6. URBAN ISSUES

6.1 SECTION CONTENT

This chapter describes issues unique to urban areas, including the factors affecting flooding, the impacts of climate, urban flood governance, community engagement, and considerations for urban coastal areas.

Phuket, Thailand, September 5, 2008: Floods on Thanon Ratuthit Songroipi Road in Patong, Phuket. Flooding is very common during the wet season in Phuket as storm drains struggle to cope with the heavy tropical downpours.
6.2 WHAT IS URBAN FLOODING?

More than half the world’s population currently lives in urban areas, and this population is expected to increase to 70% by 2050.1 Most professional flood managers do not distinguish between urban and rural floods; there is no standard definition for what constitutes an urban area. Urban areas typically consist of dense populations, a built-up physical landscape including paved streets and electricity, and other economic features, like financial centers. Rural and urban areas exist as part of a larger rural-urban continuum within the watershed, which varies as population, infrastructure and development types shift.

Urban flooding is localized flooding that occurs when the sewage system and/or drainage system lack the capacity to adequately drain precipitation. This type of flooding is often the result of a combination of factors that may accompany urbanization (an increase in the proportion of a country that is urban). These factors include an increase in impervious surfaces (those that do not allow water to be absorbed, such as rooftops, roads and parking lots); inadequate stormwater storage or drainage capacity; and poorly planned infrastructure, particularly in rapidly urbanizing areas. Riverine floods, coastal floods, pluvial and groundwater floods, and artificial system failures (e.g., dam failure) also affect urban areas (see chapter 3).2

6.3 IMPACTS OF URBAN FLOODING

Damages, costs and mortality risks are typically higher in urban floods than in rural floods due to the high concentration of people, infrastructure and other assets. Direct impacts from urban floods may be more geographically widespread and longer lasting. Urban floods disrupt assets of regional or national significance, such as large infrastructure, financial centers and health services. Indirect impacts from urban flooding include disease, reduced nutritional and educational opportunities, and loss of livelihoods.3

The number and diversity of people potentially affected by an urban flood amplify the challenge of management and response. Urban floods can occur more quickly than rural floods, and urban development may lead to flooding in areas previously unaffected. Urban populations also include transitory populations, such as workers and visitors, as well as new residents who may be unfamiliar with the timing and location of cyclical flooding. People new to an area may not know how to reach safety and may be unfamiliar with safety precautions. This heightened social vulnerability, in combination with the rapid onset of some types of urban flooding, creates a higher level of flood risk and can lead to significant loss of property – and loss of lives – when flooding does occur.

6.4 WHAT FACTORS AFFECT URBAN AREAS AND FLOODING?

The complex interactions between the following features within an urban environment aggravate flooding:

- physical factors
- climate- and weather-related factors
- governance and management factors

These components operate at various scales – local, regional, state and national – often leading to interrelated causes of flooding. For example, urban floods may result from local factors like inadequate land use planning and impermeable surfaces; regional/upstream factors like deforestation; and national/global factors like sea level rise. This complexity offers a range of opportunities for intervention.

2 Ibid.
3 Ibid.
6.4.1 PHYSICAL FACTORS

6.4.1.1 Land Use Change and Reduced Permeability

Urbanization alters existing land use patterns, frequently resulting in the loss of natural vegetation and open space. These land use changes often cover wetlands; block or redirect rivers or streams; and collect and move water through artificial channels like drains, culverts and tunnels that change the natural drainage patterns. Urbanization may affect neighboring areas (particularly those downstream), thus increasing the risk of flooding elsewhere. All of these issues have implications for flood risk management.

Impervious, or paved, surfaces – such as roads and rooftops – also increase with development. Impervious surfaces dramatically alter the urban hydrological cycle and local climate (see figs. 6.1 and 6.2).

\[\text{In urban areas, impervious surfaces increase the amount of precipitation that runs off hard surfaces – and the speed at which it travels – by reducing the opportunity for precipitation to be retained where it falls or intercepted by vegetation.}^{4}\ \text{Depending on the expanse of impervious surfaces in the watershed, surface runoff volume can increase between two to 16 times the predevelopment rate, with a corresponding reduction in groundwater recharge.}^{5}\ \text{This altered urban water cycle can turn normal urban rainfall into localized flooding or flash floods.}^{6}\]

Typically, in urban areas, the stormwater management system is made up of hard (gray) infrastructure. Gray infrastructure conveys stormwater as quickly as possible out of the urban area and into the nearest body of water.

\[\text{FIGURE 6.1 URBAN HYDROLOGICAL CYCLE EXAMPLE}\]

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4 For more discussion on these issues, see the Land Cover, Land Use and Infrastructure section in chapter 3.
water. Conventional stormwater management typically includes a collection system made up of graded roads, curbs, gutters and pipes to channel water into combined or separate sewer systems (see chapter 5 for more on engineered drainage systems).

Gray infrastructure methods manage a limited volume of stormwater by design. Today, rapid population growth, increased development and more frequent, intense precipitation events easily overwhelm existing urban stormwater management capacity. Without adequate stormwater management capacity, untreated sewage and polluted stormwater runoff enter receiving waters, thus reducing water quality and posing environmental and health risks. If collection systems cannot accommodate the increasing volume of stormwater, urban flood risk is increased.

In urban settings, the stormwater management methods outlined in chapter 5, as well as sustainable urban drainage systems (SUDs), which perform a similar function, are central to reducing pressure on existing water systems by slowing, retaining and detaining stormwater.

6.4.2 CLIMATE AND WEATHER FACTORS

6.4.2.1 Urban Microclimate and Impervious Surfaces

The increase in impervious surfaces and dense infrastructure that accompanies urbanization creates a local microclimate that is often warmer than surrounding areas.\(^7\) This is known as the urban heat island (UHI) effect. The UHI effect is caused by impervious materials used in urban areas and the concurrent reduction in vegetation. Dark materials – like asphalt – used in urban areas typically have low reflectivity, or albedo, meaning that the materials absorb heat throughout the day instead of reflecting it.\(^8\) This varies with type and density of materials. The loss of vegetation reduces the cooling effects of evapotranspiration, the shade cover of trees, and ground-level moisture.\(^9\) These conditions combine to create a warmer urban microclimate. Flood Green Guide users should consider the UHI effect as a part of the urban context when they are identifying and selecting flood management methods.

8  Ibid.
6.4.2.2 Weather and Natural Climate Variability at the Local Scale

Naturally occurring seasonal weather and multiyear climate patterns are also affected by larger-scale processes such as El Niño and La Niña, which can result in temperatures that are warmer or cooler than normal temperatures and changes in precipitation patterns.10 These can affect urban flood risk in impacted regions.

In some regions, El Niño and La Niña alter regional temperature and precipitation patterns in intensity and frequency, and can increase the likelihood of storms.11 The impacts vary by region, causing increased flooding in some areas and drought in others. Natural climate variability has some predictability, but the intensity and duration of weather patterns may shift because of climate change.12 When assessing urban risks and selecting flood management methods, flood managers should consider current climate variability, the spatial pattern of impervious surfaces, and projected climate change.

The ability of a drainage system to handle runoff from intense rainfall or rapidly melting snow or ice depends on how quickly water flows into the system. The volume of water that a system can handle over a one-hour period might not be the same volume it can handle over a 15-minute period. Intense rainfall or rapid snowmelt can lead to flooding in an area where the same volume of water falling over a longer period will not.

6.4.2.3 Global Climate Change

Climate change, caused by increasing greenhouse gas emissions worldwide, will lead to “increased frequency, intensity, and/or duration of extreme weather events such as heavy rainfall, warm spells and heat events, drought, intense storm surges, and associated sea level rise.”13 The impacts of global climate change in urban areas may vary depending on the conditions and location of the urban area. For example, increases in extreme weather events and precipitation can overwhelm urban drainage systems, causing localized flooding, riverine flooding, and increasing storm surge.14 Sea level rise from warming oceans and melting glaciers may increase the population at risk from flooding in coastal cities due to a combination of land subsidence and an increase in local sea level height.15 Sea level rise also contributes to an increase in tidal flooding and intensified storm surge. Research by the New York City Panel on Climate Change demonstrated that it is virtually certain that sea level rise alone will lead to an increased frequency and intensity of coastal flooding as the century progresses.16

These components of climate can amplify urban flooding and should be part of a flood risk assessment that identifies the range of multiple risk factors and the best methods for flood risk management.

6.4.3 GOVERNANCE AND MANAGEMENT

6.4.3.1 Inadequate Drainage Planning, Construction and Maintenance

Hard infrastructure for stormwater management – such as gutters, drains, culverts, channels and retention areas – needs constant maintenance, including debris removal and updates to increase capacity and keep up with higher volumes of runoff. If funds are not available, improvements in drainage infrastructure may fall behind the

12 Ibid.
14 Ibid.
increasing rates of stormwater runoff. Even where drainage infrastructure is in place, lack of maintenance – at times combined with inadequate trash removal and lack of waste management – can block drainage systems and lead to flooding.

6.4.3.2 Land Subsidence

Natural factors (e.g., soil types) and human factors (e.g., over-extraction of groundwater, urbanization) cause land subsidence, or the compacting and sinking of soil. Delta soils are particularly susceptible because the deltaic soil expands and contracts with water. When water or moisture in the soil is cut off or reduced – by impervious surfaces or from excessive groundwater extraction for drinking water supplies and industrial uses – the soil dries out and begins to compact. The weight of buildings and other infrastructure found in urban areas amplifies soil compaction. Hard engineering methods, such as drainage pumps, levees and dikes, can also cause subsidence. Subsidence also can cause

- changes in river systems and flows
- intrusion of salt water into groundwater sources
- increases in areas at risk of coastal and inland flooding
- damage to existing drainage and infrastructure systems

6.4.3.3 Unplanned Urbanization, Encroachment, and Occupation of Drainage Systems

This aerial image of an informal settlement in South Africa shows the minimal allocation of space to be used for drainage infrastructure. Lack of infrastructure is often related to failure of planning or inability to enforce municipal plans.

Many urban areas have grown in an unplanned or semi-planned manner. For example, the population of Lagos, Nigeria, grew from just over 1 million in the 1970s to an estimated population of 21 million in 2016. In many urban areas, municipal governments have been unable to keep up with rapid growth, lack detailed land use plans, or are unable to enforce land use regulations. New construction often encroaches on, blocks or fills in natural drainage systems such as dry streams and wetlands. Unplanned and poorly managed development raises the risk of flooding, particularly in places where formal urban planning and construction management are limited or absent. Urban land that has been set aside for drainage – including large concrete drains, storm channels and flood retention areas – often becomes settlement sites for people who cannot afford to live elsewhere. Informal dwellings in these areas obstruct drainage, leading to a significant risk to life and property in the case of flooding.

6.4.3.4 Upstream and Coastal Land Use Changes

Upstream land use changes that reduce the ability of precipitation to infiltrate the ground – including urbanization, deforestation, conversion of land for agriculture, and infilling of wetlands – can increase flood risk downstream. The flow of stormwater runoff into surface waterways increases when precipitation is unable to infiltrate the ground, thus increasing the risk of flooding downstream. Other land use changes, such as development of coastal wetland areas and loss of mangroves, can increase flood risk in coastal urban communities. For example, wetlands stabilize coastlines, filter pollution, slowly release floodwater and stormwater, and reduce the impact of storm surge. Similarly, mangroves can act as a buffer against the impacts of storm surge. Healthy coastal ecosystems, when well managed, can protect inland communities and reduce the vulnerability of people in coastal areas.

6.5 URBAN FLOOD MANAGEMENT METHODS

To develop an integrated flood management (IFM) approach, urban flood managers should examine a range of scales, from the neighborhood to the watershed, and consider a combination of hard and soft structural methods as well as non-structural methods. Guide users should refer to chapter 2 and the Flood Green Guide Framework before undertaking a project. This chapter will help inform the stage 1 contextual analysis. Urban flood managers may need to coordinate with regional partners in the watershed to address upstream causes of flooding (see chapter 3). Methods vary in cost and maintenance requirements (see chapter 5), and some methods will yield results sooner than others will. For example, improving solid waste management practices – such as collection and disposal, recycling, and clearing debris from drains and waterways – can immediately reduce the impacts of flooding. Constructing retention and detention ponds may take longer; reforestation and wetland restoration might not reduce flood risk for years but can offer co-benefits in the short term.

GUIDANCE: The Flood Green Guide recommends managers first apply IFM non-structural methods and then if needed include structural (hard and/or soft) methods as part of an integrated approach.

GUIDANCE: Information provided in this chapter should always be used in conjunction with the Flood Green Guide Framework presented in chapter 2.

20 Jha, Bloch and Lamond, Cities and Flooding, 167.
The design and operation of an urban flood risk management system consists of:

- **advocating for improved urban planning** and urban management to limit flood-prone development and reduce the risk of flooding
- **increasing public awareness and preparation** through the use of flood hazard mapping, preparedness training, warning systems and evacuation plans
- **retaining water in designated areas and reducing the volume of runoff** during a storm event using structures such as rooftop gardens, swales and detention ponds built as part of the overall drainage systems
- **improving drainage in given areas** with engineered systems like gutters, drains, culverts and channels as well as natural watercourses such as streams and rivers
- **limiting the impact of flooding to locations and facilities** by using flood barriers, flood walls and such flood-proofing strategies as buildings elevated above base flood elevation or buildings designed so the first floor can withstand a flood

Non-structural measures include awareness, preparedness and advocacy. Structural measures, such as water retention and drainage systems, can limit the impacts to flood-prone areas and contain damage to facilities. (See chapter 5 for more on non-structural and structural measures.)

Existing urban plans, processes and initiatives can be adapted to integrate flood risk management methods and achieve multiple co-benefits. For example, in urban areas with space and land constraints, multipurpose infrastructure, such as detention basins, may double as parking structures or recreational facilities.

Natural and nature-based flood management methods often help meet multiple objectives, including alternative livelihoods for poverty reduction, climate change adaptation, environmentally responsible development, and improved public health.

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**EXAMPLE:** In 2010, the Capital Development Authority (CDA) of Islamabad, Pakistan, launched the first rainwater harvesting program in the country. The Pilot Rain Water Harvesting Project used tanks, ponds and small dams to harvest rainwater at the household, neighborhood and town scales. In this case, rainwater harvesting reduced urban flood risk while providing an additional source of drinking water, which reduced vulnerability to irregular rainfall patterns (a possible result of climate change). In New York City, a 1.4-acre (0.57 hectare) rooftop farm produced over 45 tons of vegetables and managed over 3 million liters of stormwater per year. In addition to reducing flood risk, this rooftop farm provided a source of employment, food security and nutrition, and reduced air pollution.

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Using natural and nature-based methods in urban areas promotes biodiversity and ecosystem services such as water and air purification, soil stabilization, noise reduction, heat-island buffers and microclimate regulation. Research shows the introduction of nature into urban areas also reduces stress and crime levels while promoting health and well-being.

**EXAMPLE:** In 2013, the government of Barcelona, Spain, enacted its Green Infrastructure and Biodiversity Plan 2020 to achieve multiple goals, including environmental objectives to regulate the urban water cycle; social objectives to improve the quality of life in the city; and economic objectives to encourage fiscal growth.

### 6.6 URBAN FLOOD GOVERNANCE

Urban governance is a critical factor in urban flood risk management. Local governments are primarily responsible for planning, implementing and managing most of the measures that can reduce urban flood risks as well as the direct and indirect impacts of flooding. Urban governance, however, is complex, shaped by interactions among social, political and economic considerations at the local, regional, national and watershed scale. Managing urban floods often requires flood managers to work across departments (e.g., public works, development planning and environment) and across jurisdictions, since watersheds rarely follow administrative boundaries. The success of urban flood management depends on supportive social and institutional conditions as well as effective monitoring and enforcement mechanisms.

Improvements in urban flood risk management require political will and buy-in at the local and national levels as well as community participation. Private sector involvement and acceptance will help address market-based barriers, while social acceptance and community engagement are vital for the long-term success of flood risk management programs.

Governance and urban flood risk management primarily require:

- integrating flood risk management into the urban planning process
- coordinating various governmental stakeholders
- strengthening the flood risk management process through regulations, such as planning regulations, municipal bylaws and building codes
- involving nongovernmental and private sector stakeholders in flood-related decision-making
- effectively engaging and consulting with the community at all stages of flood risk management

Financing mechanisms and land use planning are the most effective regulatory systems for managing urbanization, growth and encroachment of the floodplain and other flood-prone areas.

For more discussion on governance, private sector engagement, and financing, see chapter 3.

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6.6.1 INTEGRATING FLOOD RISK MANAGEMENT INTO THE URBAN PLANNING PROCESS

Urban planning shapes the long-term development of a community or region through participatory, inclusive and transparent planning processes that guide community development. **Land use planning** is a part of urban planning and is widely viewed as the process of determining the most efficient uses of land to serve society’s economic, social and environmental goals. Land use planning means different things based on the context and country. For the purposes of the guide, land use planning is used interchangeably with spatial/regional/town planning. Land use planning identifies where different types of urban development should take place, along with the associated risks, requirements for use, and constraints or growth boundaries. In urban areas, land use planning often coincides with the development of a master plan (also known as a comprehensive or general plan). For more information about meeting flood risk management objectives with the development of a master plan, see table F1 in appendix F.

Effective land use planning can reduce exposure to floods and flood **impacts** while promoting the ecosystem services of floodplains and coastal areas. Flood risk management, however, is just one consideration among many in land use planning. Planners must make decisions within the context of competing and sometimes mutually exclusive uses for land. Within the flood management context, decisions about land use will often require a balancing act between two competing ideals: making space for development and making space for water. The overall objectives of land use planning for flood risk management should include limiting exposure to flooding (by promoting growth in areas that are less vulnerable) and managing natural resources that can reduce flood risk (e.g., wetlands, forests).

Land use decisions, therefore, should be made after undertaking a participatory planning process with community members and should take into account the results of flood risk assessments (see chapter 4).

6.6.2 COORDINATING VARIOUS GOVERNMENTAL STAKEHOLDERS

Urban flood risk management crosses multiple sectors and disciplines and is the responsibility of an array of departments, agencies and organizations – often spanning jurisdictions. Effective flood risk management requires a process of collaboration and governance to ensure the support of government and nongovernmental organizations, involvement and support of the private sector, and community engagement.

6.6.3 STRENGTHENING THE FLOOD RISK MANAGEMENT PROCESS THROUGH REGULATIONS

Planning regulations, municipal bylaws, building codes and other regulations can help manage flood risk. **Zoning** is a systematic way of regulating land use allocations and population densities across an area of interest. Zoning regulations should support and enforce the guidance provided in the land use master plan for that area. Land use plans and zoning regulations supported by monitoring and enforcement mechanisms are one of the more effective ways to limit exposure to flooding and reduce risk. Increasingly, urban governments are adopting zoning to address flood risk and disaster management. For more information on integrating flood management into zoning, see table F2 in appendix F; for more information on building regulations, see chapter 5.

6.6.4 INVOLVING NONGOVERNMENTAL AND PRIVATE SECTOR STAKEHOLDERS

Integrating flood risk management into existing urban governance frameworks requires enlisting all aspects of the affected community, including residents, local government, nongovernmental organizations and the private sector. Local governments should work to incentivize disaster risk reduction measures with private developers and landowners in flood-prone areas. Public-private partnerships (PPPs) can help local governments fund flood risk management efforts, increase flexibility in the regulatory process, access innovative technology or new expertise, and create jobs related to flood and stormwater management. For more information on involving the private sector, see chapter 3.
6.6.5 EFFECTIVELY ENGAGING AND CONSULTING WITH THE COMMUNITY

Urban flood management benefits from community engagement throughout the planning, design, implementation and monitoring phases of the Flood Green Guide Framework. Community engagement fosters the political will and buy-in necessary to implement and sustain flood management projects. Projects benefit from local knowledge of flood risk and gain increased context and cultural sensitivity. For more information about community engagement, see chapter 3.

6.7 URBAN COASTAL AREAS AND SPECIAL CONSIDERATIONS

According to the IPCC, 60% of the world’s 39 metropolises with a population of over 5 million are located within 100 km of the coast; among these areas are 12 of the world’s 16 cities with populations greater than 10 million. Urban areas are often located along coastlines and in the lower courses of watersheds in delta floodplains – like Jakarta, Indonesia; Guayaquil, Ecuador; and Lagos, Nigeria. The advantages that originally attracted people to these areas and spurred development (e.g., access to trade) become vulnerabilities in an uncertain climate with rising sea levels. Coastal urban areas are subject to multiple flood risk drivers and are uniquely vulnerable to flooding because urbanization can lead to land subsidence, erosion, and reduced natural barriers to coastal storms. Urban development often encroaches on coastal ecosystems, removing or degrading mangroves, wetlands and dunes, thereby increasing the risk of flooding. Functioning coastal ecosystems can reduce the intensity of storm surge, slow the movement of water inland, and stabilize the shoreline. For more information on coastal flood management methods, see chapter 5.

Special considerations for urban coastal areas include the following:

- **Sea level rise:** Coastal flood management efforts should account for sea level rise, which increases the volume of water and, therefore, the area affected by storm surge and tidal flooding. Sea level rise can increase the risk of saltwater intrusion into surface and groundwater, leading to contaminated drinking water and impacts to livelihoods.

- **Land use regulation (zoning):** Establishing building setbacks and no-build zones, promoting natural areas, and restricting land use activities can reduce the number of people and the amount of infrastructure exposed to flood risk when undertaken in a socially just and equitable way. Land use regulation can be particularly effective in reducing exposure to coastal flooding. Critical facility development, such as building hospitals and utilities, should be restricted in coastal flood zones and evacuation routes. Evacuation routes should ideally be located outside coastal flood zones so they can be accessed during flood events.

- **Land subsidence:** Subsidence significantly affects many urban coastal and delta areas. In many areas, land subsidence now exceeds absolute sea level rise.
rise up to a factor of 10.28 Lower land elevations increase coastal flood risk, and in combination with sea level rise, subsidence can lead to saltwater intrusion, which can reduce fresh water and contribute to upstream flooding.

Urban coastal flood management methods, discussed in chapter 5, should account for the unique environment along the coast in addition to the other contributing factors of urban flooding discussed throughout this chapter.

### 6.8 ADDITIONAL RESOURCES


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