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Land Use Planning for Urban Flood Risk Management

Urban Floods Community of Practice

KNOWLEDGE NOTES

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SUMMARY

To reduce the underlying causes of flooding and ensure continuing development gains, cities must prioritize risk-based land use planning. Globally, urban centers are at a high risk of flooding, not only from more frequent and severe hydrometeorological events and sea-level rise, but also from rapid, sprawling, and often unplanned urban development that is outpacing the construction or improvement of drainage infrastructure. A risk-based approach to land use planning is crucial to cities in both developed and developing countries.

Land use planning to manage flood risks must balance competing needs: it should seek to maximize net benefits from waterfront economic and recreational activities and ecosystem services, while ensuring minimum loss of life and property through safe location, safe construction, and safe activities. By supporting the spatial integration of "gray" (conventional) hard-engineered infrastructures with "green" infrastructure to manage water resources and protect against flooding, land use planning can help to create a balanced urban water ecosystem.

Land use planning offers many opportunities to manage floods in all stages of the disaster risk management cycle. Planning measures can minimize development in flood-prone zones; reduce water runoff through development controls for flood risk mitigation; designate routes and open spaces for better response and recovery efforts; mitigate damages from unavoidable floods; and accommodate urban growth and expansion in flood-safe areas—including through resettlement and reconstruction, when it is important to promote "build back better" practices within a risk-based land use planning framework.

Cities have used several land use tools to manage floods with varying degrees of success. Spatial plans provide the key reference to guide land use based on **flood risk assessments** and may be prepared at various administrative levels, from national policies with general directives to municipal plans with comprehensive layouts. Cities have traditionally sought to manage floods with **regulatory instruments**, such as **zoning** *(to designate floodplains or open spaces)* and **building codes** *(to ensure flood-resilient structures)*, but enforcing compliance has been difficult. More recently, cities have experimented with **economic instruments**, such as **land-based financing** and **performance incentives**. Influencing **community behavior** through risk communication and participatory methods is vital for supporting flood risk reduction. To create realistic plans that are acceptable to the community, the planning process must be supported with a participatory framework for risk diagnostics and communication, along with plan preparation, implementation, and monitoring. Ultimately, different land use tools must be used in combination for effective implementation.

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WORLD BANK GROUP

WORLD BANK GROUP Social, Urban, Rural & Resilience

WORLD BANK GROUP Water

GFDRR Global Facility for Disaster Reduction and Recovery

Integrating flood risk in the land use planning process can be challenging, requiring coordination among multiple stakeholders and institutions, both formal and informal, as well responsible decision making. Decision makers may be motivated to push for highly visible structural measures, which can show constituents that flood risk is being addressed. At the same time, resettlement is unpopular in both developed and developing countries. In developing countries, implementing land use plans is further confounded by the complexities surrounding informal settlement and unclear tenure, as well as by lack of capacity and resources. Ultimately, successful land use planning for flood risk management requires investment in two areas: (i) educating decision makers and communities about the flood risk and role of land use planning in managing it; and (ii) building sufficient technical and governance capacity to formulate, implement, and manage a flood risk–based land use planning process.

This note offers policy makers and practitioners an overview of the key aspects of land use planning used to manage flood risks in cities across the world. It includes examples from developed and developing countries to provide insight into what has worked in different contexts. It does not provide prescriptive solutions or step-by-step methodologies, since approaches will vary by context. Solutions and methodologies will depend on local land use challenges and institutional capacities, on the scale at which land use planning is undertaken, and finally on the local land use planning culture and land tenure regime, apart from technical and financial capacities.

INTRODUCTION

The frequency and severity of floods has increased in the last two decades and has begun to affect areas where flooding was once rare. Flood events are also becoming less predictable due to climate change. Flood risk is comparatively high in urban centers, and the rapid growth of cities, especially those located along rivers and coasts, increases the exposure of people and assets to flooding *(Jha, Bloch, and Lamond 2012)*. Flood risk increases when urban growth compromises natural drainage and storage areas, increases impervious cover, and reduces the infiltration capacity of soils; the resulting acceleration of runoff challenges the capacity of cities to manage drainage infrastructure. Over-extraction of groundwater has led to subsidence. In many low- and middle-income countries, historical legacies of land use regulations and building codes have created an artificial scarcity of serviced land and housing that has spurred the growth of informal construction in flood-prone hazardous zones.

Urban communities most affected by floods are (i) those in small and medium-size towns where infrastructure and institutions are inadequate; (ii) the urban poor, especially those living in slums in flood-prone locations without access to resources that could mitigate flood impacts (adequate housing, infrastructure, service provision, and social networks); and (iii) the socially disadvantaged as well as women and children, who—like the poor—lack access to resources and social networks that could help them cope with disasters *(World Bank 2010)*.

A comprehensive approach to flood risk management combines structural measures that protect against flood risk with nonstructural measures that manage flood risk. Historically, cities have chosen structural measures, which are designed for two different purposes: they either safeguard development from an estimated flood risk (through flood defenses such as levees and flood walls) or direct flood waters away from developed areas (by increasing drainage capacity with pipes, canals, and storage basins). However, structural measures alone have proven to be inadequate, for several reasons: (i) they are based on finite predictions of risk that may not account for uncertainty due to climate change or unplanned urban growth and expansion; (ii) risk may be transferred downstream if the structures do not allow adequate space for the flood volume; (iii) high up-front cost of sophisticated engineering design and building materials may not be affordable; and (iv) such measures induce complacency since communities tend to over-rely on them. Most structural measures minimize damage, but may not prevent damage. There will always be residual risk that needs to be managed with nonstructural measures.

Land use planning is a nonstructural approach that promotes prudent use of land and natural resources by guiding investment to secure community benefits from development *(UNECE 2008)*. Land use planning is "the process undertaken by public authorities to identify, evaluate and decide on different options for the use of land, including consideration of long term economic, social and environmental objectives and the implications for different communities and interest groups, and the subsequent formulation and promulgation of plans that describe the permitted or acceptable uses" *(UNISDR 2009)*. Land use planning offers several benefits:

- Different opportunities to manage flood risk, with the flexibility to address flood types, precipitation and runoff uncertainty, population growth, and land cover changes
- Coordination of flood risk in multiple sectors that involve land development (critical infrastructure and utilities, open space, and housing)
- Coordination of flood risk at multiple scales, from local plans for specific communities to multijurisdictional watershed planning
- A safe, productive, and livable urban environment at lower cost as compared to using structural systems

Land use planning is a critical component of an integrated approach to flood risk management. The Sendai Framework for Disaster Risk Reduction 2015–2030 underscores the importance of land use planning and policy to address underlying disaster risk drivers, which include unplanned and rapid urbanization, poor land management, and weak regulation of and incentives for private disaster risk reduction investment *(UNISDR 2015)*. Global networks through initiatives such as the ICLEI Resilient Cities, the UNISDR Making Cities Resilient, the Rockefeller Foundation's 100RC, and the C40 Cities have put flood risk concerns on many a city council's agenda. Cities across the globe are gearing up to address flood risks through land use planning; many are in initial stages of lobbying for commitment, and many have made significant strides in risk assessment. But the adoption of land use planning for flood risk management remains challenging.

This note reviews how land use planning is used to manage flood risks, identifies challenges in implementation, and offers recommendations for including land use planning in an integrated approach to flood risk management.

Section 1 outlines the key land use principles that guide land use planning for flood risk management.

Section 2 presents an overview of land use solutions for managing flood risk.

Section 3 describes entry points for incorporating flood risk in the land use planning process with case studies.

Section 4 identifies the challenges to developing and implementing flood risk–sensitive land use plans and highlights common barriers faced by decision makers and practitioners.

Finally, the note ends with conclusions and offers recommendations for policy makers and practitioners.

1. LAND USE PRINCIPLES

Land use planning allows communities to guide the location, type, density, and timing of development through regulations, public infrastructure investments, market incentives, and conservation of natural resources such that development is safe from flood disaster and in harmony with a sustainable urban water cycle. Within an acceptable level of flood risk, land use measures must seek to minimize loss of life and property while maximizing net benefits from waterfront economic and recreational activities and ecosystem services; this balance ensures that communities not only survive, but also adapt and grow despite disruptions from flood disasters. This balanced approach can be achieved by following three basic principles:

Principle 1: Safe location.

Land use planning must reduce existing hazard risk and prevent creation of new risks linked to hazardous location of infrastructure. Land use plans can guide development location in several ways: (i) by protecting key economic areas with hard-engineered structures; (ii) by "retreating" from chronic flood areas (e.g., low-lying coastal areas or floodplains) and from permanent flooding expected from sea-level rise; (iii) by planning preventive resettlement and redevelopment for urban growth in flood-safe areas; and (iv) by planning for critical preparedness infrastructure, such as evacuation routes within and out of flood zones, open spaces for relief operations, and community shelters and emergency facilities.

Principle 2: Safe construction.

Land use planning must both reduce current risks and prevent new risks that stem from bad design or construction of buildings and other infrastructure, specifically by promoting a "living with water" approach to development. Land use development guidelines and building codes can play an important role in fostering this approach. They can control flood sources by supporting integration of green and gray infrastructures to increase the flood-holding capacity of streets, open spaces, and waterways for better flood conveyance and drainage as well as water security. They can also ensure adoption of flood-resilient infrastructure and buildings to mitigate damage from unavoidable temporary floods. Finally, they can protect the ecosystem from pollution and prevent over-extraction of natural resources during reconstruction.

Principle 3: Safe activities.

Land use plans must reduce current risks and prevent new risks created by specific land uses and economic activities, including the flow of goods and services in particular territories. Land use planning guidelines must both (i) maximize net benefits and ecosystem services of waterfront economic activities and flood-prone zones through multifunctional land use, and (ii) support activities that protect the natural ecosystem from pollution.

2. LAND USE MEASURES

Land use planning offers multiple opportunities to manage floods in all stages of the disaster risk management cycle, from prevention to reconstruction. Land use planning measures can minimize development in flood-prone zones and reduce water runoff through development controls for flood risk prevention, designate routes and open spaces for better response and recovery efforts, mitigate damages from unavoidable flood risk, and accommodate urban growth and expansion in flood-safe areas, including during resettlement and reconstruction. After a flood, when the experience is fresh in a community's memory and political will is strong, it is especially important to take advantage of the opportunities to build back better within a risk-based land use planning framework, and thus limit future risk.

Cities have used several land use tools to manage floods with varying degrees of success. Spatial plans provide the key reference to guide land use based on flood risk assessments; they may be prepared at various administrative levels, from national policies with general directives to municipal plans with comprehensive layouts. Historically, cities have depended upon regulatory instruments, such as zoning for floodplains or open space protection and building codes for flood-resilient structures; but they have had limited success in enforcing compliance. In recent decades, cities have been experimenting with economic instruments, such as land-based financing and performance incentives. Influencing community behavior through risk communication and participatory methods is important for supporting flood risk reduction. Land use tools must be used in combination for effective implementation.

Spatial Plans

Spatial plans that incorporate measures to manage flood risk are the key reference to guide land use planning. Comprehensive plans balance community goals for growth with risk reduction and protection from hazards; they guide investments in community infrastructure, transportation, housing and neighborhood development, cultural heritage, environmental assets, and economic development (Burby 2000) as well as local flood defense requirements and regulatory standards for flood risk (WMO 2016). Spatial plans can delineate flood protection and development zones, establish emergency routes and facilities, and help ensure that infrastructure investment for urban growth is based on flood risk.

Decisions are based on the following risk designations:

- **HIGH-RISK AREAS.** Existing development in these areas must be prioritized for protection, retrofitting, or managed retreat and preventive resettlement. The economic value of central business districts justifies structural protection. Areas for retreat (floodplains, wetlands, forests, mangroves) may be designated for low-occupancy uses, including recreation, ecosystem-based livelihoods such as urban agriculture, or waterfront activities for ecotourism.

- **MODERATE-RISK AREAS.** Flood risk can be managed in these areas through a "living with water" approach. Development controls and flood-resilient building codes work with green infrastructure to reduce impervious surfaces and improve the connectivity of green spaces.

- **LOW-RISK AREAS.** Preventive resettlement and critical infrastructure such as hospitals are appropriate for these areas. Multi-nucleated urban growth and expansion can occur through a review of density controls and infrastructure upgrades.

- **CRITICAL INFRASTRUCTURE CORRIDOR NETWORK.** Strategically located and built to appropriate heights, this network consists of (i) roads and emergency routes (rights of way) to and within flood zones, (ii) community shelters and health facilities at multiple locations in close proximity to neighborhoods (rather than in a central location that could be destroyed by a disaster), and (iii) strategic open spaces for response and relief operations that can also function as temporary shelter sites and medical field stations.

Workers drain a flooded thoroughfare after a night of severe thunderstorms in Kisumu, Kenya. *Photo: Peter Kapuscinski / World Bank*

Communities tend to resist resettlement away from high-risk areas. Where it is unavoidable, it must be carefully managed and include adequate socioeconomic support (Correa 2011). More generally, planning for safe housing is essential to ensure that communities can thrive despite flood events. An adequate supply of safe and serviced land and housing in low-risk areas will make formal housing affordable and consequently help to control informal settlements in flood-prone areas.

Spatial plans are prepared at various administrative levels and for different spatial and temporal scales: (i) national land use policy plans contain general aims, objectives, and measures for future land use for all development authorities; (ii) state, district, or regional structure plans contain specific goals and mandates for a jurisdiction's land use; and (iii) municipal land use plans contain comprehensive layouts with detailed allocation of specific parcels for specific uses (WMO 2016). **Box 1 describes spatial development frameworks at various scales.**

Box 1. Examples of Spatial Development Frameworks for Flood Resilience at Different Scales

NATIONAL

For hundreds of years, the flood-prone **Netherlands** protected itself with a system of dikes that it continually strengthened. After the 1990s, when threatened flooding led to the evacuation of 240,000 people, the country shifted its approach from controlling rivers to a spatial strategy that restores floodplains and thereby increases discharge capacity (by about 10 percent) without raising dike levels. In 2006, the government adopted a flexible spatial framework ("Room for the River") for the entire Rhine-Meuse delta. Key measures include (i) river bypass where urban development has constricted river flow, (ii) restoration of reclaimed land to the river and integration with protected parks, (iii) water retention through increased storage capacity of lakes; and (iv) dike relocation to relieve bottlenecks at urban centers and development of the floodplain for compatible land uses.[a] The approach includes about 30 strategic projects throughout the major watersheds as part of a long-range plan for managing flood risks till the end of the century *(Rijkswaterstaat 2006)*.

In 2006, **Singapore's** national water agency launched the Active, Beautiful, Clean (ABC) Waters program to address periodic flooding and chronic water shortages while poised for further growth. "Active" refers to new recreational spaces, "Beautiful" to the integration of waters with urban landscapes, and "Clean" to improved water quality. The ABC program, which will be implemented in phases with over 100 projects over the next 15 to 20 years, interweaves flood resilience with urban planning by managing the catchment-level water cycle: optimized rainwater collection and storage at source through a green network and green corridors; ensured water supply and quality through natural cleansing mechanisms; and value created with active recreational land uses for functional water bodies. The green network involves parks, wetlands, storm water storage and harvesting, and porous pavements, as well as green roofs, tree pits, street-side swales, etc. To reduce flood incidence, a diversified water supply system collects storm water and used water at large scale from three main watersheds and feeds them back into the supply system after treatment. The ABC Waters program has helped reduce flood-prone areas from about 3,200 hectares in the 1970s to 30.5 hectares in 2016, despite increased urbanization.[b]

STATE/REGIONAL

In 2007, **California** adopted legislation to improve flood management at state and local levels by 2025. Since 2012, flood plans prepared by local agencies have followed water code guidelines that are based on flood protection objectives. Local plans are reviewed by a Central Valley Flood Protection Board.[c]

Da Nang, a coastal tourist destination in **Vietnam**, experiences regular flooding and drought. In 2015, the city developed a resilience action plan that sees regional cooperation in managing the upper Vu Gia Thu Bon river basin as integral to plans for the city itself. Da Nang's resilience action plan seeks to (i) widen and increase the capacity of the Vu Gia–Han basin; (ii) resettle development away from high-risk floodplains and transform the flood-sensitive area into green space; (iii) redesign transport routes that impact drainage; and (iv) develop regulations for flood-resilient housing guidelines and multifunction community safe houses for high-risk areas that cannot be resettled *(100 Resilient Cities 2016)*.

METROPOLITAN

Rio de Janeiro, Brazil's coastal tourist destination, is at risk of flooding from sea-level rise and other natural hazards. Rapid growth and high density are overwhelming the city's infrastructure and exacerbating hazard impacts. Rio's 2016 resilience strategy focuses on water, infrastructure, and social vulnerability of the poor living in favelas (informal settlements) on risky slopes; it includes protection of its urban forests, green infrastructure, a water security strategy, safe housing, and investments in flood-proof infrastructure and services as well as zoning laws. In recent years, coordinated efforts through the Center of Operations have significantly lessened the impacts of disasters. However, the resilience strategy recognizes that disaster preparedness requires mobilizing resources at the metropolitan level *(100 Resilient Cities 2016*).

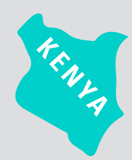
MUNICIPAL

For **Constitución, Chile**, resilience planning became urgent following the 2010 earthquake and tsunami. The 2010 post-disaster recovery and reconstruction master plan proposed (i) forested area to arrest the impact of tsunamis and serve as a vertical escape route; (ii) a retardant lagoon to mitigate tidal impact on rising flood waters, (iii) upgraded green-space standards; (iv) flood-proofed construction in high-risk zones; and (v) an efficient plan for evacuating to higher areas. These changes are intended to increase tourism potential and also improve evacuation routes.[d]

In **Kaduna, Nigeria,** where developments on low-lying floodplains are at risk of flooding, the 2010 spatial development framework zoned natural drainage channels along the river as green corridors to accommodate phased expansion of the city. The plan designates infrastructure routes to promote development and prohibits development in the floodplain, while riverside areas are zoned for agricultural and amenity use *(Jeb and Aggarwal 2008; Jha, Miner, and Stanton-Geddes 2013)*.

LOCAL AREA

In **Kibera**, the largest slum in **Nairobi, Kenya,** the poor live along the Ngong River (where the rents are lowest) and hence are highly exposed to flooding. To address the human toll of flooding as well as its effect on infrastructure, the nonprofit Kounkuey Design Initiative (KDI) has been working with Kibera residents since 2007 on scalable micro-projects. A network of active community hubs in flood-prone locations are being developed into safe places for people to live, work, and play. With funding from Swiss Re Foundation, KDI has worked with community groups, households, and government since 2015 to conduct a participatory flood risk assessment and implement flood protection schemes that will benefit about 2,000 residents *(Swiss Re Foundation 2015; Kounkuey Design Initiative 2015).*



LAND USE MEASURES

Land Use Implementation Tools

Flood risk–based land use plans give communities an overview of which areas need to be protected, evacuated, developed, or redeveloped. These plans need to be accompanied by implementation tools that are acceptable to the community and that can be enforced with local capacity and resources. Such tools can be regulator , economic, financial, or behavioral. They are summarized in table 1 and described in more detail below.

Table 1. Overview of Land Use Instruments

REGULATORY

- Zoning plans and ordinances
- Emergency plans
- Development controls (land use and density)
- Building codes (elevated structures and infrastructures, flood proofing, green building)

FINANCIAL

- Public funds
- Public-private partnerships
- Flood insurance

ECONOMIC

- Land-based financing (density transfer/ density bonuses)
- Preferential taxation
- Tax credits
- Conditional insurance
- Conditional permitting

BEHAVIORAL

- Awareness campaigns
- Mandatory risk disclosure in real estate transactions
- Early warning systems
- Capacity building

Source: Adapted from Burby 2000.

Regulatory Instruments

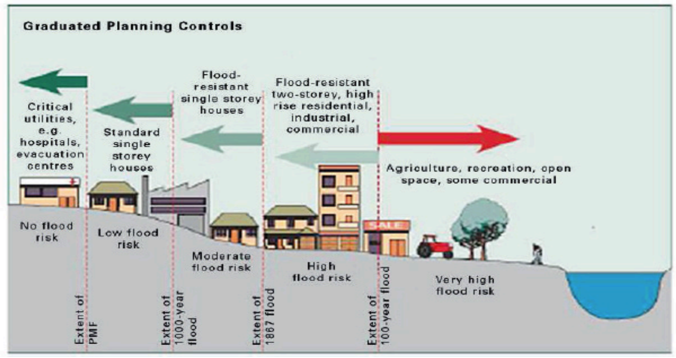
Regulatory instruments—such as zoning plans, development controls, and building codes—prevent chronic disaster risk in the siting and construction of new settlements and reduce disaster risk in vulnerable existing settlements. Over the last decade, countries with mature building code systems experienced 47 percent of disasters globally, yet accounted for only 7 percent of disaster fatalities *(GFDRR 2015)*. Risk-based regulations not only are crucial in reducing disaster risks; they also have proven to be cost-effective. Analysis of losses in Florida from Hurricane Charley in 2004 showed that compliance with risk-based building codes reduced the severity of losses by 42 percent *(GFDRR 2015)*. However, enforcement of regulatory instruments remains weak in developing countries, where finance and capacity are often lacking and land ownership and tenure are contentious.

Zoning plans demarcate areas by degree of flood risk and link them to appropriate, safe, and permissible land uses. Land use regulations and development controls determine appropriate land uses and guide neighborhood design for different flood risk zones. **Development controls** designed to manage flood risk *(see figure 1)* must establish development patterns that accommodate water storage, conveyance, and drainage, such as rainwater harvesting mandates, storm water ordinances, and green-gray infrastructure requirements. Development controls may (i) limit land use in floodway zones, (ii) allow multiple uses with elevated or flood-proofed structures, (iii) require setback from hazard, and (iv) regulate impervious surfaces. Zones where land use changes can significantly increase flood risk downstream can also be regulated to strengthen retention.

Flood zoning may prohibit development, limit development density, restrict development of highly vulnerable uses in high-flood-risk areas, and protect land reserves to provide flood storage or safeguard environmentally sensitive areas. Flood zoning can be undertaken based on average annual exceedance probabilities, and may be defined by national regulations or local government ordinances *(WMO 2016)*. The zoning approach needs to be adapted to local circumstances based on data availability. If data are missing or inadequate, planners will need to use an alternative approach, such as one based on the maximum observed floods in living or historic memory, or on the geomorphology of an area *(WMO 2016)*. Where zoning recommends relocating communities living on well-developed floodplains, the affected communities typically resist. **Box 2 describes experiences with flood zoning.**

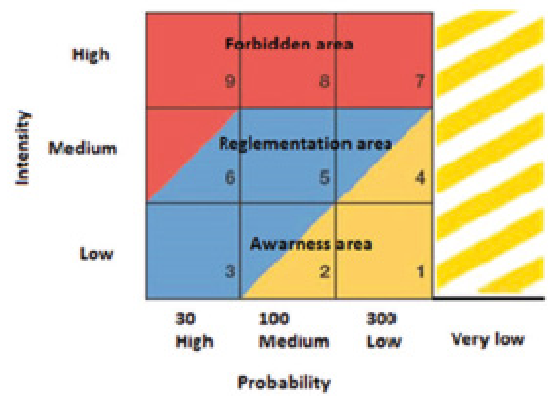
Figure 1. Land Use Regulations and Development Controls

Figure 1a. Graduated land use planning controls to reduce flood risk



Source: Hawkesbury City Council 2012.

Figure 1b. Hazard levels in Switzerland, where regulations vary with intensity and probability of flooding. In the high-risk zone (red), no new construction is allowed; in the medium-risk conditional zone (blue), new construction is allowed with special permits and restrictions (WMO 2016).



Source: FESP, FOWG, and SAEFL 2005.

Box 2. Flood Zoning

In **England**, regional planning bodies and local planning authorities use two main tools to determine suitable land for development: the Sequential Test, which directs new development to areas with the lowest probability of flooding, and the Exception Test, which allows necessary development with flood management measures in areas with medium flooding risk when suitable low-risk sites are not available. The tools do not include the effect of flood defenses in their calculations, since defenses may be overtopped or breached, or development may grow beyond their capacity to protect *(WMO 2016)*.

Nairobi has designated a 30 m riparian zone for flood protection within which all structures are deemed illegal. But implementing this policy would require evicting over 100,000 people—likely a highly contentious move. The policy has created tensions between residents and implementing agencies *(Kounkuey Design Initiative 2015)*.

Under the **Netherland's** Room for the River program, managed retreat from floodplains was achieved through eminent domain. The process was participatory, but still did not avoid holdouts and conflicts over land valuation during negotiations for relocation *(Roth and Winnubst 2014)*.

After Hurricane Katrina, the mayor of **New Orleans** determined that it was politically unfeasible to address conflict arising from relocation policies. The city permitted residents to rebuild in place regardless of further flooding threats *(Wolff 2014)*.

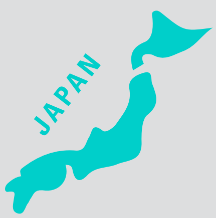
Open space zoning designates land reserves in environmentally sensitive areas such as forests and wetlands. This tool not only accommodates flood storage and reduces flood risk; it also enhances livelihoods from ecosystem services and provides urban recreational spaces (outdoor sports facilities, parks, nature reserves). Coastal ecosystems (mangroves, salt marshes, coral reefs, barrier islands, and sand dunes) protect coastlines from cyclones, storm surges, tsunamis, etc.; riverine ecosystems such as marshes, lakes, floodplains, and peatlands mitigate floods; and forests reduce the risk of soil erosion and landslides and mitigate floods. Open spaces used as a green infrastructure network typically form part of newer flood resilience plans. Ecosystem services from open space can reduce risks at lower costs than traditional gray infrastructure approaches and can enhance livelihoods; however, expertise on which approaches to use where and when is limited; few data are available on cost-benefit ratios; and permitting can be more difficult than for built projects *(Monty, Murti, and Furuta 2016)*. **Box 3 describes a range of experiences with open space zoning from different parts of the world.**

Box 3. Open Space Zoning

In **Colombia**, the land use zoning of the Arroyo Carolina micro-watershed creates exclusive areas where natural ecosystems are protected and restored *(Monty, Murti, and Furuta 2016)*.

Analysis of Hurricane Katrina's effects on New Orleans shows that levees alone offered less protection than levees acting in combination with trees within the area's coastal national parks (Murti and Buyck 2014). In light of such evidence, the U.S. Congress approved US$500 million for the restoration of coastal national parks and salt marshes in the area *(Renaud and Murti 2013*).

Planting mangroves in disaster-prone areas of **Vietnam** has had several significant benefits. The mangroves have reduced damage to dikes from typhoons by an estimated US$80,000–295,000. They have also provided coastal communities with additional income equivalent to US$344,000 to US$6.7 million, mainly through increased yields in aquaculture and other economic activities. Finally, the value of mangroves' carbon sequestration has been valued at over US$200 million *(Monty, Murti, and Furuta 2016)*.



Japan has a centuries-old history of combining green and gray infrastructure to protect its coasts from natural hazards. Gray infrastructure such as sea walls is combined with coastal green belts, highways, and zoning (residential) to establish multiple areas of defense *(Furuta and Satoquo 2016)*. After the Great East Japan Earthquake in 2011, the Ministry of the Environment decided to expand a coastal national park that had been affected by the tsunami; it would act as buffer against future natural hazards, serve as a symbol for reconstruction efforts, and promote ecotourism to contribute to the local economy *(Government of Japan 2016*). The National Resilience Act, passed in 2013, recognizes and promotes land use ecosystem functions of disaster risk reduction *(Cabinet Secretariat, Government of Japan 2016)*. The Ministry of Land, Infrastructure and Transport's new National Spatial Development Plan and the fourth National Infrastructure Development Plan (2015) also recognize the role of ecosystems in reducing disaster risk. At the local level, the Tokyo Metropolitan Government and the city of Yokohama developed a master plan for a detention basin that would accommodate increased river levels and peak discharge (a function of extensive paved areas in Tokyo) and also serve as a sports venue and natural recreational area *(WMO 2016)*. Finally, Japan combines open spaces with flood defense mechanisms such as "super levees" in urban areas; super levees may include residential or office space, and—given their elevation—can serve as evacuation points during disasters *(WMO 2016)*.

Storm water ordinances stipulate the volume of runoff permissible from project sites and control flood risk at its source. **Building codes** specify minimum design standards for materials, access points, and floor levels for development within a designated zone. Building codes to accommodate flood incidence and reduce flood losses may specify (i) elevated siting and roads, (ii) compulsory retrofitting of flood protection measures, (iii) flood proofing for critical buildings such as hospitals and emergency shelters, and (iv) planning and design for redundancy. Building codes can also specify building orientation to minimize disruption of flood flows and require emergency exits in an elevated area such as the roof *(WMO 2016)*. **Box 4 describes a range of experiences with storm water ordinances and building codes from different parts of the world.**

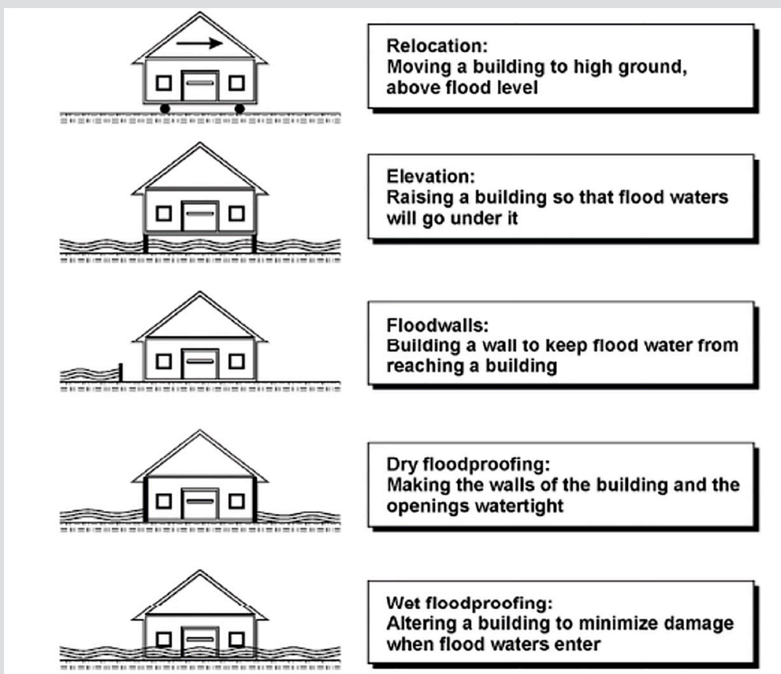
Box 4. Storm Storm Water Ordinances and Building Codes

In **New Orleans,** the City Planning Commission's updated Comprehensive Zoning Ordinance requires most new development projects to manage the first 1.25 inches of storm water on their site; hence private owners are expected to share flood risk with the city. Developers are also required to submit storm water management design plans with their development permits.

The **Seoul** Metropolitan Government mandates rainwater harvesting in new buildings larger than 5,000 m2 and existing official buildings larger than 3,000 m2. The water level in the storage tanks is monitored remotely by a disaster prevention center, and the building owner is instructed to empty the tanks depending on the weather forecast. The system increases risk awareness, enlists private owners' cooperation, and extends sewer pipes' useful life.

In **Minnesota**, development regulations for floodways (i) allow open space uses, such as gardens, farms, parks, trails, or golf courses, as long as they do not obstruct or increase flood levels; (ii) prohibit new construction or substantial improvements to existing buildings; (iii) require construction outside the floodplain to be elevated such that the lowest floor is above the regulatory flood protection elevation (RFPE); (iv) require access (driveway and access road) elevation that is no lower than 2 feet below RFPE; and (v) require setbacks from lot lines and for shoreland management or wild and scenic river ordinances *(GFDRR 2015)*.

Flood proofing through recommended best practices in building code regulations



Financial Instruments

Through its investment choices—whether transport, housing, or infrastructure—a municipality can orient land use. Public investments can discourage occupation of high-risk areas not by prohibiting their development, but by making other areas more attractive. The challenge is that financing instruments and resources, along with the ability to attract funds, are largely centralized, so that local authorities cannot effectively respond to local needs.

Financial instruments include public funds such as national transfers, donor assistance, municipal bonds, and flood loss aid linked to property taxation, recovery funds, and reinsurance; they also include public-private partnerships and flood insurance at individual, local, and national levels.

Economic Instruments

Economic instruments are financial rewards, incentives, and penalties that encourage behavior changes in businesses, households, and individuals. Cities are increasingly exploring the use of such instruments, particularly economic incentives, to implement land use plans. Using these incentives not only supplements public funds, it also encourages private developers and communities to accept and comply with flood risk–based land use plans. Economic instruments rely on market information that might not be easily accessible, and on the capacity of agents for acting rationally in economic terms.

A range of economic instruments is available to cities, including preferential taxation, tax credits, conditional insurance, and conditional permitting. Land-based financing (density transfer or density bonus) is another important instrument that has been used to manage urban growth in several countries with different resources, technical capacities, and governance systems. This instrument uses land-value capture mechanisms, such as land readjustment (LR) and transfer of development rights (TDR), which are often complex to design and implement, especially where land management capacity is poor. Local governments can improve existing land management capacity by combining LR and TDR with other municipal tools, and by strengthening municipal capacity in land administration to work with real estate markets. These steps will allow them to effectively use LR and TDR in implementing land use plans for disaster risk management. **Box 5 describes a variety of financial and economic instruments used around the world to promote flood resilience.**

The floods cause health and security hazards for the residents of low lying areas. Gamarra, Colombia. *Photo: Scott Wallace / World Bank*

Box 5. Financial and Economic Instruments for Flood Resilience

The **U.S.** National Flood Insurance Program enables participating communities to purchase insurance against flood losses in exchange for state and community floodplain management regulations that reduce future flood damages *(FEMA 2002)*. The National Flood Insurance Program also includes a voluntary Community Rating System that reduces insurance premiums for communities that proactively implement certain floodplain management practices (acquisition, relocation, and elevation of structures; restoration and protection of natural spaces; flood proofing) in excess of the program's minimum requirements.a

Singapore uses various regulations and incentives to promote water-sensitive urban design that reduces runoff. New town centers are planned as "green hearts" linked to the waterfront with "green fingers" (recreational trails). New developments are planned as high-density waterfront housing districts; vertical and skyrise greenery is promoted in private developments through density bonuses. The Urban Development Authority's LUSH (Landscaping for Urban Spaces and High-rises) program has supported development of 40 hectares of new high-rises and urban greenery. The National Parks Board Skyrise Greenery Incentive scheme provides funding support to building owners for installing green roofs and vertical greenery or building facades. Since 2009, new developments in certain neighborhoods have been required to include greenery that fills an area at least equal to the plot of land the development occupies. All new developments and redevelopments of 0.2 hectares or more are required to implement source solutions (e.g., detention tanks, rain gardens, bioretention swales) to slow down storm water runoff entering the public drainage system. In part because Singapore has encouraged private funding through incentives and then prudently leveraged these funds, its use of green mitigation measures in combination with structural measures has proved cost-effective.b

Instead of installing concrete flood protection structures to protect the city from recurrent floods, the city of **Curitiba, Brazil**, created a natural drainage system using TDR for environmental protection. TDR preserves green recreational areas and relocates slum dwellers away from flood-prone areas. Its sending areas include riverbanks, which were converted into parks to absorb overflow, and lakes, which were constructed to contain flood waters to prevent flooding downstream. City regulations restrict the area of developable land in proportion to forest area and thus increase flood storage. Tax rebates are given for having trees on private land. The resulting Curitiba park system is estimated to be five times less expensive than building flood protection canals (Dharmavaram 2013).

In **Mumbai**, the 1991 Coastal Regulation Zone (CRZ) under notification by the Ministry of Environment and Forests controls development

Box 5. Financial and Economic Instruments for Flood Resilience

along the city's rapidly urbanizing coastline. The CRZ restricts all developments within 500 m of the high-tide line, but the flood-prone (and hence comparatively affordable) CRZ remains home to many slum dwellers. The state government lacks the funding to enforce the federal CRZ notification, and offers incentive floor area ratios through a TDR program to manage slum redevelopment in the CRZ *(Dharmavaram 2013)*.

Several Indian states offer incentives for rainwater harvesting. Indore, Jabalpur, and Gwalior offer a rebate of 6 percent on property tax to encourage use of rainwater harvesting systems.

In **Chicago**, the Green Permit Program offers an expedited process for new building proposals that include green building strategies, such as green roofs. The city has also passed an ordinance requiring that large developments capture the first half-inch of rainfall on site.

In **New York state**, the Community Risk and Resilience Act (2014) requires applicants for permits or funding in specified programs to demonstrate that they have considered the risks of sea-level rise, storm surge, and flooding, and that these risks are factored into facility siting regulations. This approach ensures that mitigation of sea-level rise, storm surge, and flooding risks is added to the list of smart-growth criteria for public infrastructure *(RPA 2016)*.

Behavioral Instruments

Behavioral instruments are important for land use policies as a way to encourage co-investment between public, private, and nonprofit sectors, and to incentivize useful behaviors and discourage risky ones. Land use policy that distributes and shares risk among multiple city stakeholders helps institutionalize resilience by integrating it into the planning and policy of various sectors across the city. Risk communication is essential for management of risk. Awareness is the first step for developing safe practices on land use, and any plan should include a communication strategy.

Behavioral instruments include (i) awareness campaigns that use indicators to monitor and inform the public and foster stakeholder consensus; (ii) mandatory disclosure in real estate transactions; (iii) warning systems, including institutional coordination for emergency warning and management; and (iv) capacity building (e.g., training of communities and schools; simulation exercises), which should be based on the policy at issue, the specific stakeholders, and hazard, risk, and vulnerability assessments, as well as on lessons learned from previous disaster events. **Box 6 describes a range of behavioral instruments used to promote flood resilience in different parts of the world.**

Box 6. Behavioral Instruments for Flood Resilience

Indonesia's "PROMISE" public awareness campaign included three activities designed to increase people's involvement in disaster risk management: "town watching" to assess their own risk and promote community action planning; school safety action planning; and development and installation of a flood early warning system in at-risk communities.

Rio de Janeiro began training community leaders in urban resilience in 2015 as part of the Resilient Communities project, which is led by the Civil Defense of the City of Rio. Supported by the UNISDR My City Is Getting Ready campaign, leaders of 17 vulnerable communities signed a certificate declaring their commitment to resilience. Rio hasalso proposed partnering with a local university to offer an urban resilience curriculum through a massive open online course (MOOC); the curriculum is targeted at the general public, civil servants, and local educators and brings together urban planners, environmentalists, public and private managers, entrepreneurs, and professionals in insurance, finance, health, and law (100 Reslient Cities 2016).

In **Singapore**, support to industry is provided through design guidelines for developers and industry professionals, codes of practice, and a professional certification system for skilled professionals and tradesmen equipped to implement green features. Community engagement is encouraged through flood advisories, an interactive website, and stakeholder education, including outdoor river classrooms.

3. INTEGRATING FLOOD RISK IN THE LAND USE PLANNING PROCESS

Integrating flood risk in the land use planning process can be complex because it requires coordination among multiple stakeholders and institutions, both formal and informal. To develop plans that are realistic and acceptable to the community, the planning process must be supported with a participatory framework for diagnostics and risk communication as well as plan preparation, implementation, and monitoring.

Flood risk information sets priorities in all stages of the land use planning process, from determining the community vision, to integrating flood risk assessments, to formulating and implementing plans. Integrating flood risk in the land use planning process requires certain enabling conditions, policy frameworks, and stakeholder coordination to ensure that the community's land development goals for flood risk are accepted and implemented successfully.

Community vision and goal

Because water is usually important in local economic zones, development goals often conflict with efforts to mitigate flood risk. Flood risk cannot be fully eliminated, so communities must determine a level of flood risk that is acceptable in the context of their visions and goals, and that ensures that losses do not overcome total benefits from activities in flood-prone zones.

Enabling preconditions

A conducive policy and institutional environment is essential for developing a flood risk–based land use plan. In such an environment, the local policy frameworks for land use planning and disaster risk management must be understood, as well as the roles and responsibilities of all institutions, formal and informal, that are stakeholders in the plan preparation. (Formal stakeholders include all public agencies with a stake in land development—land use, transport, utilities, housing, etc.—apart from civil society and the private sector.) Policy assessment must consider the national land use and disaster risk management policies in addition to the local budget outlays. Hazard information provisions must be incorporated in the relevant laws and regulations. The plan preparation must establish a coordination mechanism for all stakeholders—one that is capable of working with multiple entities at multiple institutional levels—and agreements on participation and resources. An institutional mapping is necessary to understand stakeholders' relative capacities, access to resources, and incentives for participation. Clear roles and responsibilities at all administrative levels and across all stakeholders will help to minimize conflict.

Entry points

Critical entry points where flood risk information must be integrated in the land use planning process are (i) diagnostics and (ii) plan formulation and approval.

Risk assessment diagnostics identify the cause of floods, probability of occurrence, impacts on population and assets, and most vulnerable areas and communities. Development policies informed by risk diagnostics can reduce vulnerability by avoiding actions that contribute to environmental degradation, unplanned urbanization in hazardous areas, and worsening poverty. Flood risk knowledge must be based on prevailing and expected future risks. The science and methodologies of risk and vulnerability assessments are quite advanced, and benefit from access to open source data and technologies. The use of UAVs (unmanned aerial vehicles) is also proving beneficial as a relatively less expensive method to obtain high-resolution aerial imagery for baseline mapping. But several factors can limit the accuracy of flood risk assessments, such as inadequate resources, inability to access base maps or aerial imagery, and the uncertainty of flood events. Decision makers and planners need to recognize that sharply delineated flood zones on a hazard map do not reflect the true level of uncertainty; critical facilities located just outside the flood line are subject to the same actual risk as facilities inside the flood zone *(GFDRR 2015)*.

The plan formulation and approval process determines which land use measures will facilitate the community's vision and goals at an acceptable level of flood risk. The plan identifies a suite of supporting implementation tools, resources, commitments of stakeholders, and monitoring mechanisms. It also reflects decisions about the location of flood buffer zones, resettlement, and critical infrastructure. Land use measures can be assessed using cost-benefit analysis and decision support systems. Planners should select locally relevant land use approaches that respond to local flood risk, are acceptable to the local community, and can be implemented with local resources and technical capacity.

Supporting conditions. The land use planning process for flood risk management is supported by a number of conditions and processes: capacity building of stakeholders, community engagement to improve dialogue, partnerships for risk assessments, development of strategic plans, benchmarking of city resilience, and plan implementation and monitoring against indicators and scorecards. **Box 7 and Box 8 describe how governments at different levels and in different parts of the world have integrated flood risk into land use planning.**

Box 7. Integrating Flood Risk in the Land Use Planning Process

Seeking to increase its resilience to floods, **the municipality of Palo in the Philippines** reviewed local planning and development tools and then undertook participatory hazard, vulnerability, and capacity assessments. Palo identified appropriate flood risk management measures and integrated them into its development planning and Annual Investment Program. The municipality focused on using local programs and projects that served both to improve infrastructure and to reduce the risk of flood *(Jha, Bloch, and Lamond 2012)*.

In **Switzerland**, where the majority of territories have integrated hazard maps into land use(FOEN 2015), governments at various levels concern themselves with flood risk: the federal government provides financial, technical, and scientific support for flood management; the cantons (administrative divisions) are tasked with identifying risk areas and implementing flood control measures; and municipalities sometimes assume responsibility for flood control *(WMO 2016)*.

The **New Orleans City** Masterplan was launched in 2010, but its development started in 2008, and a detailed schedule was established to include proper follow-up for the actions implemented. For each strategy defined, the plan named a responsible office or agency, estimated the time for completion, and evaluated the necessary resources. Having clear roles and responsibilities assigned to specific institutions can help increase the viability of the plan *(Jha, Bloch, and Lamond 2012)*.

New Jersey has developed an ambitious water infrastructure plan that aims to reduce flooding as part of a comprehensive statewide plan to improve water supply and quality. A consortium of stakeholders—including private sector water utilities, engineering firms and contractors, regulators at the state Department of Environmental Protection and the U.S. Environmental Protection Agency, municipalities, public water and sewer utilities, environmentalists, and community organizations—has devised a measurement system to monitor the infrastructure plan. The monitoring will require utilities and local and state governments to report publicly on street and property flooding. One of the state's key goals is to promote theuse of green infrastructure—e.g., pervious pavement, bioswales, and rain gardens, which collect storm water before it hits the sewers and help prevent flooding while beautifying neighborhoods and raising property values.

Based on risk exposure, eight countries have implemented simple and fast-tracked procedures for permits for commercial buildings of less than 1,000 m2 *(GFDRR 2015*). In 2011, Macedonia developed a risk-based system that allows designers and contractors with top qualification to handle more complex and higher-risk classes of buildings, thereby reducing state control and increasing transparency.

Box 8. Norfolk's Flood Risk–Based Development Strategy

CONTEXT:

Norfolk, Virginia, a historical port city, is home to the world's largest naval station and thriving coastal communities. In recent years, flooding has become more severe and more frequent in Norfolk, partly due to sea-level rise and local land subsidence. Norfolk's comprehensive plan, plaNorfolk2030, does not address projected sea-level rise, aging infrastructure, population growth, or an uncertain regional and global economy. The city decided to work with the Rockefeller Foundation's 100RC network to address these omissions and more broadly to seek to transform Norfolk into a dynamic waterfront community for the future.

ACTIONS:

The city adopted a long-term strategy, NorfolkVision 2100, which was guided by several principles:

- Address flood resilience by planning for the city as a whole; protect flood-prone areas concurrent with development of high-density, transit-rich, livable, and affordable neighborhoods in low-risk areas.
- Use differentiated land use strategies for neighborhoods classified as four distinct community "vision areas" based on prioritization of city assets and flood risk.
- Balance flood protection with access in asset-rich areas.
- Share the flood risk reduction burden in all neighborhoods by adopting green infrastructure.

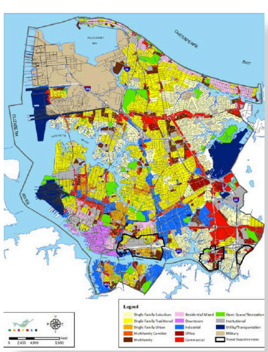
The plan was developed collaboratively by multiple city departments and agencies, residents, and stakeholder groups. Community engagement was ensured in three phases: (i) awareness raising using traditional and social media; (ii) city asset mapping workshops and online exercise; and (iii) vision development to prioritize city assets. The community asset mapping was combined with flood risk assessment to delineate four "vision areas" with distinct land use approaches *(see table)*.

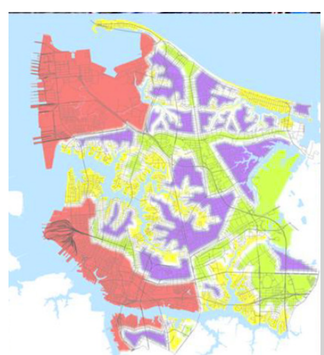
TAKEAWAYS:

- By planning for flood resilience in a way that considers flood protection concurrently with access to key economic assets and new development, Norfolk will be able to grow in a safe and sustainable manner.
- Stakeholder collaboration ensured development of relevant, realistic, and acceptable plans.

NORFOLK VISION AREA'S LAND USE APPROACHES

Vision Area		Land Use Approach
Red	High-risk areas with key city economic assets	• Add flood protection with hard and green infrastructure • Develop as transit-rich, high-density, mixed-use, mixed-income neighborhoods
Yellow	High-risk areas with established coastal neighborhoods	• Extend flood protection to existing community-developed living shorelines with wetland plants • Incentivize small-scale green infrastructure to slow sea-level rise • Improve connectivity to economic assets with flood-resilient infrastructure (key thoroughfares, transit lines, and public utilities) • Discourage development • Develop mechanisms (e.g., flood insurance and TDR) to allow residents to recoup economic value • Use flood-resilient construction to minimize losses • Where facilities cannot be reasonably protected, relocate to higher ground • Develop new urban centers as transit-rich, high-density, mixed-use, mixed-inco
Green	Lower-risk underutilized areas with key city assets	• Develop new urban centers as transit-rich, high-density, mixed-use, mixed-income neighborhoods
Purple	Low-risk areas with established neighborhoods	• Improve connectivity with key city economic assets through transportation • Redevelop underutilized neighborhoods





The plaNorfolk2030's future land use map is traditional in assigning the best future use for every property. But the NorfolkVision 2100 "vision areas map" takes a different approach; it provides general guidance on carrying out development and mitigating sea-level rise, and the boundaries between vison areas are fuzzy to reflect uncertainty given the very long time scale. The guidance of the vison areas map is expected to inform the future land use map, the capital improvement plan, future area plans, and zoning and regulatory tools. Implementation tools include zoning, transfer of development rights, and density bonuses.

Source: City of Norfolk 2016; Virginian Pilot, "The Norfolk of the Future Will Move Away from the Waterfront," August 18, 2016, *http://pilotonline.com/news/local/environment/the-norfolk-of-the-future-will-move-away-from-the/article_851bb9b2-23f0-517b-b6eb-3744db1535e2.html.*

4. CHALLENGES

While the importance of land use planning to reduce flood risks is generally acknowledged by policy makers, adoption is contentious locally. Implementing land use decisions can challenge existing control of a high-value urban resource and can thus be a messy process. For example, decision makers may be motivated to push for highly visible structural measures, which can show constituents that flood risk is being addressed. Likewise, communities may resist planning decisions such as preventive resettlement. In developing countries, land use implementation is further confounded by the complexities of informal settlement of land, as well as by a lack of capacity and resources.

Another challenge to spatial planning is that its costs versus benefits are not well understood, especially when a green infrastructure approach is compared to structural measures. Better education and outreach are needed to help communities appreciate how the required investment compares to the cost of doing nothing, meaning in this case allowing unplanned urban growth and increasing exposure and vulnerability to floods.

Lack of capacity to prepare land use plans, especially in fast-growing cities in low- and middle-income countries, poses yet another challenge. Although significant progress has been made in recent decades in hazard mapping, translation of technical information into land use regulations and building codes has been poor. Disaster modeling data are highly technical, and their implications for land use may be not clear to planning professionals and decision makers; especially challenging is how to translate probabilistic hazard modeling into local action plans with development regulations and hazard zones, which need to be referenced to corresponding building design and construction requirements. Scientific prediction of risk may not be perceived as real risk by the community.

Devastating floods in Jakarta. Indonesia. Project: JEDI.
Photo: Farhana Asnap / World Bank

Finally, even where land use plans exist, implementation is challenged by contentious land ownership and tenure status, as well as issues with stakeholder coordination, finance, permitting processes, and enforcement capacity of weak public institutions. Land procurement for public use is expensive, time-consuming, and fraught with disputes; the diversity of formal and informal stakeholders in land-based projects makes coordination complex and increases the likelihood of conflicts. Equally problematic is when land use plans are prepared by technical experts without any effective community consultation. This can happen because planning departments tend to operate in isolation from other agencies involved in transportation, housing, drainage, and water supply, and most cities lack skilled staff to manage review and monitoring of land use and building regulations. **Box 9 offers some examples of challenges that arise in trying to carry out flood risk–based land use planning.**

Box 9. Challenges

In September 2016, Hurricane Mathew caused flooding in areas of the **United States** that had not previously expected significant floods. In Louisiana, one-third of the flooded land area was outside the 100-year floodplain designated by the Federal Emergency Management Agency (FEMA). FEMA updates insurance maps only every 10–15 years; it faces political resistance when it tries to expand flood zones because homeowners don't want flood insurance to become mandatory. Hence local floodplain managers face the difficult task of encouraging homeowners to take the risk of flooding seriously when there is no legal requirement for them to own flood insurance. **Lumberton, North Carolina**, one of the cities hit hardest by Hurricane Mathew, is also outside FEMA's 100-year floodplain. Local floodplain managers invited homeowners to a meeting where they could find their homes on the floodplain map and ask questions about their risk; after weeks of advertising the meeting on the radio and in the local newspaper, nobody showed up.a

In **Mumbai, India**, administrative processes can be equivalent to 46 percent of construction costs, as compared to 1.7 percent of construction costs in countries that belong to the Organisation for Economic Co-operation and Development. Such expensive processes foster corruption and noncompliance *(GFDRR 2015)*.

5. CONCLUSIONS AND RECOMMENDATIONS

The need to integrate flood risk in land use planning is immense, given the frequency, severity, and impacts of floods in recent decades. Land use planning that incorporates flood risk information and integrates ecosystem- based measures can be cost-effective. In turn, land use planning can be integrated in all stages of a flood risk management plan—from prevention and response to reconstruction—along with other measures, both structural and nonstructural.

An understanding of flood risk should inform community priorities and decisions in all stages of the land use planning process. A set of land use instruments must be selected that addresses the type of local flood risk, that is acceptable to the community, and that can be implemented with local resources and technical capacity. Land use plans that address flood risk must be integrated within multiple sectors and at multiple scales: local area plans, city strategic plans, metropolitan visions, and watershed and national policies. This type of integration involves multiple public sector actors (city governments, public sector companies including utilities, and meteorological and planning institutions) as well as actors from civil society, educational institutions, research centers, and the private sector—and all must be coordinated to ensure they work effectively.

Planning, implementation, and enforcement of risk-based land use plans face challenges in both developed and developing countries. Where cities have succeeded, it has primarily been due to political will and citizen engagement, very often in the wake of a recent flood disaster. Once the leadership and the community take a proactive stance, they can work together to resolve challenges such as finance, technical capacity, land ownership, coordination, and enforcement. Ultimately, successful land use planning for flood risk management requires investment in two areas: (i) educating decision makers and communities about the role of land use planning in managing flood risks, and (ii) building sufficient technical and governance capacity to formulate, implement, and manage a flood risk–based land use planning process.

When decision makers appreciate the benefits of land use planning as a flood management tool, they will be better able to act on the following recommendations:

- Help communities understand their flood risk so that they demand safe and sustainable urban development from decision makers and professionals.
- Create a common goal and foster proactive collaborations between all stakeholders (government officials, civil society, communities, the private sector) and initiate institutional coordination among different sectoral agencies and levels of government.
- Establish land use planning as a cost-effective measure to manage flood risks by adopting a green infrastructure approach.
- Foster partnerships and networks to (i) advance multidisciplinary research (combining science, policy, and practice); (ii) share innovative practices in legislation, policy, stakeholder coordination, and land use regulations and incentives; and (iii) develop standards and identify research and capacity gaps.
- Promote community engagement and participation so that risk assessment and land use planning respond to local needs and reflect local cultures. Engaging the community in preparing a risk-sensitive land use plan is crucial to its acceptance, implementation, and updating.

When stakeholders have sufficient technical and governance capacity, they will be better able to act on the following recommendations:

- Draw on technical innovations—in information technology and geographic information systems—to ensure that flood risk data and real-time land use information are most effectively managed and used.
- Train city officials so they appreciate flood risk management as an integral component of a multihazard approach that will help the community reach its sustainable development goals, and so they can lead policy and administrative reforms for land use planning. Peer networks and e-learning platforms are useful training tools and can foster dialogue between large numbers of decision makers and professionals.

- Develop locally appropriate standards for land use regulations, engineering design, construction of various infrastructures, and guidelines and methodologies for retrofitting of structures. Flood risk standards must also be aligned with existing professional urban planning standards. To encourage compliance, building codes need to be stratified and accommodate the range of construction types, from sophisticated engineered buildings to non-engineered buildings built by petty contractors. Compliance is more likely where permitting processes are efficient, risk information is available and shared, building practitioners are certified, private third parties are accredited to provide review and inspection, and insurance mechanisms are used to augment building control.
- Create a pool of professionals who understand how to use risk information and work with the community to achieve socioeconomic and resilience goals through the land use planning process. Professional associations and planning schools should update professional responsibilities and curricula to integrate risk guidance.

Since land use challenges and institutional capacities vary by location, generic and prescriptive land use processes are not advisable. While the experience of other cities can be informative, each locale must assess its specific conditions and develop customized solutions. Apart from taking local technical and financial capacities into account, land use solutions must also be cognizant of local planning approaches and land tenure regimes.

Project helps to improve irrigation and drainage in over 50,000 hectares of land in rural Azerbaijan. *Photo: Allison Kwesell / World Bank*

Low income households along riverbanks prone to floods. Jakarta, Indonesia. Project: JEDI. *Photo: Farhana Asnap / World Bank*

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