to secure the capacity to make these repairs quickly so emergency traffic can make use of the roads. **Box 55** describes incentives for emergency repairs in California.

Further Reading:

Geo-hazard Management in the Transport Sector (World Bank, 2010).

Box 55 Incentives for emergency repairs

In the 1989 Loma Prieta earthquake, the California Department of Transportation was criticized for slow repairs of damaged highway overpasses. By the time of the 1994 Northridge earthquake, CalTrans was ready – when a large overpass on the Santa Monica freeway was heavily damaged, CalTrans implemented emergency repair measures which included a contract clause known as "A+B", a "cost-plus-time" bidding procedure that selected the lowest bidder based on a combination of the contract bid items (A) and the amount of time (B) needed to complete the project or a critical portion of the project, and which encouraged contractors to finish early by offering bonuses (incentives) for early completion and assessing fines (disincentives) for late completion. Incentives ranged from $20,000 to $200,000 per day. As a result, on five major projects, contractors finished anywhere from 8 to 74 days early, and received a total of over $23 million in bonuses (and no penalties).

Source: DeBlasio, et al., 2002.

Rail Transportation

Locational Mitigation

Depending on the type of available rail networks, urban planners will face different challenges. In most the developing world, rail networks tend to consist of a signal line arriving and departing from an urban area. Other regional, national or international authorities will control these rail systems jointly. Urban planners should work together with these agencies to build resilience together. In cases, where intra-urban rail networks exist, urban planners may have greater responsibility. Intra-urban networks that use above- and below-ground rails will necessarily be more complex, but will also tend to be more capacity for regulation. In any case, rail is unique in the transportation sector in that urban planners will be required to consider and understand the vehicles as well as the infrastructure.

Future rail networks will benefit greatly from **avoidance** approaches to ensure tracks are laid along higher elevations and away from natural or man-made structures that could possibly damage the system. **Relocation** will most likely be a longer-term, yet a more practical option once adequate funding is secured. Older tracks should not be discarded, but should keep in good repair as a **redundancy**. In this case, fences might be an option to discourage people from uprooting the tracks for profit.

Structural Mitigation

In addition to regularly running trains, a system for assessing the quality of the tracks in an urban area is very important. **Strengthening** measures will necessarily involve repairing the tracks as well as the foundation below the tracks. Where rail is located in hazardous zones, tracks may be raised or reinforced. Floodwalls or lowering the elevation of the area around the tracks may also be an option. **Green infrastructure** (see also **Chapter 1, section 1.6 and Chapter 2, section 2.3**), like trees planted a safe distance from the tracks may reduce flood vulnerability. Urban planners must be careful when planting trees as they can reduce the vulnerability of the system to earthquakes. Additionally strengthening measures should also incorporate the ability for railways to carry increased weight following a disaster that impacts critical supply chains.

Operational

Early warning systems and effective communication will allow trains to take adequate precautions during a natural disaster (see also **Chapter 2, section 2.6**). Slowing, stopping or reversing the course of a train will cause much less damage in an earthquake (see **Figure 24**), storm or flood. The same maintenance and repair system for railways will become integral following a disaster. As with road networks, the capacity to quickly prepare **damage assessments** is vital.

FIGURE 24 Railroad in New Zealand following earthquake

Source: American Geophysical Union.

Air Transportation

Locational Mitigation

Air transportation will have varying degrees of importance depending on the geographical location of the country and other types of transportation that handles critical supply for an urban area. Using **avoidance** or **relocation,** to place airports outside of hazardous zones, will produce the best results for keeping airport infrastructure safe from flooding, landslides. As with rail transportation, relocating an airport may allow urban planners to continue using the previous airport as a redundancy, but it is also possible to make use of smaller existing airfields, clear fields for lighter aircrafts and possibly use major road infrastructure as a redundancy as well. It may be equally important to create redundancies for the control systems that allow aircrafts to land, as they are vulnerable to earthquake, power outages and other hazards.

Structural Mitigation

Airport damage, which is commonly from flooding, may be mitigated through **strengthening** of floodwalls and berms. Because of the central importance of control towers, strengthening for earthquakes with berms around the base of the tower is particularly important.

Operational Mitigation

Early warning systems can provide precious time aircraft evacuation prior to a natural disaster. Regular **damage assessments** of transportation systems by trained responders may provide local authorities with the tools to prioritize repair and create strategies following a disaster. Additionally, the ability to quickly effect a **system reconfiguration** following a major disruption can allow for aircraft to operate at near normal conditions. Additional smaller airfields will tend to exist on the periphery or beyond the bounds of an urban area, and understanding runway lengths and maximum weight capacities can be very important. While this requires planning in advance of the disaster, it also requires well-trained responders who can quickly understand a situation and come up with a good strategy. **Box 56** describes the lessons learns from Hurricane Katrina in the air transportation sector.

Box 56 Air 2005 Hurricane Katrina: air service lessons

In the years preceding Katrina, airlines independently selected the time of their last flight before an approaching storm. This information was provided to LANOIA's Emergency Operations Coordinator for dissemination to the community as it became available. An operations plan was in place but it was flexible to allow for each storm's specific conditions. The plan permitted airlines to fly as long as they and the FAA Tower deemed weather conditions allowed for safe travel. Each airline made their own decisions within these parameters, with some choosing to cease operations sooner than others.

Immediately preceding Katrina, many airlines continued flight operations until approximately 4:00 pm, Sunday August 28th, 2005. Due to the relatively short planning window before Katrina, approximately 400 ticketed passengers were up stranded at the Airport terminal as Katrina made landfall. Hospitality leaders estimate an additional 10,000 visitors were unable to secure flights and returned to shelter in downtown hotels. Post-Katrina, the Airport was used as a nexus for evacuation and recovery operations. An old well on airport property provided potable water and a small generator provided limited electricity. A total of 30,000 evacuees were processed through the Airport following the storm.

Source: Amdal and Swigart, 2010.

Water Transportation

Locational Mitigation

The nature of water transportation systems is that infrastructure will be located within hazardous zones either because of vulnerability to flooding or other hazards like earthquakes, storms and landslides (see **Figure 25**). The traditional avoidance, redundancy and relocation may not be possible because of the nature of a waterway or harbor. It could also be that there is an acceptable level of locational risk associated this type of infrastructure. When possible, water transportation infrastructure should not be located on or near steep slopes and **avoidance** of these areas is recommended.

FIGURE 25 **Chinese fishing boats stranded along the Yangtze River**

Source: AFP, 2011.

Structural Mitigation

Structural mitigation of marine facilities should include **strengthening** of the ground adjacent to the water where there might be weak soil. Additionally, cranes and other large machinery should be reinforced to protect against earthquakes and high winds. Central offices or operations centers should have flood water and earthquake protection. It may also be possible to create **green infrastructure** (see also **Chapter 1, section 1.6 and Chapter 2, section 2.3**) that provides flood protection near impervious transportation surfaces (see **Box 57**). Surface transportation networks account for a significant amount of imperviousness in cities. This imperviousness increases surface runoff that, in turn, contributes to flood vulnerability. Green infrastructure can be a suitable approach to resilience. Funding is available for capital projects, as well as the repair, maintenance and improvement of transport systems. These funding sources can be leveraged to incorporate green infrastructure resilience measures into new projects, as well as in retrofits to large impervious areas.

Operational Mitigation

Early warning systems designed to give watercraft and water transportation facilities enough time to either evacuate or prepare for an imminent hazard is likely a practical and effective operational mitigation strategy. As with other transportation sectors, quick **damage assessments** and the ability to communicate that information to emergency planners will be key to returning facilities to operation.

Box 57 Using vegetation to limit the hazard of landslides in Seattle, USA

Landslides are a common hazard in Seattle as a result of intense precipitation and steep slopes, which causes significant impacts to the transportation system. In this area, landslides are also a secondary hazard from earthquakes and volcanic activity. In the 1990s, a study by the city government of Seattle found that a lack of vegetative cover was a major cause of slope instability, and new regulations were added to the Seattle Municipal Code pertaining to the maintenance and restoration of vegetation.

Project description: The starting point of this project was the development of the landslide map of Seattle, showing detailed information on landslide susceptibility, and a database of 1,400 landslides that occurred in the City of Seattle over the last 100 years. This provided an evidence base for decision-making and policy development for resilience against landslides. These policies are embodied in regulations and ordinances in the Seattle Municipal Code. The Regulations for Environmentally Critical Areas provide specifications for the use of vegetation on steep slopes and their buffer zones, and further mandates that construction methods should minimize the disruption of existing vegetation. Removal of trees or vegetation requires the approval of the City, and must have an associated tree and re-vegetation plan that utilizes native vegetation.

Stakeholder engagement: Seattle's Department of Planning and Development enforces the regulations on the use of vegetation in landslide-prone areas. However, the data gathering to identify hazard areas and effective prevention measures was carried out collaboratively between governments at the local, state and national level, together with research institutes and consultants. During the research phase of the project, public outreach was conducted to gather citizen opinions on the scientific approach to hazard mapping. The studies arising from the US Geological Survey Seattle Landslide Project were made available to the public, particularly to communities interested in the implementation of landslide reduction approaches. Since 1997, educational workshops on landslide hazards and mitigation approaches have been held for Seattle residents and developers. These workshops include discussions of the causes of landslides, proper drainage for sloping sites, and vegetation maintenance on slopes. The Department of Planning and Development also produces a series of Client Assistance Memos that detail the regulations affecting property owners and developers, particularly where grading is necessary for the construction of roads.

The Client Assistance Memo on "Environmentally Critical Areas: Vegetation Restoration" provides step-by-step instructions for designing and implementing vegetation restoration projects (assessment of location, preparation of a plan, choosing the plants, preparation of the site, carrying out the planting, monitoring and maintenance). It is emphasized that the ecological function of existing mature trees should be considered, and removal of existing tree canopy cover should be avoided when possible.

Key implementation lessons:

1. The development of a landslide hazard map and a database of historical landslide events provided a systematic knowledge base for determining where policies should be applied to manage risk.

2. The hazard to be mitigated (i.e., landslides causing destruction of infrastructure and disrupting the road network) was discussed fully with the community before the green infrastructure regulations were presented.

3. Stakeholder engagement and the dissemination of policies in the Seattle Municipal Code via operationally useful Client Assistance Memos ensured developers' familiarity with the City's green infrastructure regulations for increasing landslide resilience.

4. Collaboration with the US Geological Survey and private consulting firms allowed the use of the best available data, methods and experts from both the private and public sector.

Source: Green and Blue Space Adaptation for Urban Areas and Eco-Towns, 2010. Adaptation to climate change using green and blue infrastructure: a database of case studies. Manchester: University of Manchester.

Concluding Remarks

Transportations systems are vital for the quick recovery of the community and its economy. They are vulnerable to a wide range of natural hazards, but there are many opportunities for enhancing resilience. A number of these opportunities reside in reducing the initial loss. However, not all disaster risk can be prevented or anticipated, so encouraging resilience in transportation agencies, and of communities is of great value. **Table 16**, which summarizes lessons learned from the 2005 Hurricane Katrina, provides a good example for ways to improve transportation resilience.

TABLE 16 Summary of pre- and post -disaster policies

Pre-Katrina	Post-Katrina
Facility design assumed adequate flood protection	All critical building systems are designed to be flood resistant (i.e. elevated)
Allow evacuees to seek shelter in upper levels of selected buildings	Vertical evacuation is not an option
Shelters of last resort were utilized	Shelter of last resort is not an option
On site asset protection	Movable asset destinations out of harm's way
Limited evacuation response plan	City-Assisted Evacuation Plan (CAEP) now operational
No public transit for out-of-city destinations	CAEP now uses RTA, Amtrak and private carriers
Limited Memoranda of Understanding (MOUs)	New MOUs allow for maximum utilization of federal assets
Policy making did not incorporate transportation resiliency	Recent transportation policies and practices reflect some level of resiliency (i.e. CAEP)
Communication systems were limited	Little change, out of area cell phones provide backup communication
Limited offsite operation centers	Offsite operation centers have been established
Limited communication and coordination among transportation providers	Limited improvement
Selective use of Metropolitan Planning Organization as a resource base for data and intergovernmental networks	Metropolitan Planning Organization's pre-storm data and governmental / technical networks serve as valuable assets in a post storm environment

Source: Amdal and Swigart, 2010.

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Annexes

ANNEX 1 DISASTER DEFINITIONS AND CLASSIFICATIONS

(*Information in this annex is adapted from Centre for Research Epidemiology of Disasters website and publications*)

The Centre for Research Epidemiology of Disasters (CRED) defines a disaster as "a situation or event which overwhelms local capacity, necessitating a request to a national or international level for external assistance; an unforeseen and often sudden event that causes great damage, destruction and human suffering".

For a disaster to be entered into the database, at least one of the following criteria must be fulfilled: 10 or more people reported killed; 100 or more people reported affected; declaration of a state of emergency; call for international assistance.

EMDAT distinguishes 2 generic categories for disasters (natural and technological), the natural disaster category being divided into 5 sub-groups, which in turn cover 12 disaster types and more than 30 subtypes (tables below). The five-subgroup definitions are the following;

- **Geophysical**: *Events originating from solid earth (earthquake, volcano, dry mass movement).*

FIGURE 26 Natural and technological disaster classification

Natural Disasters

Biological	Geophysical	Climatological	Hydrological	Meteorological
• Epidemic Viral infectious disease Bacterial infectious disease Parasitic infectious disease Fungal infectious disease Prion infectious disease **• Insect Infestation** Grasshopper Locust	**• Earthquake** Earthquake Tsunami **• Volcano** Volcanic eruption **• Mass Movement Dry** Rockfall Landslide Avalanche Subsidence	**• Extreme Temperature** Heat wave Extreme winter condition **• Drought** Drought **• Wildfire** Forest fire Bush/brush fire Scrub/grassland Urban fire	**• Flood** General flood Flash flood Storm surge/coastal flood **• Mass movement wet** Rockfall Landslide Avalanche Subsidence	**• Storm** Tropical cyclone Extratropical cyclone Local storm

Hydrometeorological

Technological disasters

Industrial accident	Miscellaneous accident	Transport accident
• Collapse **• Explosion** **• Fire** **• Gas leak** **• Poisoning** **• Radiation** **• Other**	**• Collapse** **• Explosion** **• Fire** **• Other**	**• Rail** **• Road** **• Water** **• Air**

- **Meteorological**: *Events caused by short-lived/ small to meso-scale atmospheric processes, in the spectrum from minutes to days (storm).*
- **Hydrological**: *Events caused by deviations in the normal water cycle and/or overflow of bodies of water caused by wind set-up (flood and wet mass movement).*
- **Climatological**: *Events caused by long-lived/ meso- to macro-scale processes, in the spectrum from intra-seasonal to multi-decadal climate variability. (extreme temperature, drought, wildfire).*
- **Biological**: *Disaster caused by the exposure of living organisms to germs and toxic substances (epidemic, insect infestation, animal stampede).*

Disasters are grouped into five subgroups.

FIGURE 27 **Natural Disaster Subgroup Types**

Disaster Generic Group	Disaster Group	Disaster Main-Type	Disaster Sub-Type	Disaster Sub-Sub Type
Natural Disaster	Geophysical	Earthquake	Ground Shaking	
			Tsunami	
		Volcano	Volcanic Eruption	
		Mass Movement (dry)	Rockfall	
			Avalanche	Snow Avalanche
				Debris Avalanche
			Landslide	Mudslide Lahar Debris Flow
			Subsidence	Sudden Subsidence
				Long-Lasting Subsidence

Disaster Generic Group	Disaster Group	Disaster Main-Type	Disaster Sub-Type	Disaster Sub-Sub Type
Natural Disaster	Metrological	Storm	Tropical Storm	
			Extra-tropical Cyclone (Winter Storm)	
			Local/Convective Storm	Thunderstorm/ Lightning
				Snowstorm/ Blizzard
				Sandstorm/ Duststorm
				Generic (Severe) Storm
				Tornado
				Orographic Storm (Strong Winds)

Disaster Generic Group	Disaster Group	Disaster Main-Type	Disaster Sub-Type	Disaster Sub-Sub Type
Natural Disaster	Hydrological	Flood	General (River) Flood)	
			Flash Flood	
			Storm Surge/ Coastal Flood	
		Mass Movement (wet)	Rockfall	
			Landslide	Debris Flow
			Avalanche	Snow Avalanche
				Debris Avalanche
			Subsidence	Sudden Subsidence
				Long-Lasting Subsidence

Disaster Generic Group	Disaster Group	Disaster Main-Type	Disaster Sub-Type	Disaster Sub-Sub Type
Natural Disaster	Climatological	Extreme Temperature	Heat Wave	
			Cold Wave	Frost
			Extreme Winter Conditions	Snow Pressure
				Icing
				Freezing Rain
				Debris Avalanche
		Drought	Drought	
		Wild Fire	Forest Fire	
			Land Fires (Grass, Scrub, Bush, etc.)	

Disaster Generic Group	Disaster Group	Disaster Main-Type	Disaster Sub-Type	Disaster Sub-Sub Type
Natural Disaster	Biological	Epidemic	Viral Infectious Diseases	
			Bacterial Infectious Diseases	
			Parasitic Infectious Diseases	
			Fungal Infectious Diseases	
			Prion Infectious Diseases	
		Insect infestation		
		Animal Stampede		

Disaster Generic Group	Disaster Group	Disaster Main-Type	Disaster Sub-Type	Disaster Sub-Sub Type
Natural Disaster	Extra-Terrestrial	Meteorite/ Asteroid		

ANNEX 2 CHECKLIST FOR INFRASTRUCTURE OWNERS AND OPERATORS

The following set of questions can be helpful for private sector individuals or organizations that own or operate infrastructure in an urban environment. These questions are designed to take full account of critical infrastructure that might be compromised as a result of disasters. This approach could be used as part of a community and stakeholder participation program, which is discussed in **Chapter 2**.

This checklist has been adapted from Keeping the Country Running: Natural Hazards and Infrastructure - A Guide to improving the resilience of critical infrastructure and essential services, published by the United Kingdom Cabinet Office in 2011.

Identify Risks

STEP 1: Determine critical infrastructure necessary to continue operations

STEP 2: Determine critical infrastructure within your supply chain

Understand Hazards

STEP 3: Identify hazards of greatest concern to your critical infrastructure and supply chains.

Questions

1) Have you worked with external agencies to assess the natural hazards risks to your organization's critical infrastructure? Examples: Disaster management agency, chamber of commerce, local authorities, environmental agency, geological survey

2) Does the location of your critical infrastructure increase the risk from natural hazards?

3) Who are your key supplier and/or customers? Do they deliver an essential service for your community?

Assess Risk Understand and Vulnerability

STEP 4: Determine the capacity of your critical infrastructure to be resilient to hazards of greatest concern through location, structural design and redundancies.

Questions

1) Is it cost effective to move critical infrastructure to a safer location?

2) Is it possible to reinforce, retrofit or strengthen your critical infrastructure to make it more resilient to hazards of most concern?

3) What redundancies can you build into your critical infrastructure so you will be able to continue operations?

STEP 5: Determine your organizations level of risk.

4) Could there be a surge in demand for your services from a natural hazard? Will you be able to manage this?

5) Have you worked with your key partners in your supply chain to understand their vulnerability to natural hazards? How could their disruption affect your organization?

6) Have you worked with emergency responders, and other agencies, on how they can offer assistance following a disruption of service from a natural disaster?

Build Resilience

STEP 6: Determine your organization's acceptable risk relative to your critical infrastructure.

Questions

1) What is the acceptable level of risk for your organization?

2) Is your organization willing to accept, mitigate or cease services given specific risks?

3) Does the governing body understand the risk of disruption of services from natural hazards?

3) *Has the governing body of your organization formally accepted certain levels of risk?*

STEP 7: Determine what level of resilience is required and what resilience strategy will be adopted

4) *Does your strategy for resilience need to evolve given the hazard profile of your urban area over the next 5-10 years?*

STEP 8: Embed resilience at the core of your strategic decision making processes.

5) *Is your organization's resilience strategy championed at the governing level?*

6) *Has the governing body committed resources to improve resilience?*

7) *Has the governing body approved contingency plans?*

STEP 9: Engage with emergency responders in areas where you operate and deliver services

8) *Is there a plan in place to manage any of the following;*
   - *Loss of primary transport routes;*
   - *Reduced staff availability;*
   - *Impaired site access;*
   - *Loss of primary or alternative power*
   - *Loss of primary and alternative water supply;*
   - *Increased demand for health; emergency services*
   - *Increased demand for your services;*
   - *Supply chain disruption*

9) *Have these plans been shared with emergency responders and supply chain partners?*

10) *Does the Board seek assurances on the resilience of critical infrastructure to disruption from natural hazards at least annually?*

11) *Do you have a resilience based education and awareness program in place within your organization?*

12) *Have key staff been trained to implement emergency and business continuity plans?*

13) *Is there evidence that disaster resilience has been included in your organization's strategic decision-making and investment plans?*

Evaluate Resilience

STEP 10: Challenge, test and exercise your organizational resilience strategy.

<u>Questions</u>

1) *Have you reviewed your Organizational Resilience Strategy?*

2) *Have you identified and tested any assumptions that underpin the delivery of your strategy?*

3) *Do you have an exercise program in place that addresses the risk from natural hazards? Has it been approved by the Board? Do Board members take part in exercises?*

4) *Have you exercised more than one type of disruption at any one time i.e. loss of primary transport routes, coupled with loss of power and water supplies?*

5) *Are plans tested at least annually? Have findings been recorded and lessons learned?*

6) *Were supply chain partners and emergency responders included in these tests / exercises?*

7) *Were findings shared with the Board, supply chain partners, emergency responders, regulators and / or government?*

8) *Have you taken part in your supply chains" and / or emergency responder's tests / exercises?*

ANNEX 3 COMPARISON OF SPATIAL PLANS FOR URBAN INFRASTRUCTURE

Broad approach	Important terms and approaches	Strengths	Weaknesses and contingencies
■ Smart growth and transit-oriented development	■ Smart growth ■ Compact development ■ Integrated development ■ Mixed-use development ■ Intensification ■ Coordination ■ Transit-oriented development	■ Encourages inter-sectoral and inter-agency links ■ Encourages links between planning and implementation ■ Improves sustainability ■ Improves public transport ■ Strong transport–land-use links ■ Can slow urban sprawl	■ These good links are difficult to achieve ■ Assumes significant capacity and organization ■ Poor or narrow implementation undermines prospects ■ Popular support difficult to achieve due to conflicting views and lifestyles ■ Claimed benefits contested
■ Integrating land use and transport	■ Bus rapid transit (BRT) ■ Corridors and axes Integrated rail redevelopment ■ Linking economic activities to transport type ■ New transport/land-use models	■ Improves public transport ■ Improved usage of public transport ■ Reduces energy and improves efficiency ■ Better transport–land-use links ■ New models enable better understanding of patterns	■ Heightened property prices on transport axes can marginalize the poor ■ Required integration can be difficult to achieve ■ Needs good understanding of social and economic dynamics and space – difficult to achieve ■ Land use–transport links undermined by ■ different logics, institutional divides ■ New models still data hungry, aggregated, ■ distant
■ Strategic spatial planning and infrastructure planning	■ Strategic plans ■ Infrastructure plans ■ Transport–land use links	■ Can give long-term direction to development ■ Can avoid inequitable and unsustainable development ■ Avoids fragmented development	■ Conditions required to work are demanding difficult to achieve ■ Credible analysis ■ Inter-sectoral coordination ■ Stakeholder involvement and buy-in ■ Regular review ■ Internal champions ■ Special agencies

Broad approach	Important terms and approaches	Strengths	Weaknesses and contingencies
■ Integrated urban development and management plans	■ Multi-sectoral investment plans (MSIPs) plans (PEDPs) ■ Physical and environmental development	■ More flexible, less data demanding, and easier to prepare than master plans ■ Participatory ■ Helps to manage urban growth in context of scarce resources/capacity ■ Can be used iteratively in decision-making process	■ Problematic if seen in static or narrow way ■ Required inter-sectoral cooperation hard to achieve ■ Can be countered by political decision-making
■ Strategic structure planning	■ Integrative framework ■ Long-term vision	■ More flexible, less data demanding and easier to prepare than master plans ■ Participatory ■ Multifaceted approach ■ Combines short-term actions with long-term planning	■ Required political and stakeholder buy-in may be difficult to achieve ■ May still be relatively technocratic ■ May not provide detail necessary for some decisions
■ Linking spatial planning to infrastructure planning	■ Integrated development plans ■ Spatial frameworks	■ More flexible, less data demanding and easier to prepare than master plans ■ Participatory ■ Gives direction to infrastructure planning ■ GIS-based models can be used as an input	■ Required consistency in policy and coordination between agencies difficult to achieve ■ Can be too broad to be useful ■ May be contradicted by the market
■ Linking mega-projects to infrastructure development	■ Urban regeneration ■ Multifunctional	■ Powerful driver in urban form ■ Evolving approaches allow linking to planning over the long term ■ Building cooperation between various sectors and agencies	■ Mega-projects often politically driven and one-off: approach is hard to achieve. ■ Level of integration and cooperation difficult to achieve

Source: UN HABITAT (2009) Planning Sustainable Cities, p161.

ANNEX 4 DATA COLLECTION GUIDELINES

Terms of Spatial Data Delivery and Sharing: Promoting data accessibility is an important component of any technical disaster or climate risk project. To ensure sustainability of project results, all data collected and created should be preserved, consolidated and transferred to key stakeholders upon project completion, in a well-known or standard electronic format. Specifically the following terms should apply:

Licensing: All data procured and developed for a project is done on behalf of key stakeholders and therefore all licensing agreements should be made similarly.

Vector data: Geospatial vector data must be converted into a standard OGC format or well-known format. This list includes, but is not limited to, shape file, KML, GML, WKT. Additional formats should only be used with approval. All files must include projection parameters.

Raster data: Geospatial raster data should be converted into a standard OGC or well-known format. This list includes; geoTiff, JPEG, JPEG2000, ERDAS img, ArcInfo ASCII or Binary grid, MrSid. Additional formats should only be used with approval. All files must include projection parameters.

Tabular data: Tabular data should be converted into a readily accessible or well-known format. This list includes; CSV, tab delimited text file, or spreadsheet. Additional formats should only be used with approval.

Media/method of transfer: All data sets should be transferred on permanent media such as a CD/DVD or flash drives. Data sets that exceed the capacity of CD/DVDs or flash drives, should be provided on a hard drive or solid-state drive, as agreed by key stakeholders.

Metadata: Detailed documentation needs to be provided for each data set. This metadata must include description, source, contact, date, accuracy, and any use restrictions. A description of attributes must be provided for vector and tabular data sets. Spatial data must include details of projection. ISO standards should be used in the development of all metadata.

Derived data: All derived data generated will belong to key stakeholders and must be transferred under these terms.

In addition to the above, spatial data should be made available in a web-based data management and mapping platform, so that it can be publicly available and in multiple formats. The platform must meet the following requirements:

- Web based and accessible over the Internet,
- Allow uploading raster and vector data, along with assigning rendering and classifications,
- Enforce metadata to be entered for each data set uploaded,
- Allow definition of users and assignment of access levels to individual layers and maps as required,
- Allow viewing and interrogating spatial data, along with associated metadata,
- Allow downloading spatial data in multiple vector and raster formats, including OGC web services,
- Allow map compositions to be made combining multiple layers.

These services are currently provided by GeoNode in an open source software. More information can be found in **Chapter 4** or at http://geonode.org.

Capacity requirements for hosting GeoNode

The GeoNode website gives the following hardware requirements for the deployment of a GeoNode:

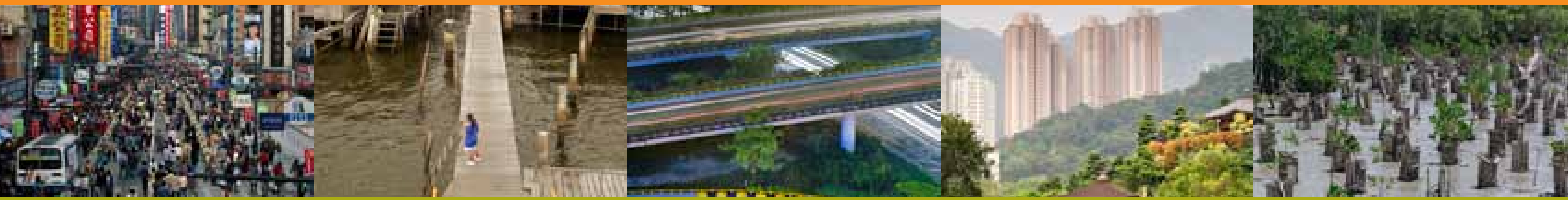
- 6GB of RAM, including swap space,
- 2.2GHz processor. (Additional processing power may be required for multiple concurrent styling renderings),
- 1 GB software disk usage,

- Additional disk space for any data hosted with GeoNode and tiles cached with GeoWebCache. For spatial data, cached tiles, and "scratch space" useful for administration, a decent baseline size for GeoNode deployments is 100GB,
- 64-bit hardware recommended.

IT-related capacity within the organizations should include:

- Experience with web development in Python/Django,
- Experience with geospatial programming such as GeoServer/GeoTools, GeoNetwork,
- Experience with OpenLayers/GeoExt, PostGIS,
- Understanding of Open Geospatial Consortium (OGC) standards: Web Feature Service (WFS), Web Coverage Services (WCS), Web Map Services (WMS) and Web Processing Services (WPS).

Building Urban Resilience



MANAGING THE RISKS OF DISASTERS IN EAST ASIA AND THE PACIFIC

THE WORLD BANK

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