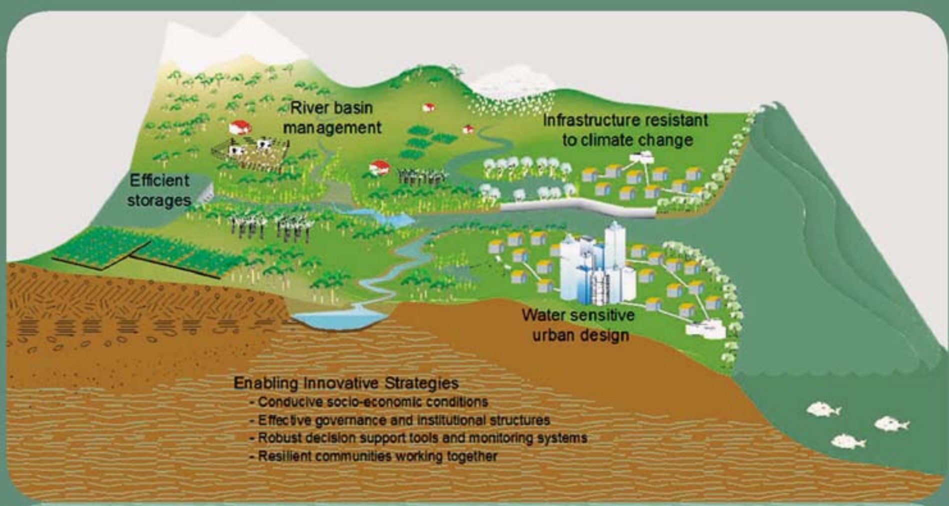
Policy Options for Effective Implementation of the Hyogo Framework for Action in Asia and the Pacific

DEVELOPING INNOVATIVE STRATEGIES FOR FLOOD-RESILIENT CITIES

Water Resources Series
No. 86



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PREFACE

This issue of the Water Resources Series presents an analysis of studies and collaborative work undertaken by ESCAP with national research units and individual experts on developing frameworks for flood management in Asian and Pacific cities. This report consists of four sections:

An overview of issues and challenges in managing urban flood risks which reviews socio-economic impacts of flooding. Impacts of urban development on flood risks are described in the context of adapting to climate change.

A synthesis of recent developments in innovative strategies for effective urban flood management.

Case studies of innovative strategies for effective urban flood management.

Policy options derived from collaborative work on urban flood management and the regional expert consultation.

The “adaptive management framework” is described as an approach to minimizing urban flood risks. Application of the framework improves understanding of each local situation, the effective use of resources and the flexibility required in dealing with diverse situations.

The concept of “transitioning towards water-sensitive cities” offers guidance for urban development planners in making informed decisions on investments, capacity development and institutional reforms that lead towards sustainable urban water management.

The report also highlights the importance of an enabling environment that is characterized by conducive socio-economic conditions, effective governance and institutional structures, resilient communities, and policy frameworks for disaster mitigation in general and urban flooding in particular. Case studies from the region illustrate different development scenarios in policy formulation for effective urban flood mitigation.

Policy options for effective urban flood management are presented in the final section as contributions toward implementation of the Hyogo Framework for Action in Asia and the Pacific. The synthesis is based on material prepared for the Expert Group Meeting on Innovative Strategies towards Flood-Resilient Cities in Asia-Pacific, held at ESCAP from 21 to 23 July 2009, as well as on selected papers in the areas of urban flooding, flood mitigation and flood-resilient cities from the region.

ACKNOWLEDGEMENTS

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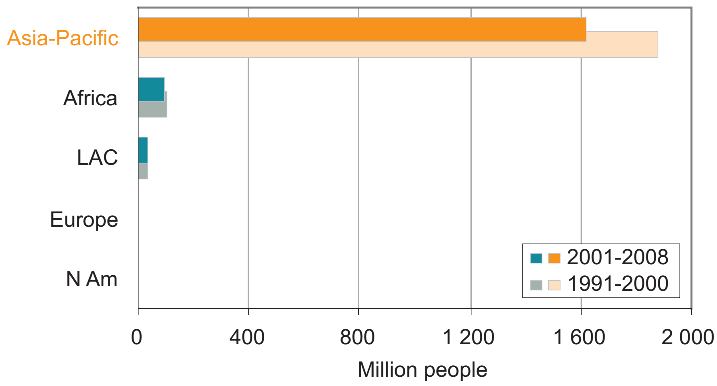
Overview of Issues and Challenges in Urban Flood Management in Asia and the Pacific

The majority of Asian urban areas are located on hazard-prone land. During the decade from 1994 to 2004, Asia accounted for one third of 1,562 flood disasters worldwide, and nearly 60,000 people were killed in floods (Arambepola and Iglesias, 2009, p. 2).

The Asian and Pacific region has experienced 42 per cent of the world's natural disasters in the 20 years since 1990, involving a disproportionate 65 per cent of the global total of victims of such disasters (figure 1). During that period, a person living in Asia and the Pacific was almost 25 times more likely to be affected by a natural disaster than someone living in Europe or North America. The majority of those affected by Asian and Pacific disasters were victims of weather-related events, with floods accounting for more than one third of natural disasters in the region.

Figure 1. People affected by natural disasters, by global region, 2001-2008 and 1991-2000



SOURCE: United Nations ESCAP (2008, figure 29.1).

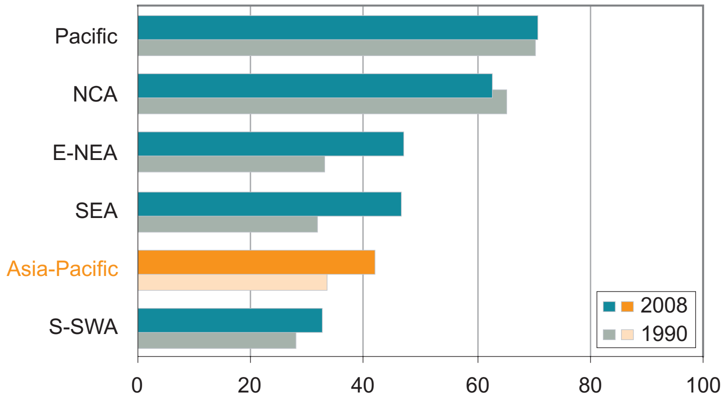
NOTES: LAC = Latin America and the Caribbean
N Am = North America.

The Asia-Pacific region is urbanizing at one of the fastest rates in the world. The urban population has been growing at 2.3 per cent per annum—faster than the global average of 2.0 per cent. With the increasing growth of urban dwellers in the region (figure 2), one third of whom are living in slums, more people are becoming vulnerable to floods.

Strategies for effective urban flood management need to be based on: (a) the accumulated knowledge of past weather events; (b) existing approaches that address the multiple components of risk; and (c) long-term climate-change scenarios.

A comprehensive strategic and systematic risk management approach should aim at reducing impacts by reducing vulnerability to flood hazards and related risks (UN/ISDR, 2007). The United Nations International Strategy for Disaster Reduction (UN/ISDR, 2009) has defined vulnerability as "the characteristics and circumstances of a community, system or asset that make it susceptible

Figure 2. Percentages of urban population in subregions of Asia and the Pacific, 1990 and 2008



SOURCE: United Nations ESCAP (2008, figure 2.1).

NOTES:
E-NEA = East and North-East Asia
NCA = North and Central Asia
SEA = South-East Asia
S-SWA = South and South-West Asia

to the damaging effects of a hazard." In commenting on the nature of hazards, it notes that "the hazards of concern to disaster risk reduction as stated in footnote 3 of the Hyogo Framework are '… hazards of natural origin and related environmental and technological hazards and risks.' Such hazards arise from a variety of geological, meteorological, hydrological, oceanic, biological, and technological sources, sometimes acting in combination. In technical settings, hazards are described quantitatively by the likely frequency of occurrence of different intensities for different areas, as determined from historical data or scientific analysis."

A. Vulnerability of cities to flooding: issues and challenges

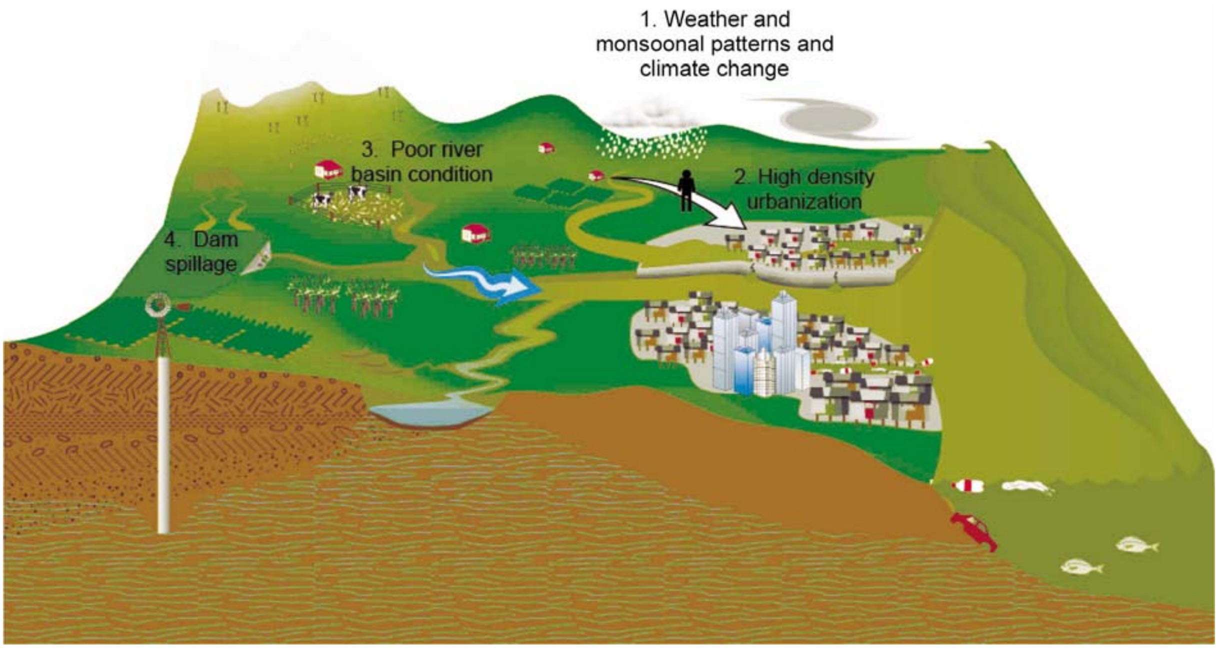
Flooding impacts the urban population mainly in terms of human health, economic activity and material infrastructure. The main health impacts include loss of life and infection by water-borne diseases and water pollution, especially where toxic-waste dumps are flooded. Impacts mostly concern the interruption of economic activity and damage to physical infrastructure.

Given the high population densities and economic value of affected Asian cities, even small-scale floods may cause substantial damage. In extreme cases flooding can set urban development back by years or even decades. Recent statistics show that economic damage from urban floods is rising (APFM, 2004).

Increasing awareness of flood risks combined with expanded planning and execution of flood management actions have improved management of the mortality risks associated with floods. However, the economic risks continue to rise along with economic and population growth in urban areas, compounded by extreme events associated with climate change. Data show that the risk of economic loss is increasing faster than mortality risk (Liu, Rashquinho and Leong, 2009, p. 2).

Flood hazards in built-up environments are a cosequence of natural and man-made factors (Mir, 2009, p. 3). The vulnerability of cities in Asia and the Pacific to flooding stems mainly from (a) weather and monsoonal patterns; (b) high-density urbanization; (c) poor river basin condition; and (d) spillage from storage and dams (figure 3).

Figure 3. Vulnerability of cities to flooding



1. Weather, monsoonal rainfall and climate change

Normal monsoonal patterns of rainfall are responsible for floods and other hydrometeorological disasters. Scientists predict that changes in weather patterns associated with climate change — including increases in storm surges, floods, drought conditions and the episodic nature of rainfall — may result in even greater impacts upon cities, especially those located on river banks, in river catchments or along the seacoast (Arambepola and Iglesias, 2009, p. 1).

Storm surges and floods have brought devastation to many Asian cities. Recent disasters in Manila, Philippines and Mumbai, India demonstrate the severity of such extreme climatic events in vulnerable areas.

In Manila, Typhoon Ketsana deluged the city with 1 month's volume of rainfall in 12 hours' time on 26 September 2009. The result was the worst flooding the capital had experienced in over 4 decades, submerging more than 80 per cent of the city, killing at least 246 people and displacing hundreds of thousands more. The flood was mainly the consequence of poor drainage and sanitation systems. Plastic bags and other refuse clogged the sewers, while above them the roads became rivers and lagoons. In the wake of Ketsana, Metro Manila was left with 10 times its usual garbage. The National Disaster Coordinating Council estimated that 797,404 families or 3,899,307 people had been affected by Ketsana throughout the country, with 288 dead and 42 missing. Some 33,430 houses had been damaged: 12,399 totally and 21,031 partially. The estimated cost of infrastructural and agricultural damage was approximately US$ 18 million (World Vision, 2009).

The Mumbai flood of 2005 affected the lives of 20 million people, destroying more than 14,000 homes and killing 1,200 people and 26,000 cattle. The topsoil from about 20,000 hectares of farmland was lost while 550,000 hectares of crops were damaged. Damage to roads and bridges was estimated at 214 million euros. Most of the drainage system collapsed, with an ensuing risk of water-borne diseases. Basic services were restored only after several weeks.

Jakarta experienced flooding in 1996, 2002 and 2007. The floods of February 2007 were the worst in the city's history, covering almost 60 per cent of the urban area and affecting 400,000 people. The water level climbed as high as 11.2 metres in Kampung Melayu, near the Ciliwung River. Flood-waters destroyed 100 houses in informal settlements (Arambepola and Iglesias, 2009, p. 1).

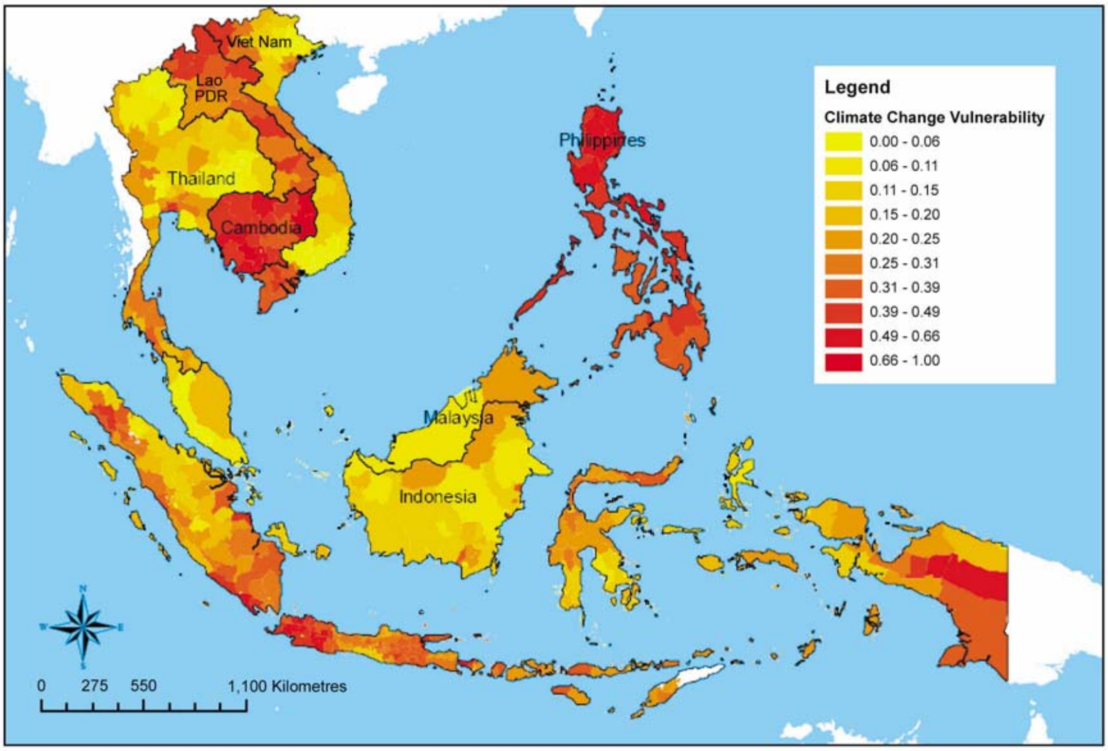
In Hanoi and some provinces in northern Viet Nam, very heavy rainfall caused flooding for up to 10 days during November 2008. The flood was the worst in the area in 25 years, compounded by the highest tidal surges in 50 years.

In neighbouring Lao People's Democratic Republic, widespread heavy monsoonal rains of more than 150 millimetres in 24 hours flooded more than 660 villages and 32,600 households along the Mekong River in the provinces of Luang Prabang, Vientiane, Borikhamxay and Khammuane in August 2008. Three people were killed, almost 30,000 hectares of rice and other crops were damaged, with losses of about 700 head of livestock (buffalos, cattle, pigs and goats) and about 1,000 domestic fowl. The direct economic losses in those four provinces amounted to some 328 billion kip (or US$ 385 million).

Changes in the Asian monsoon system can compound the challenges of managing floods in several ways. Rising sea levels exacerbate the flood risks of cities in coastal deltas. Increasing frequency of extremely high rainfall may cause landslides, posing high risks to settlements in upland areas, as well as sudden riverine floods that pose risks for the floodplains.

Global climate change further impacts flood regimes in the form of extreme rainfall events, strong tidal surges and tsunamis, and rising temperatures that in turn melt glaciers and lead to increases in river levels, among other phenomena. The Asia-Pacific region is vulnerable to climate change (figure 4). Across the region, people have lost their assets, their livelihoods or their lives in types of disasters that are likely to become more frequent or severe as a result of climate change.

Figure 4. Mapping of the Asia-Pacific region's vulnerability to climate change



SOURCE: Yusuf and Francisco, 2009.

Table. Distribution of large cities by major geographic areas, 1950-2015

Region	1950	1975	2000	2015
Distribution of the world's 30 largest cities				
Africa	1	1	2	3
Asia	**7**	**14**	**16**	**15**
Europe	12	6	3	2
Latin America and the Caribbean	4	4	6	6
Northern America	6	5	3	3
Oceania	0	0	0	0
Total cities of more than 1 million inhabitants, by region				
Africa	2	8	35	63
Asia	**27**	**86**	**194**	**288**
Europe	20	47	62	60
Latin America and the Caribbean	7	21	49	73
Northern America	14	31	41	51
Oceania	2	2	6	6
Total	**72**	**195**	**387**	**541**

SOURCE: Cohen (2006).

2. High-density urbanization

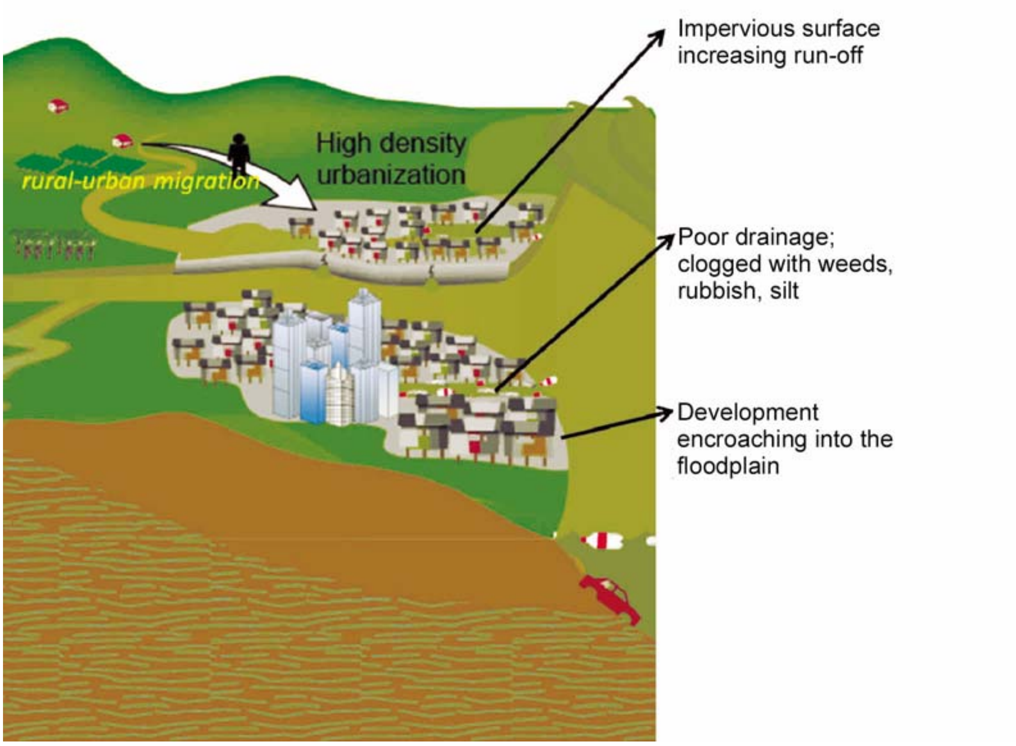
The rate of urbanization in the Asia-Pacific region is second only to that of Africa. The urban proportion of the total population is increasing steadily although still below the world average (United Nations ESCAP, 2008). As cities grow, among the greatest concerns is the massive increase in numbers of urban poor. Available data suggest that in many of the world's poorest countries, the proportion of urban poor is increasing faster than the overall rate of urban population growth. The proportion of urban poor is 43 per cent for Asia and the Pacific (Cohen, 2006). As shown in the following table, the growth in numbers of large cities in Asia is greater than in those elsewhere in the world.

People in Asia and the Pacific continue to migrate from rural to urban areas. Natural population growth in the region is about 1.1 per cent per year, but urban growth is about 2.0 per cent; the difference in growth percentage could be attributed to rural-to-urban migration or to the reclassification of rural areas into urban areas (United Nations ESCAP, 2008). Rural-to-urban migration is an essential part of economic development through which human resources move from the agricultural sector, where the marginal product of labour is lower, to the urban industrial sector, where the marginal product of labour is higher (Liu, 2008). While rural-to-urban migration helps improve the efficiency of the sectoral allocation of resources, it also exacerbates to a large extent the widespread problem of urban congestion.

Urban flooding is increased by high-density urbanization (figure 5).

(a) Impervious surfaces changing hydrology and increasing run-off. Built-up environments generate surface run-off that generally exceeds local drainage capacity, resulting in flooding. The proliferation of impervious rooftops and transportation surfaces decreases the overall run-off efficiency of the catchment. Precipitation that falls on rooftops and pavement quickly runs off instead of infiltrating the soil as it would generally do in a natural or farmed landscape. Such a radical change in surface character typically leads to increases in run-off volume and peak flow

Figure 5. High-density urbanization increases the risks of urban flooding



rates with subsequent increases in magnitude and frequency of local flooding (Pappas and others, 2008).

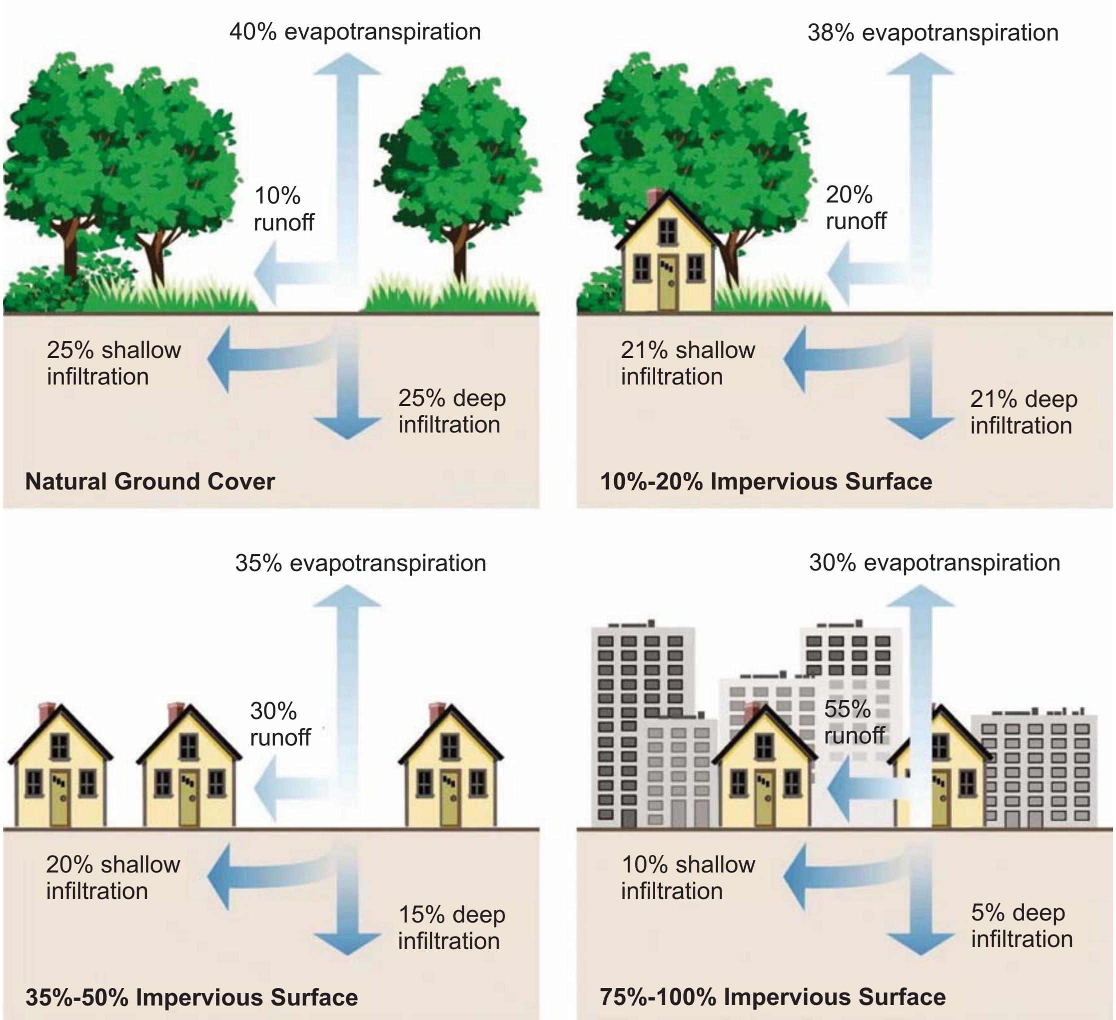
Urbanization leads to decreases in rates of infiltration and increases in surface run-off (figure 6). The physical vulnerability of urban populations is heightened by the concentration of potentially dangerous infrastructure such as solid and liquid waste storage depots and electrical facilities, among others.

(b) Poor drainage; clogged with weeds, rubbish and, silt. Local drainage capacity is composed primarily of a local storm-water drainage system with storm drainpipes, curb inlets, manholes, minor channels, roadside ditches and culverts. Such a system is intended to conduct storm flows efficiently to the community's primary drainage system, which may be a river channel, or to the nearest large body of water.

Localized flooding occurs frequently in slum areas because most of the ground is highly compacted and drains are few; pathways between dwellings become streams after heavy rain. In small and medium-sized towns and cities, the rapid development and infrastructure such as roads have failed to provide cross-drainage and have disrupted naturally occurring drainage systems.

Clogging of drains with waste that reduces the carrying capacity of the drainage systems is a major concern in many cities, particularly in developing countries with suboptimal solid waste disposal systems. Many urban drainage facilities have become dilapidated through lack of maintenance. Waste and debris tend to clog the bottlenecks in such facilities, reducing their capacity and leading to increased surface run-off and back-up impacts, causing local floods. Open channels in the semi-arid regions that are intermittently used for drainage and poorly maintained are particularly affected by the problem.

Figure 6. Influence of urbanization on different components of the water cycle



Source: US, FISRGW (1998).

(c) Development encroaching into the floodplain. With increasing population density, space becomes ever more limited and expensive. Those who cannot afford to purchase or rent space in secure environments are forced to move to cheaper places that may be located at the outskirts of town or in relatively undesirable areas inside town and that may be prone to floods and other hazards. Since the livelihoods of the urban poor often depend on the informal economies of big cities, many prefer to inhabit hazardous areas close to towns.

Two other factors aggravate such spatial marginalization. On the one hand, hazard-prone areas are often not privately owned, thus informal dwellers are less likely to be displaced. On the other hand, many urban poor are migrants from rural areas who are not familiar with the respective hazards and therefore tend to underestimate the risks in living in such areas.

In Delhi, the “trespassing of storm-water drains” is very common — whereby slum dwellings, small shops, motor garages and other adventitious developments prevent the flow of flood-waters in storm-water drains (Mahto, 2009).

3. Poor river basin condition

Conditions in a catchment or river basin affect downstream urban areas. Rainfall that is not intercepted by vegetation falls on the earth and either evaporates, infiltrates the soil or lies in depressions. Any remaining run-off flows into the steams of the catchment and eventually to the sea. Under high rainfall intensity or prolonged rainfall, the stream channels cannot contain all the surplus run-off, with resultant flooding that affects human activities downstream in rural and urban areas.

The types, causes, magnitudes and effects of floods can be divided into two categories: those associated with normal flooding that occurs naturally in the annual climatic cycle; and those associated with abnormal (and damaging) floods that are often caused by heavy rainstorms and exacerbated by the mismanagement of the catchment area (Woube, 1999).

Human intervention in the catchment area, for example in reducing the volume of riparian vegetation or practicing destructive forms of land use, often degrades conditions of a river basin. Vegetation such as trees, shrubs and grasses along river channels increases the “roughness” of the rivers that tends to slow the water flow. Removal of riparian vegetation results in stronger flows and greater erosion along river channels.

The total clearing of land for agricultural use and urban settlement, without the appropriate infrastructure to compensate for loss of drainage, results in changes in hydrology and stronger flows throughout the river basin. In Delhi, about 1,650 “unauthorized colonies” have become established on open or agricultural land without consideration given to the city plans, drainage, sewerage or related infrastructure. Those areas are thus subjected to flooding during heavy rainfall (Mahto, 2009, p. 4). In the Lao People’s Democratic Republic, deforestation has been “significantly contributing to worsening of the effects of ‘normal’ hydrological and meteorological phenomena, causing an increase of the surface run-off in quantity and velocity”. Natural means of flood mitigation have been lost (Oudomcit, 2009, p. 4).

Poor land-use practices (e.g., farming right to the edge of a riverbank, or removing riparian vegetation) can aggravate erosion of steep slopes that directly results in siltation of the rivers. Siltation tends to lead to greater overland flows. Moreover, changes in channel morphology that stem from poor land-use practices increase the unpredictability of flood flows.

Land-use changes have altered run-off characteristics. Through construction of river dams, diversions, irrigation schemes and interbasin water transfers, development projects have changed river flows significantly from their natural state. The onset, duration, distribution, force and quality of flood-waters have consequently grown as threats to continguous human settlements (Lebel, 2007).

4. Dam spillage

Water retention reservoirs and storages serve to control upstream peak flows and volumes for treatment purposes and to trap sediments from the upper catchment, as well as to store water for supply purposes. With extreme rainfall events, some storages back up into the rivers. Some extreme rainfall events could even cause breakage of storage walls and damage to downstream settlements and property. Research commissioned by the World Wide Fund for Nature (WWF) reveals that dams are often designed with a very poor knowledge of the potential for extreme flood events and without consideration of future risks, such as increases in rainfall from climatic change or increases in run-off due to deforestation or compromised wetlands. Such dams could yield more harm than good for future generations.

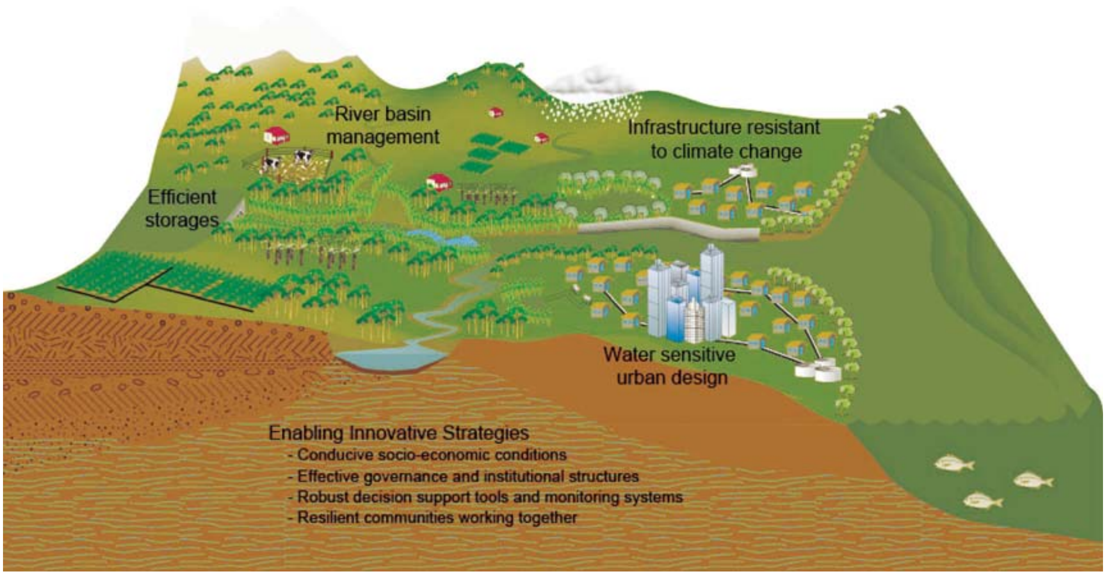
Inadequate information on some of those issues could mean that dams could be built without adequate spillways to cope with extreme floods (Pearce, 2001). A case in point is a quantitative model developed for the Mekong River and linked with a geographic information system that predicted that flooding could worsen in the long term because of estuarine siltation from the construction of dams (Le and others, 2007).

B. Managing the risks

An effective approach to reducing urban flooding and its impacts can begin with seeing the problem as one of managing floods rather than controlling them. China provides an example of such a shift from flood control to flood management that is based on structural measures, institutional mechanisms, science and technology advancement, and community involvement with people's awareness and support (Liu, 2009, p. 1).

Strategies for urban flood management should include structural and non-structural mitigation measures that take into consideration climate-change variability, including changes in the frequency and intensity of tropical cyclones (figure 7). Nonstructural measures should include strengthening legislation for urban flood management including coastal management, institutional coordination and cooperation, improvement in investment monitoring, capacity-building and the decentralization of resources from national to local levels.

Figure 7. Managing the risks of urban floods



1. General framework for innovative strategy: river basin management

"Risk-sensitive" land-use planning holds useful practices and strategies for managing river basins and water resources comprehensively. Risk sensitivity in planning can help in controlling exposure to hazards, including the impacts of upstream development on downstream areas.

Floodplains, which act as buffers in flood events, need to be recognized as part of the river system. They cannot be considered simply as part of the landscape that is available for economic development. As natural buffers, they need to be protected and/or restored to ensure that they can effectively perform their natural function of water retardation and filtration.

When restored, natural river channels and riparian vegetation slow the flows through the river channel systems. Good land management practices ensure that the natural hydrological cycle is preserved and/or restored.

In taking an integrated flood-management approach and including total water-cycle management, water from floods can also be stored for use in the dry season and diverted to dry zones or other areas.

2. "Water-sensitive" urban design for a comprehensive, water-cycle-based approach

Cities are often flooded where no effective drainage infrastructure exists. As the concrete in the built environment is impervious to natural run-off, percolation of the water into the soil underneath cannot occur. Compounded with the lack of a proper drainage system capable of handling intense rain events, "cities like Dhaka experience severe inundation problems during monsoons" (Arambepola and Iglesias, 2009, p. 3).

Drainage systems in cities should be able to handle the volumes of storm-water to which the city is exposed. Improving city infrastructure for withstanding extreme events (with, for example, appropriate drainage infrastructure and positioning of roads and bridges above flood levels) is critical. In many parts of Delhi, for example, drainage and sewer systems have collapsed, resulting in flooding. The cleaning of roads, bell mouths and gullies, and the removal of silt, debris and solid waste materials from the drains is being coordinated by the chief engineer of the municipality (Mahto, 2009, pp. 5-6).

A comprehensive way to integrate water-cycle management into urban planning and design lies through "water-sensitive" urban design. It is a philosophical approach to urban planning and design, aimed at reducing the hydrological impacts of urban development in the surrounding environment — by channelling, diverting or otherwise slowing the excessive flows of water from urban development. Storm-water management is a subset of water-sensitive urban design that is directed at providing for flood control, flow management, water quality improvement and opportunities to harvest storm-water to supplement mains water, for uses such as toilet flushing and garden irrigation but not human consumption (Lloyd and others, 2002).

"Having a holistic approach to water management is fundamental to water sensitive urban design" (HCCREMS, n.d.).

The key principles of water-sensitive urban design include the following (Wong and Brown, 2008):

- Reduction of impervious areas and addition of local detention measures to decrease run-off and manage peak flows from urban development;
- Integration of storm-water treatment into the landscape;
- Protection of natural systems within urban development;
- Restoration and/or protection of the quality of water draining from urban developments; and
- Enhancement of ecological and economic value while maintaining development costs.

Water-sensitive urban design encompasses the three elements of integrated urban water-cycle management: water supply, wastewater management and storm-water management. Water-sensitive urban design represents a significant shift in the way water and related environmental resources and water infrastructure are considered in the planning and design of cities and towns. The approach is based on the premise that urban development and retrofitting must effectively address the sustainability of the water as a resource and the health of waterways.

A range of applications is available for integrating concepts and technologies for water-sensitive design into urban development. The types of techniques include the following:

- Grassed or vegetation-covered swales — primary treatment and conveyance functions that provide for secondary treatment benefits.
- Filtration trenches — primary treatment and conveyance and detention options that provide for secondary treatment benefits.
- Bio-retention systems — secondary treatment, conveyance, detention and retention functions (through infiltration) that provide for tertiary treatment benefits.
- Wetlands — tertiary treatment system, storage and detention, with possible reuse options.
- Rainwater tanks — storage of storm-water for detention and retention that provides water for drinking and garden irrigation, car washing and toilet flushing, among other functions.
- Greywater reuse — primary treatment of household wastewater, for reuse in external irrigation or internal toilet-flushing options.
- Rain gardens, green roofs, urban forests — aesthetic function that also provides for filtering of storm-water.
- Any combination of the above and other techniques for the best possible outcomes.

In Melbourne, Australia, water-sensitive urban design is being incorporated into urban developments and road designs. The approach provides for attractive, human-scale living environments by integrating urban planning and design with management, protection and conservation throughout the water cycle (Melbourne Water, 2004).

3. Infrastructure resistant to climate change

Urban planners need to adopt structural designs that are resilient to impacts of climate change and tropical cyclones (to a level of uncertainty). Socio-economic models of flood damage in cities have independently predicted vast increases in spending on damages, likely due to climate change, in the absence of adaptive changes to infrastructure.

Infrastructure must be built to cope with future changes because budgets for public investment are so rarely available. The likelihood of climate change, its impacts and appropriate adaptation measures should therefore be acknowledged and provided for. To date most infrastructure, however, has been designed, built and maintained on the premise that the climate will stay the same into the future.

Recognition of the risks associated with climate change is a critical first step towards improving the planning of new infrastructure investments and the mitigation of potential damage to existing infrastructure (Australia, State of Victoria, 2006). In designing buildings and communities, climate change must be anticipated and provided for throughout the life of the development — and not just for current climatic conditions (Three Regions Climate Change Group, 2005).

In Viet Nam, an initiative by Development Workshop France was part of the disaster reduction programme in 1999, aimed at reducing the impact of typhoons and floods on housing. Based on risk identification and the need to show how preventive action can reduce the risks, the programme combined grassroots consultation in preventive action planning. The aim was to bring families and the active community together into the process of reducing their vulnerability by integrating storm resistance techniques into existing and future building (UNISDR, 2007).

4. Components of approach in introducing innovative strategies

Strategies for developing flood resilience in cities should include assessments of the:

- capacity of cities to cope with floods (urban characteristics including institutional capacities and physical structures for water retention);
- risks to the cities, including identification of priority targets for risk reduction and analysis of the causes and frequency of flooding, for determining the risk posed by extreme events and regular flooding; and
- technology (e.g., radar) necessary to support flood management activities.

(a) Conducive socio-economic conditions

Because flood-prone lands are often the cheapest or sole remaining areas for disadvantaged socio-economic groups to settle in, floods usually impact most severely on the poorest and most vulnerable groups of society. A vicious cycle appears to exist since the regular impacts of floods tend to exacerbate social divisions and constrain the potential for such groups to advance themselves.

Flood management strategies need to (i) contribute to alleviating poverty and enhancing the socio-economic conditions of the poor, (ii) improve the scope of livelihoods of vulnerable groups in the community and (iii) promote understanding of the cultural characteristics underlying community needs and capacity to cope with flood events.

In the Lao People's Democratic Republic, for example, measures to prevent and mitigate natural disasters buttress the poverty alleviation strategy of the Government (Oudomcit, 2009, p. 8).

(b) Effective governance and institutional structures: effective policy and planning

Key activities of the Hyogo Framework for Action 2005-2015 (UNISDR, 2005) include: (i) support from institutional and legislative frameworks for creating and strengthening disaster risk-reduction mechanisms, with responsibilities designated at national through local levels, in order to facilitate coordination across sectors; (ii) integration of risk reduction, as appropriate, into development policies and planning at all levels of government, including in poverty reduction strategies and multisectoral policies and plans; and (iii) recognition in institutional and legislative frameworks of the importance and specificity of local risk patterns and trends, with devolution of responsibilities and resources for disaster risk-reduction to appropriate subnational or local authorities.

Urban planning requires a long-term vision and should be based on principles of sustainable development. Infrastructural development in urban areas should include all the key components of sustainable urban development: adequate water supply, appropriate drainage, energy-efficient transportation, effective energy supply (electricity, gas), reliable communications, sufficient open space and buffer areas; and entertainment for the community. Additional facets of the urban environment, such as industry, trade and services, should be considered part of that systemic picture (Tran, 2009).

(c) Robust decision support tools, models and predictive capability

Effective and robust models should allow for downscaling of worldwide risk scenarios on climate change to regional level. The International Centre for Water Hazard Risk Management (ICHARM) has developed a software package, the Integrated Flood Analysis System (IFAS), as a toolkit for implementing a flood forecasting system even in poorly gauged river systems (ICHARM, n.d.). IFAS is designed to enhance local ownership of or commitment to the flood analysis system.

Critical to predictive success is the combination of (i) global data sets and real-time observations, (ii) effective and people-centred early warning systems that include alerts to communities using familiar language forms, (iii) technological support to ensure that no one is left out and (iv) strengthening of emergency response systems to flooding at all levels.

Sharing real-time hydrological and meteorological data among countries is key to efficiency in running an early warning system for the range of hazards. The Philippine Atmospheric, Geophysical and Astronomical Services Administration has developed its Community-Based Flood Early Warning System (CBFEWS), a non-structural flood-mitigating measure that is inexpensive to run. CBFEWS combines the basic components of an early warning system with disaster operation centres being managed by local government units and the response by the community. The system applies a river-basin approach and is mainstreamed in the disaster contingency plan of the community (Espinueva, 2009, p. 4).

In recent years, remote sensing technology and geographic systems have become the key tools for flood monitoring. A major development is radar remote sensing, a technique that permits delineation of flood zones and the preparation of flood hazard maps to identify vulnerable areas. Flood depth is considered crucial in flood hazard mapping. A digital elevation model developed from a combination of remote sensing and hydrological data is considered to be the most effective means of estimating flood depth. In flat terrain, the accuracy of the flood estimation depends primarily on the resolution of the digital elevation model (Sanyal and Lu, 2004).

(d) Resilient communities: communities working

Both the incorporation of people-centred approaches to community-based management of disaster risk, and the integration of disaster-risk management strategies into socio-economic development planning, are critical for effective flood management.

To ensure urban community preparedness, in situ flood management approaches should include participatory flood planning and management that involve local government and the community. Communities should also be empowered to develop their own hazard mapping and evacuation strategy. Non-governmental organizations can perform a critical service in reducing community risks and vulnerability to disasters.

A participatory approach to identifying problems and solutions can strengthen community bonds. In addressing community vulnerability to floods in Bangladesh, community-based organizations (CBOs) have formed voluntarily under the project on mainstreaming livelihood-centred approaches to disaster management. CBOs are involved from the initial stage of problem and solution identification and participate in implementing the community-based activities through the country’s Participatory Action Plan Development (UNISDR and UNDP, 2007).

II

Formulation of innovative strategies for effective urban flood management

In the Hyogo Framework for Action, five main areas of gaps and challenges in managing floods and other disasters were identified. They include:

1. Governance: organizational, legal and policy frameworks;
2. Risk identification, assessment, monitoring and early warning;
3. Knowledge management and education;
4. Reduction of risk factors; and
5. Preparedness for effective response and recovery.

Efforts to reduce disaster risks can be systematically integrated into policies, plans and programmes for sustainable development. Risk reduction could thus be supported through bilateral, regional and international cooperation, including partnerships (UNISDR, 2005).

The rationale for controls over urban development in flood-prone areas is society's obligation to protect the interest of future owners and occupiers (Ronan, 2009). Most of the benefits from the economic use of flood-prone land (a) accrue to those involved in development processes and (b) are associated with increases in land value. Subsequently, however, the costs of flood damage and mitigation works or measures are borne mostly by later owners or whole communities that were not involved in the initial development.

A. Formulating strategies using the adaptive management framework

The approach to formulating strategies using the adaptive management framework encompasses knowledge acquisition, monitoring and evaluation and leads to continuous improvement in the identification and implementation of management. The approach accommodates the need for action to be taken even before a desirable minimum of technical information is available about the problems at hand. Resource management issues can be dealt with and there is sufficient flexibility for dealing with changing socio-economic or socio-ecological relationships.

The approach is cyclical. Sequential stages in planning, implementation, monitoring and evaluation lead to improved understanding and management of the vulnerability to and risks of flooding. The approach guarantees that strategies, policies or management actions can be altered in response to changing circumstances at any time.

Adaptive management requires the capacity to monitor progress and to explain it in terms of response to management actions and other changes in the situation. Behind such a simple explanation lies a need for an in-depth understanding of the nature of the changes that have occurred, and the way in which the urban system responds to pressures, both human-induced and natural. Because urban systems are generally inherently complex, with a multitude of factors operating on them, adaptive management also requires an in-depth understanding of the way in which urban systems operate.

Figure 8. Adaptive management framework

SOURCE: Abal and others, 2005.

The development of innovative strategies to achieve flood-resilience in cities should be underpinned by the adaptive management approach.

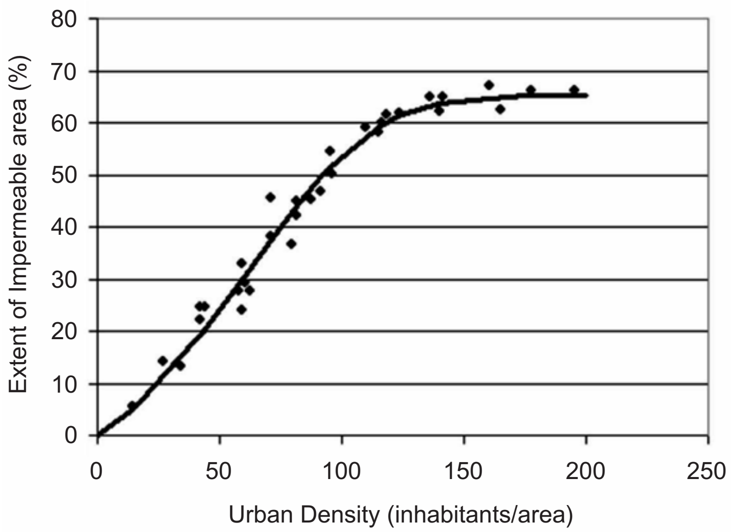
B. Developing scenarios for planning and policy formulation

Extreme events and global climate change may increase the frequency and intensity of floods, increasing the vulnerability of urban populations, particularly the most vulnerable segments, to such major hazards as extreme flood events, health hazards, cyclones and droughts, among others. Governments and institutions tasked with developing flood prediction and mitigation strategies in the highly vulnerable and expanding areas of South-East Asia face the challenges of interconnectivity of various hazards, posing difficulty in implementing a targeted decision-making process; paucity of real-time, specific and relevant data; and lack of political will. Apart from generating problems for recording of the causes of disasters, the interconnections among different hazards also accentuate the eventual impacts on the community. Hence, the development of low-cost hazard prediction and mitigation strategies for poorer nations is an important issue that needs to be addressed in Asia and the Pacific (Sidle and others, 2004).

Modelling tools can be used to study the potential effects of progressive planned urban development on storm run-off and floods. One of the main challenges in the planning of urbanization is to identify the likely effects of urban development at the planning stage, so that steps can be taken to eliminate or reduce the frequency of flooding. The planning of urban development therefore requires reliable tools that can give sound predictions of where flooding may occur, given different scenarios of urban development.

The implications of future scenarios are based on design hydrographs which are predicted using the relationship of urban planning and hydrologic parameters. Information on types of land use (residential or industrial, for instance) is important, as is the recommended population density in areas where development is planned. A robust design hydrograph can be derived from the relationship of the extent of impervious area and urban population density (Campana and Tucci,

Figure 9. A sample plot of the relationship between extent of impermeable area and urban density



SOURCE: Campana and Tucci (2001).

NOTE: Based on data from São Paulo, Curitiba and Porto Alegre, Brazil.

2001). Embedding detailed information from good model predictions in planning schemes for urban development or urban master plans can enhance confidence in the management options to address the different scenarios.

Improving the effectiveness of urban flood management requires some paradigm shifts in thinking and practice. For example, the development of policy options should be based on trends, including trends in climate change. Trends of impacts of disasters in general and floods in urban areas in particular may differ a great deal at global, regional, subregional and local levels. The following paragraphs describe scenario development for the formulation of policy options, summarizing current initiatives and assessing the trends and scenarios based on projections.

Case study 1. Application of a numerical model: the Mekong River delta in Viet Nam

The Mekong River delta, which is vital to the Vietnamese economy, has been severely impacted by a series of unusually large floods. Several dykes and weirs have been built and are continuing to be built in the delta, mainly to control floods and saltwater intrusion. A numerical model shows that the flood levels in the delta depend on the combined impacts of high river flows, storm surges, sea level rise and siltation of the Mekong Estuary resulting from the construction of dams. The model suggests that the engineering structures in the delta increase the flow velocities in the rivers and canals, thereby increasing bank erosion and deepening water levels in the rivers and canals. The result is increased flooding in the unprotected areas of the delta and increased risk of catastrophic failure of the dykes in the protected areas. The model also predicts that a sea level rise induced by global warming would enhance flooding in the delta in Viet Nam and flooding could worsen in the long term because of estuarine siltation resulting from the construction of dams.

At the scale of the Mekong River basin, a multinational water-resources management plan that encompasses the hydrological needs of the delta is required. At the scale of the delta, some run-off must be permitted for agricultural purposes, within the limits of flood prevention downstream.

SOURCE: Le and others (2007)

Most Asian and Pacific countries conduct monitoring and modelling of rainfall, run-off and inundation. Such predictions are useful in developing strategies to address urban flooding. One such example is the Integrated Water Resources Management project for the Nadi Basin Catchment in Fiji (Vaniqi, 2009, p. 6).

State-of-the-art mathematical models for the integrated assessment of the hydrology and hydraulics of catchments were useful in planning the integrated flood protection embankment-cum-Eastern Bypass Road project in Dhaka. One recommendation was that rainfall change induced by climate change should be considered in the design of the canal system as well as the pump capacity and regulator vents for the project (Khan, 2009, p. 7).

Flood risk management schemes should take into account climate variability, urban climate-specific characteristics, and the long-term impacts of possible climate-change scenarios on the frequency and intensity of floods. Recent increases in the frequency and magnitude of natural disasters such as floods, drought, and dust and sandstorms have been linked to climate change (Kang and others, 2007).

A “chained modelling” procedure could help in examining impacts of climate change on strategies for making cities flood-resilient. Chained modelling entails (a) generation and downscaling of scenarios of atmospheric increase in carbon dioxide to an appropriate river-basin scale using a regional climate model; (b) employing data from the downscaled model in a hydrologic model to generate climate-impacted stream-flows for a particular river basin; and (c) using those flows in a river basin simulation model to investigate the “sensitivity” of a reservoir system to climate change for flood risk (Kang and others, 2007).

Case study 2. Flood risk projection using chained modelling: the Yongdam Dam in the Republic of Korea

A sensitivity analysis was conducted of the flood safety of Yongdam Dam using a regional climate-change simulation. A chained modelling approach was used to run climate-change impacts on flooding scenarios, including a general circulation model (Community Climate System Model), a regional-scale climate model (Seoul National University Regional Climate Model), and a stream-flow model (Stream-flow Synthesis and Reservoir Regulation), which all inputted into a rainfall run-off model. The modelling demonstrated that average stream-flow would increase by 38.7 per cent and the variability would increase by 14.3 per cent. Th stream-flow change scenario was then inputted into the Geum River Basin Systems Simulator Model to assess the sensitivity of the current river basin system to possible climate change. The result indicated that the number of floods remains almost the same, but that the magnitude of a single flood event and recovery from it becomes worse.

SOURCE*:* Kang and others (2007)

Scenarios of non-structural measures designed to reduce risk over time deserve some consideration, in face of the (a) scope and scale of flood-related issues, (b) uncertainties of global warming, climate change and sea level rise and (c) expected upward trend in the potential costs of structural solutions (Ronan, 2009).

Case study 3. Estimations of flood risk:
Victoria State, Australia

Given the very long planning times implicit in current climate change modelling and hypothesis testing, Victoria State in Australia adopted the 50-year period from 2010 to 2060 as the basis for estimating changes in flood risk with and without possible interventions.

The status-quo scenario assumes no change in flood risk management arrangements. The implications include increases in:

- Number of new properties subject to urban storm-water flood risks;
- Urban flood risks due to increasing urban density;
- Coastal/estuarine flood risks due to sea level rise and more severe storm surges;
- Storm-water flood risks due to deteriorating street drainage systems;
- Urban flooding (mains drainage and storm-water) from increasing severity of thunderstorms associated with climate change.

The comprehensive-response scenario presents the future outlook for flood management. The scenario entails:

- Accurately identifying all flood risk areas in the State, from major floodplains to small urban flood-risk precincts;
- Ensuring that the institutional arrangements for managing flood risk operate effectively at all scales to ensure that there is no growth in risk as a result of new or renewed development of urban areas;
- Ensuring that effective awareness, education and contingency planning programmes are delivered in all areas where flood risks are significant;
- Upgrading flood warning and intelligence delivery as a State-wide, web-based service using state-of-the-art technology;
- Retiring current risk by intelligent redesign of urban precincts in the course of eventual (and inevitable) urban renewal;
- Developing technical expertise and a body of practical experience for infiltration of rainfall in urban areas. That would retire some of the current risk over time and also offset increases in urban density and storm severity associated with climate change.

An exploratory cost-benefit analysis was conducted on the two scenarios. The analysis was based on realistic estimates of the changes in various factors that could be achieved and their likely costs.

SOURCE: Ronan (2009)

Tackling the threat of climate change is becoming an increasingly urgent issue for fast-growing cities in the Asia-Pacific region. A critical arena for decision-making lies in land-use planning. An interactive scenario-based modelling approach is required to make critical conceptual insights on which more progressive land-use recommendations can be developed. The scenario analysis, however, is only one part of the strategic framework needed for urban cities. Other factors, such as the dissemination of facts and issues, and the ease and equity of communication in the community, are critical both for progress towards sustainability and the enhancement of community resilience to climate change. Issues related to sustainable urbanization are best addressed when coordinated within a strategic framework and facilitated by a system of policy formulation that combines local opinions with scientific insights (Roy, 2009).

C. Implementing innovative strategies to address climate change: "water-sensitive" cities

A critical challenge for urban communities is to create an integrated water design that is resilient to the impact of climate change. It is apparent that the conventional urban water design and management approach is highly unsuited to addressing current and future sustainability issues.

Best-practice urban water management is widely acknowledged as complex because it requires urban water planning to protect, maintain and enhance the multiple benefits and services of the total urban water cycle that are highly valued by society. They include: security of supply, public health protection, flood protection, waterway health protection, amenity and recreation, greenhouse neutrality, economic vitality, intra- and intergenerational equity, and demonstrable long-term environmental sustainability (Wong, 2006; Wong and Brown, 2008).

Defining a "water-sensitive" city is complex because of the different elements that must be considered together. A water-sensitive city integrates water supply, sewerage, storm-water and the built environment. It is a city that respects the value of urban waterways; its citizens value water and the role it plays in sustaining the environment and society. (In 2009, an Australian group of water resources professionals undertook an international study tour to help them define the concept; their findings are detailed at the website watersensitivecities09.com.)

With the widespread realization of the significance of climate change, urban communities are increasingly seeking to ensure resilience to future uncertainties in urban water supplies. Yet change seems slow, with many cities still invested in the conventional approach. Transforming cities to more sustainable urban water cities, or to water-sensitive cities, requires a social-technical reinterpretation of conventional approaches. While no example of a water-sensitive city exists, there are cities that exemplify distinct and varying attributes of the water-sensitive approach (Brown and others, 2008).

The fundamental principles underpinning the transformation of urban environments into water-sensitive cities include (a) intergenerational equity, (b) a triple bottom-line approach to the assessment of water management options, diverse water sources and water services infrastructure, (c) green infrastructure-embedding ecosystems services to mitigate the impact of urbanization on the natural environment and (d) building of social capital characterized by a smart and sophisticated community living a sustainable lifestyle. Social capital would extend to the professionals and practitioners in the water sector, in relation to their capacity for innovation and sustainable management of the city's water resources, and to all levels of government in relation to the underpinning regulatory and administrative framework (Wong and Brown, 2008).

Ensuring social-technical resiliency and overcoming city-wide vulnerability to climate change and population growth are important conditions for the water-sensitive city. When a city has a resilient system, major system disturbances (such as floods, droughts and degradation of waterway health) provide the potential to create opportunities for innovation and development. However, when a city is vulnerable, even small disturbances such as extended storm events are likely to engender dramatic social consequences (Adger, 2006).

D. Monitoring: measuring the effectiveness of urban flood strategies

One of the components of the adaptive management framework is the ability to measure the effectiveness of the strategies. Measures should be identified based on the underlying objectives of the strategies that can include the following, among others (Ronan, 2009):

Enhancement of the effectiveness of risk avoidance mechanisms such as planning to ensure that growth is limited or halted in new risk areas;

Reduction of existing risks through urban renewal and retrofitting that incorporate low-cost measures;

Reduction of the damage caused by floods by improving flood warning, flood intelligence systems, contingency planning and emergency response and recovery processes;

Improved management of urban and rural run-off to reduce flood volumes, conserve water and generate other flow-on benefits such as improved ecosystem health, amenity and lifestyle.

It is essential that the effectiveness of urban flood strategies be measured using a range of parameters/indicators that reflect the preparedness of a city as well as the impacts of the flood. Most often, indicators reflect only the impacts of floods; such indicators include reduction of deaths and reduction of economic damage. It is just as important to include parameters that reflect the preparedness of the city to reduce its vulnerability to flooding. Such measures can include: current economic growth; rates of increases in urban density; presence or absence of combined education, awareness and planning programmes; growth controls; urban run-off reduction opportunities; urban renewal improvements; and climate change and sea level rise. Such measures also provide a good baseline for the planning for effective urban flood strategies.

E. Creating a conducive institutional set-up for effective urban flood risk management

1. Mainstreaming flood management into integrated water-cycle management

The inclusion of flood management in integrated water-resources management promotes a holistic rather than a fragmented approach to flood management. While the concept of integrated water-resources management and its operationalization have already been occurring for about 10 years, the innovation lies in the development of policy, planning and institutional frameworks that embrace all of the principles of integrated water-resources management and, at the same time, incorporate a risk management approach. The combination integrates the development of land and water resources in a river basin and is aimed at making efficient use of flood plains while reducing loss of life from flooding.

As a component of an integrated water-resources management, integrated flood management requires a combination of policy, regulatory, financial and physical measures that focus on coping with floods, without the expectation of full control over them. Integrated flood management employs an approach that allows for preventive action within the full range of interrelationships between flooding and human habitation. The concept is based on the following principles (APFM, 2004):

- Employing a basin-wide approach;
- Considering floods as part of the water cycle;
- Integrating land and water management;
- Adopting a mix of strategies based on risk management approaches;
- Facilitating cooperation between different agencies;
- Ensuring a participatory approach.

The Government of Malaysia has a comprehensive approach to storm-water management, balancing considerations of flooding, water quality, aquatic habitats, riparian vegetation, recreation, aesthetics and economic issues. The Government has begun to allocate substantial funds and efforts to implement flood mitigation measures in parallel with the infrastructural developments in its recent projects such as Putrajaya, the administrative centre, and the Cyber Corridor. The Government uses the concept of control at source in flood management and addresses other issues such as prevention and mitigation of flash floods, river pollution, soil erosion, and development in highlands and low-lying lands (Seang, 2009).

In China, the Ministry of Water Resources proposed in 2003 the conceptual transition from flood control to strategic flood management, aiming to enhance understanding about interconnecting systemic disaster-related issues and total risk awareness. General flood-control capacity enhancement includes waterway dredging and restoration, engineering construction such as defensive dykes and dams, and enhancement of existing flood-prevention facilities. Storm-water was also utilized as a complementary resource for water supply, thus introducing the whole-of-water-cycle management principles (Liu, 2009, p. 2).

In India, rainwater is commonly harvested for flood prevention as well as for water supply. On-channel storage of rainwater in storm-water drains retains the water resource and helps brake the flows that result in flooding (Mahto, 2009, p. 7). Rooftop harvesting in Delhi is one example of multiple objectives served in managing floods.

In South East Queensland, Australia, the application of the integrated water cycle management approach has been initiated as illustrated in figure 10.

2. A framework for transitioning towards water-sensitive cities: a continuum

Through historical, contemporary and futuristic research involving Australian cities, the team of Brown, Keath and Wong (2008) of the International Water Centre have developed a transitions framework with six-part, progressive a typology of flood-related urban states: proceeding from the "water-supply city" to the "sewered city", "drained city", "waterways city" and "water-cycle city", culminating the "water-sensitive city". Each state or status is a subset of the next, and each state is characterized by different drives and management responses.

The novelty, practicality and applicability of the framework in Asia and the Pacific is the recognition that the transformation of a city towards the ultimate state of a "water-sensitive city" is a nested continuum of different states, rather than a direct and straightforward step. Such a framework accords with the time-bound, ideological and technological contexts that cities transition through as they evolve toward sustainability in water-related matters. One of the values of this framework is that it can be used by strategists and policymakers as an heuristic device and/or a basis for a benchmarking tool. It fosters intercity learning and comparison (Brown, Keath and Wong, 2008).

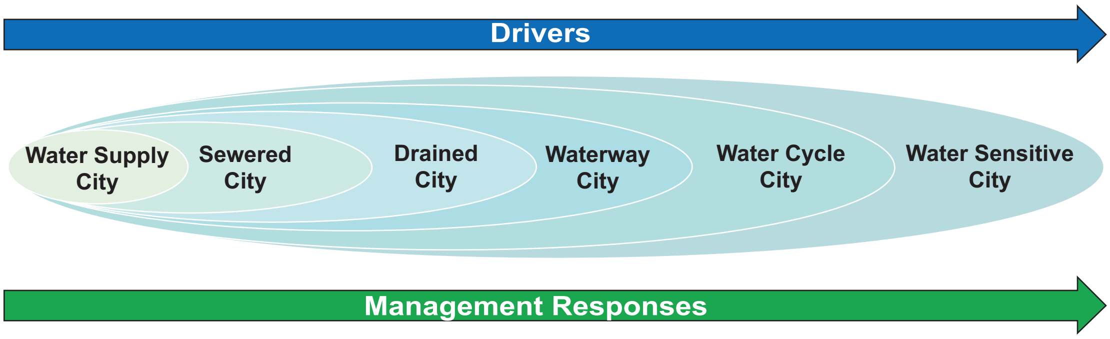
The "water-supply city", one of the first stages of the development of an urban area, is driven by the need for a public water supply. The management response is provision of the physical infrastructure or hydraulics required to provide water to households and industry. With increasing population comes the need to provide sanitation services and public health facilities. The "sewered city" is driven by that need, so the management response is a scheme for a separate sewerage infrastructure.

Further population growth requires the city to address the risks of flooding and inundation of households, hence transitioning to the "drained city". Consequently, drainage and flood protection infrastructure and flood risk management strategies are needed. Cities at that state take a conventional approach in addressing the challenges of urban flooding. Drainage and canals are constructed to divert dirty flood waters away from households and into waterways. In some parts of Asia, dykes are constructed to protect the lower-lying urban areas. Flood alert and warning

Figure 10. Integrated whole-water-cycle management in South East Queensland, Australia

SOURCE: Australia, SEQHWP (2009).

Figure 11. Continuum towards water-sensitive cities



SOURCE: Adapted from Brown, Keath and Wong (2008).

systems are also put in place to enhance the preparedness of the community. Post-flood disaster strategies are also established. However, that stage does not address the other factors that make cities vulnerable to floods; i.e., watershed, climate change and water pollution issues, among others.

An increasing community desire for social amenities from waterways, and the development of environmental values with regard to waterways, characterize the urban state of the "waterway city". The lifestyle of the community becomes increasingly affected by the state of the waterways and hence stimulates a drive to restore the ecosystem health of waterways. Further limits to growth and development motivate a city to transition to a "water-cycle city", whereby it takes advantage of opportunities to create diverse, fit-for-purpose structures and promote conservation, both of which are integral to waterway protection to ensure security in water supply and waterway ecosystem health for the growing population. Management of the total water cycle allows for diversification to alternative sources of water supply while ensuring that the environment is protected and maintained.

The ultimate stage in the proposed framework is the "water-sensitive city". Today, although there is no example of a "water-sensitive city" anywhere in the world (Brown, Keath and Wong, 2008), the concept is attracting attention and interest from practitioners working towards potentially sustainable water futures (Ison and others, 2009).

A "water-sensitive city" integrates the values of environmental restoration and protection, security in water supply, effective flood mitigation, promotion of public health amenity, liveability and economic sustainability, and a desire for the community to protect intergenerational equity and promote resilience to climate change with regard to those values (Brown, Keath and Wong, 2008).

The key principles of water-sensitive cities proposed by Wong and Brown (2008) reflect how their approach is appropriate for creating an institutional framework for urban flood-risk management as follows.

(a) *Intergenerational equity*. Communities and Governments should understand and agree that future generations should be able to enjoy security of water supply and that healthy waterways should not be compromised by current development. A long-term strategy is required in planning the technological and institutional infrastructure to deliver water services to cities.

(b) *Triple bottom-line approach*. Water and water services need to be valued in social, environmental and economic terms rather than simply as economic costs.

(c) *Integrated approach*. A total-water-cycle approach is required in managing water resources, including water supply, sewerage, flooding and storm-water services, in a manner that is beneficial to waterway, ecosystem and community health and well-being.

(d) *Diverse water sources*. Institutional systems are required that deliver a "portfolio" of water sources underpinned by a range of centralized and decentralized infrastructure, with the least cost and impact on rural and environmental needs.

(e) *City as a catchment*. Minimizing imports of drinking water and exports of wastewater to areas outside the boundaries of the city would serve to optimize the use of water resources within the city. Both storm-water and treated wastewater are considered important water sources.

(f) *Ecosystem services*. The valuation of waterways as an integral part of the city and the recognition of the ecosystem services that they provide to enhance liveability and amenity are the main drivers for the protection of environmental values of aquatic systems in the city. For example, green infrastructure for storm-water quality treatment (as part of water-sensitive urban design) would cleanse polluted storm-water and provide benefits in terms of the microclimate and amenities.

(g) *Resilience to climate change.* Diversity of water sources would ensure that the city adapts to conditions of water-scarcity and water-abundance. In addition, resilience of waterways and water resources to the risks of climate change, such as increased flooding and extreme droughts, are enhanced through strategic planning of restoration and protection of waterways.

(h) *Social capital*. The community becomes "water-smart" and socially responsible when it lives a sustainable lifestyle and is responsive to reciprocal impacts of the built and natural environments. Social capital also needs to embrace enhancement, promotion, and capacity-building for innovation and sustainable management of the its water resources, as well as to governmental enhancement of the underpinning regulatory and administrative frameworks.

(i) *Business case*. Governments and the private sector need to collaborate in creating the institutional and economic incentives to invest in sustainable solutions.

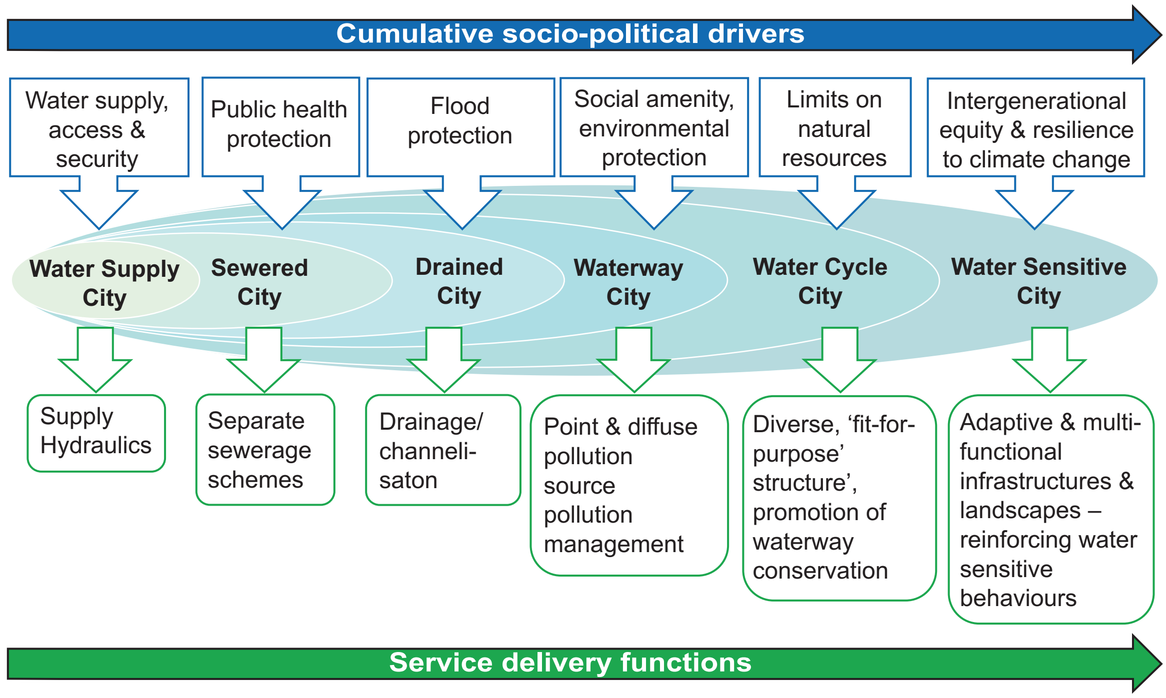
F. Applying the framework in Asia and the Pacific

Both frameworks proposed here, for mainstreaming of flood management into integrated water cycle management and water-sensitive cities, are complementary. Mainstreaming flood management into integrated water cycle management is a precursor of the transition to water-sensitive cities.

Different cities in Asia and the Pacific are in different phases in the framework towards water-sensitive cities. How is a framework converted into action? The transition framework presents a typology of different states that cities transition through in making changes to enhance their sustainability (Brown, Keath and Wong, 2008).

The drivers for water-sensitive cities include climate change and associated uncertainties as well as increasing population and urbanization, which are critical factors in achieving flood-resilient cities in Asia and Pacific. The framework provides opportunities for managing the microclimate and mitigating the urban "heat island" effect in cities, enhancing drainage infrastructure and links

Figure 12. Framework for a water-sensitive city: a proposal for an institutional set-up conducive to effective, strategic, urban flood-risk management



Source: Brown, Keath and Wong (2008)

between water and energy, ecological landscapes and social capital (Wong and Brown, 2008). All of them are relevant for the development of urban flood risk management strategies. The framework provides the basis for an urban management strategy that integrates all elements of urbanization, uses a social-technical approach and provides a common platform for evaluation of how liveable and resilient are cities (Wong, 2006).

The incorporation of the key principles of water-sensitive cities into the strategic development of flood resilience involves innovation on two levels: (1) structural (multifunctional infrastructures, storm-water harvesting and other forms.) and (2) non-structural (for community engagement, social capital, governance and institutional changes).

The six transitional states are a nested continuum, whereby the preceding state helps in shaping conditions and development of the succeeding state. As a city progresses up the ladder of transitional states, it accommodates additional, and sometimes competing, objectives. While the different transitions have been simply represented as a linear progression, cities may move in both directions across the continuum as well as jump and/or straddle different states, depending on the changing circumstances and opportunities that they face (Keath and Brown, 2008).

Implementing the framework towards a water-sensitive state (Brown, Keath and Wong, 2008) requires the following actions:

- Promoting social capital that reflects a community engaged in a sustainable lifestyle and working for intergenerational equity, in the context of climate change;
- Building and enhancing the professional capacity for innovation and sustainable management of the city's water resources that encompasses diverse, flexible, and multifunctional urban technologies and forms;
- Sustaining a flexible institutional regime that fosters the implementation of the framework.

The application of the framework would reflect the different components of innovative strategies to manage urban floods: river basin management, water-sensitive urban design, climate-change-resistant infrastructure and the integration of flood management in the scope of total water-cycle management. The application of the framework would need to become part of (a) national economic development plans that form an enabling environment, together with effective governance and institutional structures (i.e., effective policy and planning frameworks); (b) a robust decision-support system that enables short-term reactive and long-term planning; and (c) campaigns of community awareness, education and motivation.

As cities evolve, urban managers are faced with increasingly complex and multifaceted challenges. Given the significant climate change and population growth challenges that face cities and amplify urban flood risks, there is a pressing need for strategic investment in solutions that can deliver long-term, sustainable and multifaceted outcomes (Brown, Keath and Wong, 2008).

III

Innovative Strategies for Effective Flood Management

This chapter showcases good practices that address the key principles in developing innovative strategies to enhance urban resilience to flooding, drawn from the expert group meeting that was held at ESCAP from 21 to 23 July 2009, to discuss innovative strategies to enhance flood resilience in Asian and Pacific cities. The following selection of case studies from Australia, Cambodia, China and the Philippines is intended to encourage further efforts towards innovative strategies for urban flood management.

The case studies illustrate ways of implementing or adopting some of the key principles of strategies for achieving flood-resilience that have the following characteristics:

- Transition from control to management;
- Innovation in approaches that involve multifunctional infrastructures, such as a framework for water-sensitive cities;
- Mainstreaming of management strategies in the national development framework;
- Community ownership of and participation in early warning systems;
- Cognizance of risks from climate change in management strategies.

A. Developing innovative approaches using multifunctional infrastructures: a framework for water-sensitive cities from Australia

Through detailed historical, contemporary and futures research involving cities in Australia, a transitions framework was proposed by Brown, Keath and Wong (2008), with a typology of six city states (see figure 11). This framework recognizes the temporal ideological and technological contexts through which cities transition when moving towards sustainable urban water conditions.

With reference to figure 11 and the authors' work, a series of workshops on creating water-sensitive cities was held by the International Water Centre in major cities in Australia in 2009. The workshops focused on issues centred around:

- Common understanding of the vision and goals;
- Social and institutional perceptions, changes and attitudes;
- Institutional capacity and governance;
- Funding, cost and value of water-sensitive cities.

The characteristics of water-sensitive cities from the workshops may be divided into three main themes with their corollaries:

(a) **Cities as supply catchments.** A diversity of sources and use and delivery options; the resilience and adaptiveness of the city; and management of water as part of a holistic and integrated system.

(b) **Cities providing ecosystem services.** Green infrastructure, space and other visual and physical aspects of a water-sensitive city; the ambiance and atmosphere of the city; and waterways (including quality).

(c) **Sophisticated and water-smart cities.** Community acceptance and engagement on a range of institutional aspects and the incorporation of real cost in decision-making.

The main opportunities for the transition of Australian cities to water-sensitive cities that were put forward during the workshop series included needs for:

- Multifunctional infrastructures consisting of centralized and decentralized water supply, green technology and energy-efficient infrastructure, water reuse and diversity, and fit-for-purpose uses;
- Knowledge, data, information acquisition and sharing, and learning;
- Effective and relevant regulation, policy and planning;
- Measures to address social concerns and enhance awareness, support and stakeholder ownership;
- Measures to address climate change, drought and financial crisis.

Participants at the workshop discussed some constraints and enablers in the transition to water-sensitive cities. Significant constraints included the lack of resources; lack of commitment, will and support; and lack of ability to influence decisions, policy and public attitudes. Many of the constraints, with suitable shifts, also hold the key for enabling action. Organizational and local political support, high-level sectoral support and dedicated funds, along with the availability of knowledge and research, are keys to enabling action. Those findings point towards the significance of social processes in enabling the deployment of technologies for creating water-sensitive cities (Ison and others, 2009).

B. Mainstreaming flood management strategies in national development: Cambodia

Flood management strategies need to be an integral part of national economic plan of every country. In Cambodia, mainstreaming of such strategies in the national development framework is the work of the National Committee for Disaster Management, with its overarching responsibility for disaster preparedness, response and mitigation.

The National Strategic Development Plan for 2006-2010 does not directly address disaster risk reduction but incorporates it in the areas of social welfare, water resource management, and agricultural and rural development (Rinbo, 2009, p. 3). Disaster-risk reduction activities identified within those priority sectors include protecting rural areas from natural hazards, enabling communities in disaster preparedness and risk reduction, and reducing the vulnerability of the poor to external shocks, including natural hazards.

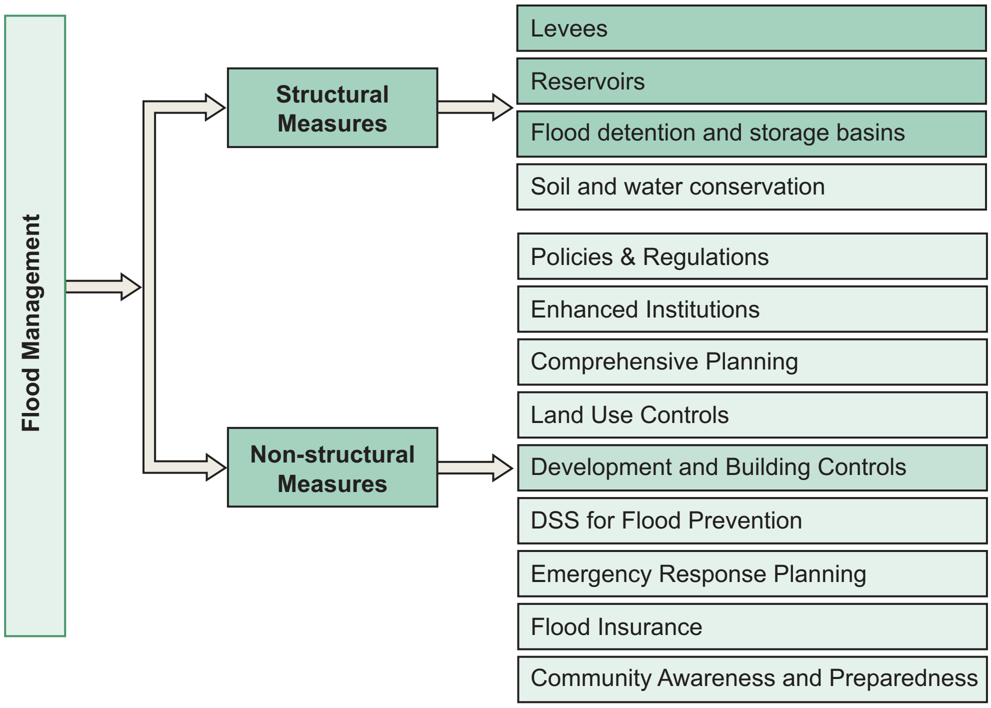
The Strategic National Action Plan 2008-2013 for Disaster Risk Reduction, prepared by the National Committee for Disaster Management and the Ministry of Planning, was launched in March 2009. The critical priorities in the plan include (a) mainstreaming disaster risk reduction into Government development planning, (b) formulating a national disaster risk management policy and legislation and (c) strengthening the national mechanism for coordinating disaster risk reduction.

The Mekong Integrated Water Resources Management Project, a regional project including Cambodia, the Lao People's Democratic Republic and Viet Nam, is aimed at improving water resources management and alleviating poverty (Rinbo, 2009, p. 5).

C. Transitioning from flood control to flood management in China

The Government of China has attached increasing importance to flood disaster prevention and reduction. On the one hand, structural measures such as dike reinforcement, river regulation, the construction of reservoirs, and the building of flood retention and storage basins have been emphasized. On the other hand, non-structural measures have been strengthened such as decision-support systems for flood prevention, pre-schemes for flood control operations, flood storage and retarding basins, and flood insurance (figure 13).

Figure 13. Structural and non-structural measures for flood management in China



SOURCE: Liu (2009).

In recent years, the risk management approach has been introduced into the development of management strategies and new policies have been proposed. The emphasis of flood prevention has shifted from attempts to control or eliminate floods to efforts to manage floods. To move from a dependence on structural measures for reducing flood damage to a balanced approach using both structural and non-structural measures, the Ministry of Water Resources of China, supported by technical assistance from the Asian Development Bank, prepared a national flood management strategy in 2005. The China Flood Management Strategy includes the analysis of specific problems, requirements and constraints, an overall strategy for flood management in China, and the details of three key tasks, five main elements and five strategic countermeasures. The three key strategic tasks identified to manage floods (Liu, 2009, pp. 5-6) include:

1. Implement a risk management approach;
2. Manage human activities to ensure that the risks of flooding are not increased;
3. Ensure utilization of flood-waters as a mechanism to control floods.

D. Directly engaging communities in flood warning systems in the Philippines

The Philippine Atmospheric, Geophysical and Astronomical Administration (PAGASA) issues early warnings against typhoons and attendant flooding, among other responsibilities. Because of the increasing incidence of floods in downstream urban areas and flash-floods in the upper reaches, PAGASA has enhanced its forecasting and warning services by engaging the community. The initiative, called the Community-Based Flood Early Warning System (CBFEWS), is a good example of a cheap, non-structural flood mitigating measure (Espinueva, 2009).

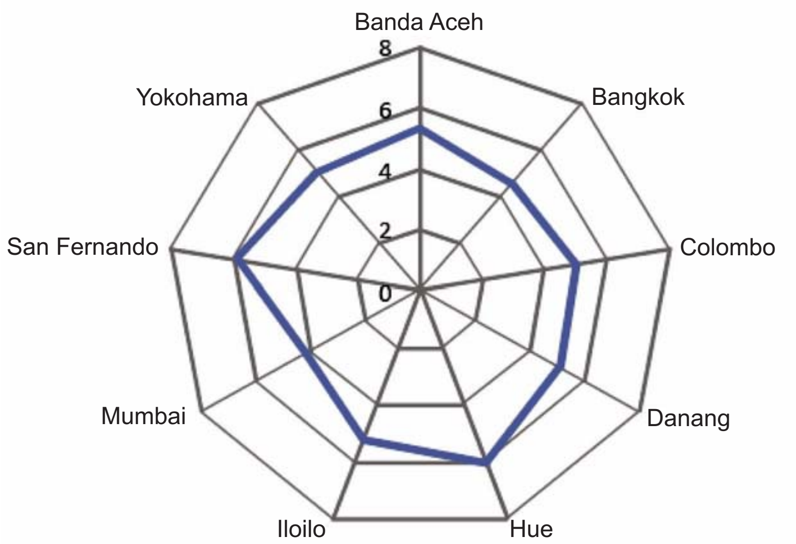
The immediate benefits of a flood-focused early-warning system are the reduction in loss of human lives and mitigation of damage to property. It allows for direct and swift community access to the output of warning devices. Community preparedness for flood events is enhanced. Local administrative units can use the tool to derive flood indices or establish the correlation between rainfall intensity and the resulting height and extent of inundation in their respective areas.

The benefits and effectiveness of CBFEWS were highlighted in August 2004 during Typhoon Marce, which brought heavy rains to the province of Bulacan and caused a significant rise of the Angat River. In addition to the storm warnings, the use of the data from CBFEWS provided the community with sufficient awareness and preparedness to harvest their aquaculture products before the fishponds were flooded (Espinueva, 2009, pp. 2-3).

E. Addressing climate change in developing flood management strategies: measuring climate disaster resilience of cities

Cities are becoming increasing vulnerable to flooding because of climate change. The International Environment and Disaster Management (IEDM) Laboratory at Kyoto University developed the climate disaster resilience index (CDRI) to measure the existing level of climate-change resilience of some cities in Asia (Shaw, 2009). The index was developed based on five resilience-based

Figure 14. Resilience mapping of nine Asian cities according to their overall CDRI



Source: Shaw, 2009, figure 1 (excerpt).

Note: CDRI = climate disaster resilience index.

dimensions: natural, physical, social, economic and institutional. Flooding is classified as one the climate-induced disasters. The resilience information, which refers to the capacity of a city to cope with climate change, is presented as overall resilience, as well as separate values for physical, social, economic and institutional resilience. Higher values of resilience are equivalent to relatively greater preparedness to cope with climate and disasters.

Initial results using the CDRI to map climate resilience in cities indicate the strengths and weaknesses of individual attributes used to compose the overall index. The results also indicate that the level of resilience does not depend on the size of cities. Similar-sized cities may experience different levels of resilience.

The degree of overall resilience and individual resilience to different attributes may influence policymakers and their countries to focus investment on critical areas of potential future risk, in order to enhance the degree of resilience of cities and communities.

The initial phase of the study looks at nine Asian cities: Banda Aceh, Indonesia; Bangkok, Thailand; Colombo, Sri Lanka; Danang, Viet Nam; Hue, Viet Nam; Iloilo, Philippines; Mumbai, India; San Fernando, La Union, Philippines; and Yokohama, Japan.

IV

Policy Options for Effective Flood Management and Flood Resilience of Cities

One of the main reasons for high levels of economic loss and mortality from flooding is increased exposure to flood events in many fast-developing Asian countries. With a high proportion of migration to urban areas and unpredictable weather patterns owing to climate change phenomenon, cities are becoming increasingly vulnerable to flood disasters. Irrespective of whether urban floods are the result of overflowing rivers or poor maintenance of urban drains, the damage is significant.

With expanding knowledge about disasters and their impact on society and development, efforts to reduce disaster risks should be systematically integrated into development planning and supported through bilateral and multilateral private and public partnerships.

The following policy options have been formulated as a result of contemporary research in the region that has focused on key development areas. They constitute the collective thinking of the participants at the ESCAP meeting in 2009 on innovative strategies for flood-resilient cities in Asia and the Pacific that generated the content of this publication.

1. Flood risk management schemes should take into account climate variability and long-term impacts of climate change. A comprehensive risk-reduction approach should encompass issues related to hazards, vulnerability and exposure in both current and future scenarios.
2. Integrated flood management approaches should involve harvesting of flood-waters, where possible, for use during the dry periods and diversion to drier areas according to need.
3. Community-based disaster risk management approaches should be integrated with socio-economic development planning for effective engagement of communities in overall flood management.
4. Participatory urban flood management should be encouraged with full participation of the communities and local administrations. Communities should be empowered to develop their own flood hazard maps and evacuation plans.
5. Hinterland protection, eco-system management and integrated land and water resources management should receive priority in integrated flood management plans.
6. Global and real-time data sets should be used for effective warning for people exposed to flood disasters. Early warning systems, rapid dissemination of alerts and use of local languages for clear understanding should be components of flood management approaches.
7. Improvement in water retention, increasing open-space water infiltration and rainwater harvesting should be incorporated into urban risk management and development plans.
8. Existing urban development guidelines should be revised to include potential climate change.

9. Risk assessment methodologies should be revised to incorporate current and future urban development and climate change scenarios.
10. International and regional organizations are encouraged to assist countries in the region to improve the efficiency of monitoring and evaluation of flood risk assessments by providing access to remote sensing and other real-time information.
11. International and regional organizations are requested to assist countries in downscaling climate change information to national and local levels.
12. Capacity-building should be encouraged for effective communication and long-term prediction of flood management using new technologies.
13. The mandate of local administrations should be strengthened for managing disaster risk reduction and allocating resources between national and local administrations.
14. Sharing of experience and knowledge, and raising of awareness among local administrations and cities, should be promoted, together with enhanced capacity to address flood risk management.
15. National platforms should be used for encouraging the mainstreaming of flood disaster-risk reduction into development planning.
16. Authority for flood management should be mandated through appropriate policy, legislative and institutional arrangements.
17. Local administrations in disaster-prone areas should be encouraged to allocate part of their internal revenue to disaster risk reduction.
18. Disaster risk reduction and community-based disaster risk management should be mainstreamed into the urban development planning process.
19. Risk-transfer measures should be streamlined and strengthened to mitigate immediate impacts of disasters.
20. Public-private partnerships should be encouraged for urban disaster-risk reduction.
21. Disaster risk reduction should be incorporated into academic curricula at all levels of education.

Innovative strategies for developing urban flood-resilience should be underpinned by adaptive management approaches. Use of the adaptive-management framework could lead to identification of suitable tools to reduce urban flooding. Such an approach could yield reliable predictions of where urban flooding might occur under varying development scenarios. One of the main challenges encountered by urban development planners is that of developing an integrated water-management design that is resilient to the impacts of climate change including storm-water drainage and flooding. Under current climatic vagaries and the complex nature of urban migration, a paradigm shift in urban water-management designs will be required in the future.

With the significance of climate change and population growth facing cities, the need to allocate investments in sustainable development solutions is urgent. The framework for transitioning toward water-sensitive cities offers a tool for urban development planners to identify critical areas of risks and attributes. Investments could thus be targeted for capacity development, institutional reforms and structural interventions that could contribute to sustainable urban water management and enhance flood-resilience in cities.

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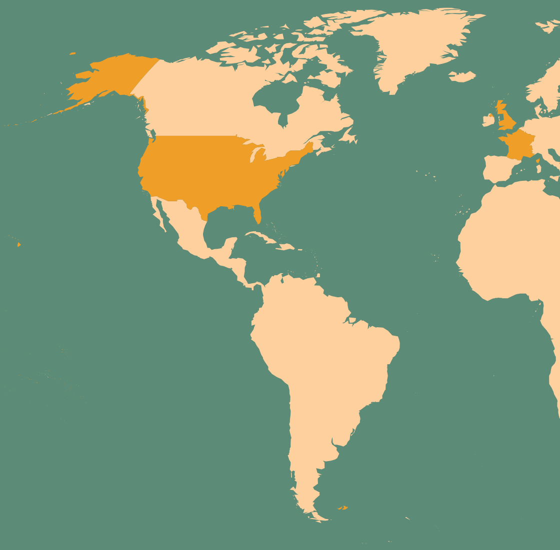

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