Urban Climate Resilience
For the first time in three years, global carbon emissions increased in 2017 rather than remaining flat. Managing cities’ climate risks becomes increasingly important when considering that 70 percent of the world’s population is expected to be living in urban areas by 2050, up from 50 percent today. Their exposure to extreme weather events such as heavy monsoon rains, hurricanes, rising temperatures, inland flooding, and rising sea levels puts the majority of the global population at risk, especially vulnerable groups living in informal, unstable structures. Given that one in seven people live in informal settlements in urban areas, there is a huge opportunity for cities to help these communities build their resilience.

A study conducted by the University of Washington estimates that the world will likely experience a median temperature increase of 3.2°C by 2100. Analysis suggests that rising sea levels present the greatest threat to cities globally, with 275 million people worldwide living in areas that will be flooded should the temperature increase. Asian cities will be worst affected, including 17.5 million people in Shanghai, 8.4 million in Hong Kong, and 5.2 million in Osaka, but every region will feel the effects.

Climate-related risks are conservatively expected to cost cities an average of $123 billion annually in losses to projected economic output or GDP, according to the Lloyd’s City Risk Index. Improving resilience in the 279 indexed cities could decrease the GDP at risk by as much as $73.4 billion per year. Much of this risk to GDP and economic growth is the result of the concentration of businesses in urban areas,
which create employment, generate tax revenue, and provide goods and services to the city. The physical effects of climate change could disrupt supply chains, lead to lost productivity resulting from health issues, and incur costs associated with rebuilding or repairing physical assets such as buildings and transport infrastructure. Cities are also increasingly seeing a higher concentration of physical, financial, and human resources within their boundaries, raising the stakes for both cities and businesses to understand climate risks and opportunities, and invest in urban resilience.

Although cities across the globe will face the effects of climate change, the nature of the impact will depend on the geography and context of each city. Given their extreme vulnerability to the effects of climate change, it is essential that cities implement policies, invest in projects, and develop strategies for building long-term, sustainable, urban resilience.

Why Cities Should Act

With climate change exacerbating cities’ exposure to economic and physical impacts, there is a strong imperative for cities to ensure that they develop in a climate-smart way over the coming decades by investing in resilient infrastructure now. Achieving developmental goals in rapidly urbanizing areas over the next few decades will only be made more difficult by the challenges of climate change. Cities need to act; services, people, and systems such as transport, energy, water, and communications are particularly interlinked in urban areas, which results in a co-dependent system that needs to be made resilient at every link to prevent the failure of the whole chain.37

Building urban resilience means improving a city’s capacity to survive, adapt, and grow despite chronic and acute risks and shocks, which are often inter-sectoral and arise from a variety of sources.38 Achieving development objectives such as improved health, access to water and electricity, and reduced poverty that reduce vulnerable populations’ sensitivity and exposure to stresses and shocks can increase their capacity to adapt to climate impacts and build climate resilience. This requires a holistic approach that enhances social, economic, and environmental development across populations (see box on economic, social, and environmental resilience in cities).

City planning and infrastructure investments made today will have long-term impacts and shape the direction of urban growth and development for decades. Infrastructure built now will need to anticipate the climate impacts and needs of the future. These decisions can ensure that urban assets and residents can withstand climate impacts, while helping to shape urban economic and demographic growth for a sustainable, responsible, resilient future.

Investing in and paying for resilience and prevention upfront can help avoid much greater damages and costs in the future. Every dollar spent on pre-disaster mitigation measures where urban areas intersect with wildlands in the United States, for example, results in savings of six times that amount in post-disaster recovery.39 Even spending on improving building codes will result in four times that amount saved in dollar terms.40 Measures that help make a city more resilient can also have co-benefits for mitigation, which can help cities access much-needed climate finance for reducing their emissions.41

How Cities are Building Resilience

The first step for cities to build resilience, manage climate risk, and explore climate opportunities is to understand their exposure and sensitivity to different climate impacts. They can then develop strategies to adapt to these.42 Building resilience involves avoiding adverse events, limiting their impact, or enhancing recovery,3 and adapting to climate change means reducing the vulnerability of people or systems to climate impact and climate-variability risks by maintaining or increasing adaptive capacity and resilience.44

As the effects of climate change increase in frequency and intensity, the performance of investments and assets is being affected in many cities (as shown by increasing insurance losses worldwide, many concentrated in urban areas).41 The rising risks and costs are pointing to the urgent need for assets that are climate resilient—assets and investments that incorporate in their design and operation the best available information about the impacts expected during their lifecycle and design remediating actions to ensure they avoid financial, environmental, and social underperformance.
build resilience against flooding. Larger cities with higher population densities than their smaller counterparts are not only more energy-efficient, but also tend to have lower per capita emissions.

**Cities around the world are at various stages of planning**, with 210 cities already having a climate change adaptation plan in place and 111 cities in the process of creating one as of 2016. They are using a variety of tools to develop and mainstream their adaptation strategies and activities. One such tool is the Climate Risk and Adaptation Framework and Taxonomy developed by the Compact of Mayors and partners, which helps cities plan and implement their adaptation actions through a standardized framework for reporting climate hazards and impact, as well as risk and vulnerability assessments. Another is the City Strength Diagnostic developed by the World Bank and the Global Facility for Disaster Reduction and Recovery, which helps city planners and stakeholders identify the range of climate impacts that a city might face, the critical gaps and potential weaknesses within the city, and the high-priority actions and investments needed to address those gaps and build resilience. Since the resilience requirements and adaptive capacity of each city differ, tools such as the City Resilience Index allow cities to benchmark their progress against themselves rather than by comparison with others, through over 50 indicators that draw on both qualitative and quantitative data to measure and assess resilience.

Cities are also working together and participating in global initiatives that help them assess their vulnerability, develop strategies, provide technical assistance for implementation, and find financing. These initiatives also hold cities accountable to their own climate and resilience commitments. As of March 2017, 28 cities have taken the 10% Resilience Pledge, which commits participating mayors to earmark 10 percent of their cities’ existing annual budgets, without raising additional public funds, for resilience-building projects and activities. Members of 100 Resilient Cities are collaborating with and learning from each other. For example, Surat has a memorandum of understanding with Rotterdam Partners to collaborate on projects to make both cities more resilient, with a focus on wastewater recycling, waste-to-energy systems, and smart city information technology.

Each city’s climate resilience strategy should be uniquely tailored to its specific requirements and characteristics, based on geography, population density, and other local considerations. For example, the city of Ahmedabad, India, is increasingly exposed to heat waves, so it has developed a Heat Action Plan that includes an early warning system and an Interagency Disaster Risk Reduction Plan. Accra, Ghana, is implementing an integrated smart flood management framework to
HOW TO MAKE CITIES MORE RESILIENT:
UN International Strategy for Disaster Reduction and Global Facility for Disaster Reduction and Recovery checklist

The Ten Essentials for Making Cities Resilient Checklist Summary

1. Put in place organisation and coordination to understand and reduce disaster risk, based on participation of citizen groups and civil society. Build local alliances. Ensure that all departments understand their role in disaster risk reduction and preparedness.

2. Assign a budget for disaster risk reduction and provide incentives for homeowners, low-income families, communities, businesses, and the public sector to invest in reducing the risks they face.

3. Maintain up-to-date data on hazards and vulnerabilities. Prepare risk assessments and use these as the basis for urban development plans and decisions, ensure that this information and the plans for your city’s resilience are readily available to the public and fully discussed with them.

4. Invest in and maintain critical infrastructure that reduces risk, such as flood drainage, adjusted where needed to cope with climate change.

5. Assess the safety of all schools and health facilities and upgrade these as necessary.

6. Apply and enforce realistic, risk-compliant building regulations and land-use planning principles. Identify safe land for low-income citizens and upgrade informal settlements, wherever feasible.

7. Ensure that education programmes and training on disaster risk reduction are in place in schools and local communities.

8. Protect ecosystems and natural buffers to mitigate floods, storm surges and other hazards to which your city may be vulnerable. Adapt to climate change by building on good risk-reduction practices.

9. Install early warning systems and emergency management capacities in your city and hold regular public preparedness drills.

10. After any disaster, ensure that the needs of the affected population are placed at the centre of reconstruction, with support for them and their community organisations to design and help implement responses, including rebuilding homes and livelihoods.
City-Specific Approaches to Urban Water Resilience

**TOO MUCH WATER (LONDON, ENGLAND)**

To manage tidal flood risk in the short, medium, and long-term, London has developed the Thames Estuary 2100 Plan (TE2100). This plan seeks to protect London and surrounding areas from rising sea levels, from the 90 centimeter rise predicted by 2100 to a worst-case scenario rise of up to 2.7 meters, and an increase of 40 percent in peak river flood flows.

TE2100 sets out options for adaptation, finding that the preferred intervention is a staged long-term modification of the existing Thames flood barrier combined with local measures to manage flooding, including flood forecasting and emergency planning.

The plan seeks to protect 1.3 million people and $360 million worth of property from flood risk, and work has already started on implementing the first 10 years of investment in flood defenses. After a competitive bidding process involving five firms, the UK Environment Agency awarded its largest single flood management contract for the delivery of the $392 million program to private engineering and construction company, CH2M Hill.

The city has also worked with insurers to create Flood Re, a publicly funded reinsurance pool that covers properties at high risk of flooding. Since 2016, households with low to normal flood risk have standard insurance, and those with the highest risk are passed on to Flood Re by insurers. The goal is to help incentivize flood-proof building in at-risk areas and phase out high-risk assets.

**TOO LITTLE WATER (CAPE TOWN, SOUTH AFRICA)**

In February 2018, Cape Town faced the likelihood of running out of water within two months. It has since delayed “Day Zero”—first to 2019 and now indefinitely. Heavily focusing its adaptation strategy on household users, the government instituted emergency regulations, including limiting people to 50 liters of water per day. An online water dashboard allows residents to monitor daily fluctuations in dam levels, weekly targets and actual water use, and updated water restrictions.

To prepare for the long term and prevent this situation in future, Cape Town implemented a Water Resilience Plan in January 2018, which seeks to implement a series of water augmentation schemes in stages over a few months. Procurement and commissioning have already begun for some projects, providing an opportunity for private sector investment in groundwater extraction and desalination in the first tranche, and water reuse and wastewater treatment in the second tranche. Planned tenders include further desalination and augmenting the local aquifer and spring.
Chief Resilience Officers are senior-level city government officials that help to coordinate the resilience efforts of 100 Resilient Cities member cities. They work across government departments to help improve internal communications, bring together a broad range of stakeholders to learn about the city’s challenges and resilience agenda, and lead the city’s process of developing and implementing its resilience strategy. These Chief Resilience Officers were interviewed to showcase a diverse range of priorities and approaches being adopted to build resilience in cities with different climate impact and economic contexts.

Cities are coming together through groupings such as C40, which brings together a network of over 90 of the world’s megacities to turn their urban density into an opportunity for mitigation and resilience. International organizations are also playing their part. The UN Making Cities Resilient Campaign works to raise awareness, identify city government budget allocations to invest in resilience and disaster risk-reduction activities, and help cities create and implement resilient urban development plans, while targeting private sector partners. Similarly, the World Bank’s City Resilience Program seeks to help city governments design urban resilience projects and access financing for such projects. In its first year of operation, the program has engaged with over 40 cities, conducted city diagnostics and investment planning workshops, and developed strategies for private capital mobilization through debt, PPPs, and land value capture.

The next frontier for urban climate resilience is to expand beyond megacities, acknowledging the huge expected growth in small and medium-sized cities. According to the UN, some of the fastest-growing urban areas are Asian and African cities with populations under 1 million. To accommodate this growth, these cities will need new infrastructure and buildings, presenting a compelling opportunity to ensure that this new construction is green and resilient.
“To have better climate resilience in a city, we need to join hands not only with the government but also with the private sector and the local communities and neighborhoods. The government should be the champion of urban resilience work. However, we need private sector investment to leverage public sector funding to build sustainable urban resilient projects in Da Nang.”

— Cuong Dinh Quang, Chief Resilience Officer, Da Nang
Mexico City is one of the most populous cities in the world, with about 22 million inhabitants in the greater metropolitan area. Due to its location, it is vulnerable to flooding, mudslides, and earthquakes. As a result, the city has a keen interest in building its future resilience—and it is doing just that.

Mexico City established its Resilience Agency in 2016, with an articulated strategy to develop and implement resilience projects throughout the city, and mainstream resilience into the city’s urban planning, with a focus on good governance, environmental management, and risk reduction. Resilience has since been embedded into the city’s new constitution created in 2017, which forms a legal mandate for government agencies to work across sectors to help develop and implement these projects.

The day after its Resilience Agency was established, a major earthquake struck the city. Although the agency’s main focus over the past 12 to 18 months has been largely on projects related to seismic resilience, it is also focusing on broader resilience projects.

Beyond seismic resilience, the city’s Resilience Plan identifies additional priority areas, all of which present opportunities for private sector participation, including:

- Mobility (private bike-sharing and car-sharing schemes)
- Water management systems to prevent leaks
- Access to markets for agri-products
- Public spaces.

As part of the Resilience Plan, a monitoring and evaluation system has been developed. This system will help create a learning platform and coordinate efforts between relevant stakeholders. It will also help identify opportunities for projects to move from a pilot to a full-scale program for potential private sector investment. The city’s Resilience Plan has identified three time horizons for identifying and implementing resilience projects—the end of 2018, to 2025, and to 2040, the last of which takes a longer perspective linked to promoting transformational adaptation.

— Arnoldo Matus Kramer, Chief Resilience Officer, Mexico City
PORTO ALEGRE, BRAZIL

“Climate resilience in Porto Alegre is about supporting an integrated way of life, and building resilience is about bringing together environmental sustainability and economic development, helping each understand the drivers for the other.”

— Rodrigo de Souza Corradi, Chief Resilience Officer, Porto Alegre

Porto Alegre aims to use enhanced economic resilience as a means to strengthen climate resilience by extensively involving the private sector in cultivating the innovation industry within city limits and connecting to other parts of the district. With the help of the World Bank’s City Resilience Program and Deloitte, Porto Alegre is putting together a pipeline of projects for private investment in resilient infrastructure. Like previous projects in the city, these will not carry the “resilience” label, but they will seek to mitigate climate concerns such as reducing displacement due to climate impacts, connect to the needs of the community by creating jobs, and appeal to the interests of both the city government and the private sector. It is hoped that the city can identify and implement these “anchor projects” between the city government and the private sector to catalyze more investment in resilient infrastructure and help preserve the urban farmland within Porto Alegre, which is the second largest in the world.

Porto Alegre intends to finance these projects through traditional infrastructure financing models and private investment through public-private partnerships (PPPs). The city is also working with the World Bank to develop approaches for municipal access to international funding and resilience finance, potentially with a local bank assuming risk and acting as a go-between.

The city’s urban resilience agenda has been driven predominantly by the local government. The Chief Resilience Officer’s team is helping to connect partners from industries and interest groups to engage with the local government. The government of Porto Alegre has recently allowed legislative flexibility for financing resilient urban projects in an attempt to use public resources to attract private investment. Until early 2018, legislation capped PPP investment to between 1 percent and 2 percent of public GDP, but this has now increased to match the 7 percent available at federal level.
Quito is working rapidly to address the effects of climate change. Increased rainfall, ongoing flooding, and accompanying landslides have resulted in many deaths and damage to housing in the most vulnerable sectors of the city. Rising temperatures have created harsher conditions, particularly affecting the agricultural sector. The city also faces mobility challenges due to scattered and uncontrolled urban sprawl.

To help address these challenges, the city of Quito hired a Chief Resilience Officer in 2016, who sits on the city’s General Planning Agency. In 2017, the city established a resilience strategy based on broad consultations with stakeholders.

One of the projects arising from Quito’s resilience strategy is the city’s first metro line, designed to achieve an integrated and efficient transportation system that is resilient to the city’s climate risks. This metro line is being financed by the local and central governments, as well as CAF—the Development Bank of Latin America, the Inter-American Development Bank, and the World Bank. As part of the metro line project, the government established a regulation to encourage private sector development in the nodes around the metro. The city intends to conduct an international tender to attract private sector investment to construct eco-efficient buildings, and thereby attract economic activity, in these nodes.

The public and private sectors are also working together to design how the city’s agroindustry should be developed to be more environmentally friendly and inclusive, and to avoid adverse events related to food security.

In addition to transit-oriented development and agriculture, the city is focused on establishing special development zones near the Quito airport to create jobs by providing incentives to certain industries. The city is also working on a project to clean Quito’s major river, the Machángara. In both projects, there are opportunities for private sector engagement and investment.

---

**QUITO, ECUADOR**

“*When defining urban resilience strategies, a city must be willing to adapt and adjust to its climate risks both now and in the future. For holistic urban resilience development to take shape, there is a need to focus on developing less attractive public spaces where resources are most scarce. Usually, these are the parts of the city where the most vulnerable populations live and where urban resilience development is needed most.*”

— David Jácome Polit, Chief Resilience Officer, Quito
Semarang, Indonesia

“To continue moving climate action forward, Semarang looks to the national level government to put relevant policies in place. The city also needs to think about urban climate resilience more practically and transfer these concepts and know-how to the related agencies and local communities to achieve enhanced impact.”

— Mohammad Luthfi Eko Nugroho, Development Planning Agency of Semarang/Resilience Team

Semarang is a coastal city in Indonesia with both hilly areas and coastal plains. One of its most pressing concerns is water—the city experiences tidal flooding and flash floods. In recent years, flooding has intensified due to sea level rise, coastal erosion, and land subsidence. At the same time, the city’s population is growing rapidly, exacerbating traffic congestion and urban sprawl.

To help address these issues, Semarang developed a City Resilience Strategy in 2016. It focuses on encouraging sustainable energy and water management practices, integrated mobility, preparedness for disaster and disease outbreaks, new economic opportunities, transparent public information and governance, and competitive human resources. Urban resilience strategies are also embedded in the city’s Medium-Term Urban Development Plan, which are then applied to the projects and duties assigned to all government agencies across sectors.

Semarang has implemented innovative programs for enhancing the adaptive capacity of vulnerable communities along the city’s West Flood Canal, initiated the use of renewable energy and rainwater harvesting, planted vetiver grass to prevent landslides, rehabilitated mangroves to protect coastlines, and invested in early warning systems for floods and vector-borne diseases. Some of these projects, such as urban farming, integrate a gender component to ensure women are involved in these economic opportunities. The city is also working to improve its public transport system—Trans Semarang—while reducing greenhouse gases and air pollutants in line with the SDGs. The city is raising awareness about climate resilience within the public and private sectors, and among local communities.

Most of the projects under way are largely funded by the city through provincial and national budgets, as well as donor agencies and universities. This presents an opportunity for national government policies to encourage private investment in climate-smart projects. Semarang is also proposing a PPP for a street lighting project, which would involve energy service companies, supported by the Ministry of Energy and Mineral Resources.
The Surat Municipal Corporation has created the Surat Climate Change Trust to formalize and institutionalize resilience, and allow the municipality to access external financing. The first of its kind in the country, the trust includes multiple stakeholders, including elected officials and public sector representatives. The trust developed an Urban Resilience Strategy, with a focus on water, mobility, affordable housing, and economic and social resilience. Projects implemented under the strategy range in size from a few thousand rupees to $180 million.

To date, financing for these projects has been dependent mainly on local and central government funds. But there are potential opportunities for the private sector in water, solid waste management, and affordable housing. For example, it takes 1 billion liters of water each day to produce 40 million meters of synthetic fabric. To bridge the gap in water supply, private companies are invited by tender to set up tertiary treatment plants.

In 2010, the city established that any new commercial developments need to have a water harvesting facility, but this decree has not been enforced. The Surat Municipal Corporation is conducting an audit, which, once complete, will inform an enforcement policy that may include tax incentives and concessional pricing. An aquifer mapping was recently completed to identify site construction for French wells, which would give the city access to about 150 million liters of potable water per day at a lower cost than traditional methods. The Surat Municipal Corporation is also setting up state-of-the-art sewage treatment plants, which will supply 115 million liters of treated or recycled wastewater per day for industrial use by March 2019.

Waste management is another major challenge for the city. Up to 85 percent of solid waste is taken to a dumpsite and there is no segregation at the source. Opportunities also lie in affordable housing. Housing is being built for low-income communities living in vulnerable areas, but it is not energy-efficient. The city is accepting special proposals from the private sector through a tender process to bring them into some of these projects. The main challenge has been awareness and enforcement, and the city’s seven zonal chiefs have been given the legal mandate to improve awareness and enforcement of climate-smart practices and urban management across sectors.
The Role of the Public and Private Sector

City governments can play a central, catalytic, and convening role in building resilience. They can invest directly in projects to increase city resilience, such as the flood walls commissioned by Cologne, Germany,76 or the transformation of Shenzhen, China, into a water supply catchment area through the adoption of the “sponge city” concept.77 Similarly, city governments can ensure that all infrastructure and other developmental projects that they invest in are planned and implemented in a way that enhances the city’s ability to adapt to climate change, while creating a pipeline of resilient projects for private sector investment.

By introducing building codes and other mandatory regulations, as well as launching fiscal and non-fiscal incentives, city governments can create a policy environment that encourages resilient urban development. Planning initiatives that prioritize adaptation of urban infrastructure and habits can also play a part in bringing together communities, businesses, and people in a way that helps those cities prepare for the future.

City governments will have to work beyond their territorial limits and coordinate across geographies, jurisdictions and systems to comprehensively build resilience, as the effects of climate change are not restricted by municipal boundaries.

The private sector has an important role to play in urban resilience. With many competing priorities for public finances and limited budgets, cities will need to unlock vast private sector investment in resilience. Climate change presents both risks and opportunities for the private sector. Companies face physical risks such as disrupted supply chains and extreme weather events: regulatory and compliance risks associated with expected future climate and carbon-related laws and regulations like carbon taxes; other transitional risks including reputational impact from being perceived as irresponsible corporate citizens; and declining worker productivity due to bad air quality, lack of adequate water and other infrastructure, and adverse climate impact. At the same time, investments in green products as well as in resilience-building infrastructure such as green buildings and floodwalls present potential new business and revenue opportunities. So, it makes sense for businesses to invest in and support urban resilience. Companies and cities’ disclosures to the CDP (formerly known as the Carbon Disclosure Project) revealed that, despite some variation in expected severity and timing, cities and businesses are aligned in their recognition of local climate risks. 76 percent of the 207 cities that disclosed their environmental data in 2014 reported that climate change would impact business, and cities are taking action to reduce climate risks that businesses have also separately assessed as serious risks.78 Strategies implemented and actions taken by local governments to improve the city’s adaptive capacity also help build business resilience and prevent the relocation of business operations to urban areas with less climate risk exposure.

Forward-thinking companies are already seizing opportunities. For example, Siemens, the European electrical engineering conglomerate, has developed a practice area focused exclusively on resilient cities, providing services and products that range from remotely controlled distributed energy systems to decentralized wastewater treatment to engineered flood defenses.79 Global infrastructure and engineering company AECOM offers integrated resilience solutions for cities, working on projects to provide water to 2.6 million people through green infrastructure in San Francisco, defend Edinburgh from flooding, build a network of smart, sustainable cities along the Delhi-Mumbai industrial corridor, and regenerate and renew Kuala Lumpur’s waterfront.80 In Caieiras, Brazil, state-owned enterprise Sabesp, recognizing the risk flooding poses to its operations, has developed a Corporate Climate Change Adaptation Plan and jointly invested in a $22 million fund to support research on water management across São Paulo.81 Businesses are recognizing that making cities resilient is no longer an option, but a necessity, which has created a market for innovative, climate-smart business models, products, and projects.

Planning for climate change effects may soon impact cities’ creditworthiness and rates at which they can borrow. Credit rating agency Moody’s has announced that it will be considering a city’s long-term adaptation and resilience measures against extreme weather events as part of its rating methodology.82 Any downgrades to a city’s credit rating due to a lack of preparedness for climate shocks will make it more expensive and difficult to access financing, not only for resilience-building investments but for all projects.
Financing Resilience

Connecting cities with financing is an essential component of building urban resilience strategies. Investment in urban infrastructure for developing countries tends to be funded by the public sector, but this is often insufficient given competing priorities and limited resources. According to a report by the World Bank and the Global Facility for Disaster Reduction and Recovery, without significant investment in resilience, cities worldwide may face $314 billion each year in damages by 2030, up from the $250 billion they face today.83 By some estimates, required global investment in low emission and climate resilient urban infrastructure amounts to between $4.5 trillion and $5.5 trillion annually.84 The sheer scale of the requirement necessitates the unlocking of alternative sources to government financing. The Global Facility for Disaster Reduction and Recovery report finds that the financing needed lies with the private sector, with up to $106 trillion in capital available from institutional investors such as pension and sovereign wealth funds, but only 1.6 percent of this is used for infrastructure investments.85

One of the barriers to increased private sector participation in resilience-building projects, particularly large infrastructure investments, is the challenge of monetizing the benefits of such projects. This is due to the combination of several factors, such as the inherent difficulty in monetizing socioeconomic benefits, the often large and diverse stakeholder groups including vulnerable populations without the ability to pay for the benefits from the interventions, and uncertainties related to climate effects and the timing of benefits that depend on when an extreme climate event might occur. Existing large protective projects are
largely publicly funded due to the difficulty in monetizing them, such as the Dutch Delta Works or the Thames Barrier. However, new potential projects are exploring other financing options that may make private investment feasible through innovative ways of structuring multi-purpose, and consequently multi-benefit, interventions with benefits that can be easily monetized, such as the New York Harbor Storm-Surge Barrier, whose final feasibility report is expected by 2022.

Tapping into institutional investment in resilience-building and resilient infrastructure will be invaluable in helping cities access the finance they need to adapt to climate change. Institutional investors are relatively risk averse when it comes to infrastructure, primarily due to the political risk, cost overruns, and long tenors associated with such projects. This has also limited their interest in investing in infrastructure projects that build urban resilience. But multilateral climate finance has reduced the risk profile of resilient infrastructure, which presents an investment opportunity of more than $52 trillion between 2015 and 2030 in the core sectors of power, transport, wastewater, and energy-efficiency, according to a study by the Brookings Institution. The report finds that multilateral entities like the Climate Investment Funds, the Green Climate Fund, and the Global Environment Facility have been instrumental in de-risking low-carbon resilient infrastructure projects, delivering concessional climate finance, and crowding in private finance.

Innovative financial products to bridge the gap between resilient infrastructure and financing are already being piloted, primarily in cities in developed countries, such as the municipal bonds and green bonds discussed below. A new financial mechanism suggested by the Global Infrastructure Basel Foundation proposes the creation of a new asset class to match institutional investors’ finances for resilient infrastructure projects. The proposed hybrid sustainable infrastructure asset class will merge the incomes of equity and debt providers over the lifespan of infrastructure, securing sustainable cash flows with a risk/return profile between the two sources.

Cities are finding innovative ways to use existing financial products and alternative funding sources to finance their resilience projects. Washington, D.C.’s municipal water utility issued a $350 million
bond in 2014 that helped the city build resilience to flooding, improve water quality, and promote biodiversity and waterfront restoration. This was extended in 2016 through a performance-based $25 million variable-rate green bond for green infrastructure and storm water absorption, which rewards investors if the city exceeds its wastewater reduction targets. In 2017, Pune, India, raised funds through its municipal corporation to revamp the city’s water supply system. Mexico City became the first Latin American city to issue a green bond for $50 million to be used to build resilience through energy-efficiency, water management, and sustainable transport initiatives.

Several institutions are attempting to develop “resilience bonds” or similar financial products that are focused on adaptation and resilience. The World Bank Group is developing a set of resilience metrics that may be used to help define and structure such financial products. The Climate Bonds Initiative is developing an adaptation and resilience framework. In another concept under development, the insurer accounts for the expected impact of a planned investment into a resilience-building project and lowers the premium that the city will have to pay, allowing the cost savings to finance the project. The dividend from a resilience bond can also theoretically be used to finance projects beyond infrastructure, such as awareness campaigns and community-building exercises. Cities can link insurance coverage, such as catastrophe bonds, with capital investments in resilient projects and systems like flood barriers and green infrastructure to anticipate and reduce the impact and losses from potential climate-related events. In 2015, design firm re:focus adopted this concept and created the RE.bound program in partnership with private financial institutions. The program adapts the catastrophe bond model to climate risk and creates resilience bonds.

Innovative financing is expanding in developed countries but is still difficult to access for municipalities in emerging markets. Few cities in emerging markets are able to issue bonds, and those that can are likely to be deterred due to higher underwriting and modeling costs associated with catastrophe or resilience bonds.

While cities can mitigate the impact of natural disasters, flooding, and other climate-related extreme events, they still have to rebuild after the fact. Insurance is a key mechanism for ensuring that the economic and financial repercussions of physical climate effects are kept at a manageable level. These products must be designed and priced to be most effective to support cities in their rehabilitation and rebuilding efforts, provide coverage for business continuity, and buffer lost public sector tax revenue and assets. The underlying asset should account for both current and future climate impacts and baseline thresholds so that it is independent of subsidies, with adequate coverage and affordable deductibles. International insurance companies such as Swiss Re and AXA are recognizing the potential of such products, and are providing insurance packages and services specifically for climate adaptation and disaster risk mitigation. Lloyd’s of London has proposed four new methods to encourage investment in resilient infrastructure, including an insurance-lined loan package with interest payments that factor in the implementation of resilience measures. By reissuing high-yield catastrophe bonds, insurance companies provide long-term financial risk coverage for local governments in the case of a disaster.

Sharing the risk through PPPs can also be an attractive way for cities to leverage private sector capital and expertise for resilience-building projects. The World Bank recently supported a PPP to help build energy resilience in Zambia through investments in scaling solar energy. Similarly, IFC is supporting a PPP in Córdoba, Argentina, through a $300 million financing package in partnership with commercial banks. The project seeks to construct and improve critical road infrastructure, which will help build urban transport resilience. Cities can also use their existing budgets to prioritize resilient investments, and embed resilience in non-climate-related projects that they are already investing in. Developing country cities are also adapting other, more traditional forms of infrastructure financing to build more resilient assets. Financing alternatives include capturing increases in land value, embedding resilience standards for procurement, and accessing targeted funds for resilience. Some of these climate finance methods are explored further in the chapter on financing climate-smart investments in cities.
FLOOD MANAGEMENT IN JAKARTA (WORLD BANK)

In 2012, the World Bank initiated a program to build urban resilience to climate change in East Asia using a risk-based approach to public investment decisions. Indonesia is one of the world’s fastest growing economies, and its capital city Jakarta is the country’s political and economic center. About 40 percent of the city is below sea level and there are 13 rivers that flow through the area. Combined with insufficient infrastructure, these topographic features put the city in a vulnerable position. The World Bank mapped all 2,688 neighborhood boundaries in Jakarta for the first time to assess their flood preparedness. It also partnered with Indonesia’s National Agency for Disaster Countermeasure and the Australian government to introduce InaSAFE, a software program to understand the impact of a disaster and to adequately prepare for it. In 2013, the World Bank supported Indonesia’s efforts to automatically assess the damage and loss from flood disasters with additional software.

COASTAL TOWN INFRASTRUCTURE IN BANGLADESH (ASIAN DEVELOPMENT BANK)

An estimated 8.6 million people in Bangladesh’s coastal regions are highly vulnerable to rising sea levels. These towns also suffer from large infrastructure deficits and natural resource constraints that exacerbate their sensitivity to climate change. The Asian Development Bank (ADB) has initiated a project to support climate resilience and disaster preparedness in eight coastal towns (each with populations of 15,000 to 60,000 people). The project grant is funding the construction of climate resilient infrastructure (roads, drains, and cyclone shelters). It will also be used to develop an integrated drainage plan and a solid waste and fecal sludge management plan that will incorporate a PPP business model.

METRO MANILA FLOOD MANAGEMENT PROJECT (WORLD BANK)

The Philippines is expected to suffer long-term and repetitive damage from extreme weather patterns brought about by climate change. In Metro Manila, the need for climate change adaptation measures is particularly dire. Solid growth in the capital region has attracted an increasing number of migrants from rural areas, who typically move to informal settlements in danger zones. With one out of every five people in Metro Manila now living in informal settlements, worsening flood events are having devastating effects for those without adequate shelter. The World Bank is providing $207.6 million to improve flood management in selected areas of Metro Manila. The project is investing in a range of flood protection measures, including constructing 20 new pumping stations, modernizing 36 existing pumping stations, improving the associated waterways and drainage channels, and expanding water retention capacity across the city through green infrastructure, where suitable. The loan is also supporting the design and execution of asset management and maintenance plans, as well as resettlement away from the estimated 16 drainage areas.
INTEGRATED FLOOD AND ENVIRONMENTAL RISK MANAGEMENT IN THE CHONGQING LONGXI RIVER BASIN (ADB)

The Longxi River Basin in China’s Chongqing Municipality is a sub-basin of the Yangtze River and forms part of the primary buffer zone of the Three Gorges Reservoir. Because the reservoir is the main source of drinking water and fresh fish for millions of people, the Chinese government has prioritized environmental pollution control and ecological security in the buffer zone. The Longxi River Basin has experienced increasingly intense and frequent floods, water quality degradation, and ecological disruption in recent years. The ADB’s $150 million loan will demonstrate a flood and environmental risk management approach that emphasizes the flood-waste-ecosystem relationship, risk mapping, and accountability mechanisms in the Longxi River Basin. This includes a range of measures, such as ecological dikes, waste collection and treatment facilities, temporary water retention facilities, wetlands, bio-shields, and emergency shelters. The project’s approach can be replicated in similar watersheds along the Yangtze River Basin and other countries in the region.

FLOOD-RESILIENT INFRASTRUCTURE IN BARRANQUILLA, COLOMBIA (IFC)

Barranquilla is a city in northern Colombia on the Caribbean Sea. For decades, street flooding (“urban creeks”) caused by heavy rainfall has been one of the main issues affecting the city. IFC has established a long-term strategic partnership with the municipality under the Latin America and Caribbean Cities Initiative, which comprises a combination of investment and advisory services to further develop the city’s infrastructure. The investment component will likely support Barranquilla’s urban infrastructure capital expenditure program, focusing on the construction of its storm water drainage system. The advisory services package is focused on knowledge sharing in sustainable cities solutions; capacity building for the introduction of green building standards in a new urban development area called Ciudad del Río; introducing energy-efficiency standards; and capacity building to share best practices in environmental and social standards for infrastructure projects.
Economic, Social, and Environmental Resilience in Cities

Three converging trends have come to characterize the 21st century: urbanization, globalization, and climate change. The world today is more densely populated and interconnected than ever before, which requires new models of governance to respond to challenges old and new. From extreme weather to refugee crises to disease pandemics to cyber-attacks, planning reactively and making decisions in silos will not give cities the fundamental strength and flexibility they need to thrive in the face of shocks and stresses.

Acute shocks are sudden, sharp events that threaten a community, such as earthquakes, disease outbreaks, or acts of terrorism. Chronic stresses—such as high unemployment, overtaxed or inefficient public transportation systems, or recurrent flooding—weaken the fabric of a community over time and exacerbate shocks when they occur. Cities rarely have the luxury of tackling just one shock or stress at a time, but rather are confronted by interdependent combinations at the same time.

Urban resilience is the capacity of individuals, communities, institutions, businesses, and systems within a city to survive, adapt, and grow no matter what kinds of chronic stresses and acute shocks they experience. A focus on resilience will allow cities to prosper and prepare them for challenges both expected and as-yet unimagined.

Resilience thinking requires cities to look holistically at their capacities and risks. The current approach to urban development is to work in silos, with one team designing disaster recovery plans, another exploring sustainability issues, another focused on livelihoods and well-being, and yet another on land-use planning and infrastructure. While that may be an efficient way to structure the work of a city, it is not the most effective way to grapple with the diverse challenges we face today. Planning for a resilient future entails tackling challenges and creating solutions in an integrated, inclusive, risk-aware, and forward-looking manner. This will allow cities to enjoy the multiple benefits that such solutions offer.

An investment in resilience-based planning, projects, and practices will return cost-savings, cost-avoidance, and multiple benefits across city systems. Decision-makers and investors need to be explicit about maximizing the co-benefits of their investments and deploy projects that serve communities in both the good times and the bad.
**Jakarta, Indonesia—Decentralized Wastewater Treatment**

In 2017, only 62 percent of Jakarta’s population had access to clean, piped water. Only 4 percent had access to the sewerage system, resulting in almost three quarters of all households relying on ground water or river water, which is frequently polluted. Jakarta has prepared a Wastewater Master Plan, which, if fully implemented, will ensure that 65 percent of its residents will be covered by the piped sewerage system by 2022.

Jakarta’s city government is investigating the management and operation of decentralized, odorless wastewater treatment plants on government-owned public space across the city. Such a system would help close the gap between a large-scale centralized system and inadequate onsite solutions, especially in low-income neighborhoods. This would improve sanitation and access to clean water for communities, while reducing health costs and emissions. The city has identified potential pilot sites and is reviewing the opportunities, constraints, and relevant technologies for each location, with the expectation of implementing the pilot in several sites in 2018, and plans to expand across the city in time. Partners could help address issues surrounding decentralized systems, such as solving procurement challenges, connecting to the city-wide water supply plan, ensuring financial feasibility, and engaging communities.

**Montevideo, Uruguay—Master Plan for Pantanoso Stream Basin**

The Pantanoso Stream Basin, spanning 77 square kilometers (km²) in the city of Montevideo, covers agricultural rural areas, residential zones, and informal settlements, with nearly a third of households in the zone falling below the poverty line. The lack of services and infrastructure in informal settlements contribute to water and air pollution, while the flood risk and poor perception of the area discourage much-needed new investment.

Montevideo has conducted initial assessments specifying five areas for investing $500 million in the Pantanoso Basin, addressing environmental, economic, social equity, connectivity, and community engagement needs. Through various initiatives, the city aims to improve air and water quality, maintain wetland environmental services, and reduce flood risk in the target basin area. Montevideo is seeking partners and funding to pursue a circular economy and sustainable economic growth. By investing in new housing and improving existing housing stock, creating new public recreational spaces, and establishing strong community partnerships, the city aims to address social equity issues. It is also pursuing investments in new pedestrian and cycling infrastructure, as well as new bridges over the watercourses, to improve connectivity beyond the extensive existing bus network. With support, the city hopes to design and implement a citizen consultation and participation process to create a plan for Pantanoso.

**Santa Fe, Argentina—Estación Belgrano**

In 2008, after 20 years of neglect, the city of Santa Fe began renovating its iconic Belgrano Railway Station through private and public investment, successfully transforming it into an important site for exhibitions, fairs, and conventions. The Argentinian government recently made a commitment to recovering derelict public lands nationwide. The city is seizing the opportunity to further bolster the value of the wider Belgrano area by developing 22 hectares of underused and flood-prone public land surrounding the now thriving station. The revitalization project will integrate this zone into the urban grid through mixed-use development including hotels, shops, restaurants, office space, and housing. The city intends to develop the site using blue-green infrastructure to reduce flooding while increasing publicly accessible green space and ensuring a sustainable environmental footprint. The World Bank, in collaboration with 100 Resilient Cities, is providing support for the pre-feasibility studies. The project is in its initiation phase in 2018, with the city focused on creating a master plan for the redevelopment of public land by 2019. Overall, the Belgrano development will require an estimated investment of $100 million.