URBAN DEVELOPMENT SERIES

BANKING ON CITIES

Investing in Resilient and Low-Carbon Urbanization

Chandan Deuskar, Sally Murray,
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Ibrahim Ali Khan, and Augustin Maria

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Foreword

Cities are on the frontlines of climate action. This message is resonating louder than ever—from COP29 to the World Urban Forum and beyond. Urban areas concentrate people, infrastructure, and economic activity—all of which are increasingly vulnerable to climate risks. They also account for a major and growing share of global greenhouse gas emissions. The choices cities make today will shape the climate trajectory of tomorrow.

Nowhere is this more urgent than in low- and middle-income countries (L&MICs), where rapid urbanization presents both a challenge and a once-in-a-generation opportunity. These cities can still chart a path to resilient, low-carbon growth—if the right investments are made in time.

So what should those investments be? What will they cost? And where will the funding come from?

Banking on Cities: Investing in Resilient and Low-Carbon Urbanization tackles these questions head on. Leveraging state-of-the-art data and modeling, this report estimates the scale and scope of essential urban investments in L&MICs through 2050. It focuses on sectors critical to climate mitigation and adaptation: urban transport, energy-efficient buildings, solid waste management, water and wastewater, flood protection, and heat resilience.

The costs will be high: between US$256 billion and US$821 billion per year of capital investment will be needed. But this report goes beyond highlighting the costs—it offers a roadmap. It outlines which financing

strategies are best suited to different investment types and explores how cities can mobilize resources from across the spectrum: Municipal budgets, national governments, development banks, private capital, carbon credits, and more. Crucially, it urges us to look beyond climate-specific sources of finance, recognizing that much of the investment will require tapping broader financing sources.

Still, these investments are not out of reach, especially when one realizes these investments are not additional to "business as usual." Rather, they are core urban investments in sectors like mobility, waste management, and flood protection. In other words, urban climate investments are not a separate category of investments but instead represent core urban development done the right way.

This report is both a call to action and a practical guide. Cities and national governments can use it to inform bold, forward-looking urban strategies that align climate goals with financial sustainability and development priorities.

The time to act is now. The future is urban, and the world is banking on cities.

Ming Zhang
Global Director
Urban, Resilience, and Land Global Department
The World Bank

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Executive summary

Introduction

Urban climate action is essential for cities to protect their populations, build strong and resilient economic foundations, and meet targets for greenhouse gas (GHG) mitigation. The economic viability of cities in low- and middle-income countries (L&MICs) is in jeopardy because of rapidly increasing climate change hazards and nonresilient urban growth pathways. The national climate mitigation commitments of L&MICs will not be achieved without decisive lower-carbon growth trajectories in cities. Globally, 56 percent of the world's population lives in cities. Because cities increasingly concentrate people and assets, they also concentrate many climate risks, and cities account for 70 percent of global GHG emissions.

Cities in L&MICs have a unique opportunity to develop in more resilient and low-carbon ways. The current stock of infrastructure and buildings in L&MICs is only a small fraction of that needed by 2050. The fact that much of their building and infrastructure stock has yet to be built means that L&MIC cities could learn from the mistakes of other cities, to develop in more efficient, resilient, and low-carbon ways. Doing so, however, will require adequate financial and technical capacity and supportive institutions. An important first step is determining how much the key resilient and low-carbon investments in L&MICs will cost and where cities should look for resources to pay for these investments. This involves breaking down the "financing gap" into multiple differentiated "gaps," each of which will require differentiated strategies to fill.

Estimating investment costs for resilient and low-carbon urbanization up to 2050

Public capital costs of resilient and low-carbon urban investments in all L&MICs, across several sectors, are estimated to be about US$256–821 billion annually. This estimate includes the cost of public investments for resilient and low-carbon urban transportation; energy efficiency in buildings; resilience and reduced emissions from urban water supply and wastewater treatment; protection from flood and heat hazards elevated by climate change; and solid waste management to control methane emissions and reduce flooding. The estimated cumulative capital cost of these investments from 2020 to 2050 is between US$7.9 trillion and US$25.5 trillion. This is equal to US$256 billion and US$821 billion per year, respectively, or 0.8 to 2.6 percent of the combined GDP of L&MICs. The cost of operating and maintaining these investments adds between US$525 billion and US$548 billion each year to these costs, an additional 1.7 to 1.8 percent of GDP.

Although absolute costs are concentrated in upper-middle-income countries (about US$5.5–18.0 trillion up to 2050), costs as a share of GDP are highest in low-income countries. The investments identified have capital costs of 2.5 to 8.4 percent of the combined GDP of low-income countries, compared with 0.9 to 2.6 percent in lower-middle-income countries and 0.8 to 2.5 percent in upper-middle-income countries.

Current spending on these investments appears to be substantially below the estimated costs. The Cities Climate Finance Leadership Alliance (CCFLA 2024) estimates that urban climate finance flows to L&MICs for expenditures approximating those included in this report amounted to just US$92 billion in 2021–22, including both capital and operating expenditures. This corresponds to only 11 to 36 percent of the total annual capital costs discussed and just 7 to 12 percent of the combined capital and operations and maintenance costs per year. Most of this amount, US$73 billion, went to upper-middle income countries. Only US$18 billion flowed to lower-middle income countries and US$1 billion to low-income countries. These numbers are conservative, however, especially due to knowledge gaps regarding local and national government spending in L&MICs. Data from the Organisation for Economic Cooperation and Development shows that total public investment, across all sectors and geographies, was 5.7 percent of GDP on average in L&MICs

in 2020, with subnational investment being 1.3 percent of GDP (OECD-UCLG 2022). The share of these investments allocated to urban climate measures is unknown. However, taken together, the evidence suggests that, while needs are significantly larger than current spending, they are probably not orders of magnitude larger.

Many of the low-carbon and resilient investments analyzed are the most effective and inclusive urban investments regardless of climate goals. For example, developing efficient public and nonmotorized transport services supports economic activity, makes mobility more affordable, and reduces local traffic and air pollution, in addition to its benefits for climate change mitigation. Improving the energy efficiency of buildings reduces household energy costs and reduces the load on energy infrastructure. Improving solid waste management, greening public spaces, and other investments discussed here contribute to local quality of life irrespective of climate change. In addition, these resilient and low-carbon investments typically create more jobs per dollar than investment in other types of infrastructure, including many that can be done by urban residents with limited training, such as tree planting, waste collection, and recycling.

Funding, financing, and efficiency to meet investment costs

Just as "climate investments" are not a separate category of investments, "climate finance" is not a separate category of finance. This report considers any financial resources that can be tapped to support resilient and low-carbon urban investments to be a form of "city climate finance," regardless of whether these resources are designed to address climate-related investment needs.

Although climate-specific sources of funding (for example, carbon credits) or financing (for example, green bonds) can support the investments identified in this report, non-climate-specific resources and the wider strengthening of public financing are—and are likely to remain—most important. For this reason, solutions for mobilizing resources for climate-resilient and low-carbon public investments in cities are inseparable from solutions for strengthening broader urban public finance, in areas such as municipal own-source revenue, public borrowing, intergovernmental transfers, public-private partnerships (PPPs), expenditure efficiency, asset management, and so on. The report outlines a

framework for addressing the financing gap, based on reducing costs through efficiency savings, monetizing the benefits created by each project as funding for investments, and exploiting appropriate sources of financing.

Reducing investment costs through urban efficiency

The magnitude of urban climate finance needed to meet these costs can be reduced through efficient and well-coordinated urbanization. Cities can enhance investment efficiency in various ways. Spatial coordination and efficient growth reduce the costs of maintenance, operation, and investment in new infrastructure. Targeting and prioritizing investments ensure that they are as impactful as possible despite fiscal constraints. Mainstreaming mitigation and adaptation allows all investments and recurring expenditures to contribute to resilience and emission reduction, reducing the need for separate investments. Aligning third-party incentives with urban resilience and mitigation goals also reduces the need for public investments.

Analysis in this report highlights the potential for efficient investment to reduce the magnitude of investment costs. For example, low-cost transport policies promoting compact urban growth can reduce GHG emissions and investment costs at the same time, whereas in the case of flood protection, complementing dikes and levees with nature-based solutions, zoning, and building-level dry floodproofing can reduce costs.

Sources of funding

Identifying revenues, savings, and indirect benefits from resilient and low-carbon urbanization is a useful starting point for identifying funding sources for these investments. This report presents a framework that cities can use to identify sector- and investment-specific resources for resilient and low-carbon urban investments. It analyzes the benefits generated by different investments, how these benefits can be monetized as revenues (for example, through user fares and fees, carbon credits, land value capture, and other means) and savings (for example, reduced energy costs, reduced expenditure on roads, and so on), and how these funds can be used to attract and repay investment financing, including climate-specific products such as green bonds. Most investments require some public funding amid scarce resources, making the

sound financial and economic appraisal of individual projects, analysis of options, cost-effectiveness of designs, risk assessments, and other means of reducing costs critical to ensure public efficiency and financial sustainability.

Potential funding resources for resilient and low-carbon investments vary by investment type. The following are a few examples:

- Investments in building energy efficiency and rooftop solar energy (estimated costs: US$2.4–6.6 trillion cumulatively up to 2050, or 0.25–0.69 percent of GDP) can pay for themselves over time through energy savings, but they require arrangements to turn those future savings into upfront finance, for example, energy service companies, energy efficiency certification to overcome information asymmetries, appropriate energy tariffs that do not distort incentives, and others, along with public subsidies for energy efficiency improvements where needed.
- Flood protection measures not only demand an extraordinary magnitude of investment (estimated costs: US$1.6–9.5 trillion up to 2050, or 0.2–1.0 percent of GDP for coastal and riverine flood protection, and US$930 billion to US$6 trillion up to 2050, or 0.1–0.6 percent of GDP for stormwater drainage) but also typically require public funding, because their positive externalities (benefits accruing to the public at large) make them difficult to monetize. However, as flood protection enables property development, private property developers or owners may be incentivized to pay for some flood resilience investments, either directly or through indirect land value capture mechanisms such as taxes and fees.
- Heat resilience interventions such as urban greening, emergency warning and response, and others have relatively low costs (estimated costs: US$38–60 billion up to 2050, or 0.004–0.006 percent of GDP) but require ongoing budget support rather than one-time project-based investment. Opportunities for private sector investment are limited to private property owners' contributions, such as through greening, cool roofs, ventilation, and so on.
- In the case of municipal solid waste management (estimated costs: US$681 billion cumulatively up to 2050), annual operating costs (0.27 percent of GDP) exceed capital investment costs (0.07 percent of GDP). These costs can be partially covered by waste collection fees and revenues from the sale of materials and energy. However, even if private operators are involved

and partially paid through such revenues, solid waste management requires ongoing public funding. This is usually via municipalities but is often supported by national government transfers, because of the limited fiscal resources of municipal governments.

- The large size and positive externalities of resilient and low-carbon transportation investments in cities (estimated costs: US$2.2–2.4 trillion cumulatively up to 2050, or 0.23–0.25 percent of GDP) mean that they usually require public funding from general sources. Revenues from fares and other sources rarely cover even operating costs, which means that project financing cannot usually be repaid through project revenues alone and requires public subsidy. Spatially efficient urbanization that is well coordinated with transportation infrastructure can reduce infrastructure needs, improve the financial viability of services, and create opportunities for land value capture. Carbon crediting is suited to certain types of transport investments (for example, electrification of public vehicles) but can be challenging for others (for example, construction of metros).
- The public sector remains the main source of financing for resilient and low-carbon water supply and wastewater management in most L&MICs. Climate-related costs (estimated costs: US$16–52 billion by 2050, or 0.002–0.005 percent of GDP) cannot be easily separated from baseline investments in the sector and so are unlikely to use distinct sources of climate finance. Reforming tariffs is important to support cost recovery to the extent possible, although public subsidies often remain necessary to ensure affordability.

Sources of financing

Cities require stronger readiness for commercial financing, where applicable. Substantial private financing has been committed to climate action. However, to access this, cities need to meet certain foundational criteria—such as creditworthiness, absorptive capacity, and a sound regulatory environment for borrowing and PPPs—as well as project bankability. Most lower-income and smaller cities, but also many upper-middle-income and larger cities, are at early stages of building these foundations, whereas many L&MIC urban climate projects face inherent bankability challenges, such as low

end-user repayment capacity and the prevalence of externalities. Although financial fundamentals, and project revenues, efficiency, and savings can be strengthened, many investments will continue to rely on public subsidy. All parties should ensure these necessary subsidies are well targeted and do not distort incentives for efficiency and cost recovery or crowd out commercial financing.

Institutions including national governments and development banks, multilateral development banks (MDBs), climate funds, and private investors offer (or provide a market for) certain financial products tailored to climate investments. For example, some (mostly national, but sometimes local) governments in middle-income countries have successfully issued green bonds for urban investments, although the long-term net costs of green bonds are not necessarily favorable compared with standard bonds. MDBs and climate funds are also increasing the amount of support available for resilient and low-carbon urban investments, often through general obligation debt that does not rely on individual investments generating sufficient revenue for repayment.

Recommendations for cities and national governments

Cities must create the right conditions for resilient and low-carbon investment. As discussed earlier, this report describes how cities can identify opportunities for funding, financing, and efficiency for climate-related investments. Cities should take further actions to facilitate resilient and low-carbon investment. This includes developing long-term climate-sensitive investment plans to attract climate funders and financiers, building technical expertise in climate-sensitive project preparation and implementation, enhancing creditworthiness through sound and transparent public financial management systems, developing efficient and transparent land markets to facilitate the use of land value capture instruments, and others.

National governments must provide leadership to fund, finance, and unlock wider resources for resilient and low-carbon urban investment. They must ensure that fiscal transfer systems provide adequate, timely, and predictable disbursements to cities. Performance-based grants with climate criteria can

enable and incentivize cities to achieve climate-related targets. National governments can also provide technical assistance to local governments on project identification, preparation, risk mitigation, financing, and implementation to enhance the bankability of projects. This includes providing frameworks for accreditation and certification (for example, green bond frameworks; measurement, reporting, and verification for emission reductions; green building codes); platforms to pool projects and disseminate funding and financing; and regulations to support project-level financing, general obligation government borrowing, and private sector borrowing for green investments.

In addition, national development banks are increasingly engaging in climate mitigation and adaptation initiatives. International financing sources present certain challenges for L&MIC borrowers at the subnational level, such as currency disparities and the need for sovereign guarantees. A national development bank, owned by a country's government, may be better placed to channel financing for green urban investments by subnational bodies like municipalities. Similarly, national climate funds can facilitate the financing of a country's climate-oriented development strategy, including in cities.

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Abbreviations

BAU	business-as-usual
CAPEX	capital expenditure
CCFLA	Cities Climate Finance Leadership Alliance
COP29	29th United Nations Climate Change Conference
EAP	East Asia and Pacific
ECA	Europe and Central Asia
EE	energy efficiency
EGP	Egyptian pound
EPR	Extended Producer Responsibility
ESA	energy service agreement
ESCO	energy service company
EV	electric vehicle
FY	fiscal year
GDP	gross domestic product
GHG	greenhouse gas
HIC	high-income country
IEA	International Energy Agency
IFC	International Finance Corporation
L&MIC	low- and middle-income country
LAC	Latin America and the Caribbean
LIC	low-income country
LMIC	lower-middle-income country

MDB	multilateral development bank
MIC	middle-income country
MENA	Middle East and North Africa
NBS	nature-based solutions
OECD	Organisation for Economic Co-operation and Development
OPEX	operating expenditures
PPP	public-private partnership
PV	photovoltaic
RCP	Representative Concentration Pathway
SAR	South Asia Region
SLB	sustainability-linked bond
SSA	Sub-Saharan Africa
SSP	Shared Socioeconomic Pathway
SWM	solid waste management
TERI	The Energy and Resources Institute
UMIC	upper-middle-income country
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
ZAR	South African rand

CHAPTER 1

Introduction

Summary

- Cities in low- and middle-income countries (L&MICs) have an urgent need for resilient and appropriate low-carbon investments and must look beyond climate-specific sources of finance to meet this need.
- Urban climate action is essential for cities to protect their populations, build strong and resilient economic foundations, and meet targets for greenhouse gas mitigation. Globally, cities account for 56 percent of the world's population and 70 percent of greenhouse gas emissions.
- The economic viability of cities in L&MICs is particularly in jeopardy, because of rapidly increasing climate change hazards and nonresilient urban growth pathways.
- Cities in L&MICs have a unique opportunity to develop in more resilient, energy-efficient, and low-carbon ways, avoiding the mistakes of other cities. However, doing so will require the overcoming of financial and institutional capacity constraints.
- This report provides the most comprehensive and up-to-date assessment of key urban investment costs for resilience and low-carbon growth in L&MICs' major urban sectors (transport, buildings, solid waste, water and wastewater, flood protection, and heat protection) until 2050.
- This report also identifies opportunities to close the financing gap—breaking a single large gap into multiple component parts with differentiated strategies.

- Climate finance is not a separate category of finance. Although climate-specific sources of funding (for example, carbon credits) or financing (for example, climate funds) can contribute to financing some of the investments identified in this report, most of the financing is likely to come from non-climate-specific sources, including national and local government budgets and lending from multilateral development banks, development finance institutions, national development and infrastructure banks, and wider commercial banks.
- City climate finance is not limited to municipal finance. A large share of investments will need to be financed outside the balance sheet of local governments.

Cities in low- and middle-income countries (L&MICs) need to invest in resilient and low-carbon growth. Cities experience stronger climate impacts than rural areas, and within cities, the most economically and socially marginalized populations are the most affected (IPCC 2022). Cities in L&MICs are the most exposed and least resilient to climate change–related hazards (Mukim and Roberts 2022). These cities must act now to prevent a dramatic rise in emissions as their populations and incomes grow to avoid lock-in to energy and greenhouse gas–intensive urban assets, services, and spatial forms; to contribute to national emission-reduction commitments; and to reduce local pollution and inefficiencies from a high-carbon growth trajectory. Approximately 70 percent of global consumption-based greenhouse gas emissions today are estimated to be caused by urban areas (IPCC 2022)—a figure that may rise in the absence of climate action as the global urban population rises from about half today to two-thirds by 2050. However, cities can also be part of the solution for curbing emissions. The Coalition for Urban Transitions (2019) estimated that global urban emissions can be cut by 90 percent by 2050 if cities move from a business-as-usual trajectory, while creating jobs and economic returns of US$23.9 trillion. A 2016 report estimated that actions in cities can deliver 40 percent of the reductions that are necessary to limit global warming to 1.5°C (C40 Cities Climate Leadership Group and Arup 2016). Although L&MICs have historically contributed very small amounts to global warming, they must nevertheless set themselves on low-carbon growth trajectories before unsustainable and costly urban forms and technologies are locked in.

However, L&MICs have struggled to mobilize adequate resources for resilient and low-carbon urban development. This is due to tight global and national

financing environments, challenges in revenue mobilization, unreliable and insufficient intergovernmental fiscal transfers, broader institutional weaknesses, and constraints to private financial mobilization. This report addresses these challenges by analyzing the climate-related investment costs in urban areas in L&MICs and identifying actionable solutions tailored to specific sectoral challenges.

This report analyzes the cost of key investments for low-carbon and climate-resilient urban development in all L&MICs from 2020 to 2050 across several sectors. For the purposes of this report, "city climate finance" refers to any form of funding or financing that can be used for resilient and low-carbon urban investments, that is, investments that reduce emissions or manage climate risks. Most urban investments are made primarily to support local livability or economic development, but they can nonetheless be made more climate resilient and low carbon. For this reason, it is not always possible to distinguish climate investments from broader development investments. This report estimates the overall cost of resilient and low-carbon urban investments in selected critical sectors.[1] This report covers the following sectors and investments:

- **Transportation:** Low-carbon urban transportation (public and nonmotorized transportation, public investments in electric vehicle charging infrastructure), and investments in resilience for urban roads.
- **Building energy:** Energy efficiency improvements and rooftop solar energy in new and existing buildings, including all costs related to public buildings and subsidies for private buildings.
- **Solid waste management:** Waste collection, sorting, landfilling, landfill gas capture, composting, anaerobic digestion, recycling, advanced treatment, and energy recovery.
- **Water and wastewater:** Investments related to flood and drought resilience of the water and wastewater sector, and reducing GHG emissions from wastewater.
- **Flood protection:** Dikes and levees, dry floodproofing of buildings (preventing water from entering buildings), nature-based solutions for coastal and riverine flooding, and drainage for pluvial flooding.
- **Heat resilience:** Urban greening and heat wave early warning and response.

This report only focuses on public investments and assets. It includes public investments in public assets, private investments in public assets (for example, through commercial debt or public-private partnerships of various kinds), and public investments in private assets (for example, public subsidies for energy efficiency improvements in private buildings). It excludes investments made by private households and firms in private assets, such as the cost of private electric vehicles to households or the cost to private firms to make their assets climate resilient.

This report discusses urban investments,[2] whether they are made by municipal or other levels of government, reflecting that decentralization takes different forms across L&MICs. For example, in Addis Ababa, Ethiopia, most expenditures are made by the local governments using own-source revenues, whereas in Alexandria, Egypt, most expenditures are made by national agencies or by the local governments using transfers from the national government. For this reason, this discussion includes, but is not restricted to, municipal finance, which focuses on local government resources. Municipal finance for climate-related investments is explored in detail in a report by the World Bank and UNCDF (2024).

Notes

1. The approach used to estimate investment costs in this report is unrelated to the estimation of climate change cobenefits of the World Bank's projects. Because of differences in methodologies and objectives, none of the analysis presented here should be used in the context of calculating climate change cobenefits of development finance.
2. Because of differences in models and data sources used for different sectors, what counts as urban varies by sector: The transport model uses the Organisation for Economic Co-operation and Development's definition of functional urban areas; the building and stormwater management sectors include all areas in L&MICs given that most investments in these sectors occur in urban areas; water and wastewater rely on the National Aeronautics and Space Administration's urban areas as defined by the global Urban-Rural Mapping Project; flood protection (coastal and riverine) uses gridded urban areas from the 2UP model; and heat resilience uses the Global Human Settlement Layer.

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CHAPTER 2

Investment costs for resilient, low-carbon cities

Summary

- Resilient and low-carbon urban investments in all low- and middle-income countries (L&MICs), across several sectors, will cost between 0.8 and 2.6 percent of their GDP up to 2050.
- Based on analysis done for this report, the cumulative capital costs up to 2050 of key resilient and low-carbon urban investments in L&MICs amount to an estimated US$7.9–25.5 trillion, which is equivalent to US$256–821 billion per year.
- The cost of operating and maintaining these investments adds an estimated US$525–548 billion each year to these costs, an additional 1.7–1.8 percent of GDP.
- The range of estimates reflects different climate scenarios, different investment decisions, and in some cases the efficiency of the investments.

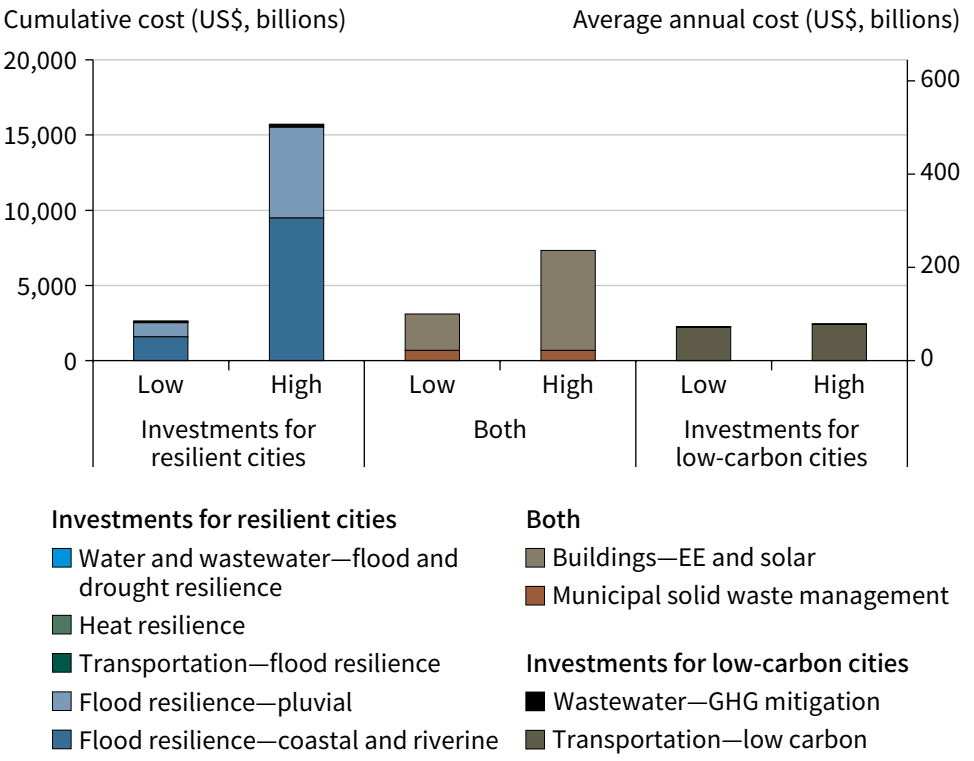
Total costs across all sectors

Key low-carbon and resilient urban investments will cost low- and middle-income countries (L&MICs) an estimated 0.8–2.6 percent of their combined GDP. These estimates of capital investment costs are based on analyses conducted for this report across several urban sectors: transportation, buildings, solid waste management, water and wastewater, flood adaptation,

and heat adaptation. Low- and high-cost estimates were developed for most sectors to establish a range based on investment and policy choices, climate and urbanization projections, and varying unit costs. Although estimates generated in this report are subject to a high degree of uncertainty because of their global, cross-sectoral, and forward-looking nature, they nonetheless help to characterize the relative costs across sectors and countries, to better inform discussions of potential sources of climate finance.

In absolute terms, the investment costs are estimated to be US$7.9–25.5 trillion cumulatively up to the year 2050, or US$256–821 billion per year. Cumulative costs up to 2050 include an estimated US$2.6–15.7 trillion for investments supporting resilient cities, US$2.2–2.4 trillion for investments related to low-carbon cities, and US$3.1–7.3 trillion for investments supporting both (refer to figure 2.1). By income group (refer to figure 2.2

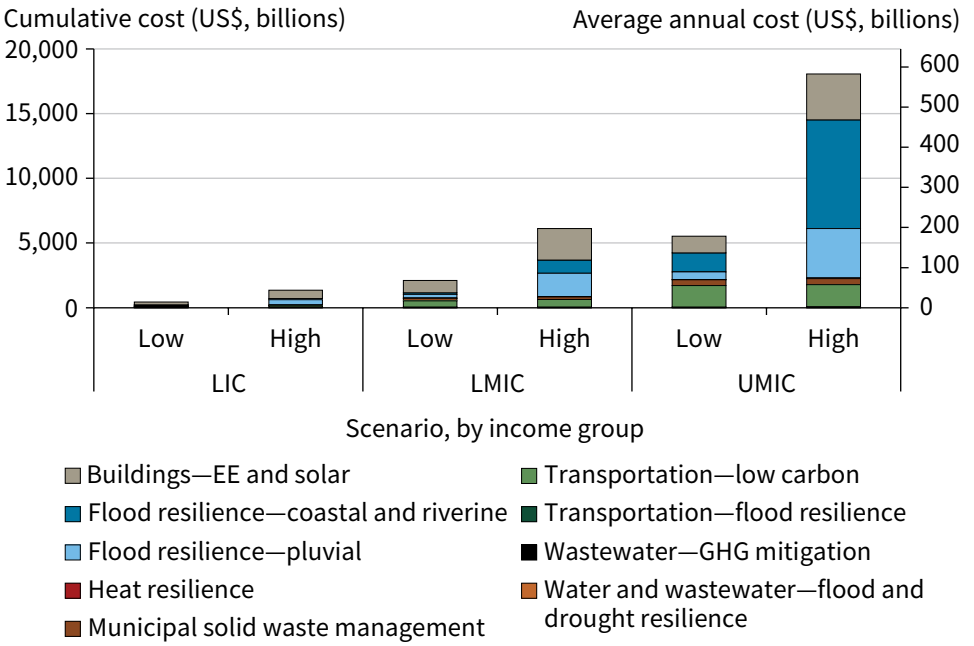
FIGURE 2.1 Estimated capital costs in all sectors for L&MICs, 2020–50, cumulative and annual



Source: Original figure for this book.
Note: EE = energy efficiency; GHG = greenhouse gas; L&MICs = low- and middle-income countries.

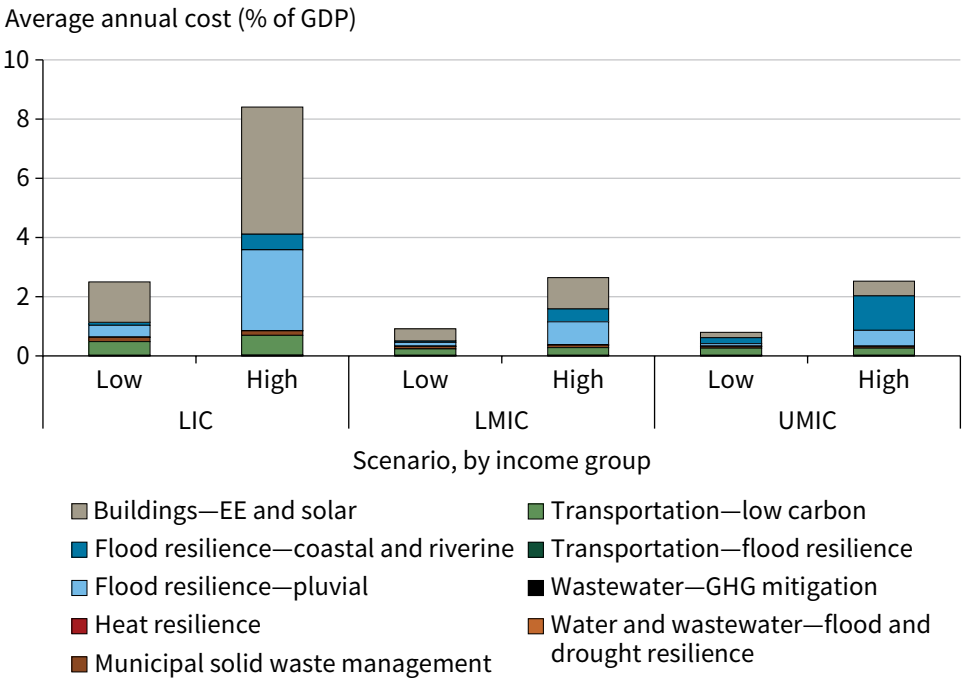
and figure 2.3), upper-middle-income countries have the highest costs in absolute terms (an estimated US$5.5–18.0 trillion up to 2050), whereas low-income countries have the highest in terms of share of GDP (2.5–8.4 percent of GDP). By region (refer to figure 2.4 and figure 2.5), these costs are greatest in the East Asia and Pacific region in absolute terms (an estimated US$4.0–11.8 trillion by 2050, or roughly half the total L&MIC costs). However, as a share of GDP, the costs are greatest in Sub-Saharan Africa (1.8–6.4 percent of GDP). The ranges quoted reflect low- and high-cost estimates for each sector, based on alternative investment and policy choices, climate and urbanization projections, and unit costs (refer to figure 2.6). The cost of operations and maintenance of these investments is US$525–548 billion per year (1.7–1.8 percent of GDP) across all L&MICs, largely in the transportation sector. Operations and maintenance costs represent a particularly large share of GDP in L&MICs, about 9 percent in both scenarios.

FIGURE 2.2 Estimated capital costs in all sectors for L&MICs, by income group, 2020–50, cumulative and annual



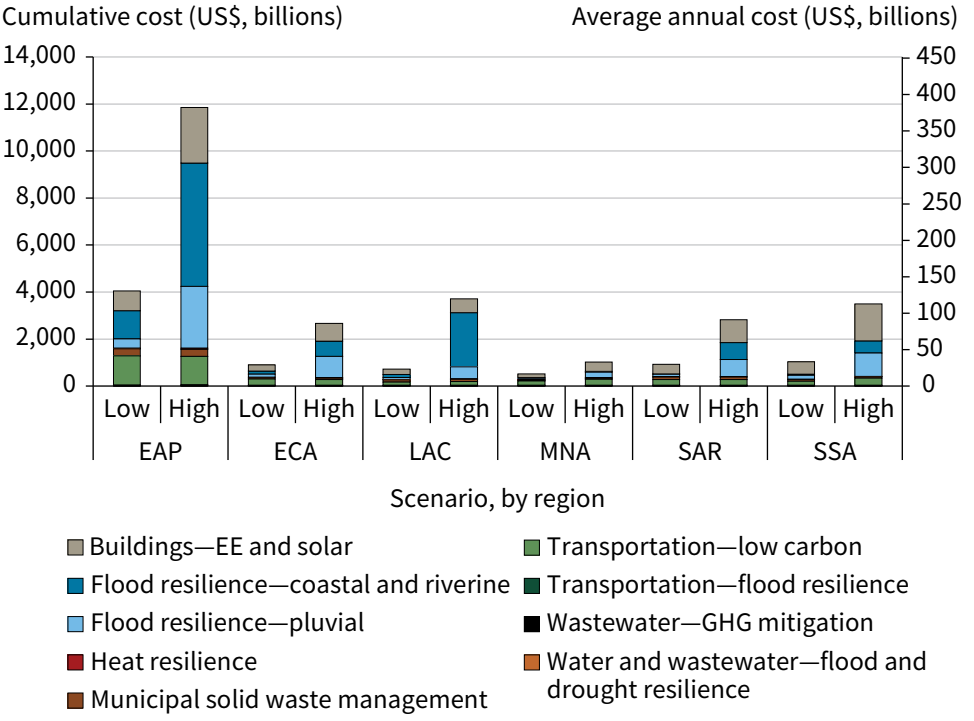
Source: Original figure for this book.
Note: EE = energy efficiency; GHG = greenhouse gas; LIC = low-income countries; LMIC = lower-middle-income countries; L&MICs = low- and middle-income countries; UMIC = upper-middle-income countries.

FIGURE 2.3 Estimated capital costs in all sectors for L&MICs, by income group, 2020–50, share of GDP



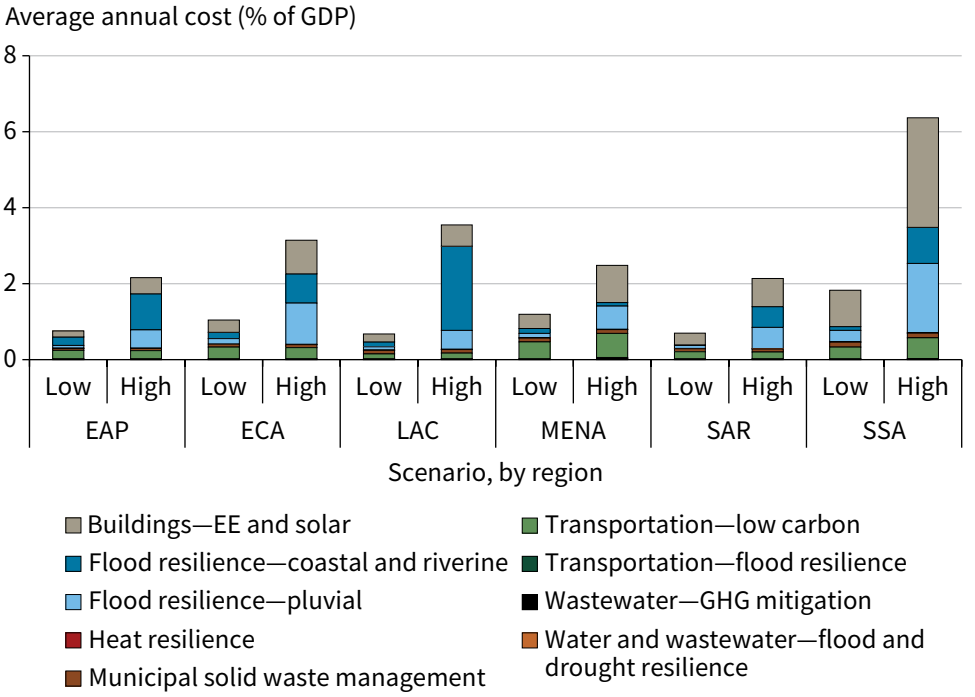
Source: Original figure for this book.
Note: EE = energy efficiency; GHG = greenhouse gas; LIC = low-income countries; LMIC = lower-middle-income countries; L&MICs = low- and middle-income countries; UMIC = upper-middle-income countries.

FIGURE 2.4 Estimated capital costs in all sectors for L&MICs, by region, 2020–50, cumulative and annual



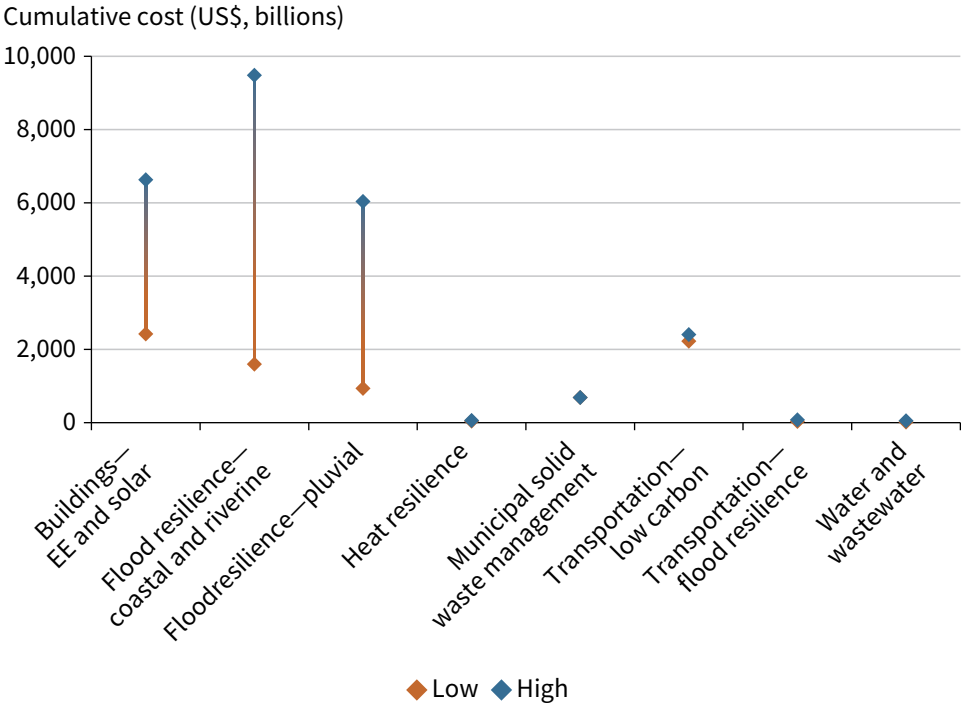
Source: Original figure for this book.
Note: EAP = East Asia and Pacific; ECA = Europe and Central Asia; EE = energy efficiency; GHG = greenhouse gas; LAC = Latin America and the Caribbean; L&MICs = low- and middle-income countries; MENA = Middle East and North Africa; SAR = South Asia; SSA = Sub-Saharan Africa.

FIGURE 2.5 Estimated capital costs in all sectors for L&MICs, by region, 2020–50, share of GDP



Source: Original figure for this book.
Note: EAP = East Asia and Pacific; ECA = Europe and Central Asia; EE = energy efficiency; GHG = greenhouse gas; LAC = Latin America and the Caribbean; L&MICs = low- and middle-income countries; MENA = Middle East and North Africa; SAR = South Asia; SSA = Sub-Saharan Africa.

FIGURE 2.6 Range of estimated capital costs for L&MICs, by sector, 2020–50, cumulative



Source: Original figure for this book.
Note: EE = energy efficiency; L&MICs = low- and middle-income countries.

Table 2.1 summarizes the scenario assumptions for each sector. A background paper accompanying this report describes the methodologies and results of the investment cost estimation for each sector in more detail (Murray et al. 2025). Additional sectoral background papers prepared for this report go into greater detail and are available on request (refer to box 2.1).

TABLE 2.1 Summary of scenarios used in cost estimations

Low scenario	High scenario	Source of variation
Buildings: Energy efficiency and rooftop solar energy		
EDGE Level 2 + 20 percent solar: 50 percent of existing buildings are retrofitted to use 35 percent less energy by 2050, and all new construction is made energy-efficient to use 40 percent less energy by 2055 (EDGE Level 2); rooftop solar in new and existing buildings reduces energy consumption by 20 percent where technically feasible. Includes costs for all public buildings and 5 percent of private buildings.	***EDGE Level 3, no grid-supplied energy use:*** All existing buildings are retrofitted to use 35 percent less energy by 2050, and all new construction is made energy efficient to use 40 percent less energy by 2035; rooftop solar in new and existing buildings supplies all of the remaining 60 percent of energy where technically feasible; this scenario aims for net-zero energy consumption wherever rooftop solar is technically feasible (EDGE Level 3). Includes costs for all public buildings and 5 percent of private buildings.	Investment choices
Flood resilience: Coastal and riverine		
Cost-effective hybrid measures (RCP 4.5): For each subnational region, selects the lower cost option between two approaches: only structural disaster risk reduction measures (dikes and levees) or a combination of nonstructural measures when possible (dry floodproofing of buildings, zoning restrictions, foreshore vegetation) and structural measures to achieve constant relative risk in an RCP 4.5 SSP2 climate scenario. (Dry floodproofing costs are only included for public buildings.)	***Structural measures only (RCP 8.5):*** For each subnational region, estimates the cost of structural disaster risk reduction measures (dikes and levees) to achieve constant relative risk in an RCP 8.5 SSP3 climate scenario.	Investment choices; climate projections

(Table continues on next page)

TABLE 2.1 Summary of scenarios used in cost estimations (*continued*)

Low scenario	High scenario	Source of variation
Flood resilience: Pluvial		
Low costs per square kilometer, lower urbanized area by 2050: Uses the lowest cost per square kilometer of land protected (excluding outliers) to calculate investment costs for the total urbanized area in all L&MICs in 2050 based on SSP2 projections.	***High costs per square kilometer, higher urbanized area by 2050:*** Uses the highest cost per square kilometer of land protected to calculate investment costs for the total urbanized area in all L&MICs in 2050 based on SSP3 projections.	Unit costs; urbanization projections
Heat resilience		
Urban greening and heat wave early warning and response (baseline heat): Implementation of heat action plans (including heat and vulnerability assessments, early warning systems, communications, and heat wave preparedness and response measures) and urban greening in ~5,300 urban areas in L&MICs that currently experience at least one day of high heat stress in the baseline period (2012–16).	***Urban greening and heat wave early warning and response (RCP 8.5):*** Implementation of heat action plans and urban greening in ~8,000 urban areas in L&MICs that are projected to experience at least one day of high heat stress in 2050 under RCP 8.5.	Climate projections
Municipal solid waste management		
No open dumping by 2030; 25 percent composting and 15–25 percent recycling per income group by 2050: Elimination of open dumping in L&MICs by 2030, with landfilling partially replaced over time with recycling, composting, and incineration. By 2050, a quarter of waste is composted.		Not applicable

(Table continues on next page)

TABLE 2.1 Summary of scenarios used in cost estimations (*continued*)

Low scenario	High scenario	Source of variation
Transportation: Low carbon		
Current ambition: Corresponds to International Transport Forum's "current ambition" scenario, which represents current trends and expected policy developments, with costs related to public transportation vehicles and their operation added for this report. Includes 10 percent of electric vehicle charging costs (the rest being assumed to be private commercial investments).	***High ambition:*** Corresponds to International Transport Forum's "high ambition" scenario, which represents the trajectory under the most ambitious yet feasible transport policies, with costs related to public transportation vehicles and their operation added for this report. Also includes complementary policies for effective demand management (pricing instrument, speed and parking restrictions, and others) and compact land use; and technological improvements allowing higher vehicle efficiencies and penetration of cleaner energy sources. Includes 10 percent of electric vehicle charging costs.	Investment and policy choices
Transportation: Flood resilience		
Current ambition investments flood-adapted if exposed to 40+ cm of flooding (RCP 4.5): Incremental costs of making new urban transport infrastructure in L&MICs (based on the low-carbon transportation low scenario described above) flood-adapted if exposed to more than 40 cm of flooding under an RCP 4.5 climate scenario with a return period of 100 years.	***High ambition investments flood-adapted if exposed to 15+ cm of flooding (RCP 8.5):*** Incremental costs of making transport infrastructure in L&MIC cities (based on the low-carbon transportation high scenario described above) flood-adapted if exposed to more than 15 cm of flooding under RCP 8.5 with a return period of 100 years.	Investment choices; climate projections

(Table continues on next page)

TABLE 2.1 Summary of scenarios used in cost estimations (*continued*)

Low scenario	High scenario	Source of variation
Water and wastewater		
Lower ambition and risk: Incremental cost of resilience of basic water supply (achieved by 2050) and of wastewater treatment infrastructure to high or greater flood depth (SSP2-RCP 4.5); of increasing water supply for resilience to drought (SSP1-RCP 2.6); and of reducing GHG emissions by retrofitting existing treatment infrastructure and treating untreated wastewater.	***Higher ambition and risk:*** Incremental cost of resilience of safely managed water supply (achieved by 2030) and of wastewater treatment infrastructure to medium or greater flood depth (SSP3-RCP 8.5); of increasing water supply for resilience to drought (SSP5-RCP 8.5); and of reducing GHG emissions by retrofitting existing treatment infrastructure and treating untreated wastewater.	Investment choices; climate projections

Source: Original table for this book.
Note: EDGE is an internationally recognized green building standard, certification system, and software application created by the World Bank's International Finance Corporation; RCP = Representative Concentration Pathway, which refers to a climate change scenario defined in greenhouse gas (GHG) concentration; L&MICs = low- and middle-income countries; SSP = Shared Socioeconomic Pathway, which refers to a climate change scenario defined by its demographic and socioeconomic trajectory.

BOX 2.1 Background papers describing the investment cost analysis

A background paper accompanying this report describes the methodologies and results of the investment cost estimation for each sector in more detail.

- Murray, Sally, Juan Sebastián Leiva Molano, Chandan Deuskar, Ibrahim Ali Khan, and Augustin Maria. 2025. "Estimating the Costs of Resilient and Low-Carbon Urbanization."

(Box continues on next page)

BOX 2.1 Background papers describing the investment cost analysis *(continued)*

Further sectoral background papers prepared for this report go into greater detail and are available on request:

- Hutton, Guy. 2024. "Climate Finance Needs for Urban Water Supply and Wastewater."
- Mortensen, Eric, Timothy Tiggeloven, and Philip J. Ward. 2024. "Analysis of Investment Costs for Coastal and Riverine Flood Protection in Low- and Middle-Income Country Cities."[a]
- Smith, Ian. 2024. "The Potential for Urban Trees to Reduce Heat Stress in a Changing Climate."
- Trouvé, Mallory, and Luis Martinez. 2024. "The ITF Global Urban Passenger Model—Scope & Approach."

a. This background paper draws on the following scientific papers: Mortensen et al. (2023), Mortensen et al. (2024), and PBL (2023).

Resources currently available for public investments may not be sufficient to meet the above-mentioned estimated costs alongside wider development needs, particularly in lower income countries. As discussed earlier, the capital investments identified in this report will cost between 0.8 and 2.6 percent of the GDP of L&MICs, but this rises to 2.5–8.4 percent of GDP when looking only at low-income countries. According to data from the Organisation for Economic Co-operation and Development (OECD), total public investment (not limited to urban or climate-related investments) in 2020 averaged 5.7 percent of GDP across a sample of L&MICs, of which subnational capital investment averaged 1.3 percent of GDP. Average municipal revenues were 1.7 percent of GDP in low-income countries, 3.6 percent in lower-middle-income countries, and 5.2 percent in upper-middle-income countries, illustrating the substantial disparity in resources

(OECD and UCLG 2022). (In OECD countries, the average municipal revenue is equivalent to 7.8 percent of GDP [OECD 2020].) A substantial portion of municipal revenues are allocated to current expenditures such as salaries (OECD and UCLG 2016). OECD does not report the share of these revenues and capital investments allocated to urban climate investments.

The Cities Climate Finance Leadership Alliance (CCFLA) estimates recent (2021–22) annual financial flows for resilient and low-carbon urban investments specifically (CCFLA 2024). These estimates are based partly on project-level data and partly on sector-level estimates derived from the stock of existing infrastructure. They are likely conservative, particularly given limited data on spending by L&MIC local and national governments. Comparisons between the costs identified in this report and the financial flows identified by CCFLA should be treated with caution, because of differences in scope and methodology between studies. With these caveats in mind, current levels of investment appear to fall far short of needs. Analysis of CCFLA data shows finance flows to L&MICs for investments in categories that overlap at least partially with those examined in this report (low-carbon and/or resilient buildings and infrastructure, transport, solid waste, water and wastewater, and others and cross-sectoral, excluding investments made by households and individuals) amounted to just US$92 billion in 2021–22, including operations and maintenance. This corresponds to only 11–36 percent of the total annual capital costs discussed earlier, and just 7–12 percent of the combined capital and operations and maintenance costs per year.

The investments in L&MICs reported by CCFLA are largely in upper-middle-income countries. Of the US$92 billion noted above, the vast majority, US$73 billion (79 percent), flowed to upper-middle-income countries. About US$18 billion (20 percent) went to lower-middle-income countries, whereas only US$1 billion (1 percent) went to low-income countries. The data also showed that US$80 billion (87 percent) was for activities classified under climate change mitigation. This included US$42 billion for mitigation activities related to transportation and US$36 billion for mitigation activities related

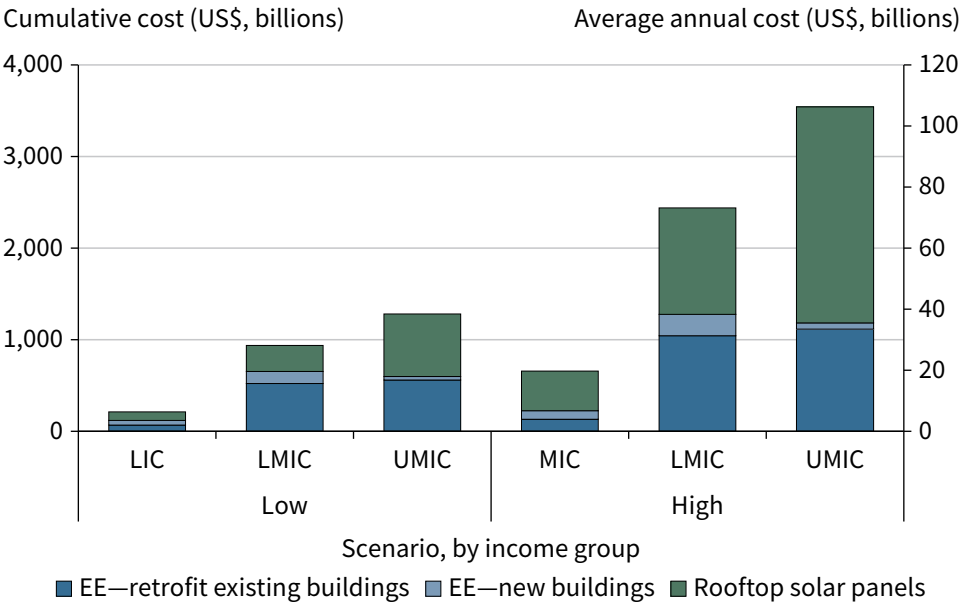
to buildings and infrastructure. Apart from the amount classified as being for L&MICs, a larger amount, US$298 billion, is classified as being for multiple countries, which may also include L&MICs, although it is not possible to disaggregate this using the available data. (Refer to table 1.1 in the background paper for this report [Murray et al. 2025] for more details.)

Buildings: Energy efficiency and rooftop solar energy

We identify US$2.4–6.6 trillion of investments in building energy efficiency and rooftop solar energy in L&MICs. In annualized terms, this is the equivalent of US$78 billion per year (0.25 percent of the combined GDP of L&MICs) in the low scenario (EDGE Level 2 + 20 percent solar; refer to table 2.1) or US$214 billion per year (0.69 percent of GDP) in the high scenario (EDGE Level 3). The estimated costs cover the implementation of energy efficiency measures and installation of rooftop solar panels in all public buildings, plus 5 percent of the cost in private buildings, which is the share assumed to be provided as public subsidies. The energy efficiency costs cover a combination of measures related to efficient cooling and heating; lighting, including maximizing natural light; energy-efficient appliances; and others, as determined by the International Finance Corporation's EDGE green building certification standards. Several of these measures improve heat resilience at the building scale (cool and green roofs and walls, insulation, natural ventilation, energy-efficient mechanical cooling, and others), although the cost of these heat resilience measures cannot be disaggregated from energy efficiency costs overall with the data available. According to CCFLA (2024) data, the annual flows of finance in L&MICs for buildings and infrastructure amounted to US$36 billion in 2021–22. This includes investments in addition to the ones included in this report, which cannot be disaggregated from this total, suggesting that investment costs will at least double. The estimated costs are highest in upper-middle-income countries in absolute terms (refer to figure 2.7), whereas as a share of GDP the costs are highest in LICs (refer to figure 2.8). In terms of regional breakdown, the costs are highest in absolute terms in the East Asia and Pacific region (refer to figure 2.9), whereas as a share of GDP they are highest in Sub-Saharan Africa (refer to figure 2.10).

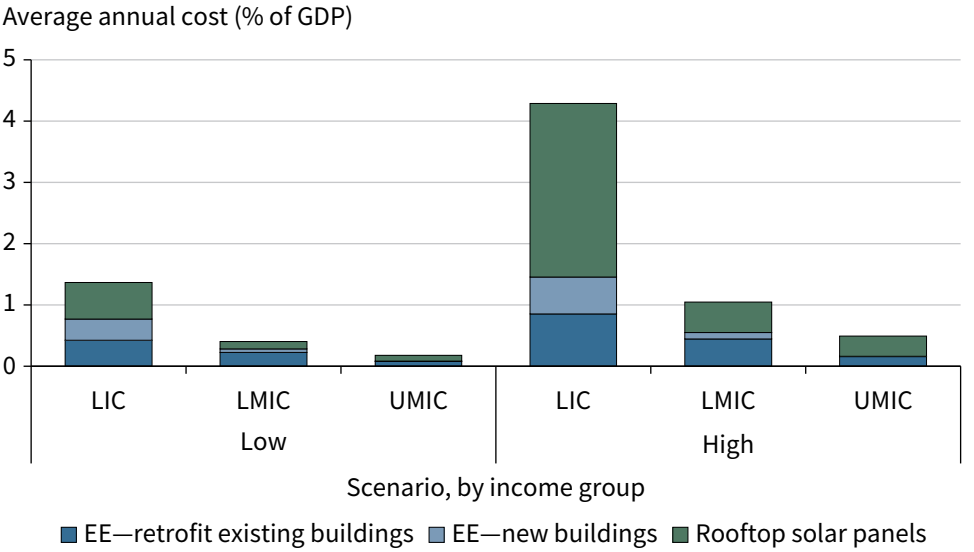
Rooftop solar energy and energy efficiency retrofits, particularly in residential buildings, present the greatest opportunities for emissions reductions. The low scenario is estimated to reduce annual greenhouse gas (GHG) emissions by 350 million metric tons of CO_2 equivalent GHG from retrofits, 54 million tons from new green buildings, and 720 million tons from rooftop solar energy, a total reduction of 1.125 billion tons per year. The high scenario is estimated to reduce annual GHG emissions by 701 million metric tons of CO_2 equivalent from retrofits, 96 million tons from new green buildings, and 2.729 billion tons from rooftop solar energy, a total reduction of 3.526 billion tons per year. Most of the estimated costs for energy efficiency improvements (76 percent for retrofits and 92 percent for new buildings) are associated with residential buildings, because these represent more than 90 percent of both existing and projected new floor area in L&MICs. However, residential buildings represent only about 70 percent of the estimated GHG emissions reductions in both existing and new buildings, because of their lower energy intensities compared with nonresidential buildings.

FIGURE 2.7 Estimated capital costs in buildings (EE and solar) for L&MICs, by income group, 2020–50, cumulative and annual



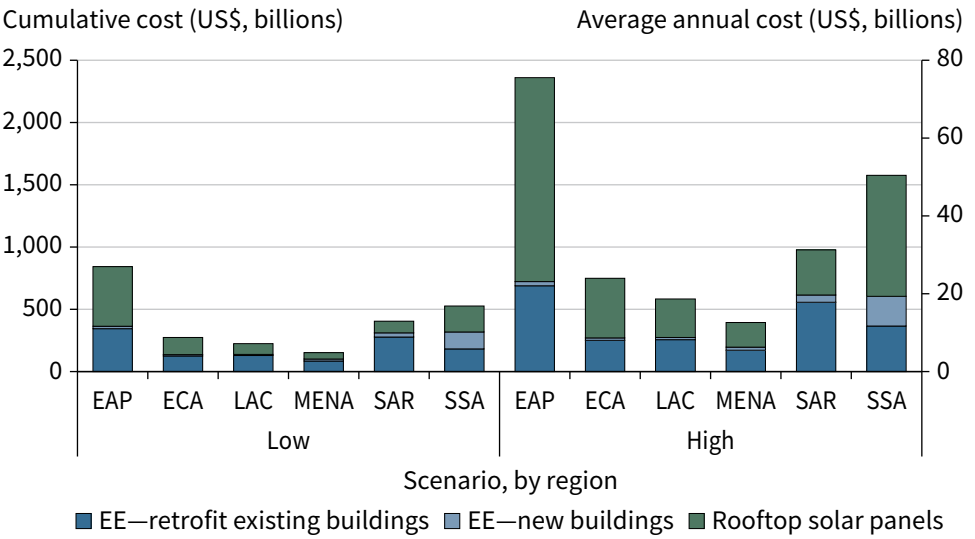
Source: Original figure for this book.
Note: EE = energy efficiency; LIC = low-income countries; LMIC = lower-middle-income countries; L&MICs = low- and middle-income countries; UMIC = upper-middle-income countries.

FIGURE 2.8 Estimated capital costs in buildings (EE and solar) for L&MICs, by income group, 2020–50, share of GDP



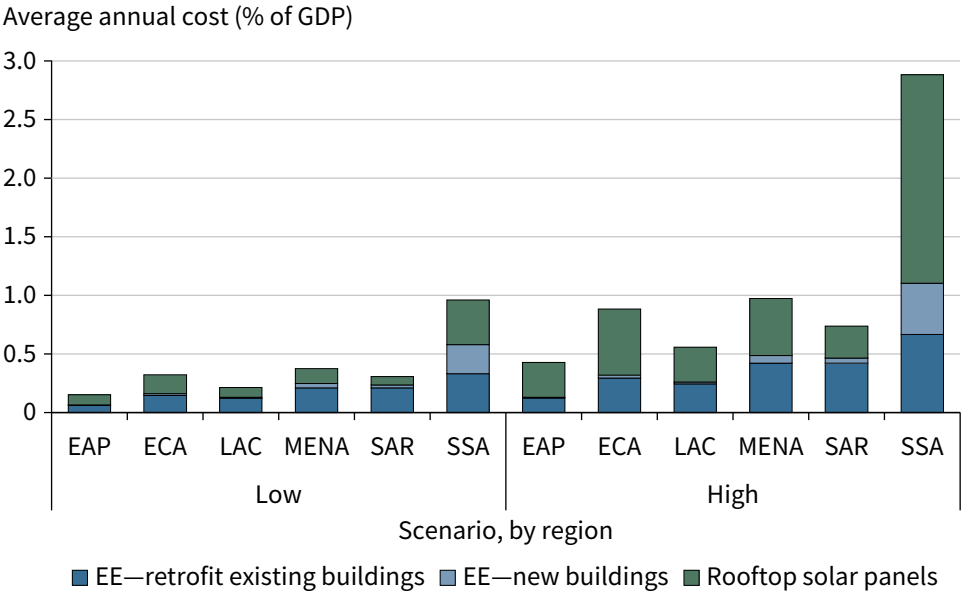
Source: Original figure for this book.
Note: EE = energy efficiency; LIC = low-income countries; LMIC = lower-middle-income countries; L&MICs = low- and middle-income countries; UMIC = upper-middle-income countries.

FIGURE 2.9 Estimated capital costs in buildings (EE and solar) for L&MICs, by region, 2020–50, cumulative and annual



Source: Original figure for this book.
Note: EAP = East Asia and Pacific; ECA = Europe and Central Asia; EE = energy efficiency; LAC = Latin America and the Caribbean; L&MICs = low- and middle-income countries; MENA = Middle East and North Africa; SAR = South Asia; SSA = Sub-Saharan Africa.

FIGURE 2.10 Estimated capital costs in buildings (EE and solar) for L&MICs, by region, 2020–50, share of GDP



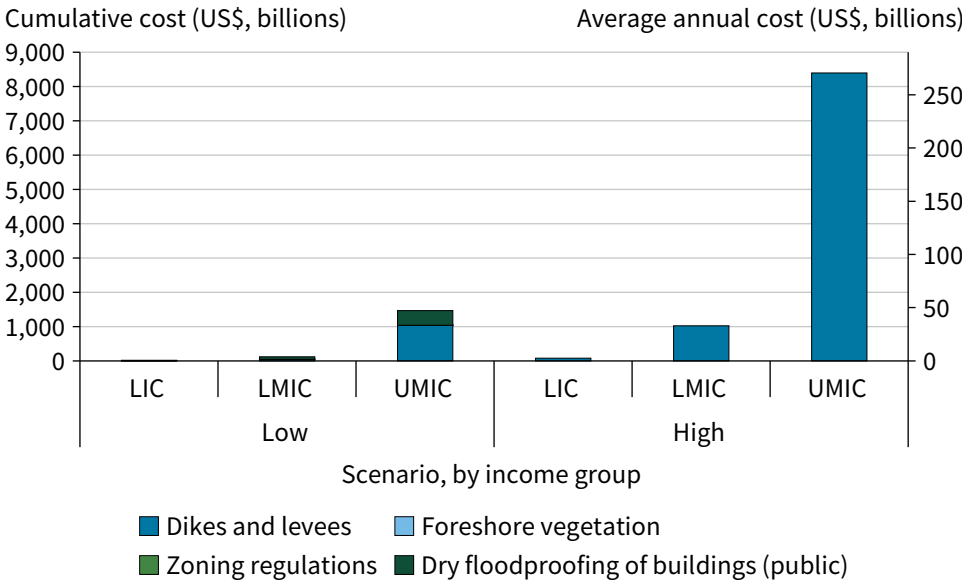
Source: Original figure for this book.
Note: EAP = East Asia and Pacific; ECA = Europe and Central Asia; EE = energy efficiency; LAC = Latin America and the Caribbean; L&MICs = low- and middle-income countries; MENA = Middle East and North Africa; SAR = South Asia; SSA = Sub-Saharan Africa.

The cost of energy efficiency retrofits for existing buildings is five to six times higher than that of energy efficiency measures in new buildings. This is partly because existing floor space in all L&MICs is over three times that of the new floor space projected to be built up to 2050, and partly because the cost of retrofitting buildings is higher than the cost of building in an energy-efficient manner to begin with. In the average L&MIC, using energy-efficient construction techniques in a new building adds 6.2 percent to baseline construction costs for residential buildings and just 3.9 percent for nonresidential buildings. Although the cost of rooftop solar panels is substantial, particularly in the high scenario where it exceeds the cost of energy efficiency investments, rooftop solar energy is a direct substitute for other forms of energy generation (which are not included in this report) and would reduce their cost accordingly.

Flood resilience: Coastal and riverine

Coastal and riverine flood protection measures in urban areas in L&MICs could have the highest investment costs across the sectors included in this report. Estimates developed for this report suggest that as climate change intensifies hazards and future urban growth intensifies exposure, additional coastal and riverine flood protection to prevent an increase in damages as a share of GDP will require between US$1.6 trillion in a low scenario and US$9.5 trillion in a high scenario in L&MICs up to 2050 (refer to table 2.1 for explanations of these scenarios).[1] This is the equivalent of US$52–306 billion per year, or 0.17–0.98 percent of the total projected GDP of L&MICs. Costs are highest in upper-middle-income countries both in absolute terms and as a share of GDP, as shown in figure 2.11 and figure 2.12. Although these figures include the costs of foreshore vegetation and zoning

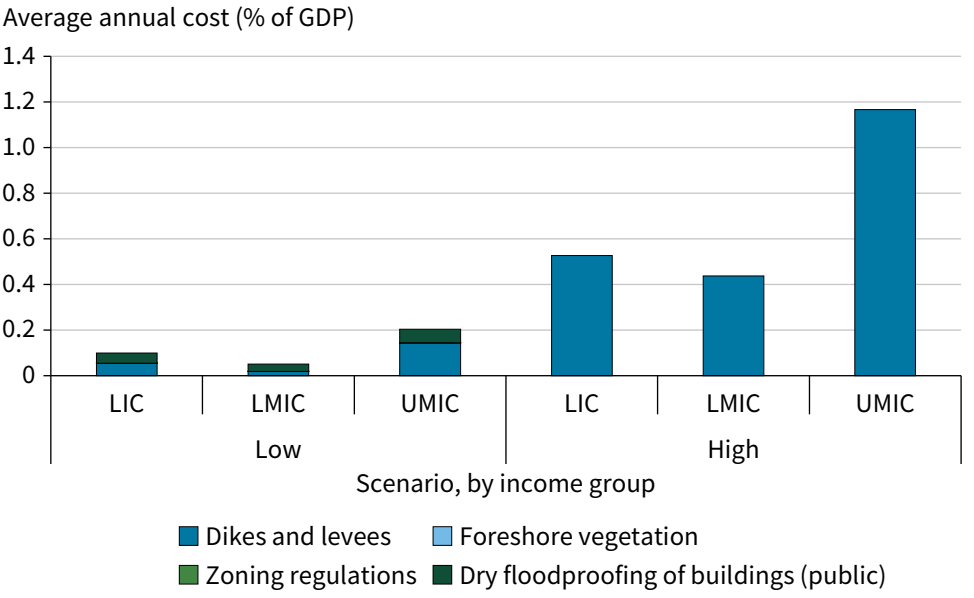
FIGURE 2.11 Estimated capital costs in flood resilience (coastal and riverine) for L&MICs, by income group, 2020–50, cumulative and annual



Source: Original figure for this book.
Note: LIC = low-income countries; LMIC = lower-middle-income countries; L&MICs = low- and middle-income countries; UMIC = upper-middle-income countries.

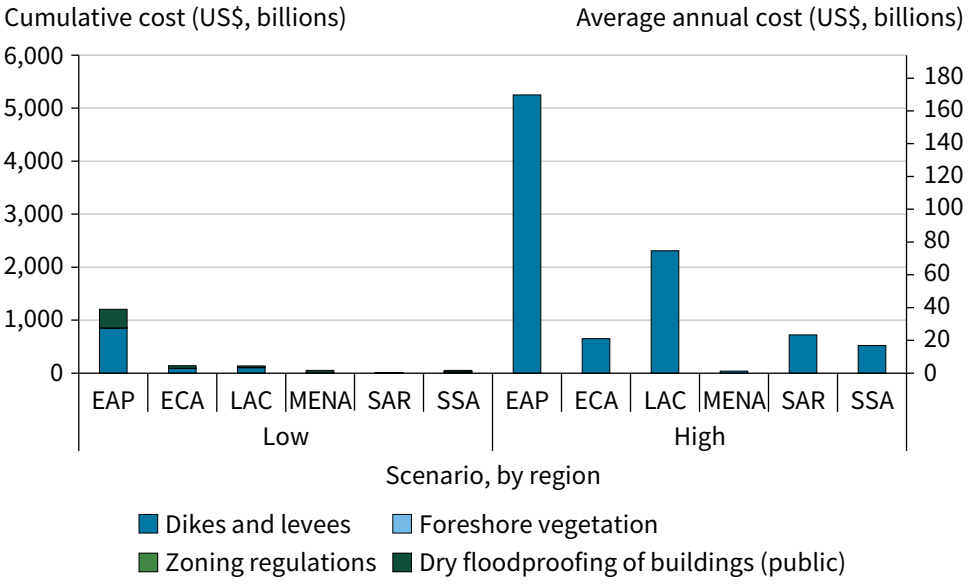
restrictions where applicable, these costs are so much smaller than the costs of other measures that they are not visible in the figures. Costs are highest in the East Asia and Pacific region in absolute terms (refer to figure 2.13), but they are highest in Latin America and the Caribbean region in terms of share of GDP (refer to figure 2.14). According to CCFLA (2024) data, total tracked finance in 2021–22 for all adaptation investments (that is, not only coastal and riverine flood protection) in "emerging markets and developing economies" was just US$6.4 billion, a fraction of our estimated annual costs in L&MICs, and in all countries was US$9.5 billion, although this may partly reflect limited data availability.

FIGURE 2.12 **Estimated capital costs in flood resilience (coastal and riverine) for L&MICs, by income group, 2020–50, share of GDP**



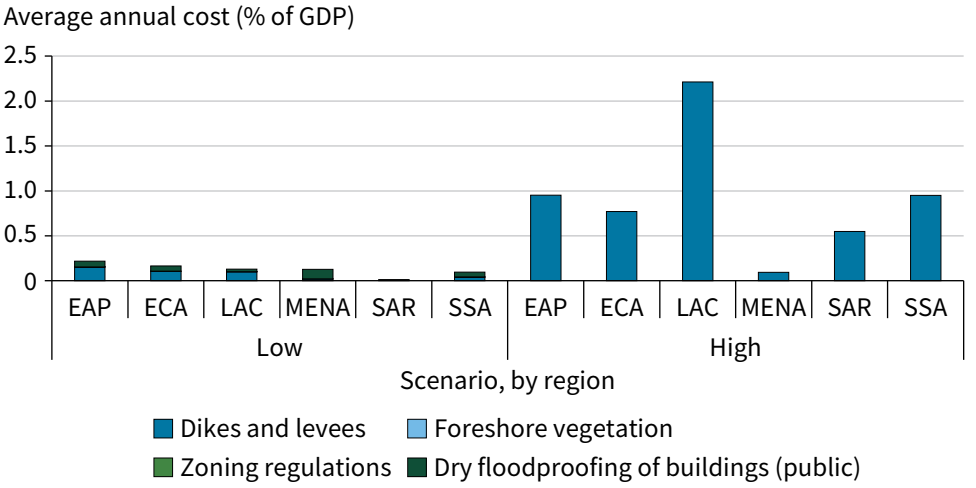
Source: Original figure for this book.
Note: LIC = low-income countries; LMIC = lower-middle-income countries; L&MICs = low- and middle-income countries; UMIC = upper-middle-income countries.

FIGURE 2.13 **Estimated capital costs in flood resilience (coastal and riverine) for L&MICs, by region, 2020–50, cumulative and annual**



Source: Original figure for this book.
Note: EAP = East Asia and Pacific; ECA = Europe and Central Asia; LAC = Latin America and the Caribbean; L&MICs = low- and middle-income countries; MENA = Middle East and North Africa; SAR = South Asia; SSA = Sub-Saharan Africa.

FIGURE 2.14 **Estimated capital costs in flood resilience (coastal and riverine) for L&MICs, by region, 2020–50, share of GDP**



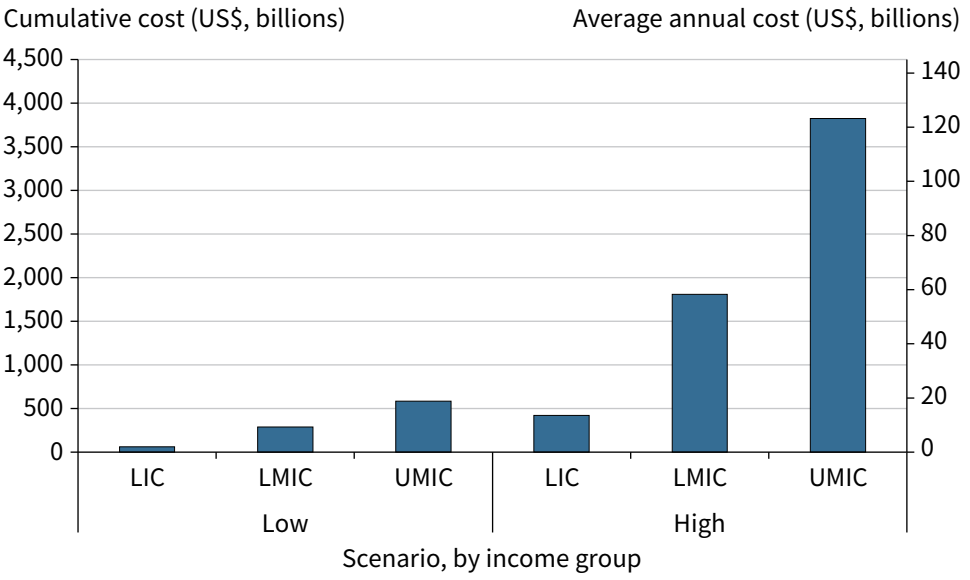
Source: Original figure for this book.
Note: EAP = East Asia and Pacific; ECA = Europe and Central Asia; LAC = Latin America and the Caribbean; L&MICs = low- and middle-income countries; MENA = Middle East and North Africa; SAR = South Asia; SSA = Sub-Saharan Africa.

Flood resilience: Pluvial

Pluvial flooding causes significant disruptions in cities, and this challenge is expected to worsen as a result of climate change, urban microclimate phenomena, and urban heat island effects, which are anticipated to increase thunderstorm activity. To mitigate the threat of urban flooding, robust drainage infrastructure capable of managing stormwater runoff is essential. This need is especially acute in cities in L&MICs, where stormwater drainage systems are often insufficient to cope with existing precipitation levels.

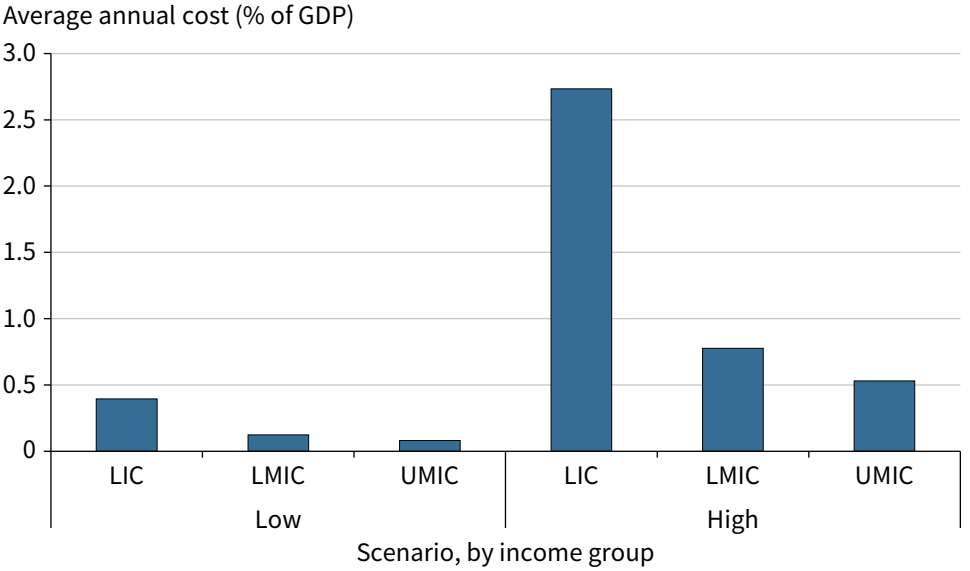
The cumulative costs to install stormwater drainage to protect the total urban land area in L&MICs from pluvial flooding by 2050 are projected to be US$930 billion in the low scenario and US$6.04 trillion in the high scenario. In annualized terms, these costs amount to US$30 billion in the low scenario and US$195 billion in the high scenario, or 0.1–0.6 percent of total L&MIC GDP. Although the costs in low-income countries are lower than in other income groups (Figure 2.15), when viewed as a share of GDP, the costs to low-income countries are very high, particularly in the high scenario (Figure 2.16). Costs are highest in the East Asia and Pacific region in absolute terms (Figure 2.17) and in Sub-Saharan Africa in terms of share of GDP (Figure 2.18). These estimates are based on the cost of stormwater drainage per square kilometer of protected urban land, as reported in past and ongoing World Bank investment projects or studies. True costs of urban drainage are highly context dependent, influenced by factors such as local precipitation patterns, the extent and condition of the existing drainage network, the proportion of impervious surfaces, land use patterns, topography, and other variables, which were not available for this report, partially explaining the large range between the low-cost and high-cost estimates (Ferguson et al. 2023). Further analysis would be needed to validate and refine these cost estimates.

FIGURE 2.15 **Estimated capital costs in flood resilience (pluvial) for L&MICs, by income group, 2020–50, cumulative and annual**



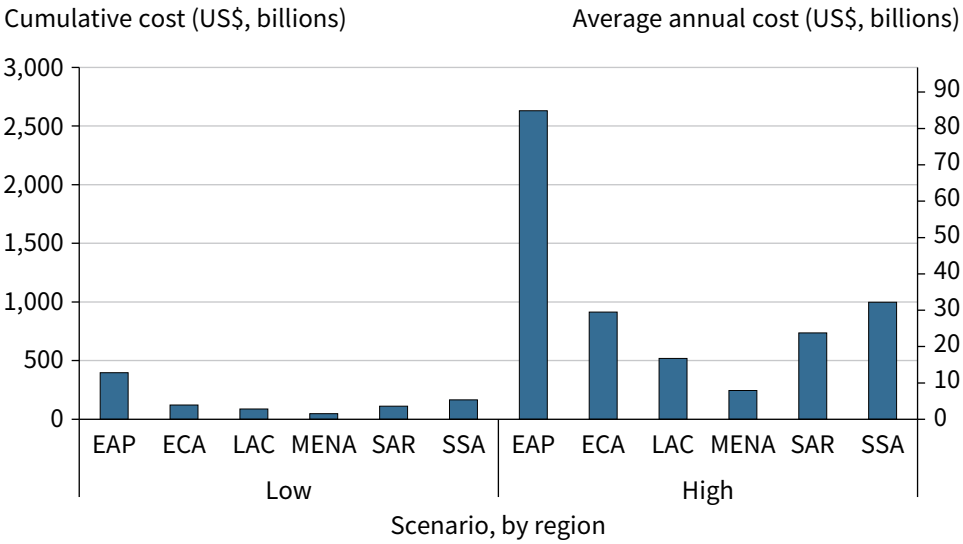
Source: Original figure for this book.
Note: LIC = low-income countries; LMIC = lower-middle-income countries; L&MICs = low- and middle-income countries; UMIC = upper-middle-income countries.

FIGURE 2.16 **Estimated capital costs in flood resilience (pluvial) for L&MICs, by income group, 2020–50, share of GDP**



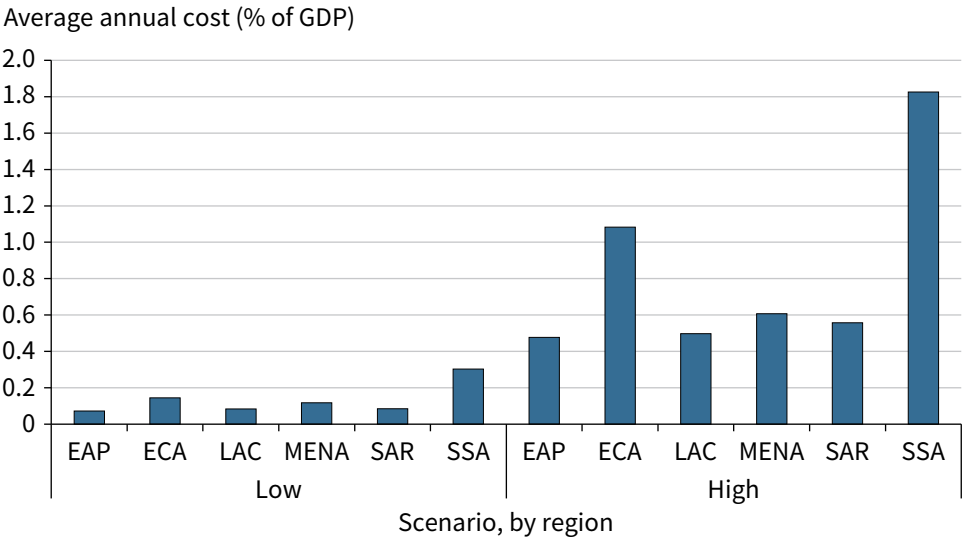
Source: Original figure for this book.
Note: LIC = low-income countries; LMIC = lower-middle-income countries; L&MICs = low- and middle-income countries; UMIC = upper-middle-income countries.

FIGURE 2.17 Estimated capital costs in flood resilience (pluvial) for L&MICs, by region, 2020–50, cumulative and annual



Source: Original figure for this book.
Note: EAP = East Asia and Pacific; ECA = Europe and Central Asia; LAC = Latin America and the Caribbean; L&MICs = low- and middle-income countries; MENA = Middle East and North Africa; SAR = South Asia; SSA = Sub-Saharan Africa.

FIGURE 2.18 Estimated capital costs in flood resilience (pluvial) for L&MICs, by region, 2020–50, share of GDP

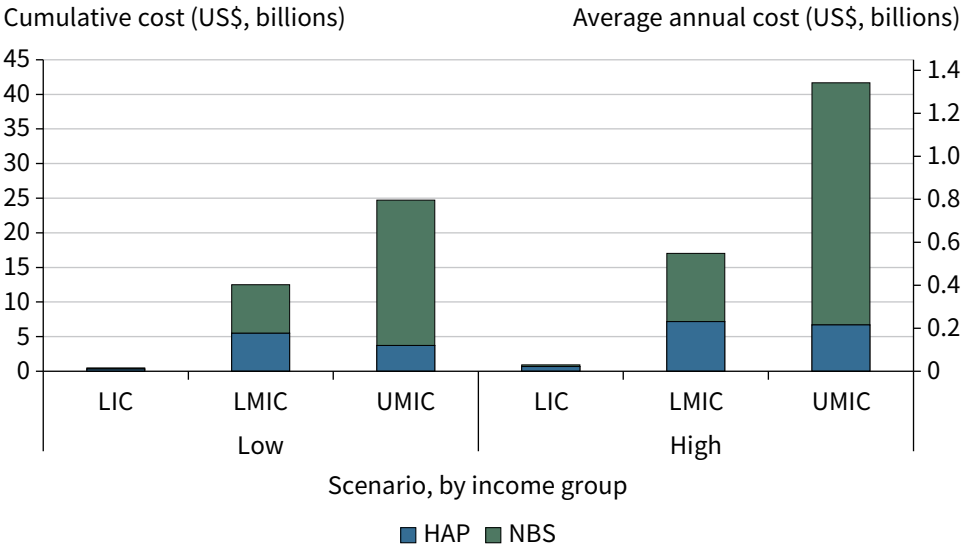


Source: Original figure for this book.
Note: EAP = East Asia and Pacific; ECA = Europe and Central Asia; LAC = Latin America and the Caribbean; L&MICs = low- and middle-income countries; MENA = Middle East and North Africa; SAR = South Asia; SSA = Sub-Saharan Africa.

Heat resilience

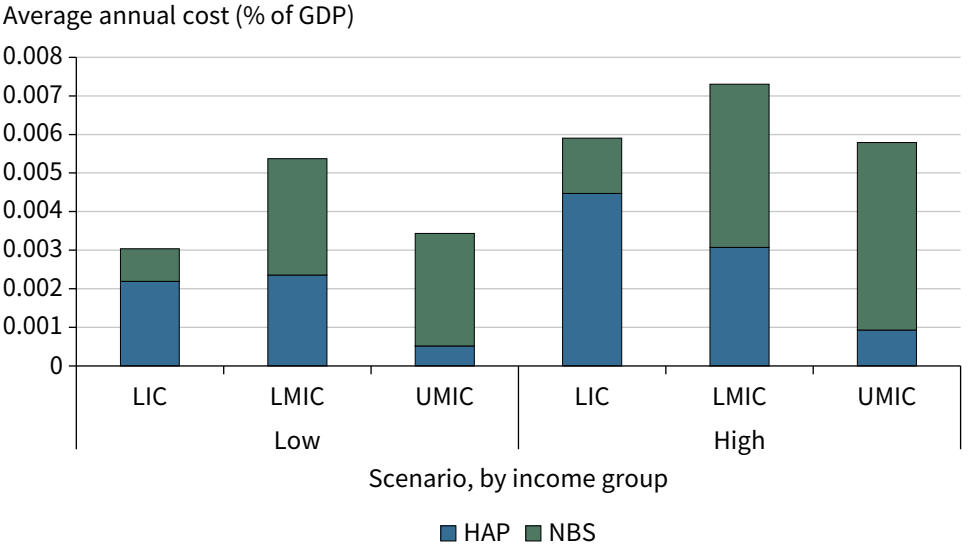
Heat adaptation investments can be highly effective at relatively low cost (US$38–60 billion by 2050 across L&MICs). Nature-based solutions (that is, urban greening) and the implementation of heat action plans, including adoption of early warning systems and other heat adaptation actions, can save lives and improve health and productivity. We identify US$38 billion (low scenario) to US$60 billion (high scenario) of investments to improve resilience to rising urban heat (refer to table 2.1). In annualized terms, this is the equivalent of US$1.2–1.9 billion. These costs correspond to a relatively small share of the combined GDP of all L&MICs from 2020 to 2050: 0.004 percent in the low scenario and 0.006 percent in the high scenario. The difference between the high and low scenarios is primarily driven by climate projections. The high scenario accounts for a larger number of cities expected to experience high heat stress by 2050, compared with the low scenario. Breaking down the costs by income group, absolute costs are highest in upper-middle-income countries (refer to figure 2.19), though as a share of GDP they are highest in lower-middle-income countries (refer to figure 2.20). By region, they are highest in absolute terms in the East Asia and Pacific region (refer to figure 2.21), whereas as a share of GDP they are highest in the South Asia region in the low scenario and the Middle East and North Africa region in the high scenario (refer to figure 2.22). Land acquisition costs that may be associated with increasing tree cover are not included in these cost estimates.

FIGURE 2.19 Estimated capital costs in heat resilience for L&MICs, by income group, 2020–50, cumulative and annual



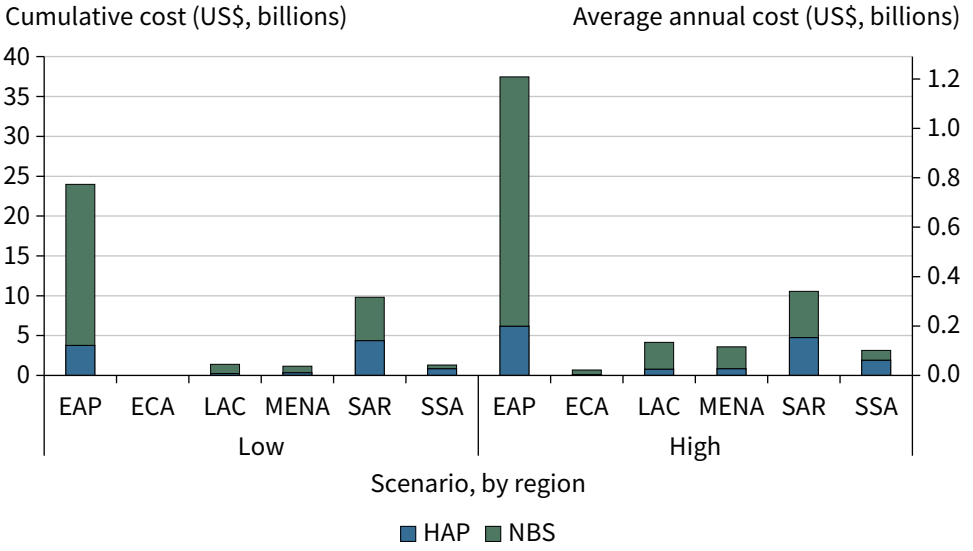
Source: Original figure for this book.
Note: HAP = heat action plan; LIC = low-income countries; LMIC = lower-middle-income countries; L&MICs = low- and middle-income countries; NBS = nature-based solutions; UMIC = upper-middle-income countries.

FIGURE 2.20 Estimated capital costs in heat resilience for L&MICs, by income group, 2020–50, share of GDP



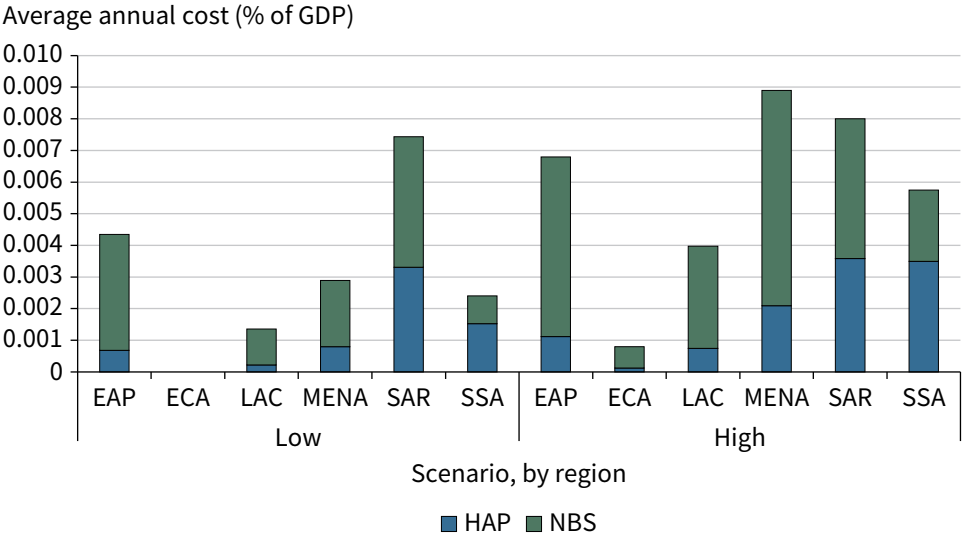
Source: Original figure for this book.
Note: HAP = heat action plan; LIC = low-income countries; LMIC = lower-middle-income countries; L&MICs = low- and middle-income countries; NBS = nature-based solutions; UMIC = upper-middle-income countries.

FIGURE 2.21 Estimated capital costs in heat resilience for L&MICs, by region, 2020–50, cumulative and annual



Source: Original figure for this book.
Note: EAP = East Asia and Pacific; ECA = Europe and Central Asia; HAP = heat action plan; LAC = Latin America and the Caribbean; L&MICs = low- and middle-income countries; MENA = Middle East and North Africa; NBS = nature-based solutions; SAR = South Asia; SSA = Sub-Saharan Africa.

FIGURE 2.22 Estimated capital costs in heat resilience for L&MICs, by region, 2020–50, share of GDP

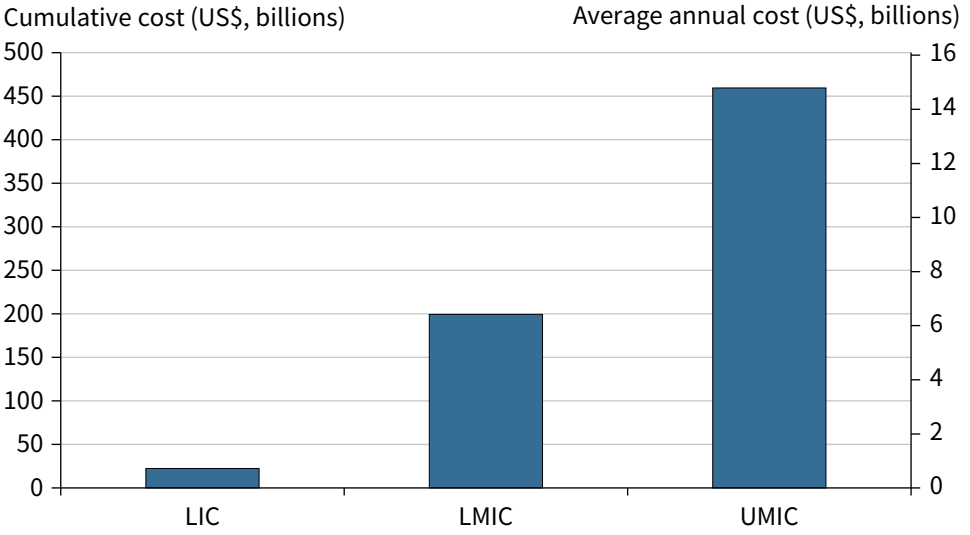


Source: Original figure for this book.
Note: EAP = East Asia and Pacific; ECA = Europe and Central Asia; HAP = heat action plan; LAC = Latin America and the Caribbean; L&MICs = low- and middle-income countries; MENA = Middle East and North Africa; NBS = nature-based solutions; SAR = South Asia; SSA = Sub-Saharan Africa.

Municipal solid waste management

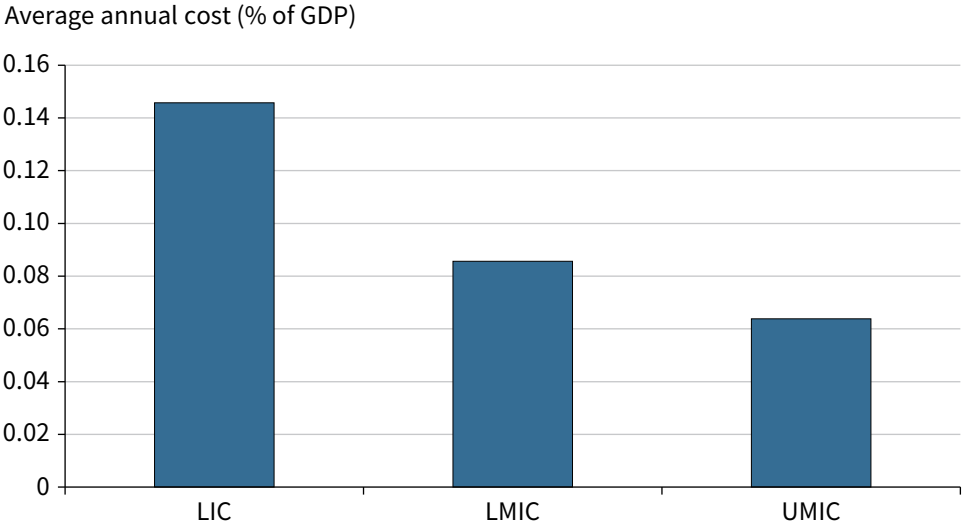
Effective, climate-smart solid waste management yields both mitigation benefits through reduced methane emissions and adaptation benefits by reducing blockages in drainage systems. We estimate US$681 billion of cumulative capital investments in solid waste management in L&MICs from 2020 to 2050. These costs account for the entire solid waste management system, with strong climate ambitions (refer to table 2.1). In annualized terms, this is the equivalent of about US$22 billion per year, or 0.07 percent of the combined GDP of all L&MICs. However, the estimated cost of operations and maintenance associated with these investments (that is, the cost of delivering solid waste management services on an ongoing basis) is higher than the capital costs: US$83 billion per year (0.27 percent of GDP). Revenue from the sale of recyclables and energy can offset annual costs by over 20 percent by 2050. By income group, investment costs are highest in absolute terms in upper-middle-income countries (refer to figure 2.23), whereas as a share of GDP they are highest in low-income countries (refer to figure 2.24). By region, costs are highest in the East Asia and Pacific region (refer to figure 2.25) but represent a much higher share of GDP in Sub-Saharan Africa (refer to figure 2.26). Figure 2.27 shows a breakdown of these investments over time. These investments are estimated to result in a 64 percent reduction in annual solid waste management GHG emissions in L&MICs, from 1,322 million tons of CO_2 equivalent in 2020 to 477 million tons in 2050. With these investments, emissions in 2050 would be lower than in a business-as-usual scenario by 2,199 million tons annually (82 percent).

FIGURE 2.23 Estimated capital costs in solid waste management for L&MICs, by income group, 2020–50, cumulative and annual



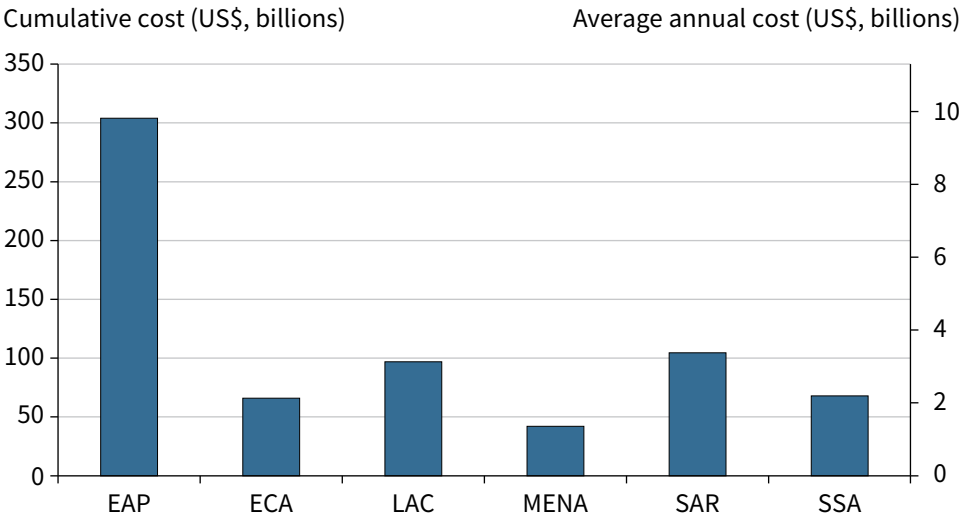
Source: Original figure for this book.
Note: LIC = low-income countries; LMIC = lower-middle-income countries; L&MICs = low- and middle-income countries; UMIC = upper-middle-income countries.

FIGURE 2.24 Estimated capital costs in solid waste management for L&MICs, by income group, 2020–50, share of GDP



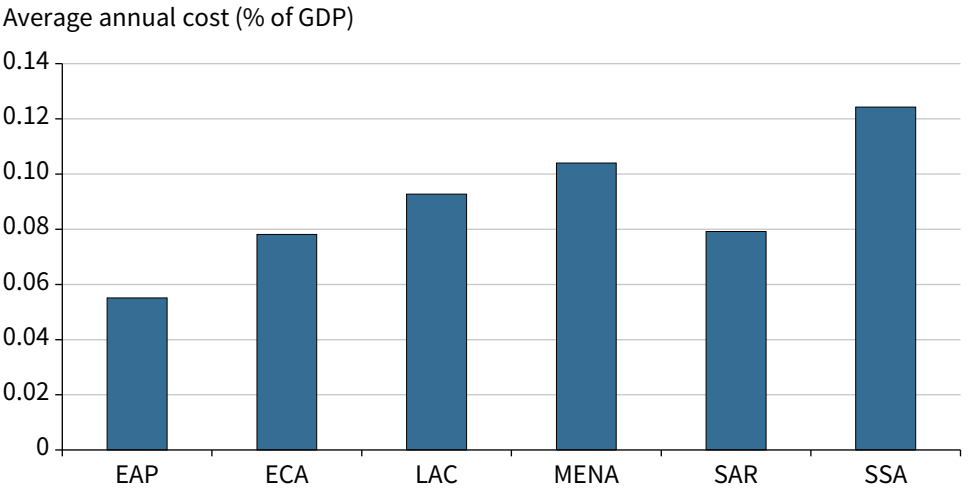
Source: Original figure for this book.
Note: LIC = low-income countries; LMIC = lower-middle-income countries; L&MICs = low- and middle-income countries; UMIC = upper-middle-income countries.

FIGURE 2.25 Estimated capital costs in solid waste management for L&MICs, by region, 2020–50, cumulative and annual



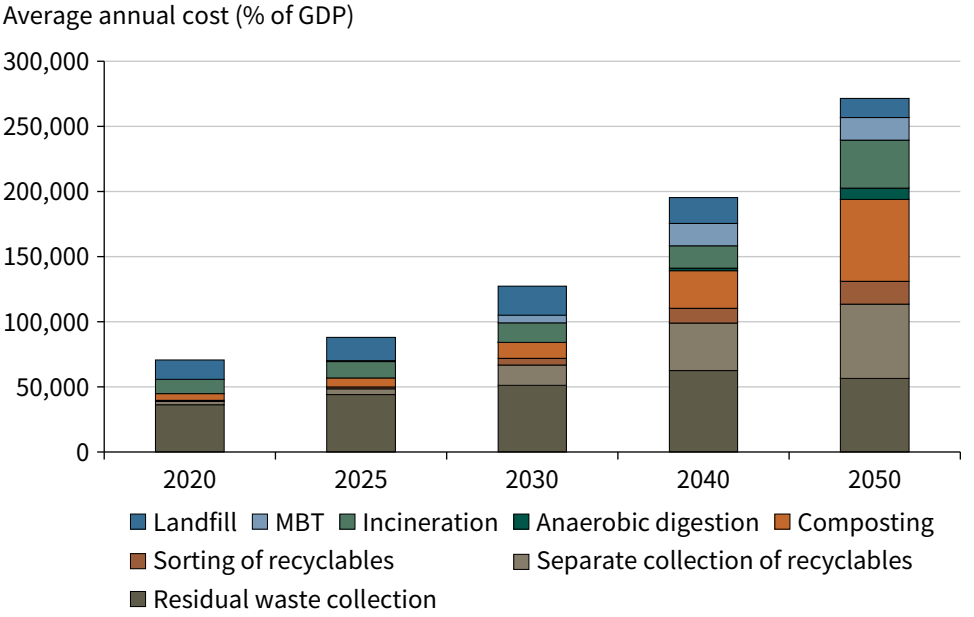
Source: Original figure for this book.
Note: EAP = East Asia and Pacific; ECA = Europe and Central Asia; LAC = Latin America and the Caribbean; L&MICs = low- and middle-income countries; MENA = Middle East and North Africa; SAR = South Asia; SSA = Sub-Saharan Africa.

FIGURE 2.26 Estimated capital costs in solid waste management for L&MICs, by region, 2020–50, share of GDP



Source: Original figure for this book.
Note: EAP = East Asia and Pacific; ECA = Europe and Central Asia; LAC = Latin America and the Caribbean; L&MICs = low- and middle-income countries; MENA = Middle East and North Africa; SAR = South Asia; SSA = Sub-Saharan Africa.

FIGURE 2.27 Projected annual solid waste management costs, by waste management operation over time (undiscounted), all L&MICs



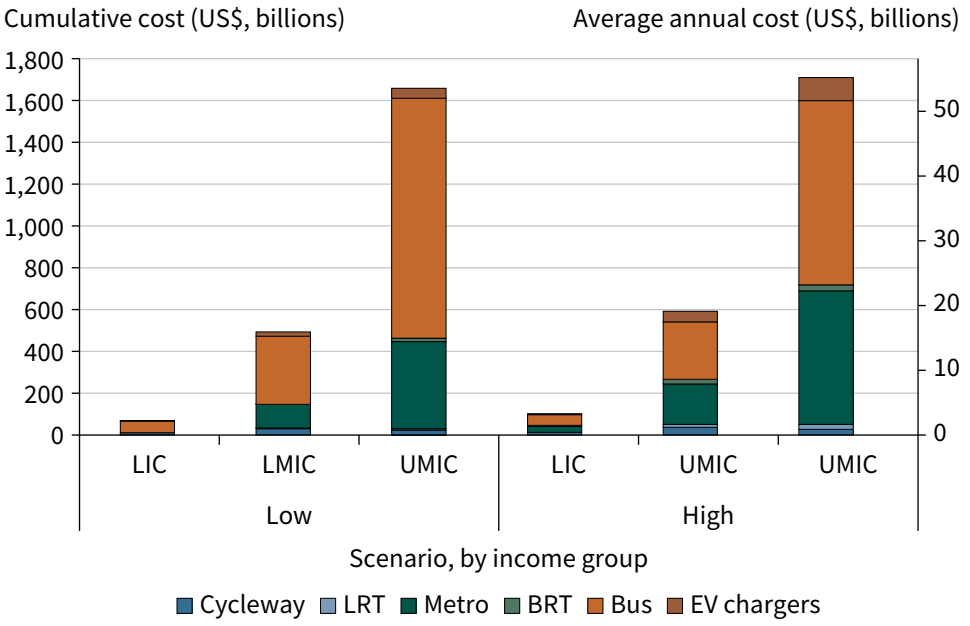
Source: Original figure for this book.
Note: L&MICs = low- and middle-income countries; MBT = mechanical biological treatment.

Urban transportation

Public investment in low-carbon urban transportation in L&MICs will cost over US$2 trillion up to 2050. The total cumulative capital costs of investments in low-carbon urban transportation in L&MICs amounts to US$2.2 trillion in the low scenario and US$2.4 trillion in the high scenario. In annualized terms, this equates to US$72–78 billion per year (0.23–0.26 percent of total L&MIC GDP). The lower estimate corresponds to current levels of commitment, whereas the higher estimate corresponds to a more ambitious investment scenario aligned with the Paris Agreement (at the level of the overall transport sector, including nonurban transportation and high-income countries). The largest share of the estimated capital investment costs in low-carbon urban transport are for buses (69 percent in the low scenario and 50 percent in the high scenario), with the share of electric buses being determined by country- and scenario-specific assumptions. The next largest share is for metro rail (24 and 36 percent, respectively). The remaining investments, which include public investments in electric vehicle charging, nonmotorized transport, and light rail and bus rapid

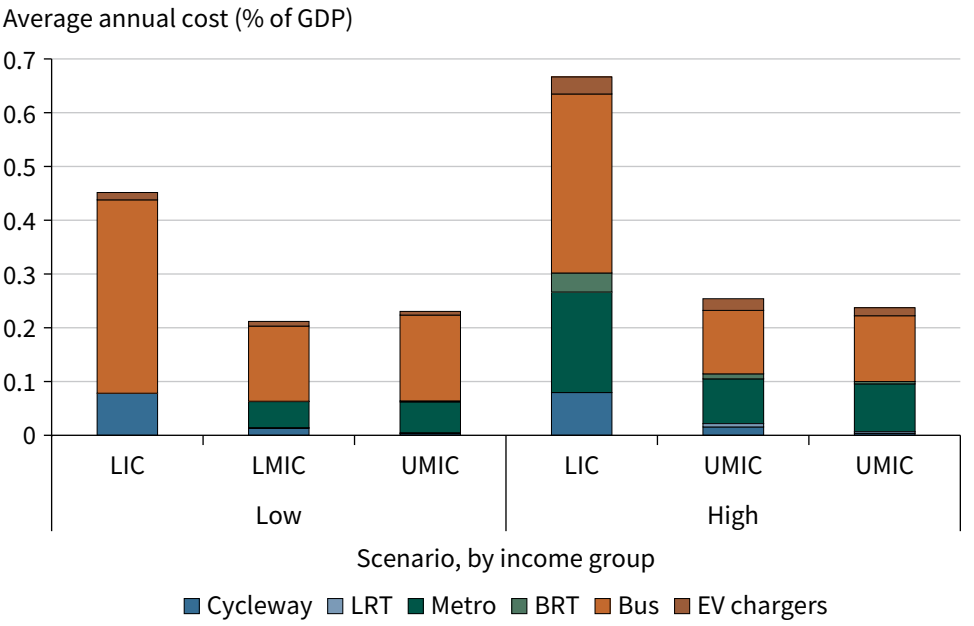
transit systems, together make up 7 and 14 percent of the total investment costs in the low and high scenarios, respectively. The costs are highest in upper-middle-income countries in absolute terms (refer to figure 2.28) but high in low-income countries in terms of share of GDP (refer to figure 2.29). More than half (55 percent) of the total low-carbon urban transport investment costs in L&MICs are in the East Asia and Pacific region (refer to figure 2.30). However, in terms of the share of total regional GDP, which reflects both the relative size and wealth of regions, the costs are highest in the Middle East and North Africa, Sub-Saharan Africa, and Europe and Central Asia regions (refer to figure 2.31). In comparison with the total capital investment costs of US$72–78 billion in L&MICs, CCFLA (2024) estimates that US$44 billion was allocated for similar transport investments in 2021–22.

FIGURE 2.28 Estimated capital costs in transportation (low carbon) for L&MICs, by income group, 2020–50, cumulative and annual



Source: Original figure for this book.
Note: BRT = bus rapid transit; EV = electric vehicle; LIC = low-income countries; LMIC = lower-middle-income countries; L&MICs = low- and middle-income countries; LRT = light rail transit; UMIC = upper-middle-income countries.

FIGURE 2.29 Estimated capital costs in transportation (low carbon) for L&MICs, by income group, 2020–50, share of GDP



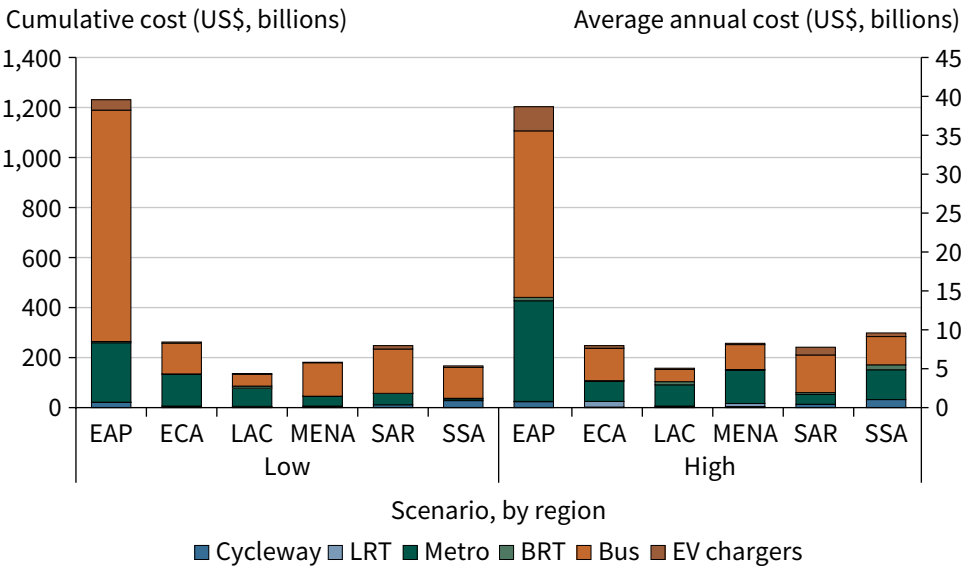
Source: Original figure for this book.
Note: BRT = bus rapid transit; EV = electric vehicle; LIC = low-income countries; LMIC = lower-middle-income countries; L&MICs = low- and middle-income countries; LRT = light rail transit; UMIC = upper-middle-income countries.

The cost of operation and maintenance of buses is greater than all capital expenditures in low-carbon urban transport. The annual operations and maintenance costs of buses are US$411–419 billion across L&MICs, about 1.4 percent of total L&MIC GDP. Buses make up nearly all (95–96 percent) of operation and maintenance costs across public transport.

Policy decisions and technological developments affect emissions reductions more than investments. In the low scenario, annual GHG emissions in L&MICs are expected to increase by 41 percent from 570 million tons of CO_2 equivalent in 2019 to 805 million tons in 2050. In the more ambitious high scenario, annual GHG emissions from urban passenger transport in L&MICs decrease by 76 percent, from 570 million tons of CO_2 equivalent in 2020

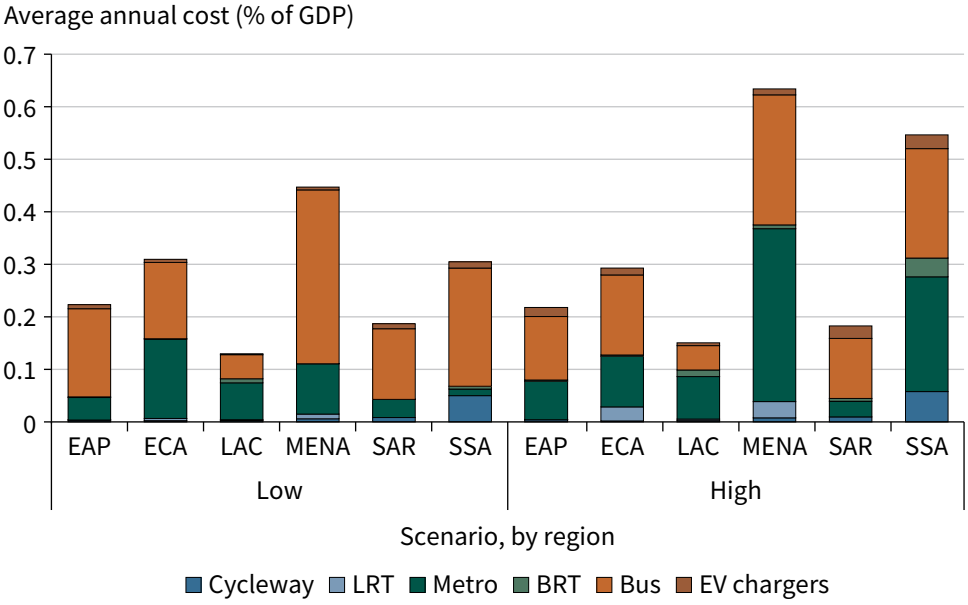
to 134 million tons in 2050. Thus, the high scenario results in 671 million tons or 83 percent lower annual GHG emissions than the low scenario by 2050. Notably, the bulk of this reduction in emissions results from the policy decisions and technological development included in the scenario. These include policies for effective transportation demand management (pricing instrument, speed and parking restrictions, and others) and compact land use, along with technological improvements allowing higher vehicle efficiencies and penetration of cleaner energy sources. The investments by themselves result in emissions reductions of just 22 percent from emissions in 2019 to emissions in 2050.

FIGURE 2.30 Estimated capital costs in transportation (low carbon) for L&MICs, by region, 2020–50, cumulative and annual



Source: Original figure for this book.
Note: BRT = bus rapid transit; EAP = East Asia and Pacific; ECA = Europe and Central Asia; EV = electric vehicle; LAC = Latin America and the Caribbean; L&MICs = low- and middle-income countries; LRT = light rail transit; MENA = Middle East and North Africa; SAR = South Asia; SSA = Sub-Saharan Africa.

FIGURE 2.31 Estimated capital costs in transportation (low carbon) for L&MICs, by region, 2020–50, share of GDP



Source: Original figure for this book.
Note: BRT = bus rapid transit; EAP = East Asia and Pacific; ECA = Europe and Central Asia; EV = electric vehicle; LAC = Latin America and the Caribbean; L&MICs = low- and middle-income countries; LRT = light rail transit; MENA = Middle East and North Africa; SAR = South Asia; SSA = Sub-Saharan Africa.

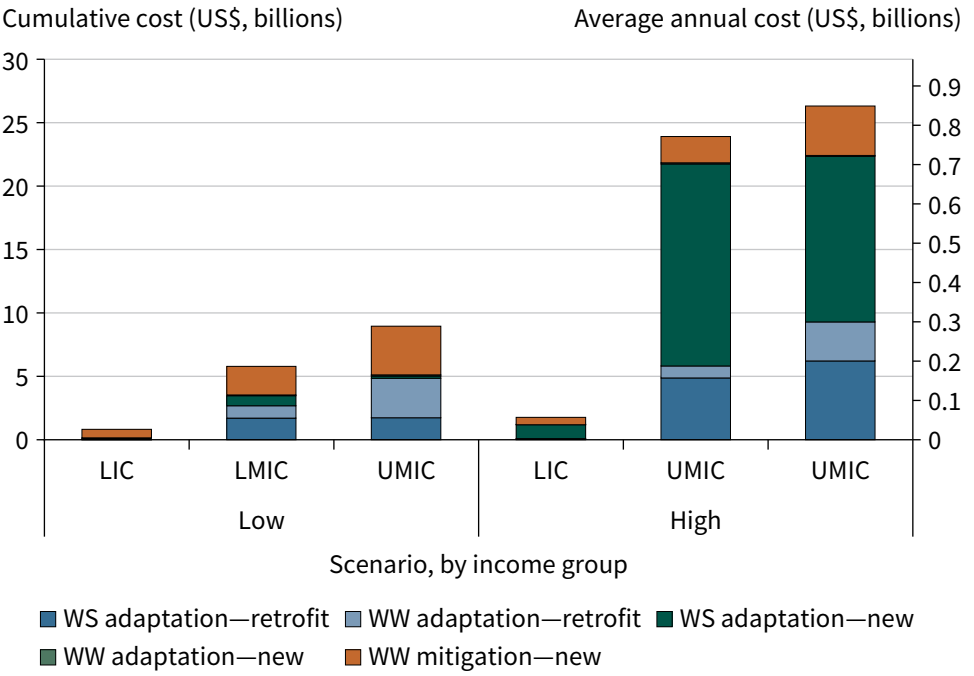
Adapting these investments, as well as all new urban roads, to flooding in exposed areas would require an additional US$32–73 billion up to 2050, or US$1.0–2.4 billion per year. Integrating resilience measures could add about 1.4–2.9 percent to the base investment costs (but can yield positive returns in the long run; see Koks et al. 2019). Because these estimates are based on the transportation modeling described previously, the largest cost differences stem from the level of ambition in the high versus low scenarios. For adaptation, the higher costs in the high scenario are also driven by two other factors: (1) more extreme climate scenarios and (2) a lower risk threshold for the application of resilience measures, which together result in the application of resilience measures to a larger share of transport infrastructure.

Water and wastewater

The costs of investments to make urban water and wastewater resilient and low carbon are relatively small but critical. The total cumulative capital costs up to 2050 of climate-related investments in urban water and wastewater in L&MICs amount to US$16 billion in the low scenario and US$52 billion in the high scenario.[2] Investments to make this sector resilient and low carbon include adapting water supply and wastewater infrastructure to flood risk, increasing water supply to adapt to drought risk, and improving wastewater treatment to reduce methane emissions. As well as more ambitious climate goals, the high scenario also achieves a higher standard of water supply coverage at a more rapid pace (refer to table 2.1).

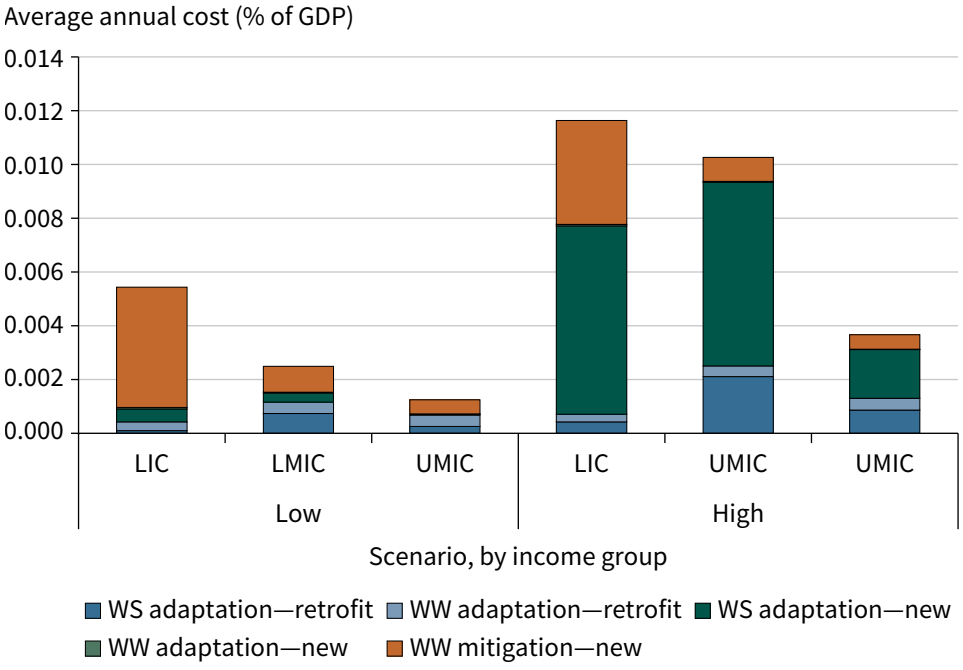
The incremental costs of investments for making this sector resilient and low carbon represent approximately 69 percent on top of baseline investment costs in the low scenario and 16 percent in the high scenario. In annualized terms, this is the equivalent of US$502 million per year and US$1.7 billion per year in the low and high scenarios, respectively. These figures correspond to relatively small fractions of the combined GDP of all L&MICs: 0.002 percent and 0.005 percent in the low and high scenarios, respectively. However, the estimated cost of operations and maintenance associated with these investments is higher than the capital costs. The operations and maintenance costs are US$1.7 billion per year (0.005 percent of GDP) in the low scenario and US$4.0 billion (0.013 percent of GDP) in the high scenario. In absolute terms, the costs are concentrated in middle-income countries (refer to figure 2.32), although as a share of GDP, costs are highest in low-income countries (refer to figure 2.33). Costs are distributed relatively evenly across regions in L&MICs (excluding the region of Europe and Central Asia, which has lower costs; refer to figure 2.34) but represent the highest share of GDP in the Middle East and North Africa region and Sub-Saharan Africa region (refer to figure 2.35).

FIGURE 2.32 **Estimated capital costs in water and wastewater for L&MICs, by income group, 2020–50, cumulative and annual**



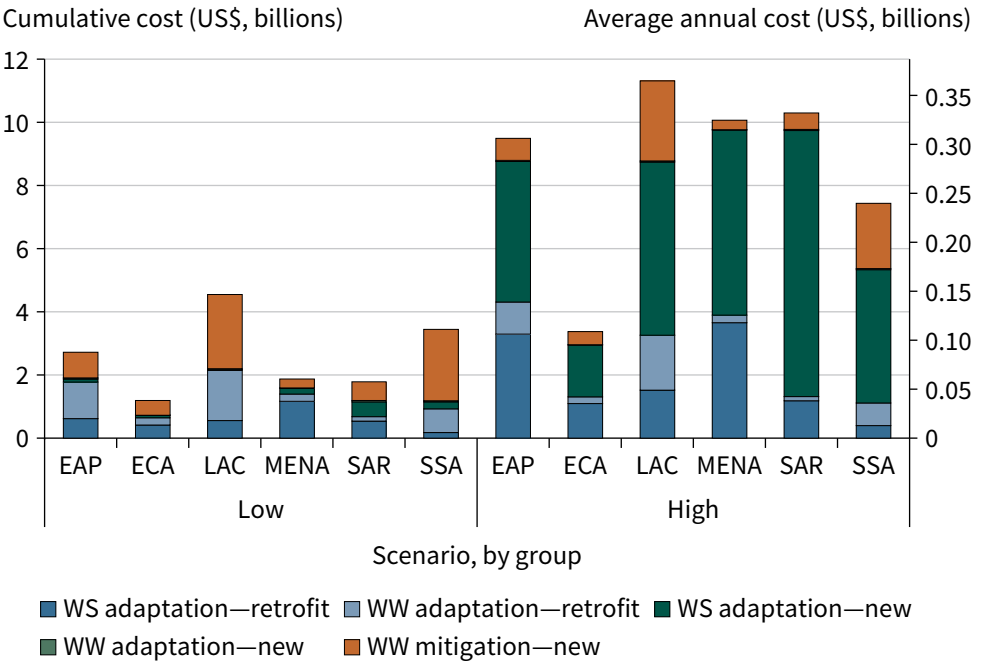
Source: Original figure for this book.
Note: LIC = low-income countries; LMIC = lower-middle-income countries; L&MICs = low- and middle-income countries; UMIC = upper-middle-income countries; WS = water supply; WW = wastewater.

FIGURE 2.33 Estimated capital costs in water and wastewater for L&MICs, by income group, 2020–50, share of GDP



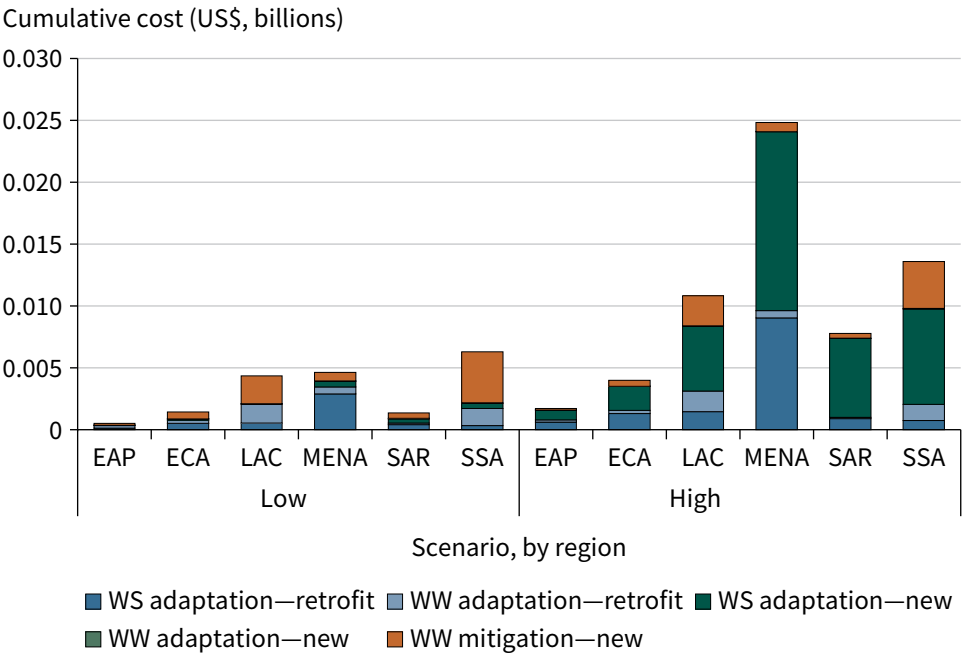
Source: Original figure for this book.
Note: LIC = low-income countries; LMIC = lower-middle-income countries; L&MICs = low- and middle-income countries; UMIC = upper-middle-income countries; WS = water supply; WW = wastewater.

FIGURE 2.34 **Estimated capital costs in water and wastewater for L&MICs, by region, 2020–50, cumulative and annual**



Source: Original figure for this book.
Note: EAP = East Asia and Pacific; ECA = Europe and Central Asia; LAC = Latin America and the Caribbean; L&MICs = low- and middle-income countries; MENA = Middle East and North Africa; SAR = South Asia; SSA = Sub-Saharan Africa; WS = water supply; WW = wastewater.

FIGURE 2.35 Estimated capital costs in water and wastewater for L&MICs, by region, 2020–50, share of GDP



Source: Original figure for this book.
Note: EAP = East Asia and Pacific; ECA = Europe and Central Asia; LAC = Latin America and the Caribbean; L&MICs = low- and middle-income countries; MENA = Middle East and North Africa; SAR = South Asia; SSA = Sub-Saharan Africa; WS = water supply; WW = wastewater.

Conclusion

The investments analyzed represent a significant share of GDP, particularly in low-income countries. However, despite their benefits for climate-resilient and low-carbon urbanization, we need not think of them as a distinct category of "climate investments." Most of them are crucial for providing core urban services, infrastructure, and buildings that not only strengthen resilience and promote low-carbon urbanization but also enhance service delivery, reduce costs, and improve quality of life. The following chapters examine how capacity to make these substantial investments can be enhanced through improved efficiency and effective funding and financing strategies.

Notes

1. The model includes costs for dry floodproofing of buildings where applicable, but whereas the original model estimates the costs for all buildings, the costs reported here are only for public buildings.
2. As with all the investment costs presented in this report, the approach used to estimate investment costs for water supply and wastewater management here is unrelated to the estimation of climate change cobenefits of the World Bank's water and wastewater projects. Because of differences in methodologies and objectives, none of the analysis presented here should be used in the context of calculating climate change cobenefits of development finance.

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SPOTLIGHT 1: ALEXANDRIA, EGYPT

Summary

- Alexandria, Egypt, exemplifies the challenges related to limited fiscal autonomy, which are faced by many cities in low- and middle-income countries.
- The Governorate of Alexandria is unable to take on debt, limiting its own fiscal capacity. As a result, most climate-related investments in Alexandria are made either by the central government or by the local government using transfers from the central government.
- The government is making significant climate adaptation investments in the city, particularly for coastal resilience.
- Despite having made some large mitigation investments, including a metro rail project, the gap between current spending and mitigation investment costs remains high.
- Relatively small expenditures in institutional capacity building and actions on policies and incentives can have significant impacts.
- Recent moves toward decentralization in Egypt could help subnational governments gain better access to finance for resilient and low-carbon investments in the coming years.

Context

Alexandria, the second largest city in the Arab Republic of Egypt, faces several threats from climate change, including sea level rise, extreme heat, and increased rainfall. Alexandria has a population of 5.4 million inhabitants.[1] The city is a commercial and industrial hub, and the country's most important port.[2] The city is also responsible for an estimated 12.3 million tons of CO_2 equivalent greenhouse gas emissions per year, of which around 7.3 million tons (59 percent) come from the built environment, 4.3 million tons (35 percent) from transportation, and 0.7 million tons (6 percent) from solid waste (World Bank 2023). Lying on the Mediterranean coast, the city is exposed to various natural hazards that are exacerbated by climate change, including the following:

- **Sea level rise and coastal erosion:** Rising sea levels caused by climate change pose a direct threat to Alexandria because of its low-lying coastal location. This phenomenon increases the risk of coastal flooding and erosion, which can damage infrastructure, homes, and livelihoods. Related to sea level rise, Alexandria is also threatened by tsunamis from the Mediterranean Sea, which are likely to exceed 1 meter in height by 2030.[3] The combination of rising sea levels and human activities such as coastal development and sand mining exacerbates coastal erosion in Alexandria. As beaches and protective dunes disappear, the city becomes more vulnerable to storm surges and high tides, leading to increased flooding and property damage. By 2050, sea levels in the Mediterranean may rise by 1 meter as a result of global warming. Even with half a meter of sea level rise, 30 percent of the city of Alexandria may be submerged, causing the displacement of at least 1.5 million people and the loss of 195,000 jobs.[4]
- **Extreme heat:** Alexandria is projected to experience high heat stress conditions by 2050. Depending on the climate scenario, Alexandria could experience high heat stress conditions (Wet Bulb Globe Temperature > 30°C)[5] for up to 17 days per year.
- **Increased precipitation:** Increased rainfall has led to the flooding of some areas in the city in recent years (Fahmy 2023). The road drainage network accommodates around 1 million cubic meters of rain, whereas the city receives approximately 18 million cubic meters per day.[6] Observations and global climate models show increasing intensity and frequency of extreme precipitation events, increasing the risk of flash flooding (World Bank 2023).

Resilient and low-carbon investments in Alexandria

Most of the resilient and low-carbon investments in Alexandria are made by central government agencies. This is in keeping with the high reliance of local governments in Egypt on central government capacities and budget. In the period 2022–23, national entities invested the equivalent of around 4.5 billion Egyptian pounds (EGP), or US$145 million[7] in investments related to climate change mitigation or adaptation in Alexandria.[8] This amounted to approximately 10 percent of total central government investments in the city. The investments by national agencies in Alexandria were mostly for adaptation (refer to table S1.1 and figure S1.1), particularly coastal protection, in response to the threats described in the previous section. Of the mitigation-related

investments, most were for transportation, including the purchase of electric buses and conversion of public buses to natural gas.

Nearly all the investments made by the Governorate of Alexandria were funded by national government transfers. The Governorate of Alexandria itself made only EGP 137 million (US$4.4 million) worth of resilient and low-carbon urban investments in 2022–23, less than 3 percent of the national investments mentioned earlier. Almost all of this (EGP 128 million, or 93 percent) was funded by central government transfers. In general, nearly 90 percent of all local investments in Alexandria have been funded by central government transfers in recent years. The rest is funded by own-source revenues and special funds and revenues. Resilient and low-carbon investments made by the governorate represented around 13 percent of overall investments by the governorate and were mostly in solid waste management. In addition, the governorate spent EGP 770 million (US$16 million) on recurring expenses, also related to waste management. The governorate itself cannot borrow or issue bonds. Through the central government, Alexandria also works with donor countries, as well as international organizations and funds such as the European Union Chamber of Commerce, the Green Climate Fund, and the Word Bank, to access funding, technical assistance, and expertise for climate change adaptation and mitigation projects.

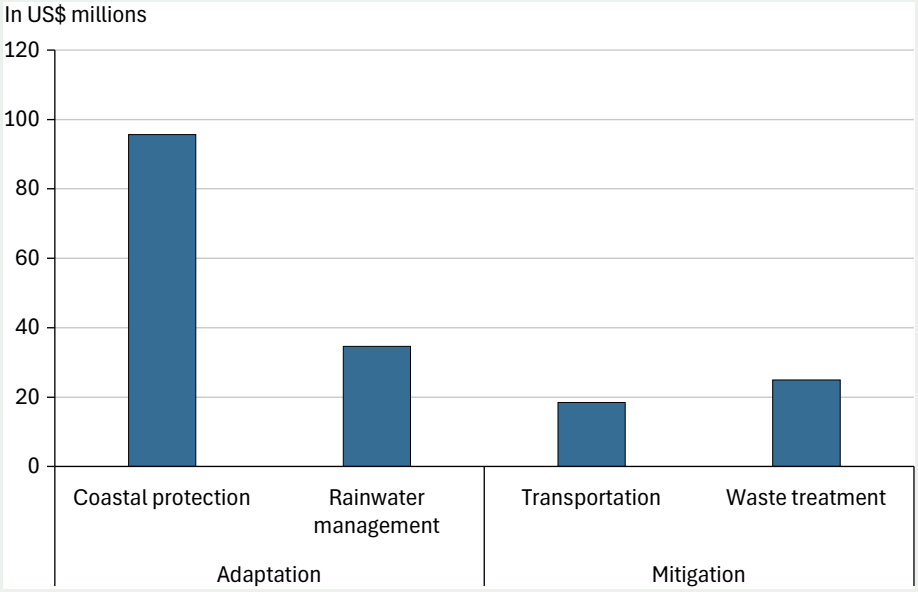
The government is making significant resilient and low-carbon investments in Alexandria. The data in table S1.1 provide a snapshot of a single year (2022–23). However, there are other projects under implementation that started in previous years or that are yet to start. The largest climate-related investment in the city is an urban transportation project, in which a diesel train line is being converted to an electric metro line, which was announced in 2023. This EGP 45.5 billion (US$1.46 billion) project is being implemented by the Ministry of Transportation and so is not included in the budgetary data provided by the Governorate of Alexandria shown in table S1.1. It was financed by the European Investment Bank, the European Bank for Reconstruction and Development, the French Development Agency, and the Asian Infrastructure Investment Bank.[9] The governorate is also expanding the use of solar energy in the city, including in public buildings and public spaces, partly through its own budget and partly with grant support from the European Union. A coastal management project to enhance climate adaptation across the Nile Delta and North Coast regions of Egypt, currently under preparation, is being funded by the Green Climate Fund and the Ministry of Financial Resources.

TABLE S1.1 Low-carbon and resilient investments in Alexandria, FY2022–23

Sector	Project	Cost in Egyptian pounds	Funding entity
Resilience			
Rainwater management	Rainwater management strategy project	EGP 1,075 million (US$34.7 million)	Ministry of Housing, Utilities and Urban Communities
Coastal protection	Coastal protection	EGP 2,966 million (US$95.7 million)	Ministry of Irrigation and Water Resources
Heat resilience	Afforestation works in streets and public squares: 320,000 trees	EGP 2.1 million (US$67,700)	Central Gardens administration, Ministry of Military Production, Ministry of Environment, and civil society
Resilience total		*EGP 4,043 million (US$130 million)*	
Low carbon			
Transportation	Purchasing 55 electric buses	EGP 410.0 million (US$13.2 million)	Alexandria Passenger Transport Authority through the National Investment Bank and the Ministry of Local Development
	Converting most public transport buses to natural gas: 50 buses	EGP 30.3 million (US$0.98 million)	Alexandria Passenger Transport Authority and Ministry of Finance
	Redevelopment of Misr Railway Station Square (emissions reduction from improved traffic flow)	EGP 131.5 million (US$4.2 million)	Ministry of Planning and Economic Development (except EGP 5 million from governorate funds)
Solid waste management	Household organic waste	EGP 704 million (US$22.7 million)	Self-financing from the governorate through fees and special funds and accounts
	Medical waste	EGP 52 million (US$1.7 million)	Self-financing from the governorate
	Industrial hazardous waste disposal	EGP 18 million (US$0.58 million)	Self-financing from the governorate
Low-carbon investments total		*EGP 1,346 million (US$43.4 million)*	
Total		**EGP 5,389 million (US$173.8 million)**	

Source: Original table for this book, based on data from Alexandria Governorate, Ministry of Planning and Economic Development.

FIGURE S1.1 Resilient and low-carbon investments in Alexandria, FY2022–23



Source: Based on data from Alexandria Governorate, Ministry of Planning and Economic Development.

Estimated resilient and low-carbon investment costs

Although Alexandria is already investing in climate change adaptation, relatively small expenditures on planning and capacity building could help improve the city's ability to adapt to climate change. The World Bank recently worked with the Governorate of Alexandria to develop the Alexandria Green City Action Plan (World Bank 2023), which included an assessment of the need for investments in climate change adaptation and mitigation in Alexandria up to 2030 (refer to table S1.2 and table S1.3). Comparing the annualized cost of adaptation investments identified in the plan (refer to table S1.2, fourth column) to the actual investments in 2022–23 discussed earlier (refer to table S1.1) shows that significant adaptation investments are already taking place, with the total volume of adaptation investments in that year alone being nearly in line with those identified in the plan for the period up to 2030. Among the investments not yet taken up, relatively small expenditures on planning and capacity building (listed under "Multiple" in table S1.2) could have an ongoing impact on the city's ability to adapt to climate change.

TABLE S1.2 Adaptation investment costs in Alexandria

Sector	Measure	Cost (in US$ millions)		
		CAPEX, cumulative to 2030	CAPEX, annualized	OPEX, annual
Flood resilience	Implement rainwater drainage network	2	0.24	0.10
	Upgrade wastewater network	5	0.74	0.20
	Upgrade streets	16	2.29	0.30
	Develop new water sensitive urban design models	2	0.24	0.10
Erosion and marine submersion	Prepare shoreline protection plan	2	0.29	0.10
	Implement 10 km coastal protection	65	9.29	0.10
Multiple	Establish the infrastructure network center	1	0.10	0.04
	Establish a climate change risk management unit	0	0.01	0.02
	Establish the asset management unit	0	0.04	0.04
	Update plans and policies with climate considerations	1	0.07	0.10
Adaptation total		93	13.31	1.10

Source: Based on data from Alexandria Green City Action Plan.
Note: This table excludes investments for resilience to seismic risk, which is not usually considered a climate risk. It also excludes water scarcity investments identified under adaptation to avoid duplication with water reuse investments included under mitigation. CAPEX = capital expenditures; OPEX = operating expenditures.

By contrast, the current level of investment in mitigation will need to be increased significantly if it is to approach the levels identified in the plan. This holds true even when including the US$1.46 billion metro rail project that is under implementation. Although the city has already made important investments in the public transport infrastructure and the electrification of buses, the plan identifies further investments in energy efficiency in municipal buildings, electric vehicle (EV) charging infrastructure, solid waste management, and water and wastewater, which remain to be made (refer to table S1.3). Some of the most impactful mitigation actions identified in the plan are ones that do not require direct investment by the government but rather policies and incentives that enable and facilitate those investments. Among the investments identified in the plan, in the near term, the governorate is focusing on the solid waste management and water and wastewater sectors as its top priorities, followed by an eco-friendly park and further investments in low-carbon public transportation.

TABLE S1.3 Mitigation investment costs in Alexandria

Sector	Measure	GHG savings (%)	Cost (in US$ millions)	
			CAPEX, cumulative to 2030	CAPEX, annualized
Built environment and energy	Implement solar rooftop PV program	12.2	1,953	279.00
	Mandate rooftop solar hot water	13.1	1,067	152.43
	Municipal buildings energy efficiency refurbishment	**0.9**	**241**	**34.43**
	Building retrofit program	4.2	1,502	214.57
	Incentivize Green Building certification	1.0	17	2.43
Transportation	**Add bus rapid transit system**	**5.8**	**2,836**	**405.14**
	Electric microbuses	4.5	1,350	192.86
	Add light rail transit system	**1.2**	**2,111**	**301.57**
	Create car-free zones	0.9	Minimal	Minimal
	Finance EV through banks[a]	0.8	1,365	195.00
	Provide EV charging infrastructure	**0.7**	**101**	**14.43**
	Mandate retirement of inefficient vehicles	0.3	381	54.43
	Electrify conventional bus fleet	**0.3**	**131**	**18.71**
Solid waste management	**Add/expand centralized composting facilities**	**1.7**	**594**	**84.86**
	Add/expand materials recovery facilities	**0.8**	**53**	**7.57**
	Add/expand centralized anaerobic digestion	**0.8**	**6**	**0.86**
Water and wastewater	**Reduce unaccounted-for water losses**	**0.2**	**113**	**16.14**
	Mandate efficient fittings in new buildings	0.1	41	5.86
	Mandate efficient fittings in existing buildings	0.1	36	5.14
	Reuse wastewater at municipal scale	**0.0**	**329**	**47.00**
	Direct costs total	***12.4***	***6,515***	***930.71***
Mitigation total		49.6	14,227	2,032

Source: Based on data from Alexandria Green City Action Plan.
Note: Data in bold indicate direct costs to the government. CAPEX = capital expenditure; EV = electric vehicle; GHG = greenhouse gas; PV = photovoltaic.
a. Private EVs are not included in the investment cost estimates developed for this report, as discussed in chapter 1. However, they are included here because they were included in the Alexandria Green City Action Plan.

Broadening its sources of finance would allow Alexandria to make the mitigation investments identified in its Green City Action Plan. The plan lists potential financing options for mitigation investments (refer to table S1.4). For those investments that involve direct costs to the government, the plan recommends mostly municipal revenues and government transfers, which have been the source of funding for most recent investments. It also recommends municipal loans or bonds for several investments and a leasing model for EV charging infrastructure, although the Governorate of Alexandria does not yet have experience with either.

TABLE S1.4 Mitigation investment costs and potential financing options

	Measures	Cost (US$ millions)	GHG savings (%)	Potential financing options							
				Municipal revenue/ govt. trans.[b]	Municipal loans/ bond (incl. CPF)[d]	PPPs (multiple contract modalities)	Product-as-a-service or leasing of assets	Carbon credits and pricing	Property linked financing	On-bill financing	Private financing through local intermediaries
Built Environment	Implement rooftop solar PV program	1,953	12.2	✓	✓		✓		✓		✓
	Mandate rooftop solar hot water	1,067	13.1						✓		✓
	Implement EE refurbishment program for 20 percent of municipal buildings[c]	241	0.9	✓	✓		✓				
	Building retrofit program	1,502	4.2						✓	✓	✓
	Incentivize green building certification (for example, EDGE)[a]	58	1.1						✓		✓
Transportation	Add BRT system[c]	2,836	5.8	✓	✓	✓					
	Electric microbuses	1,350	4.5				✓				✓
	Add LRT system[c]	2,111	1.2	✓	✓	✓					
	Create car-free zones	Minimal	0.9	✓							
	Finance electric vehicles through banks	1,365	0.8				✓				✓
	Provide EV charging infrastructure[c]	101	0.7	✓	✓	✓	✓				
	Mandate retirement of inefficient cars and motorcycles	381	0.3				✓	✓			✓
	Electrify conventional bus fleet[c]	131	0.3	✓	✓	✓					

(Table continues on next page)

TABLE S1.4 Mitigation investment costs and potential financing options *(continued)*

	Measures	Cost (US$ millions)	GHG savings (%)	Potential financing options							
				Municipal revenue/ govt. trans.[b]	Municipal loans/ bond (incl. CPF)[d]	PPPs (multiple contract modalities)	Product-as-a-service or leasing of assets	Carbon credits and pricing	Property linked financing	On-bill financing	Private financing through local intermediaries
Waste	Add/expand centralized composting facilities[c]	594	1.7		✓	✓					
Waste	Add/expand materials recovery facilities[c]	53	0.8	✓	✓	✓					
Waste	Add/expand centralized anaerobic digestion[c]	6	0.8	✓	✓	✓					
Water	Reduce unaccounted-for water losses[c]	113	0.2	✓	✓	✓					
Water	Mandate efficient fittings in existing buildings	36	0.1		✓	✓			✓	✓	
Water	Reuse wastewater at municipal scale[c]	329	0.0	✓	✓	✓					
	Total	14,226	49.6								

Source: Alexandria Green City Action Plan.

Note: BRT = bus rapid transit; CPF = climate performance-based (loans or bonds); EE = energy efficiency; EV = electric vehicle; GHG = greenhouse gas; govt. trans. = government transfer; LRT = light rail transit; PPPs = public-private partnerships; PV = photovoltaic.

a. Measure includes efficiency fittings in new buildings.

b. Central transfers are the primary source of funding for local investments in Alexandria.

c. Direct cost item.

d. Climate performance-based loans or bonds.

Accessing finance for resilient and low-carbon urban investments

Recent moves toward decentralization in Egypt could help subnational governments gain better access to finance for resilient and low-carbon investments in the coming years. Subnational governments such as the Governorate of Alexandria have limited ability to independently raise revenues and therefore remain highly dependent on the central government for finance. Accessing sufficient and timely financing is challenging, particularly for resilient and low-carbon urban investments for which there are no specific financial allocations. However, the Government of Egypt has made some important steps toward decentralization recently. For example, the Government Action Plan for fiscal 2025–27 includes decentralization as a key priority, and the government has recently launched its decentralization initiative and new local development programs. Such steps may help subnational governments in Egypt gain better access to finance for resilient and low-carbon investments in coming years.

Notes

1. Population data from Egyptian Central Agency for Public Mobilization and Statistics (CAPMAS), "Detailed Population Estimates as of January 2023, Government of Egypt," accessed April 4, 2025, https://www.capmas.gov.eg/Admin/Pages%20Files/202331512347%D8%B9%D8%AF%D8%AF%20%D8%A7%D9%84%D8%B3%D9%83%D8%A7%D9%86%20%D8%B9%D9%84%D9%89%20%D9%85%D8%B3%D8%AA%D9%88%D9%89%20%D8%A7%D9%84%D9%85%D8%B1%D8%A7%D9%83%D8%B2%20%D9%88%D8%A7%D9%84%D8%A7%D9%82%D8%B3%D8%A7%D9%85%20%D9%81%D9%89%201%D9%80%201%D9%80%202023.pdf.
2. Alexandria Governorate, "Why Invest in Alexandria?" accessed April 4, 2025, http://www.alexandria.gov.eg/Alex/english/invest.html.
3. Rehab Abdel Mohsen, "Scenarios for the Sinking of Alexandria . . . Will History Repeat Itself in 2050? (Investigation)," *Ozone* (December 29, 2022), accessed April 4, 2025, https://ozoneeg.net/archives/5015.
4. SWI, "Alexandria Is Threatened with Submersion Due to Climate Change," *SWI Swissinfo.ch* (Swiss Broadcasting Corporation, November 2, 2022), accessed April 4, 2025, https://www.swissinfo.ch/ara/%D8%A7%D9%84%D8%A7%D8%B3%D9%83%D9%86%D8%AF%D8%B1%D9%8A%D8%A9-%D9%85%D9%87%D8%AF%D8%AF%D8%A9-%D8%A8%D8%A7%D9%84%D8%BA%D8%B1%D9%82-%D8%A8%D9%81%D8%B9%D9%84-%D8%AA%D8%BA%D9%8A%D8%B1-%D8%A7%D9%84%D9%85%D9%86%D8%A7%D8%AE/.

5. Wet Bulb Globe Temperature estimates the effect of temperature, relative humidity, wind speed, and solar radiation on humans (US National Weather Service, National Oceanic and Atmospheric Administration, "Wet Bulb Globe Temperature," n.d., accessed April 4, 2025, https://www.weather.gov/lwx/heat).
6. See note 4.
7. The average exchange rate during fiscal year 2022–23 is 31 Egyptian pounds to US$1 (Source: Central Bank of Egypt).
8. Data shared for the purpose of this report: "Alexandria Governorate Projects in Climate Change (FY 2022–23)," submitted by the Office of the Governor of Alexandria.
9. Metro Report International, Railway Gazette Group, "Alexandria Metro Contract Signed" (2023), accessed May 23, 2024, https://www.railwaygazette.com/metros/alexandria-metro-contract-signed/65219.article.

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CHAPTER 3

Efficiency to limit investment costs

Summary

- Realizing efficiency savings will be critical to the financial feasibility of low-carbon and resilient urban investments and to enabling cities to do more with limited resources.
- Efficient and coordinated urban growth can promote efficiency savings while reducing emissions and climate risks.
- Cities can also achieve greater efficiency by mainstreaming mitigation and adaptation in investment design and implementation, prioritizing and targeting investments strategically, and aligning third-party incentives.
- Even where funding and financing are available, absorption and execution of available funds tend to be low. Improving execution and absorption is critical to translate financing into development outcomes and avoid mounting unsustainable repayment obligations.

Overview

Efficient and well-coordinated urban management lowers the cost of urban investments, operation, and maintenance. Cities can achieve greater investment efficiency through spatial coordination, the mainstreaming of

mitigation and adaptation into investment design and operation, improved targeting of investments, third-party incentives for accountability, and improvement in absorptive capacity. Table 3.1 provides examples of how investment costs can be reduced in different sectors through the various forms of efficiency discussed in this chapter.

TABLE 3.1 Examples of actions that reduce public investment costs

Sector	Investment	Actions to reduce investment costs
Buildings	Public subsidies for energy efficiency improvements and rooftop solar panel installation in private buildings	• Combining energy efficiency and resilience retrofits • Encouraging/enabling green building practices through green building certification, training in energy-efficient construction, developing certification, and fostering capacity in energy-efficient construction by setting high standards for public buildings
Flood resilience	Dikes and levees, stormwater drainage, nature-based solutions	• Using accurate data and modeling of flood hazard to target investments • Selecting the appropriate flood protection measure (for example, dikes versus mangroves) based on cost-benefit analysis • Implementing land use planning and regulations to deter urban growth in flood-prone areas • Preserving natural drainage and retention of stormwater
Heat resilience	Heat action plans and tree planting	• Targeting vulnerable populations during heat waves • Targeting tree planting to populated areas with high heat exposure • Selecting climate-appropriate plant species • Preserving existing natural vegetation
Transportation	Public transportation infrastructure and services	• Adopting compact growth, where relevant • Coordinating transport with land use • Prioritizing public and nonmotorized forms (for example, congestion and parking charges, bus lanes)
Water supply	Drought-resilient water supply	• Reducing leakage (nonrevenue water)
Solid waste management	Improved collection and treatment of solid waste	• Adopting Extended Producer Responsibility schemes that incentivize waste reduction

Efficient and coordinated spatial growth

Efficient and coordinated urban growth can reduce climate risks and greenhouse gas (GHG) emissions for a relatively low cost. Risk-sensitive urban growth management reduces the expansion of populations and assets into flood-prone areas and preserves natural drainage systems and flood barriers such as foreshore vegetation, reducing the need for gray protective infrastructure and reducing losses from hazards. Urban growth management can also help to address urban heat, by preserving trees and other green space, water bodies, and wind flow—all of which have a cooling effect. Urban management that promotes efficient and transit-oriented urban growth—that is, growth that is spatially contiguous and at relatively high densities, with land use well coordinated with transportation infrastructure—reduces transportation emissions. It does this by reducing the length of private vehicle trips and allowing more trips to be made by public and nonmotorized transportation and by reducing the emissions embodied in construction materials such as cement and steel (through more compact housing and infrastructure). Buildings in denser cities also usually consume less energy per capita, resulting in lower emissions from energy consumption (Deuskar 2021).

Efficient and coordinated urban growth also reduces investment costs in cities through the construction and maintenance of urban roads, water pipes, sewerage, and other infrastructure. In this way, efficient and coordinated urban growth leads to (a) reduced GHG emissions, (b) reduced climate risks, and (c) reduced infrastructure costs. The impact of compact growth on costs is illustrated by the urban transportation analysis in this report. The "high ambition" scenario for urban transportation involves far more investment in public and nonmotorized transportation than the "current ambition" scenario but also assumes denser urban growth, which results in savings because of a reduced need to expand the road network. Investment costs for road network expansion are about 17 percent lower in the high ambition scenario than in the current ambition scenario, which offsets roughly 12 percent of the difference between the high and low scenarios. Further savings on the maintenance of roads and buses in the high ambition scenario mean that, when these wider savings are considered, the total annual capital and operating costs of the two scenarios are nearly identical, despite the much lower emissions in the high ambition scenario.

Spatial coordination also allows the same investment to serve multiple functions, further reducing investment costs. For example, in addition to serving their primary function for recreation, urban parks can provide flood protection during storms by temporarily retaining stormwater, while their trees provide shade for heat resilience at other times and even absorb carbon from the atmosphere. Well-located investments also increase land values in surrounding areas, which creates opportunities for land-based financing of urban infrastructure if revenues can be captured and incentives aligned across horizontal borders.

Urban form refers to the spatial characteristics of an urban area, including the size and shape of its built-up extents and the distribution of densities and land uses within it. Urban form not only affects infrastructure needs but in turn is also shaped by infrastructure. Cities in low- and middle-income countries often have limited capacity to produce and enforce spatial plans and regulate densities through land use regulations, particularly where there are high levels of informality. By contrast, the location of infrastructure, particularly roads and water infrastructure, has a direct impact on urban form by directing where households and businesses can locate. Thus, infrastructure and urban form are in a mutually reinforcing cycle. Well-coordinated and efficient infrastructure provision results in efficient urban form, which in turn reduces future expenditure on infrastructure provision and maintenance.

Benefits of spatial efficiency: City case studies

The benefits of spatially efficient urban growth are demonstrated by city-level analytics in several countries. The following sections examine the impact of spatial efficiency on costs, resilience, emissions, and other outcomes in Amman, Jordan; Chongqing, China; and five cities in Central Asia.

AMMAN, JORDAN

Spatially efficient urban expansion in Amman, Jordan, could protect residents from flood risk and cut GHG emissions in half while saving billions of dollars. An analysis of Amman estimated the impacts of different spatial growth scenarios on various outcomes (Kaw et al. 2022). The business-as-usual (BAU) scenario for Amman anticipates that, by 2050, the city would add about 340 square kilometers to its existing footprint of 570 square kilometers in 2020.

By contrast, other urban growth scenarios, named Plan 2050, Ambitious 2050, and Net Zero 2050, envision adding 214, 45, and zero square kilometers of new urban area, respectively. The three maps in figure 3.1 depict the 2020 footprint of Amman in dark green and the expansion area under the different scenarios in light green. Each of these scenarios also involved making other infrastructure investments—in renewable energy, energy efficiency, public transportation, and other sectors. Comparing the infrastructure costs of the Ambitious 2050 scenario with those of the BAU scenario illustrates the impact of compact growth. The Ambitious 2050 scenario results in only half the GHG emissions of the BAU scenario and exposes a smaller share of its population to flooding than the BAU scenario. Despite including several new investments in energy efficiency, public and nonmotorized transport, and other areas, it also *saves* the city around US$4 billion (refer to figure 3.2). This is because its compact growth vastly reduces the need for new gray infrastructure (roads, water supply, sewerage, public lighting, and electric networks).

FIGURE 3.1 Projected urban expansion in Amman, Jordan, by 2050, in the BAU scenario, Plan 2050 scenario, and Ambitious scenario

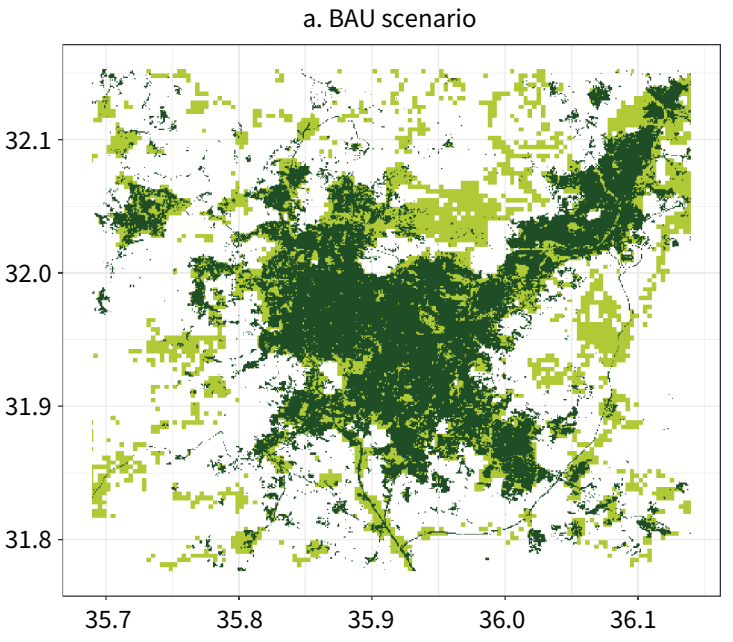

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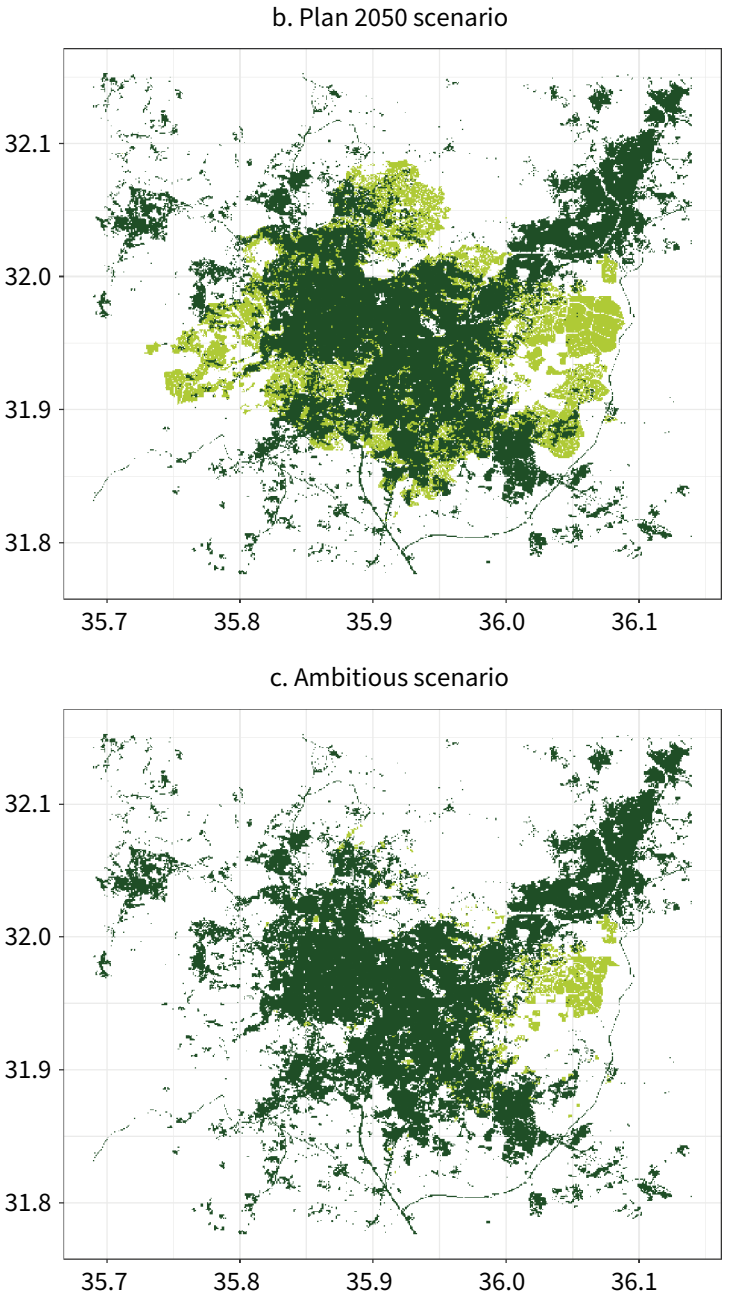
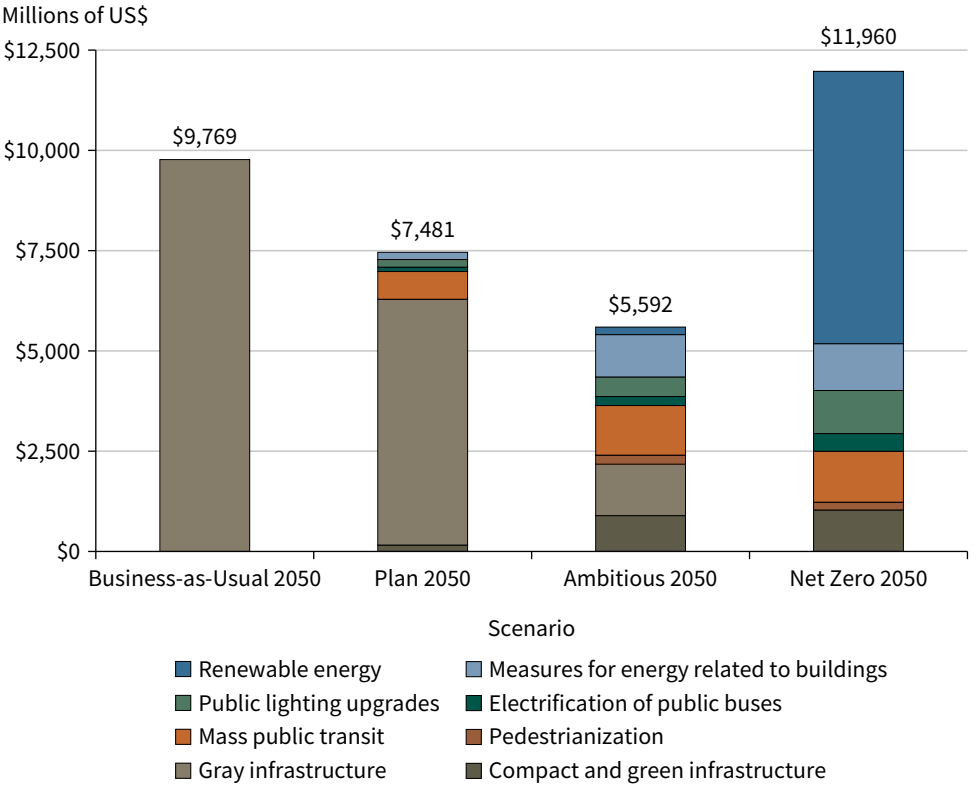
FIGURE 3.1 **Projected urban expansion in Amman, Jordan, by 2050, in the BAU scenario, Plan 2050 scenario, and Ambitious scenario (*continued*)**



Source: Kaw et al. 2022; World Bank 2022.
Note: BAU = business-as-usual.

FIGURE 3.2 Total capital expenditure of new infrastructure and local policies, Amman, Jordan

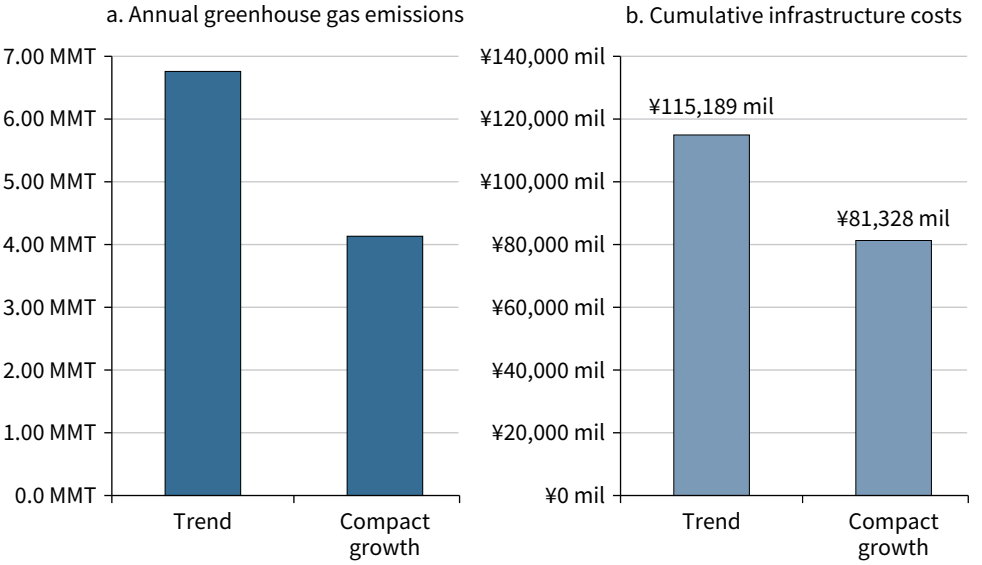


Source: World Bank 2022.

CHONGQING, CHINA

Similar results were obtained in an analysis of Chongqing, China. Chongqing, already a large city with an urban population of 7.4 million in 2015, is expected to grow to 13.2 million by 2035. The analysis modeled two scenarios—a trend (BAU) scenario and a compact growth scenario—both of which projected the same population and job growth up to 2035. However, the compact growth scenario had a population density 20 percent higher than the trend scenario, as well as a different spatial development pattern (featuring small, walkable blocks and transit-oriented development rather than large superblocks, among other differences). The modeling suggested that the compact growth scenario would reduce annual CO_2 emissions from car travel by 2.6 million metric tons compared with the trend scenario (refer to figure 3.3). The compact growth scenario also reduced the amount of road, water, and sewer infrastructure

FIGURE 3.3 Trend and compact growth scenarios in Chongqing, China: Annual greenhouse gas emissions from automobiles and cumulative infrastructure costs up to 2035



Source: World Bank 2019.
Note: In panel b, the cumulative infrastructure costs are in Chinese yuan. MMT = million metric tons.

required, resulting in savings of nearly 30 percent in capital expenditures, not including lower operations and maintenance costs. The compact growth scenario also improved access to jobs and services, reduced local air pollution, and lowered household costs on transportation and home energy use (World Bank 2019).

FIVE CENTRAL ASIAN CITIES

Efficient and coordinated growth in five cities in Central Asia has also been estimated to reduce flood and heat risk, carbon emissions, and basic infrastructure costs. Analysis of Almaty (Kazakhstan), Bishkek (Kyrgyz Republic), Dushanbe (Tajikistan), and Namangan and Shakhrisabz (Uzbekistan) compared "no-intervention" (BAU) scenarios with "vision" scenarios, developed through participatory processes with local authorities and other stakeholders (Huang, Eisenberg, and Velasco 2024). The vision scenarios assumed that population growth would be accommodated within

the 2020 urban footprint because of densification strategies to the extent possible, resulting in population density increases of between 20 and 36 percent. The vision scenarios also incorporated key urban policy measures and capital investments. Figure 3.4 shows a selection of the estimated impacts of the two scenarios. The vision scenarios resulted in substantially lower flood hazard exposure, urban heat island hazard exposure, and GHG emissions, among other positive results. The vision scenarios also resulted in other benefits (not shown), including higher access to urban services and amenities, lower levels of air pollution, lower levels of water consumption, higher levels of wastewater treatment, and higher solid waste management coverage. The cost of basic infrastructure (roads, water networks, sewerage systems, public lighting, and electricity grids) was much lower in the vision scenarios in all cities. The capital costs associated with the vision scenarios were roughly the same as the no-intervention scenarios in all cities except Almaty. The higher ambitions of Almaty, of achieving carbon neutrality by 2050, required larger capital investments, primarily in renewable energy.

FIGURE 3.4 Projections of outcomes resulting from different scenarios in five Central Asian cities

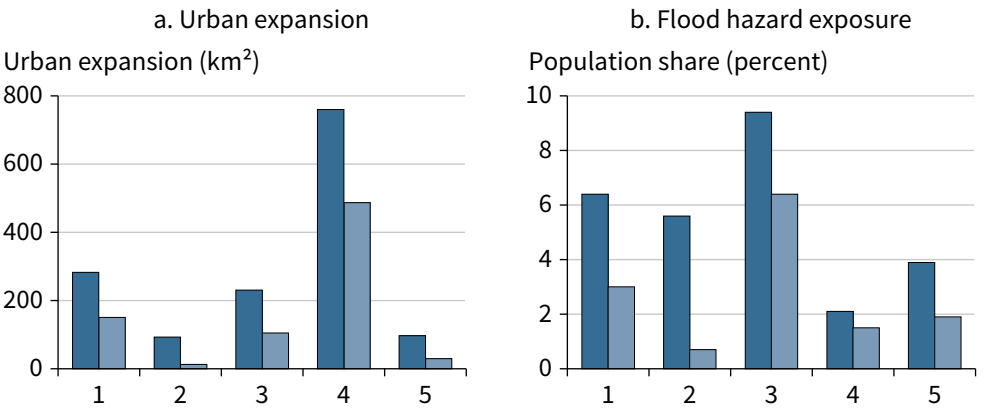


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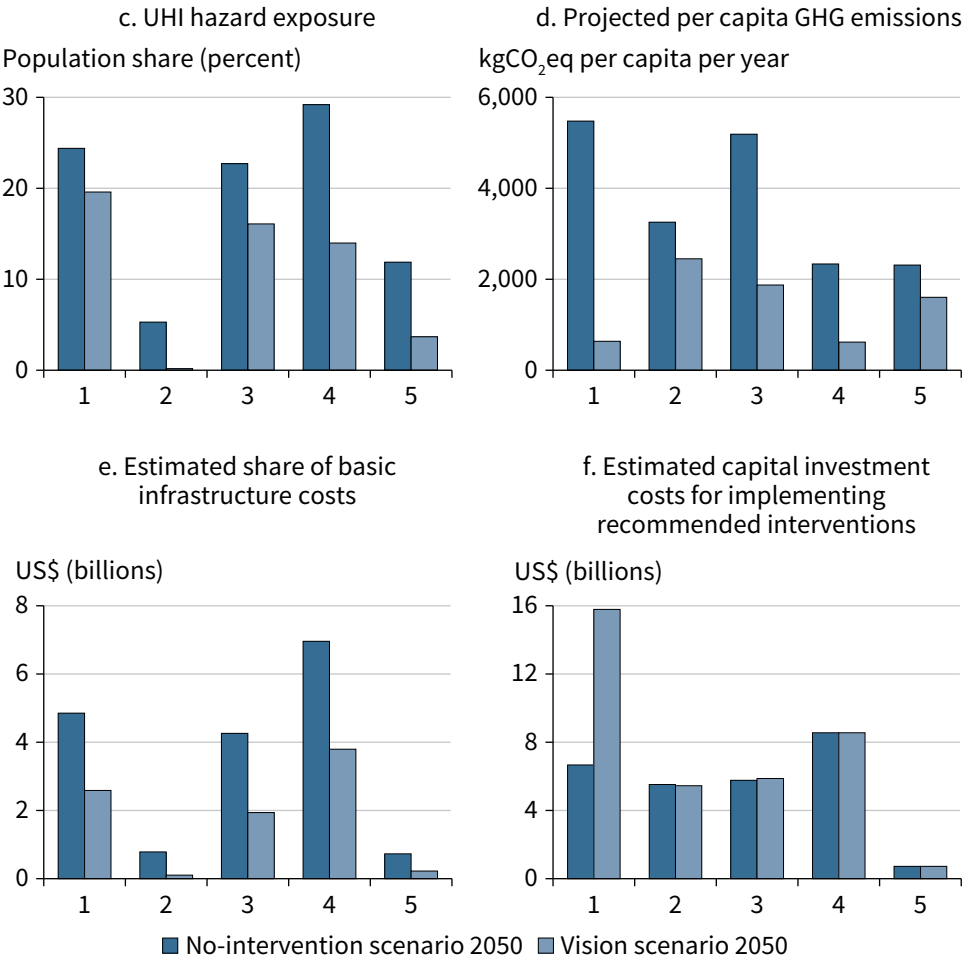
FIGURE 3.4 Projections of outcomes resulting from different scenarios in five Central Asian cities (*continued*)



Source: Original figure for this book adapted from World Bank (Huang, Eisenberg, and Velasco 2024) based on urban performance modeling and SFRARR Population Layer and Hazard Maps (Scaini 2022).
Note: GHG = greenhouse gas; $kgCO_2eq$ = kilograms of carbon dioxide equivalent; UHI = urban heat island.

Other means of reducing investment costs through efficiency

MAINSTREAMING MITIGATION AND ADAPTATION GOALS AND ACTIONS

Rather than only addressing mitigation and adaptation as distinct categories of investment, integrating these goals into investment designs, operation, and

maintenance can raise efficiency. Building assets such as roads, bridges, and buildings to hazard-informed, context-appropriate resilience standards can reduce the need for additional hazard protections (such as flood barriers), reduce the cost of damages and restoration over time, and save costs compared to adding later retrofits. Likewise, integrating energy efficiency goals upfront in buildings is much more efficient than installing later retrofits, and combining efficiency and resilience goals realizes further savings (refer to the background paper for this report [Murray et al. 2025]). Infrastructure that is designed upfront to serve multiple objectives can also reduce costs compared with multiple disconnected projects. This may be achieved, for example, by a "complete streets" approach that combines public and nonmotorized transport (mitigation) with natural drainage, trees for heat protection, and other resilient design measures (adaptation). In Seoul, Republic of Korea, for example, the landmark Cheonggyecheon Restoration Project revitalized a core corridor of the central business district by removing an elevated highway and restoring the stream buried below it, creating a multifunctional green-blue public space that improved flood protection; reduced air pollution; and significantly increased amenity, which, in turn increased property values and business growth in the downtown area (Robinson and Hopton 2011). Adaptive reuse, or repurposing existing buildings for new functions, provides a cost-effective and lower-emission alternative to demolition and new construction. For example, in the Ahmedabad Heat Action Plan (Ahmedabad, India), public buildings, temples, and malls are temporarily transformed into cooling centers during heat waves, providing relief to vulnerable populations (Ahmedabad Municipal Corporation 2019). Planning and budgeting for regular asset management and maintenance are crucial to avoid more costly subsequent repairs or rebuilds and to uphold the efficiency and extend the lifespan of the infrastructure.

TARGETING AND PRIORITIZING INVESTMENTS

Targeting investments based on accurate data and modeling reduces costs. For adaptation investments, knowing the spatial and temporal distribution of flood risk, heat vulnerability, or other hazards, and of vulnerable populations and economic assets, allows adaptation measures to target areas where they are most impactful and cost-effective. For example, transport resilience costs can be greatly lowered by building only flood-resilient transport in flood-prone areas (Rozenberg and Fay 2019), and heat adaptation measures can prioritize densely populated locations with higher predicted heat stress

(Smith 2024). Data and modeling can also inform the selection of more cost-effective measures. The flood protection analysis for this report finds that the same level of flood protection can be achieved at much lower costs by substituting some dikes and levees for nature-based solutions, zoning, and dry floodproofing buildings in appropriate locations. Targeting and prioritization also help reduce costs for mitigation measures. For example, analysis for this report finds that low-cost or cost-free policy measures can reduce transport investment costs and emissions by encouraging compact development. Preparing a GHG inventory helps identify the most cost-effective mitigation actions in any given city.

ALIGNING THIRD-PARTY INCENTIVES

Aligning the incentives of private firms and households to support mitigation and adaptation reduces the need for public investment. Funding and financing strategies themselves can incentivize private actors (and local governments) toward, or away from, low-carbon behaviors, or they can be neutral (Benitez and Bisbey 2025). For example, Colombia uses several policies related to taxes, interest rates, and certification to incentivize green construction (refer to box 3.1). Policies such as carbon, road, and fuel taxes and parking fees raise funds while encouraging low-carbon behaviors. Conversely, waste collection and public transport user fees raise essential funds but discourage low-carbon resilient options. Building codes and zoning can incentivize construction away from flood plains. Extended Producer Responsibility schemes internalize waste externalities for producers, to encourage more efficient use of materials and reduce municipal solid waste management expenses while raising funds. Landfill fees or quotas can encourage recycling, or spur open dumping, depending on the suitability of their design and implementation. Emissions regulations, traffic management, road designs, and parking fees can encourage the use of cleaner transport modes. Reforms to fuel and energy pricing can reduce distortions that lock consumers and producers into inefficient, carbon-intensive technologies. Concession contracts with the private sector, such as for transportation or solid waste management services, should condition payments on the efficient provision of services where feasible. Transfers from central to local governments should also be carefully designed to avoid discouraging private market participation, and to encourage efficient and climate-smart use of funds.

BOX 3.1 Aligning incentives for a green building transformation in Colombia

In Colombia, a combination of government incentives and innovative private sector financing has positioned the country as a regional leader in green construction. In 2015, the Colombian government introduced Latin America's first mandatory green building code, requiring new residential and commercial buildings to meet energy efficiency standards. This regulatory push, reinforced by tax incentives for energy-saving technologies, has created a favorable environment for private sector investment, lowering cost barriers for developers and homebuyers to invest in sustainable buildings.[a]

To further drive market participation, the government introduced innovative financing mechanisms to make green investments more attractive. In 2016, Bancolombia, the country's largest bank, issued Colombia's first green bond, using the proceeds to offer developers loans at interest rates 0.5–2 percent lower than commercial rates, contingent on obtaining preliminary certification from an accredited green building scheme.[b] This model directly aligned financing conditions with climate mitigation objectives, incentivizing developers to integrate energy efficiency into their projects. Five additional commercial banks followed, launching green financial products, such as green mortgages, which offered improved financing terms to encourage homeowners to invest in energy-efficient properties or renovations.[c] By lowering borrowing costs while delivering long-term energy savings, these financial products helped accelerate the adoption of green construction practices while making sustainable housing more accessible.

Industry partnerships were also important in scaling Colombia's green building market. The Colombian Chamber of Construction, in collaboration with the International Finance Corporation, promoted the EDGE certification platform and built green building capacity among developers, banks, and government officials.[d] Between 2021 and 2022, 27 percent of new buildings in the country obtained an EDGE certification. By early 2025, 285,000 EDGE-certified housing units—73 percent classified as affordable housing—have been constructed, representing 19.7 million square meters of certified floor space across 1,053 projects.[e]

(Box continues on next page)

BOX 3.1 Aligning incentives for a green building transformation in Colombia *(continued)*

This transformation has not only attracted over US$11.5 billion in private investment but also generated significant annual savings in energy, water, and greenhouse gas emissions.[f] It demonstrates how aligning public incentives, private investment, and innovative financial instruments can drive sustainable urban development.

a. Cecilia Lozada Andrade 2021.
b. IEA 2024.
c. IFC 2023.
d. Sintali 2023.
e. CAMACOL, n.d.
f. World Bank 2023.

ABSORPTIVE CAPACITY

Increasing capacity to utilize finance where available helps ensure continued access to finance. Even where funding and financing are available, absorption and execution capacity tend to be low at both national and local levels. For example, analysis of World Bank BOOST data for Uganda reveals national underspending of US$370 million versus allocated budgets across three sectors (transport, water, and drainage) over three years.[1] In other words, more than half (55 percent) of the budget for these three sectors (an average of US$123 million per year) remained unused. Similarly, the 2020–21 budget of Kisumu County in Kenya, which contains the third largest city in Kenya, shows only 32 percent execution of their investment budget (comprising transfers from the national government).[2] Failure to implement investments once financed leads to the accumulation of financing obligations (including mounting interest) without the attendant revenue stream, savings, or public benefit, making finance even less sustainable. Ensuring efficient disbursement of finance when available is therefore an important means of securing future finance and reducing overall financing needs.

Notes

1. Analysis of World Bank Uganda BOOST Data for this report, budget years 2009–10, 2015–16, and 2016–17 (Washington, DC: World Bank, 2020). https://www.worldbank.org/en/programs/boost-portal/country-data.

2. The Republic of Kenya, Office of the Comptroller of Budget, September 2021. https://nairobiassembly.go.ke/ncca/wp-content/uploads/paperlaid/2022/COB-ANNUAL-COUNTY-GOVERNMENTS-BUDGET-IMPLEMENTATION-REVIEW-REPORTS-FOR-FY-2020-2021.pdf.

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CHAPTER 4

Funding and financing to meet investment costs

Summary

- Funding is the precursor to sustainable financing. To access repayable finance, cities must first develop nonrepayable funding streams to meet financial obligations and operational and maintenance costs.
- Although climate-specific sources of funding (for example, carbon credits) or financing (for example, green bonds) can support the investments identified in this report, non-climate-specific resources are likely to remain most important.
- National governments have a crucial role in the provision of funding, financing, and a supportive institutional environment.

Funding

- Identifying revenues, savings, and indirect benefits from resilient and low-carbon urbanization is a useful starting point for identifying funding sources for these investments.
- This section presents a framework that cities can use to identify sector-specific funding for resilient and low-carbon urban investments.

- The investments discussed in this report may generate revenues (for example, public transportation fares, waste collection fees, and others) or savings (for example, reduced energy costs and reduced expenditures on roads), which can be used to pay for the investments, at least in part, through various financing mechanisms.
- These investments also produce indirect benefits that can be monetized through carbon markets and land value capture.
- Investing in urban resilience allows the urban economy to continue to grow while weathering climate shocks and other disasters and thus has important social and economic benefits. These externalities are not easily monetized at the level of individual investments but justify the use of public resources.

Financing

- Government entities can issue bonds or debt to finance resilient and low-carbon urban investments from the private sector, local or international development banks, and other sources.
- Several large cities in middle-income countries have successfully issued bonds, including green bonds, although the full costs of green bonds are not necessarily lower than regular bonds.
- Project-level private finance for resilient and low-carbon urbanization can be appropriate for investments that generate sufficient revenue, whereby borrowers have the necessary implementation capacity and operate in a supportive regulatory and institutional environment.

Overview

A step-change in financial mobilization is needed for cities in low- and middle-income countries (L&MIC) to respond to climate change. Not only does this involve expanding access to repayable finance, but it first involves developing funding streams to meet financial obligations and operational

and maintenance costs. This chapter identifies strategies through which stakeholders may enhance funding and financing to meet resilient and low-carbon urban investment costs.

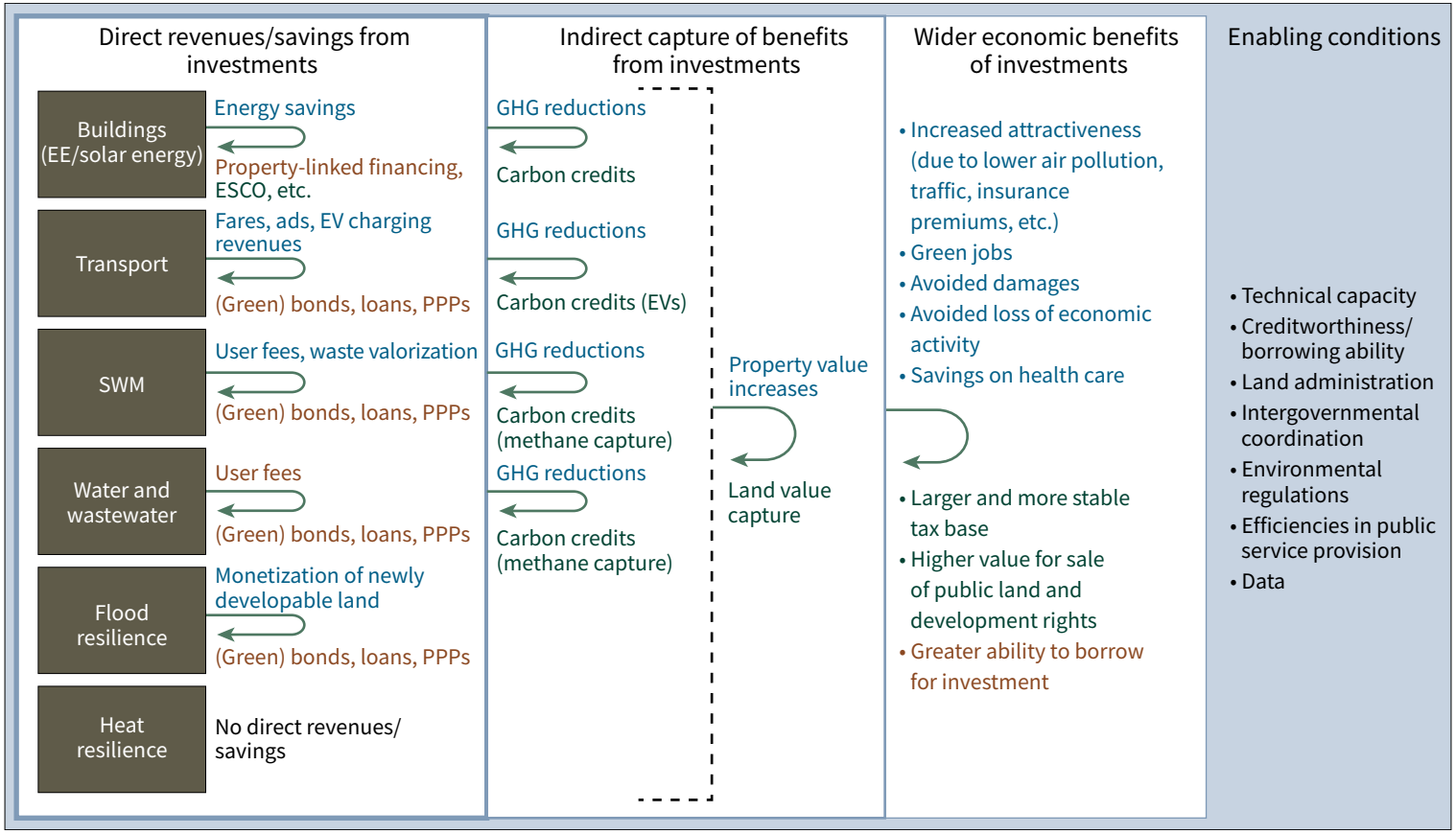
Consistent with recent World Bank reports, this analysis distinguishes "financing" (repayable instruments) from "funding" (nonrepayable instruments). More precisely, "financing" refers to raising money for investments for which remuneration is expected by the finance provider (for example, debt repayment, equity proceeds, or profits/payments under a public-private partnership, or PPP). Any nonrepayable flows (such as grants, fiscal transfers, user fees, and tax revenues) are "funding." Financing relies on funding; financing creates repayment and financing costs over the long term, which must be repaid with funding.

Funding: Sources of funding for resilient and low-carbon urban investments

In order to finance more, one needs to fund better.[1]

Identifying revenues, savings, and indirect benefits from resilient and low-carbon urbanization is a useful starting point for identifying funding sources for these investments. Figure 4.1 presents a framework that identifies how sector-specific resources for resilient and low-carbon urban investments can be identified and developed. The black boxes on the left of the figure represent investments. Blue text shows revenues, savings, or other benefits generated by these investments, which can be monetized and used to directly pay for the investments or to repay finance raised for the investments. Mechanisms to turn those benefits into upfront resources, including repayable financing options, are shown in the figure in red (and discussed in the financing section), whereas nonrepayable funding sources such as carbon credits and land value capture are shown in green. The enabling conditions listed on the right of the figure are needed to facilitate all these mechanisms.

FIGURE 4.1 Framework for funding and financing resilient and low-carbon urban investments



Source: Original figure for this book.
Note: EE = energy efficiency; ESCO = energy service company; EV = electric vehicle; GHG = greenhouse gas; PPPs = public-private partnerships; SWM = solid waste management.

DIRECT REVENUES AND SAVINGS FROM INVESTMENTS

Many resilient and low-carbon urban investments deliver benefits that generate either revenues or savings, which can be used to partially cover the costs of these investments. For example, investments discussed in this report generate revenues such as public transportation fares and waste collection fees and savings such as reduced energy costs and reduced expenditures on roads. These are shown in the first column in figure 4.1 ("Direct revenues/savings from investment") and described in more detail in table 4.1. In some cases, the revenues or savings might be sufficient to cover the entire cost of the investments, for example, building energy efficiency retrofits or flood protection of high-value urban land. However, other revenues, such as metro rail fares or waste collection fees, tend to be much smaller, particularly compared to the capital costs of the associated infrastructure, so they usually only partially cover operational costs. In such cases, investments will need resources beyond direct revenues and savings.

TABLE 4.1 Examples of revenues and savings from investments (blue) and mechanisms with which they can be used to pay for investments (orange)

Sector	Costs	Benefits	Revenues/savings	Monetizing mechanisms
		Revenues		
Buildings	Rooftop solar panel installation	Energy generation	Revenues from sale of solar energy to the grid (where possible)	Borrowing against future revenues (loans/bonds); sharing costs and revenues with private operators through public-private partnerships
Flood resilience	Dikes and levees, nature-based solutions	Property development on previously flood-prone land	Proceeds from property sale/lease	

(Table continues on next page)

TABLE 4.1 Examples of revenues and savings from investments (blue) and mechanisms with which they can be used to pay for investments (orange) *(continued)*

Sector	Costs	Benefits	Revenues/savings	Monetizing mechanisms
Solid waste management	Waste collection and disposal	Service to residents; production of energy, compost, and secondary raw materials	Revenues from waste service fees, landfill fees, and sales of energy, compost, and secondary raw materials	
Transportation	Public transportation infrastructure and services	Service to residents	Fare revenues	
Water supply and sanitation	Water delivery/ wastewater treatment	Service to residents	Revenues from user fees	
Savings				
Buildings	Energy efficiency retrofits; rooftop solar panel installation	Reduced grid-supplied energy consumption for property owners	Savings on energy costs	Property-linked financing, energy service companies, energy service agreements, and others
Solid waste management	Reuse and refill schemes, deposit refund schemes, and sorting/ treatment of recyclable waste subject to Extended Producer Responsibility schemes	Reduced need for waste disposal	Savings from reduced public expenditures on landfill and disposal	Reallocation of budgets
Transportation	Public transportation infrastructure and services	Compact growth supported by public transportation	Savings from reduced public expenditures on road construction and maintenance	

Source: Original table for this book.

INDIRECT BENEFITS FROM INVESTMENTS

Other benefits can be monetized through carbon markets and land value capture. These are depicted in the second column in figure 4.1 ("Indirect capture of benefits from investment") and in table 4.2.

TABLE 4.2 Examples of other benefits of investments (blue) and mechanisms that can be used to pay for investments (orange)

Sector	Costs	Benefit	Positive externality	Monetizing mechanisms
Buildings	Energy efficiency retrofits, rooftop solar panel installation	Reduced GHG emissions	Reduced global climate impacts	Carbon crediting
Solid waste management	Waste prevention measures, waste management operations to reduce GHG emissions			
Transportation	Electrification of public vehicles			
Water supply and sanitation	Wastewater treatment to reduce GHG emissions			
Flood resilience	Dikes and levees, nature-based solutions	Reduced flooding	Increased land value	Land value capture (property tax, tax increment financing, betterment charges, developer exactions, lease/sale of public land)
Heat resilience	Urban greening	Reduced impacts of extreme heat		
Transportation	Public and nonmotorized transportation infrastructure	Time and costs saved by residents on urban mobility		

Source: Original table for this book.
Note: GHG = greenhouse gas.

Carbon credits can improve the financial viability and attractiveness of urban mitigation investments by monetizing the global public goods they create. Reductions in greenhouse gas (GHG) emissions brought about by certain low-carbon urban investments can be monetized through carbon markets, including voluntary markets and compliance markets, such as the trade of mitigation outcomes between countries under Article 6 of the Paris Agreement (refer to box 4.1). Urban local governments around the world have experimented with carbon credits, with some early successes in diverse upper-middle-income contexts. For example, under the Clean Development Mechanism of the Kyoto Protocol, the Municipality of Salta (Argentina) raised funds for a project capturing landfill methane gas by selling carbon credits (World Bank 2007). Similarly, in Moldova, the national government supported 13 municipalities to invest in energy efficiency across public buildings, offsetting the cost by selling the carbon credits generated through the project (World Bank 2016). In India, the Surat Municipal Corporation implemented methane capture at a local landfill, reducing emissions by 1.2 million tons of CO_2 equivalent; the project generated credits that were sold in the voluntary market, funding part of the city's waste management upgrades (TERI 2021). There are also emerging opportunities for cities to benefit from the trade of carbon credits between countries under Article 6 of the Paris Agreement. For example, Switzerland's purchase of Internationally Transferred Mitigation Outcomes from Thailand is allowing Bangkok to purchase 4,000 electric buses and the associated charging infrastructure, in the first such agreement under Article 6.[2] Switzerland is also piloting another project for methane reduction through waste recycling and composting in Ghana, also under Article 6 (UNEP 2025). This initiative is detailed in box 4.2.

BOX 4.1 Voluntary carbon markets

Two types of carbon markets coexist: compliance markets and voluntary markets. Compliance markets are driven by regulatory requirements, in which companies are mandated by country-specific, region-specific, or industry-specific regulatory bodies to purchase carbon credits (allowances and offsets) up to a set volume limit to match their emissions. In contrast, voluntary carbon markets are driven by companies and individuals who

(Box continues on next page)

BOX 4.1 Voluntary carbon markets *(continued)*

commit to reducing their carbon footprints through carbon offsets without any regulatory mandate. Voluntary markets operate in a credibility and reputation-driven environment, with participants motivated by the desire to avoid negative perceptions from customers or investors and to attract sustainability-minded stakeholders. There are no penalties for nonparticipation in the voluntary markets.

According to an assessment by the World Bank, in Thailand and Viet Nam, carbon credits can significantly enhance the financial attractiveness of key urban investments, such as retrofitting buildings to improve energy efficiency, installing rooftop solar panels, upgrading to LED streetlights, and transitioning to electric vehicles. For electric vehicles, carbon credits are particularly advantageous for two- and three-wheelers, for which the credits constitute a larger share of the capital cost, and of these, those used for ride hailing and delivery purposes are more attractive because of intense usage. For these types of investments, the monitoring, reporting, and verification process is straightforward, with tested and approved methodologies that have been in use for the past two decades, developed by the United Nations Framework Convention on Climate Change and used for the Clean Development Mechanism of the Kyoto Protocol.

The carbon intensity of a city's electricity (both existing and future) is a critical factor in determining the mitigation potential of activities. For example, in a city with high-carbon electricity, the electrification of vehicles has lower mitigation potential, whereas energy efficiency retrofits of buildings, which reduce electricity consumption, have higher mitigation potential than they would in a city with a low-carbon grid.

Carbon credits, combined with energy savings, can greatly enhance the financial viability of small-scale projects. Aggregating emission reductions from individual interventions, such as a single rooftop solar installation, often incurs high transaction costs for packaging and selling credits on carbon markets. This challenge is especially pronounced in low- and middle-income cities, where underdeveloped market participation further raises costs and reduces financial returns from isolated projects. However, when small-scale interventions are

(Box continues on next page)

BOX 4.1 Voluntary carbon markets *(continued)*

aggregated into a portfolio of thousands, the scale can justify the transaction costs, making it possible to tap into carbon markets and secure the additional financial returns needed to make these projects viable. City governments can play a critical role by enabling the aggregation of interventions across both public and private assets at scale, which can significantly improve the financial attractiveness of these efforts. In many cases, savings from reduced energy consumption would remain the main driver of energy efficiency or renewable energy investments, but carbon credit revenues can serve as a secondary incentive, especially in places with higher carbon intensity, acting as a "cherry on top" of the energy savings. By strategically leveraging their influence, city governments can help streamline participation in voluntary carbon markets, making it crucial to invest in building their capacity to lead and coordinate such initiatives.

Carbon markets also often require robust monitoring, reporting, and verification systems. Many cities in low- and middle-income countries lack the necessary infrastructure. Addressing this requires well-designed capacity-building programs, such as the World Bank's Carbon Initiative for Development, which supports small-scale urban projects in Africa and Asia.

Carbon markets, both international compliance and voluntary, are at an inflection point. With several outstanding issues on Article 6 recently resolved at the 29th Conference of the Parties to the United Nations Framework Convention on Climate Change, commonly known as COP29, expectations are high for its operationalization in the coming years (particularly under Article 6.4, the successor to the Clean Development Mechanism).[a] In voluntary markets, there has recently been a significant drop in the market value of traded carbon credits, from US$1.9 billion in 2022 to US$723 million in 2023, primarily attributed to environmental integrity concerns. Prices also remained low overall in 2023, at about US$6.53 per metric ton of CO_2 equivalent on average compared with US$7.37 in 2022.[b]

Concerns regarding the credit quality of some project types and integrity of claims made against the use of credits for meeting corporate climate commitments have played a role in this reduction, alongside

(Box continues on next page)

BOX 4.1 Voluntary carbon markets *(continued)*

macroeconomic pressures. There are ongoing efforts by a variety of stakeholders to restore trust and transparency in carbon markets. This includes the Engagement Roadmap for Carbon Markets, launched by the World Bank at COP28.[c] Through the roadmap, the World Bank is working with key stakeholders in the carbon market ecosystem to address critical bottlenecks impeding growth of these markets and building country capacities to develop high-integrity markets.

a. World Bank 2020.
b. Ecosystem Marketplace 2024.
c. World Bank 2023b.

BOX 4.2 Ghana's participation in global carbon markets[a,b]

Ghana's National Clean Energy Access Programme (NCEP), initiated by its Environmental Protection Agency, aims to increase access to clean and affordable energy in line with Ghana's Nationally Determined Contributions to climate action. The program leverages Article 6 of the Paris Agreement, which facilitates cooperation between countries to meet their climate goals. In 2020, a bilateral agreement with Switzerland enabled Swiss companies to finance projects under the NCEP in return for internationally transferred mitigation outcomes.

The KliK Foundation, responsible for offsetting a portion of Switzerland's transportation emissions, has committed approximately US$700 million to the NCEP for project investments, with an additional US$150 million expected from carbon credit revenues. The foundation's investments under the NCEP cover a range of sectors, including clean cooking, sustainable agriculture, and renewable energy.

Key to the NCEP's strategy is a digital measurement, reporting, and verification platform that tracks solar photovoltaic (PV) generation and emission reductions, along with a solar PV rooftop program supporting up to 1 megawatt of capacity. From 2021 to 2030, the NCEP aims to prevent the emission of 350,000 tons of CO_2 equivalent.

(Box continues on next page)

BOX 4.2 Ghana's participation in global carbon markets[a,b] *(continued)*

Addressing the challenge of perceived risk in renewable energy projects, the NCEP offers performance-based payments for emissions reductions and supports securitized loans with concessional terms to improve access to financing. This approach aims to create a more attractive investment environment and promote the uptake of clean energy solutions.

Expanding on the NCEP's framework, the government of Ghana has approved the transfer of mitigation outcomes for a second project to Switzerland at COP28. This project focuses on sustainable composting to reduce methane emissions, with plans to establish four composting facilities that will improve organic waste management, reduce environmental health risks, and support commercial waste initiatives.

a. UNDP 2023.
b. IEA 2023.

Carbon crediting is most applicable to investments that result in clearly quantifiable and attributable emissions reductions, for which there are well-established monitoring, reporting, and verification protocols. These include building energy efficiency and rooftop solar energy investments, electrification of public vehicles, and solid waste and wastewater investments that reduce GHG emissions. Digital monitoring of emissions, for example, by using sensors and online software platforms, can help measure and verify emissions reductions from some investments, in turn facilitating the generation of carbon credits at reduced transaction costs. Carbon credit opportunities are less well established when emissions reductions are more difficult to quantify and attribute, for example, in the case of new metro rail systems, which result in broad modal shifts.

Increases in land value brought about by investments can help pay for the investments. Most of these investments—public and nonmotorized transportation investments, waste collection, flood protection, urban greening, and others—bring about local benefits in terms of quality of life, which increase local land values. Even investments that may reduce land values in their immediate vicinity, such as waste and wastewater treatment

plants, would increase land values in the areas served by them. These land value increases can be "captured," that is, made available to pay or repay the cost of these investments, in various ways. If property values are assessed accurately and taxed efficiently, the increased value should translate into increased property taxes, which can help recover costs to general municipal budgets. However, more targeted land value capture instruments may also be used at the individual project level, including tax increment financing, betterment charges, developer exactions, and others (table 4.3). Cities or implementing agencies may also acquire land prior to making the investments and then lease or sell it once its value has increased because of the investments. For example, the metropolitan rail network in Hong Kong SAR, China, is largely funded through the value of real estate immediately around and above rail stations (refer to box 4.3).

TABLE 4.3 Examples of land value capture instruments

Instrument	Description	Context in which instrument is used
	Voluntary participation	
Air rights contracts	Rights to use the space above land to build a private property	Used in Canada, France, India, the Philippines, Poland, the United States, and by government entities managing transit-oriented development
Conversion fee	Conversion of land classified as nondevelopable for development	Used in India, Indonesia, and the United States
Land/property sale	Sale of ownership of vacant or underused municipal land or property	Widely used
Land readjustment	Government reparcels and regularizes privately owned land in predefined area; reserves spaces for public use and infrastructure; some sites pay for infrastructure; and returns smaller but more valuable plots to previous owners	Ethiopia, Germany, India, Japan, the Philippines, and Republic of Korea
Leases or concessions	Contract allowing a private sector tenant rights to use a site for a period of time, for a payment	Widely used for short-term leases of vacant municipal land/property; less for commercial investments

(Table continues on next page)

TABLE 4.3 Examples of land value capture instruments *(continued)*

Instrument	Description	Context in which instrument is used
PPPs/joint development agreements	Joint development between municipality and developer for private and/or public use on municipal land	Cost-sharing joint development agreements for delivering public-use facilities widely used in OECD countries (as PPPs)
Sale of development rights/density bonuses	Rights that allow a developer or property owner to exceed the base zoning density in exchange for a payment or an in-kind contribution of public use facility (such as public spaces)	Some cities in Brazil, some big cities in many OECD countries, and Singapore
Mandatory participation		
Betterment charge	One-time charge for increase in property value from new infrastructure	Israel, a few cities in Latin America, and Spain
Developer charge/ exaction	One-time contribution of land for public facilities/infrastructure in exchange for development rights	Widely used for funding off-site infrastructure and municipal services
Local property tax	Mandatory recurrent tax levied on land, buildings	Africa (25 countries), Asia (24 countries), Canada, Europe (33 countries), Latin America (16 countries), and the United States
Real estate capital gain tax	Levied on increase in property value from its initial purchase	Canada, Pakistan, and the United States
Real estate transfer tax	Levied upon completion of transaction	Australia, France, Japan, Russian Federation, Türkiye, the United Kingdom, and the United States
Special assessment district	Recurrent fee to recover infrastructure costs from property owners in designated area	The United States, for medium/ large-scale infrastructure development (roads, water)
Tax increment financing	Assigning revenues collected from increased tax base to designated area for development	The United States, for medium/ large-scale infrastructure, urban regeneration, environmental rehabilitation

Source: Original table for this book adapted from Kaganova, Peteri, and Kaw 2024.
Note: OECD = Organisation for Economic Co-operation and Development; PPPs = public-private partnerships.

BOX 4.3 The Rail + Property model[a,b]

The Mass Transit Railway Corporation (MTRC), a publicly listed company with the government of Hong Kong SAR, China, as its main shareholder, provides a significant portion of the city's public transportation. The MTRC's Rail plus Property (R+P) model is a strategic approach that combines property development with the expansion of the transit system. By acquiring land at predevelopment prices and leveraging the increased value postdevelopment, particularly for commercial properties near new stations, the MTRC has established a substantial revenue stream that frequently exceeds revenues from its transit services.

The R+P model facilitates the construction of new railway lines and the planning and creation of integrated commercial and residential communities along the railway alignment, which in turn enhances land values and increases ridership. The profits from property sales are used to finance new railway projects, enabling the MTRC to maintain reasonable fare levels without resorting to government subsidies. This model is a well-executed example of the effective use of land value capture mechanisms, such as land sales, joint development, leasing of development rights, and commercial leasing near stations, which are viable in cities where the government can offer land under favorable terms.

However, this model is not easily replicable. For example, the Guangzhou Metro Corporation's (GMC) efforts to adopt the R+P model have met with significant challenges. Policy limitations and a disconnect with public transport–oriented development objectives have hindered the model's successful replication. Despite the GMC's control over land, high redevelopment costs and a competitive real estate market have posed substantial barriers. Although the corporation has expanded its revenue sources through station-based advertising and commercial leases, these measures have not fully realized the potential of the R+P model.

a. Salon and Shewmake 2011.
b. MTR Corporation 2024.

The implementation capacity needed for land value capture varies by instrument. A relatively simple form of land value capture is the sale or lease of public land for which value has increased as a result of public investments in the surrounding area. The collection of property tax can be a form of land value capture, because the value of land, and the corresponding tax that can be collected on it, can be increased by public investments. However, although most cities are empowered to collect property tax, challenges related to property records, valuation, and governance have prevented cities in L&MICs from taking full advantage of it (Kelly, White, and Anand 2020). Other forms of land value capture that involve the collection of taxes and fees face similar challenges and may also require special legislation to enable their use. For example, Colombia's experience with its betterment levy demonstrates that, despite the complex methodology for assessing and distributing the levy, it can raise substantial revenues when there is a clear link between public benefits and property owners' willingness to pay (Borrero 2011). Many land value capture instruments require trust among property owners, and between property owners and public authorities, which are lacking in many L&MICs. For example, land readjustment schemes often require landowners to agree to reduce the size of their land parcels for authorities to build infrastructure and sell some land to recover infrastructure costs. This requires landowners to coordinate among themselves and to trust that the public infrastructure will be built in a timely manner, which can be challenging, especially in contexts without an established history of such schemes.

WIDER ECONOMIC BENEFITS OF RESILIENT AND LOW-CARBON DEVELOPMENT

Urban investments can generate positive economic feedback loops that grow and stabilize the fiscal capacity for further investment. Some of these are listed in the third column in figure 4.1 ("Wider economic benefits of investments"). Investing in urban resilience allows the urban economy to continue to grow while weathering climate shocks and other disasters and thus has important social and economic benefits. Developing efficient public and nonmotorized transport services supports economic activity and reduces local air pollution and traffic, in addition to its benefits for climate change mitigation. These investments, along with improvements in solid waste management (SWM), greening of public spaces, and others, make a city more attractive, particularly

to high-skilled workers who can boost a city's economy. Some of these benefits can be partially monetized through land value capture, but not entirely.

Resilient and low-carbon investments also create green jobs. Many of the investments discussed in this report create more jobs than the number created by the same amount of investment in other types of infrastructure in the same sectors. For example, an investment of US$1 million in energy efficiency (green construction and retrofits) is estimated to create between eight and 21 jobs, compared to three jobs created by the same investment in fossil fuel industries. A US$1 million investment in public transport and electric vehicles creates 15–28 jobs, compared to eight jobs if spent on road construction. US$1 million invested in nature-based solutions (tree planting, restoration, and management) creates 40 jobs, whereas the same amount spent on gray water infrastructure creates 20 jobs. Many of these green jobs can be done by urban residents with limited training, for example, tree planting and recycling (Gulati et al. 2020).

These wider city-scale economic benefits justify the use of public funds for investments, which cannot be easily monetized at the level of individual investments, but they can create revenue streams or savings to help offset public funds invested, for example, central government tax revenues, intergovernmental transfers, proceeds from leasing or selling public land, and others. Savings from phasing out carbon-intensive subsidies, such as fuel subsidies, can also be redirected toward resilient and low-carbon investments, yielding a double climate benefit without additional costs (World Bank 2022a, 2023a).

APPLYING THE FUNDING FRAMEWORK TO SECTORAL INVESTMENTS

Matching specific investments to specific funding sources can help unlock resources for resilient and low-carbon urbanization. Resilient and low-carbon urban development involves a wide range of investments across sectors with varying characteristics. The investments vary in terms of their size, their potential for generating revenues and savings, whether they produce externalities, whether climate-related costs are separable from baseline costs, whether they involve larger upfront costs or recurring costs, whether they require action by one or many actors, and others. As a result, different sectors,

and even different investments within each sector, are suited to different financial solutions, as discussed in detail in the following sections.

Funding building energy

Well-selected energy efficiency and rooftop solar investments in buildings generate sufficient savings to pay for themselves over time. The energy cost savings over time usually exceed the cost of energy improvements, which means that building owners and others can use various means for these savings to pay back the initial costs. For example, private energy efficiency service providers (such as energy service companies) can secure commercial debt financing to implement an energy efficiency project on behalf of a building owner and then repay the loan from the savings generated by the improvements (Derbyshire and Limaye 2014). In the case of public buildings, budgeting agencies can allocate financing for energy upgrades through the budgetary process and then scale back future energy allocations to capture energy cost savings. Publicly owned energy efficiency revolving funds can provide financing to building owners for energy efficiency investments, who repay the loans through energy savings. Under "utility on-bill financing" schemes, utility companies finance energy upgrades and then recover their investments through utility bills. "Property-linked financing" is a similar mechanism by which costs are recovered through property tax bills rather than utility bills. Energy service agreements (ESAs) are yet another variation. Under ESAs, building owners continue paying their energy bills at baseline (pre-retrofit) amounts. The energy provider is paid for only the actual energy consumed by the buildings, whereas the remaining amount, that is, the savings brought about by the energy efficiency retrofit, is repaid to the financier (Singh 2018). For example, the Renewable Resources and Energy Efficiency, or R2E2 Fund, established by the national government in Armenia finances municipal building energy retrofits through an ESA (World Bank 2014).

Despite the cost-effectiveness of building energy improvements, other challenges exist. Although the savings on energy costs generated by these investments over time are often greater than the upfront cost of the investments, this does not always mean that the investments are made. Many building owners lack the upfront capital, knowledge, or capacity to make the necessary investments, particularly in existing buildings. The fact that building energy efficiency is not easily observable makes it difficult to sell (or build into

rental prices), which in turn disincentivizes investment by developers. In the case of public buildings, incentives may be misaligned, because the entities making decisions about building designs or improvements may not be the ones paying energy bills.

Governments can encourage energy efficiency in new and existing buildings through their roles as regulators and large property owners. Governments can implement and enforce building codes, pertaining either to the design of specific components of a building or to its overall energy performance standards (World Bank 2024). Among other benefits, improved energy efficiency reduces peak electricity demand, allowing significant savings in power sector investments (World Bank 2022b). Over time, compliance with such codes forces the construction industry to develop and adopt energy efficiency measures at a large scale, mainstreaming efficient practices and reducing costs. Governments enacting new construction codes need to ensure that they simultaneously develop the technical capacity and dedicate the budgetary resources necessary to monitor compliance with these codes, which is often a greater challenge than creating them (Hallegatte, Rentschler, and Rozenberg 2019). Public sector institutions are also large and prominent building owners, which means that energy improvements in public buildings can have a large impact on GHG emissions while also raising public awareness and stimulating changes to construction practices and products on energy upgrades.

Funding flood resilience

Flood protection measures protect the loss or degradation of existing urban assets, unlock significant land value, avoid loss of economic activity, and protect human life and health. These measures can allow cities to continue to perform their economic functions amid risks and protect assets from damage or destruction. Flood protection can increase the usability and attractiveness of urban land, improving land values and making funding through land value capture possible as a result. For example, flood barriers allow property development on land that may otherwise be too high risk, with cities partnering with private developers to develop the land and protective infrastructure. Flood protection investments can also pay for themselves through more indirect forms of land value capture, such as taxes and betterment charges. In some cases, particularly near city centers, the land value appreciation brought about by flood protection investments could

be equivalent to the cost of the upfront investments (Avner et al. 2021). By safeguarding valuable assets, flood barriers can also reduce the need for repairs and rebuilding, generating savings that can be used to repay financing or increasing access to insurance products.

Some flood protection measures consist of building new infrastructure in a more resilient manner, which may not incur significant costs, especially when resilient construction techniques are mainstreamed. These include the incremental costs of improving the flood resilience of investments in urban transport and water infrastructure. Because these adjustments cost a relatively small fraction of the overall investment cost and must be integrated into wider engineering designs and plans, they are likely to be financed along with the infrastructure itself, by the same investor, whether public or private. Although resilient design and construction may require some early public investment in the development of standards and training in resilient techniques, they may not incur significant costs after they become mainstream. As with flood barriers, resilient design and construction can reduce lifecycle costs of repair and rebuilding, generating savings that can be used to repay financing or increase access to insurance products.

Funding heat resilience

Heat resilience interventions can save lives at relatively low cost. Although these are equivalent to only a small fraction of investments needed in other sectors, they can nonetheless be lifesaving during heat waves, which suggests that these measures should be prioritized globally as "low-hanging fruit" (Roberts et al. 2023). This is particularly the case considering that these types of interventions, namely, early warning systems and heat action plans, have relatively low take up at a global scale and that heat-related deaths continue to rise worldwide (Zhao et al. 2024). Despite their relative affordability, heat resilience interventions require careful coordination and sustained funding. They involve collaboration across multiple stakeholders, such as transportation departments (for planting and maintaining street trees), public health departments and medical facilities, as well as schools and eldercare facilities that cater to vulnerable groups. Recurring expenditures, rather than large upfront costs, mean that they require ongoing budgetary support as opposed to one-time project finance. Although heat resilience measures are usually not monetized, their benefits to the local economy in terms of avoided

losses from illness and death are likely to exceed their costs (Toloo et al. 2013; Williams et al. 2022). Private property developers or owners can be incentivized or required to plant or pay for nearby street trees. This would be a form of land value capture, because trees would not only lower temperatures but also improve property values. However, public funding would likely still be needed, especially in lower-income areas.

Funding municipal solid waste management

The level of ambition for SWM services is guided by operating costs more than capital investment costs. SWM is not just a basic municipal function but can also be a key contributor to resilient and low-carbon urbanization, because it can help reduce flood risk by reducing blockages in drainage systems, as well as reducing methane emissions. SWM is also essential for a circular economy, by channeling materials and resources toward further utilization and back into the economy. Although there are some more capital-intensive investments in the waste sector, such as sanitary landfills, advanced waste treatment, and waste-to-energy plants, ongoing collection and disposal services make up a larger share of costs than capital projects.

SWM is funded mainly through general municipal budgets in L&MICs, and to a smaller extent by user fees and revenues from the sale of recyclable waste commodities and energy produced. SWM represents a significant municipal budgetary expense, estimated to be in the range of 20 percent of municipal expenditures in low-income countries, 10 percent in middle-income countries, and 4 percent in high-income countries on average (Kaza et al. 2021). Waste collection fees typically only cover a small share of the costs of SWM service delivery in L&MIC contexts, owing to a combination of low user payment capacity, weak administration, and strong externalities present in waste management. Waste recycling and recovery could generate additional revenues for local authorities through the sale of produced secondary raw materials, compost, and energy generated from waste, but such revenues are unlikely to pay for most SWM operating costs. However, these, together with the avoided disposal costs and external economic benefits, could be significant at the level of individual waste management facilities and operations, such as separate waste collection, composting, material recovery facilities, and waste-to-energy plants. The SWM analysis conducted for this report estimates that these revenue sources currently cover less than 10 percent of annual SWM costs (operating

costs plus depreciation of assets) in all L&MICs combined, which may increase to a little over 20 percent by 2050. However, in certain cases, the combination of user fees and energy sales may be significant. For example, Belgrade, Serbia, built a waste-to-energy facility using a PPP, in which 20–25 percent of project finance come from private investors who are being repaid through user fees and sales of energy and heat generated by the landfill.[3]

Regulations, taxes, and carbon crediting can help reduce or repay public SWM expenditures. Extended Producer Responsibility schemes, which make manufacturers of certain products responsible for the management of resulting waste streams, such as packaging waste, electrical and electronic equipment, spent batteries, used tires, and end-of-life vehicles, can help reduce public SWM costs and are now in place in several middle-income countries. The use of economic instruments such as landfill taxes, product taxes on materials such as plastic bags and other single-use plastics, and deposit return schemes could play a substantial role in the future. Carbon crediting has been used to fund certain SWM activities, such as landfill gas capture and waste-to-energy production (refer to the "Indirect Benefits from Investments" section), but is less applicable to support other activities within the waste hierarchy, such as waste prevention, reuse, and recycling, which also show significant potential for GHG reduction.

Funding transportation

The large size and positive externalities of urban transportation investments mean that they usually require public funding from general sources. Although public transportation investments generate some direct revenues, mainly in the form of transit fares, these cannot fully pay the operating costs (covering about 75 percent of operating costs on average), let alone the massive capital investment costs (Pulido and Portabales Gonzalez 2015). As a result, in L&MICs, finance repaid through general government funds is typically required for large transportation investments.

However, cities should explore opportunities for land value capture and carbon crediting. Transportation investments enhance land values in surrounding areas, and thus financing can be partially serviced using funds from land value capture. This could include the sale or lease of public land close to transit stations whose value is increased by transit investments.

Other mechanisms such as betterment charges, tax increment financing, and others are also possible but require a relatively high level of capacity in terms of land use planning and tax collection. Carbon crediting has also been used to indirectly capture the benefits of urban transportation investments in some cases. As mentioned, Bangkok is purchasing 4,000 electric buses through the sale of carbon credits from Thailand to Switzerland under Article 6 of the Paris Agreement. Cities can also subsidize emissions reductions from electrification of private vehicles, aggregate these emissions reductions, and sell them as carbon credits on international voluntary markets, recovering the cost of the original subsidies.[4] However, carbon crediting may not be well suited to all transportation investments, mainly because of the complexities of quantification methodologies. For example, although it is possible to quantify and attribute emissions reductions generated by switching from diesel buses to electric buses, it is less straightforward to do so for emissions reductions resulting from citywide shifts from existing modes to a proposed new metro system. As a result, carbon crediting has generally not been sufficiently explored for metro rail investments.

Coordinating transportation infrastructure and land use can help lower emissions, reduce costs, and increase revenues. Coordinating public transportation and land use is essential to achieving a shift away from private vehicles, or discouraging the widespread adoption of private vehicles in cities where this has not yet happened. This reduces GHG emissions and increases revenue from fares. Convenient and reliable public transportation that is spatially coordinated with urban density also discourages urban sprawl, which reduces the need for public expenditures on the construction and maintenance of roads and other infrastructure. Finally, it enables land value capture by maximizing the demand for land near transportation investments (refer to box 4.3).

Funding water and wastewater

The public sector remains the main source of funding for water and wastewater in many L&MICs. The provision of water and wastewater services generates revenues through tariffs (user fees), which are important not only as a funding source but also for ensuring accountability on the part of service providers. Reforming tariffs is often an important first step to reducing public costs to the extent possible. However, water tariffs are usually set below cost recovery levels, to ensure affordability and political acceptance, and because of the positive

externalities generated by service provision in the sector (for example, local public health benefits, reduced methane from untreated wastewater). This necessitates subsidies from public budgets. As a result, most investment in the sector is publicly funded, with only 8 to 9 percent of project-level infrastructure investments provided by the private sector, according to a recent World Bank report (Joseph et al. 2024). Low efficiency in the sector in many countries results in losses and low utilization of currently available budgets. Addressing these issues can help reduce the need for new infrastructure investments.

Financing: Sources of finance for resilient and low-carbon urban investments

Most investments discussed in this report are likely to be financed through sources not exclusively targeting climate adaptation or mitigation. In many cases, financing challenges are not specific to climate action but rather affect all urban financing. These general challenges of urban financing are discussed at length elsewhere (refer to box 4.4), so this chapter focuses instead on the subset of financing sources and opportunities that are particularly relevant for resilient and low-carbon urban investments.

BOX 4.4 Additional readings on financing solutions for urban investments

There is considerable literature on financing urban investments. Following are key references that readers may consult for additional information.

Subnational finance

- *Subnational finance for climate-related investments*
  - Barbara Samuels and Emilie Maehara. 2025. *How National Governments Can Increase Finance for Subnational Climate Action.* "Report in Support of the COP28 Presidency Initiative Coalition for High Ambition Multilevel Partnerships (CHAMP)," C40, GCOM, and Bloomberg Philanthropies. https://www.c40.org/wp-content/uploads/2025/02/CHAMP-Guidebook-Executive-Summary.pdf.

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BOX 4.4 Additional readings on financing solutions for urban investments *(continued)*

- ❍ White, Roland, and Sameh Wahba. 2019. "Addressing Constraints to Private Financing of Urban (Climate) Infrastructure in Developing Countries." *International Journal of Urban Sustainable Development* 11 (3), 245–56. https://doi.org.10.1080/19463138.2018.1559970.
- ❍ World Bank and UNCDF (United Nations Capital Development Fund). 2024. *Local Governments Climate Finance Instruments—Global Experiences and Prospects in Developing Countries.* Washington, DC: World Bank.

- *General subnational finance*
  - ❍ Farvacque-Vitkovic, Catherine, and Mihaly Kopanyi, eds. 2014. *Municipal Finances: A Handbook for Local Governments.* Washington, DC: World Bank.
  - ❍ World Bank Group. 2025. *Unlocking Subnational Finance: Overcoming Barriers to Finance for Municipalities in Low- and Middle-Income Countries.* Washington, DC: World Bank. http://hdl.handle.net/10986/43104.

Sector-specific financing publications by the World Bank:

- *Transportation*
  - ❍ Benitez, Daniel, and Jyoti Bisbey. 2025. *Financing Climate Action for Transportation in Developing Countries.* Washington, DC.
  - ❍ Pulido, Daniel, and Irene Portabales Gonzalez. 2015. *Boosting Mass Transit through Entrepreneurship: Going Beyond Subsidies to Reduce the Public Transport Funding Gap.* Washington, DC.
  - ❍ Suzuki, Hiroaki, Jin Murakami, Yu-Hung Hong, and Beth Tamayose. 2015. *Financing Transit-Oriented Development with Land Values.* Washington, DC.

- *Energy efficiency*
  - ❍ Derbyshire, William, and R. Dilip. 2014. *Financing Municipal Energy Efficiency Projects.* Washington, DC.

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BOX 4.4 Additional readings on financing solutions for urban investments *(continued)*

- ESMAP. 2014. *Improving Energy Efficiency in Buildings: Mayoral Guidance Note #3*. Washington, DC.
- Singh, J. 2018. *Energy Efficiency in the Public Sector.* Washington, DC.

- *Solid waste management*
  - Kaza, Silpa, Lisa Congyuan Yao, Perinaz Bhada-Tata, Frank Van Woerden, Theirry Martin, Rene Michel, et al. 2018. *What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050.* Washington, DC.

- *Water and wastewater*
  - Joseph, George, Yi Rong Hoo, Qiao Wang, Aroha Bahuguna, and Luis Andres. 2024. *Funding a Water-Secure Future: An Assessment of Global Public Spending*. Washington, DC.
  - Khemka, Rochi, Patricia Lopez, and Olivia Jensen. 2023. *Scaling Up Finance for Water. A WBG Strategic Framework and Roadmap for Action*. Washington, DC.

To close financing gaps, cities and national governments will need to strengthen their readiness for commercial financing and to optimize their use of different financing sources according to the nature of cities and projects. Although private lenders and investors have pledged trillions of dollars for climate mitigation and adaptation, L&MICs have struggled to attract such resources to the types of urban investments considered in this report. Attracting private finance requires the right combination of financing demand (creditworthiness, absorptive capacity to prepare and execute projects, and bankable projects), supply (the depth and character of the financial sector), and the mediating environment (de jure and de facto qualities of the institutional environment that mediate supply and demand, such as the policy and regulatory framework for borrowing or PPPs). Cities cannot attract the financing required without addressing demand-side factors and the regulatory environment. Private finance also requires bankable projects, and public finance is often needed because of project-level factors such as low end-user repayment capacity and the presence of externalities, as discussed in the section on funding.

GENERAL OBLIGATION BORROWING FOR RESILIENT AND LOW-CARBON INVESTMENTS

(Green) bonds for urban investments

Cities in L&MIC face several challenges that make borrowing for urban investments difficult. On the demand side, governments (especially at the municipal level) in L&MICs are often insufficiently creditworthy, because of limited revenue streams, weak financial management, higher currency risk, and overall sovereign debt risk. Of the 100 largest cities in developing countries, only 38 are currently rated as investment grade by an international or local rating agency, of which only 13 are in low-income or lower middle-income countries. Only 34 cities in 11 L&MICs have issued a bond at the municipal level (World Bank, forthcoming). Borrowing must also account for debt ceilings and absorptive capacity. Macroeconomic instability, political risks, and regulatory uncertainty in L&MICs further deter investment and raise borrowing costs, whether at local or national levels. On the supply side, local capital markets are underdeveloped in many L&MICs, with limited liquidity and participation. The costs associated with issuing bonds—such as obtaining credit ratings, meeting regulatory requirements, and ensuring transparency—can be prohibitively high, particularly for capacity- and resource-constrained L&MIC municipalities, and demands for green bond issuance are even more stringent. Many municipalities in L&MICs lack the technical expertise and institutional capacity to design, structure, and monitor green projects aligned with international standards, such as those set by the Climate Bonds Initiative.

Despite these challenges, some creditworthy municipalities in middle-income countries have successfully experimented with debt, including green bonds. The issuance of green bonds (that is, those that are used to invest in green projects) reached US$700 billion in 2023. Although L&MIC cities captured less than 5 percent of this volume (OECD 2023), there are several examples of the use of green bonds for urban investments in various middle-income countries. Johannesburg's green bond issuance (US$140 million) in 2014 was one of the first successful green bond issuances in Africa and demonstrated a replicable model for financing urban sustainability in Africa. Funds were allocated to solar water heaters, biogas to energy conversion, and energy efficiency improvements in municipal buildings. Following this, the city of Cape Town raised US$76 million through a green bond issuance in 2017

to fund water management, low-carbon transport, coastal protection, and energy efficiency projects. More recently, subnational governments in India have raised capital for green projects through green bonds: Ghaziabad Nagar Nigam, a civic body in Uttar Pradesh, raised a US$20 million issuance in 2021, and the Indore Municipal Corporation raised a US$87 million issuance in 2023.[5] Green bonds issued by national governments can also be used to finance urban infrastructure. For example, the Dominican Republic recently issued its first sovereign green bond, raising US$750 million to invest in low-carbon urban public transport such as monorails, metros, and cable cars; efficient and resilient water and wastewater management; and other investments.[6]

Green bonds are not necessarily less expensive for issuers. Interest rates on green bonds are not consistently lower than those on regular bonds. Even when they are, green bonds include additional expenses such as legal fees, certification costs, and administrative expenses related to a green bond's issuance, which diminish the benefit of a lower interest rate. Nonetheless, green bonds may come with other benefits. For example, the Dominican Republic's green bond helped diversify the investor base, attracting European investors who might not have otherwise invested. In China, the government provides various incentives and favorable policies for green bond issuers, which are not available for regular bonds (refer to box 4.5).

BOX 4.5 Financing low-carbon infrastructure in Chinese cities with green bonds

For decades, local government revenues from land sales financed much of China's urban infrastructure. However, in the recent transition toward low-carbon urban infrastructure, the financing structure has shifted from a heavy reliance on land-based approaches toward more market-oriented vehicles. Although precise data are difficult to obtain, the main sources of financing are government budgets, including transfers from national and provincial governments, commercial bank loans, green credits, green bonds, multilateral development bank (MDB) loans, and international grants.

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BOX 4.5 Financing low-carbon infrastructure in Chinese cities with green bonds *(continued)*

China's green bond market has grown rapidly since the first issuance in 2015 and has become an important source of financing for low-carbon urban infrastructure. By the end of 2023, China had issued US$616 billion of labeled green bonds in domestic and overseas markets, of which nearly US$372 billion met the Climate Bonds Initiative's green definition.[a] Approximately 30–40 percent of China's green bonds directly support low-carbon urban projects, including renewable energy, public transportation, energy-efficient buildings, and sustainable water management.[b] Green bonds have gained popularity in Chinese cities because of the access to a broader investor base, both domestic and international, and lower borrower costs, especially for officially labeled green bonds.[c] In addition, the Chinese government has prioritized the development of a green financial system, providing incentives and favorable policies for green bond issuers, including subsidies, tax breaks, or technical support, which are not available for regular bonds.

Certain enabling conditions have supported the successful issuance of green bonds for urban infrastructure in China. These conditions include the following:

- Policies and regulations that provide financial incentives
- Clear green bond standards[d] that set out criteria for green bond–eligible projects
- Harmonization of domestic and international standards that helps Chinese green bonds gain credibility in the global markets
- Provincial and central government backing that reduces the risk for issuers and increases investor confidence
- Development bank involvement to provide credit enhancements and technical support
- Growing investor demand for green finance products to support environmentally beneficial projects.

Megacities such as Beijing, Chongqing, Guangzhou, Shanghai, and Shenzhen led the charge, issuing green bonds to finance

(Box continues on next page)

BOX 4.5 Financing low-carbon infrastructure in Chinese cities with green bonds *(continued)*

large-scale infrastructure. These cities have access to sophisticated financial markets and the technical expertise necessary for launching green bond issuances. The main issuers of green bonds to support low-carbon urban infrastructure include municipal governments, state-owned enterprises for utility services, private companies that are involved in the development and management of green urban assets, and national and local development banks (refer to table B4.5.1 for examples). The maturity of green bonds in China typically ranges from 3 to 10 years. This aligns with the payback periods of low-carbon projects, such as renewable energy installations and building energy efficiency upgrades. Some green bonds issued by larger state-owned enterprises or municipal governments may extend up to 15 years or more, especially for large-scale infrastructure projects like metro systems or wastewater treatment facilities.

TABLE B4.5.1 Examples of green bonds issued to support low-carbon urban infrastructure

City	Issuer	Year of issuance	Amount (US$)	Yield range	Types of projects supported
Beijing	Beijing Infrastructure Investment Co., Ltd.	2017, 2019, 2021	1.4 billion	2–4%	Metro expansion, energy-efficient subway stations, renewable energy use
Chongqing	Chongqing Water Group	2017, 2020	210 million	3–4%	Sustainable water management, sewage treatment, water recycling systems
Guangzhou	Guangzhou Development District Green Industry	2019, 2021	420 million	3–4.5%	Industrial energy efficiency, green building certification

(Box continues on next page)

BOX 4.5 Financing low-carbon infrastructure in Chinese cities with green bonds *(continued)*

TABLE B4.5.1 Examples of green bonds issued to support low-carbon urban infrastructure *(continued)*

City	Issuer	Year of issuance	Amount (US$)	Yield range	Types of projects supported
Shanghai	Shanghai Pudong Development Bank	2016, 2018, 2022	2.8 billion	2–5%	Renewable energy (solar, wind), energy-efficient buildings, sustainable water management
Shenzhen	Shenzhen Energy Group	2018, 2020	700 million	3–5%	Waste-to-energy plants, electric vehicle charging infrastructure

Sources: Original table for this book based on financial data and project details from various green bond prospectuses and financial reports of the respective issuers.

Green bonds can be structured as general obligation bonds, revenue bonds, or a combination of both, depending on the issuer's financial structure, project type, and investor preferences. In the case of Chinese cities, if the issuers are municipal governments or state-owned enterprises, general obligation bonds are commonly used because they can be advantageous for projects that may take time to generate steady revenue (for example, Beijing's municipal green bonds for subway expansion). By contrast, corporate issuers or public-private partnership projects might use project-specific income for repayment purposes to align with revenue-generating green initiatives (for example, Shenzhen Energy Group's green bonds for waste-to-energy facilities). This structure assures investors that repayments are closely tied to the green project's operational success. Green bonds could also be structured under a hybrid approach, in which issuers combine general revenues with project-specific income to secure bond repayment (for example, Shanghai Pudong Development Bank's green bonds for sustainable water management).

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BOX 4.5 Financing low-carbon infrastructure in Chinese cities with green bonds *(continued)*

Green bonds could be a useful financing tool for small- and medium-size cities, but their application may face constraints. Smaller cities typically have lower credit ratings, making it difficult to attract investors without guarantees or offering higher yields to compensate for the higher risk. Their infrastructure projects may be too small for green bond financing. These cities may also lack the technical capacity to design and manage projects that meet green bond standards. Green bond issuance involves legal fees, certification costs, and administrative expenses—fixed costs that can be prohibitive for smaller municipalities and smaller investments, making bond issuance less attractive. In addition, investors are often more attracted to larger, more liquid markets such as those in megacities, where there is less perceived risk and more opportunities for large-scale investments. Potential solutions to address these constraints include pooled issuances, credit enhancement, subsidies for certification costs, and technical assistance and capacity building.

MDBs can help small- and medium-size cities, access green bonds. They can provide technical assistance for green bond issuance, support project preparation, and offer credit enhancements to improve the cities' creditworthiness. MDBs often collaborate with local governments to identify viable projects, align them with international green standards, and attract institutional investors by providing partial guarantees or cofinancing arrangements. By building local capacity and facilitating access to capital markets, MDBs significantly enhance the ability of smaller cities to finance low-carbon infrastructure projects through green bonds.

a. Climate Bonds Initiative 2024.
b. Zhang, Ziying, and Wang 2024.
c. Li, Zhang, and Wang 2022.
d. People's Bank of China, n.d.

Sustainability-linked bonds

Sustainability-linked bonds (SLBs) are bonds for which the financial or structural characteristics—for example, interest rates, premiums, or penalties—vary depending on whether the issuer achieves certain predefined sustainability targets, such as GHG mitigation targets (ICMA 2023). SLBs are a relatively

recent innovation, having risen rapidly in popularity after their first issuance in 2019. Thus far, they have mostly been issued in high-income countries. According to the Organisation for Economic Co-operation and Development, developing countries issued only 13 percent of total SLB value in 2021, falling to 5 percent in 2022. SLBs have also been issued almost exclusively by the private sector, with public sector issuances representing just 2 percent of total SLB value. Thus, SLBs may have the potential to support resilient and low-carbon urban investments in appropriate L&MIC contexts, but they are not yet a well-established financial instrument for this purpose (OECD 2024).

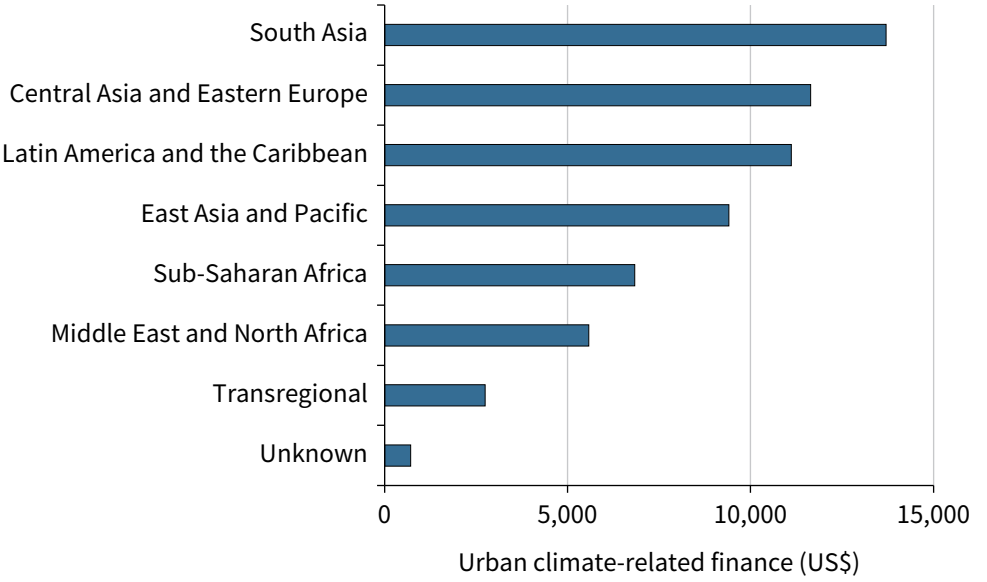
Infrastructure debt funds

Infrastructure debt funds are financial products, such as mutual funds or exchange-traded funds, that pool fixed-income investments, including bonds, securitized products, money market instruments, and floating rate debt. These are attractive to investors because of their stability and relatively low management costs. As with SLBs, debt funds can be used to support resilient and low-carbon urban investments, but they require capacity building before they can be issued at scale in L&MICs.[7]

Multilateral development banks and international climate funds

Multilateral development banks (MDBs) are providing an increasing amount of climate finance, but the share going to urban investments remains relatively small. MDBs have increased their total climate finance (that is, finance for investments with climate benefits) from an annual average of US$57 billion in 2017–18 to US$93 billion in 2021–22, based on tracking of 10 MDBs by Cities Climate Finance Leadership Alliance (CCFLA) (Negreiros et al. 2023). However, only 21 percent of this tracked climate finance from MDBs went to urban projects (as defined by CCFLA) between 2015 and 2022 (US$62 billion out of US$287 billion). This share remained roughly constant over this period. About 32 percent of MDB urban climate finance (US$9 billion over the 2015–22 period) was for adaptation (largely water and wastewater), 40 percent was for mitigation (mostly energy supply, which is a sector not included in this report, and transport), and 29 percent was for projects with multiple climate objectives. The South Asia, Central Asia and Eastern Europe, Latin America and the Caribbean, and East Asia and Pacific regions received the largest volumes of city climate finance from MDBs (figure 4.2).

FIGURE 4.2 Urban climate-related finance from multilateral development banks, by region, 2015–22



Source: Negreiros et al. 2023.

International climate funds are also available to support resilient and low-carbon urban investments. For example, the Green Climate Fund has supported electric urban mobility, green housing, and other urban investments through a combination of loans, grants, and cofinancing from other sources.[8] The Climate Investment Funds and Asian Development Bank Climate Change Fund also support resilient and low-carbon urban investments in L&MICs, usually through grant funding, technical assistance, and support in raising finance from other sources.[9] The Global Environment Facility's Sustainable Cities program works alongside development banks to provide finance for environmental projects in urban areas, including, for example, urban greening in Freetown, Sierra Leone; flood protection and low-carbon mobility in several Indian cities; waste management in Indonesian cities; and other interventions.[10]

National development banks, commercial banks, and climate funds

National development banks are increasingly engaging in climate mitigation and adaptation financing. International financing presents challenges for

municipalities in L&MICs, including currency fluctuation, regulatory constraints, the need for sovereign guarantees, and capacity constraints. A national development bank, owned by a country's government, is often well placed to channel finance to municipalities, offering local currency finance on the supply side and addressing capacity constraints on the demand side. National development banks can enhance support and incentives for climate-smart investments, such as requiring that investments meet certain criteria for resilience and mitigation and creating dedicated windows for urban climate projects. Nevertheless, while harnessing the advantages of national development banks, it is also important to create a level playing field between private and government-owned financial institutions where possible, to avoid crowding out private commercial finance.

In Brazil, federal, regional, and state development banks are scaling up the allocation and flow of climate finance to cities and municipalities with federal support. Institutions like BNDES, Banco do Brasil, and Caixa Economica Federal have a broad reach, with Banco do Brasil serving 97 percent of Brazil's 5,570 municipalities. These banks are increasingly engaging in climate mitigation and adaptation initiatives as integral components of their commercial operations and commitment to environmental, social, or governance principles. Brazilian banks expect a competitive advantage for being environmentally conscious and are also motivated by supportive federal policies. An example of federal support is the "Resilient and Sustainable Cities" pillar of the government's new Growth Acceleration Program, which aims to invest more than US$20 billion in resilient and green urban development (World Bank and UNCDF 2024).

National climate funds are also helping to mobilize and direct financing to climate-oriented development strategies (World Bank and UNCDF 2024). National climate funds can help to provide strategic and country-driven leadership of climate financing, as well as pooling, blending, and coordinating financing and investments and addressing capacity constraints (UNDP 2011). For example, Guyana's REDD+ Investment Fund mobilizes resources for projects aligned with the government's low-carbon development strategy. The Rwanda Green Fund has, among other activities, supported local authorities to green District Development Plans, building district capacity to design climate-smart investments and apply for green financing and funding.[11]

PROJECT-LEVEL PRIVATE FINANCE

Although private financial institutions—predominantly banks and institutional investors—are incorporating climate change into their future allocation decisions, much of the private capital pledged for resilient and low-carbon urban investments (supply) remains unutilized, partly because of a dearth of bankable projects (demand). A study of the 26 top banks indicated that 77 percent have made commitments toward net zero.[12] An analysis of 10 of the largest global banks indicated total capital commitments for climate projects of more than US$6 trillion. However, the capital mobilized by financial institutions for climate projects is significantly lower than commitments, with most not being on track to meeting their commitments.[13] In Africa, private equity, venture capital, and infrastructure funds contributed only about 1 percent of total climate finance in 2020.[14] A supportive policy and regulatory framework, as well as creditworthy borrower, is needed (refer to box 4.6). However, even with these factors in place, private financiers require viable projects capable of making repayments, with transparent financial models that outline credible and adequate cash flows. Although some resilient and low-carbon urban investments can meet these criteria, fully funding projects using private sources is challenging when they principally (1) produce global or local "public goods" whose benefits are not easily monetized or (2) serve end-users with low repayment capacity. Project-level private capital has most often been channeled toward mitigation projects and especially low-carbon energy generation (a sector not included in this report beyond rooftop solar energy in buildings), where financial viability tends to be stronger. Table 4.4 provides a high-level example of the potential for private sector participation in urban investments, by sector.

BOX 4.6 De-risking urban investments[a]

Private investment in resilient and low-carbon urban projects is often constrained by risks, particularly in developing countries. To counter these risks, public institutions use de-risking mechanisms to improve project creditworthiness and attract additional private financing. De-risking in climate finance encompasses several risk types. Sovereign risk involves

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BOX 4.6 De-risking urban investments[a] *(continued)*

the risk of government default on debt obligations. Political risk arises from uncertainties that are due to political instability or changes within a country. Business or project risk refers to the potential failure of a project to repay its debts because of unforeseen challenges or poor performance.

Policy makers in developing countries use a range of public instruments to meet these challenges. Policy de-risking instruments aim to remove barriers that cause risks by using policy and programmatic interventions. For example, renewable energy projects often require permits and approvals where unclear institutional responsibilities or lack of experience can increase costs and discourage investment. Policy de-risking might streamline permitting processes and provide capacity building to administrators. Financial de-risking instruments transfer risks to public actors like development banks, including loans, guarantees, and political risk insurance. Recognizing that not all risks can be mitigated or transferred, direct financial incentives such as price premiums, tax breaks, and carbon offset proceeds may be used to compensate for residual risks and costs.

Credit enhancement mechanisms, particularly guarantees, are integral to financial de-risking. They provide a financial safety net, covering part of the losses if a borrower defaults, thereby reducing credit risk and improving terms for investors. They are an essential tool to mobilize local currency financing from commercial banks, which often have the largest assets under management in low- and middle-income countries, and therefore one of the main potential sources of financing for green investments. Examples of guarantee products include those provided by the Green Guarantee Company, which targets de-risking initiatives for climate change adaptation and mitigation projects, with a particular focus on green bonds and loans that feature transparent impact measurement in emerging markets and developing economies.[b] In addition, the International Finance Corporation's (IFC's) risk sharing facility, although not exclusively for climate-related investments, provides commercial risk coverage through bilateral loss-sharing agreements. This risk sharing facility is designed to help project originators who need to safeguard against credit risk but do not require additional capital. It operates by

(Box continues on next page)

BOX 4.6 De-risking urban investments[a] *(continued)*

having the IFC agree to cover a certain portion of losses that go beyond an initial "first loss" level for a group of approved assets. The main purpose is to improve the originator's capacity to create new assets within a certain category.[c]

However, guarantees are not comprehensive solutions for market failures. They cannot address policy barriers or compensate for a lack of capacity in lenders or borrowers. Overreliance on guarantees can lead to moral hazard, perverse incentives, and fiscal risks, because they may shift risk to guarantors if the borrower's creditworthiness is inadequate. Thus, although de-risking can facilitate investment, it must be applied with caution to avoid compromising the integrity of the systems it seeks to enhance.

a. Carneiro 2024; Choi 2022; Choi and Laxton 2023; CPI 2024; World Bank and UNCDF 2024.
b. The Green Guarantee Company 2024.
c. IFC 2023.

TABLE 4.4 Potential for private sector participation in urban investments

Potential for private sector participation	Investment type	Rationale
Full private funding possible	Buildings (energy efficiency)	• Self-funding is possible through the savings they generate over time. • Future savings from energy retrofits can be leveraged to provide upfront capital. • Private energy efficiency service providers can secure commercial debt financing to implement projects for building owners, repaying the loans with energy savings.
Blended (public and private) funding possible	Water and wastewater	• Prices for piped water and wastewater often do not reflect true economic value or service costs, because of criticality and political sensitivity of provision, positive externalities, and low ability to pay. • The public sector is the primary financier for piped water and wastewater in many L&MICs. • Private provision of bottled, trucked, and well water is common where piped water is inadequate.

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TABLE 4.4 Potential for private sector participation in urban investments *(continued)*

Potential for private sector participation	Investment type	Rationale
	Solid waste management	• Solid waste management generates some revenue but is usually highly subsidized overall because of the positive externalities that it produces. • Private firms participate predominantly as operators, subsidized by ongoing budgetary support. • Funding is primarily through municipal budgets in L&MICs, with a small portion from user fees and revenues from recyclable waste and energy production.
	Transport	• Projects require public funding because of large upfront costs and positive externalities. • Direct revenues are generated that only partially cover operating costs and do not address capital investment costs. • Without mechanisms to generate revenues for funding capital expenditures, private sector participation will be constrained to an operator role. • Land value capture mechanisms that monetize the increase in surrounding land values can be explored.
Mostly public funding needed	Flood protection	• Municipal flood protection infrastructure is challenging to finance privately, because its benefits are dispersed across many stakeholders over time. It relies heavily on public funding, grants, and concessional financing. • Land value capture can provide funding, with emerging examples in high-income countries yet to be widely replicated in L&MICs. • Building-level measures can be funded by private building owners.
	Heat resilience	• Private sector can be incentivized to invest at plot/workplace level (for example, greening, cool roofs, adjusted work hours). • Public funding is required for measures such as municipal trees, early warning systems, and emergency services.

Source: Original table for this book.
Note: L&MICs = low- and middle-income countries.

Green banks can provide low-cost financing and technical support for sustainable projects, leveraging public funds to attract private capital. Green banks have significant potential to address the climate finance needs of cities in L&MICs by mobilizing private capital for sustainable urban infrastructure projects. These banks can provide tailored financial products such as low-interest loans, guarantees, and blended finance solutions. By leveraging limited public funds to attract private investment, green banks can help cities overcome financial barriers and scale up climate action. Although green banks are not yet well established in L&MICs, there are some successful examples from high-income countries, such as the Connecticut Green Bank, established in 2011. The Connecticut Green Bank was the first state-level green bank in the United States and has been instrumental in mobilizing private investment for clean energy projects. The Connecticut Green Bank has significantly increased the deployment of renewable energy and energy efficiency projects throughout the state. It offers various financial products, including loans, leases, and power purchase agreements, tailored to meet the needs of different stakeholders, from homeowners to large commercial entities. The bank's innovative approach has led to substantial growth in the clean energy sector, creating jobs, reducing GHG emissions, and lowering energy costs for consumers. The success of the Connecticut Green Bank has inspired the creation of similar institutions in other states. For instance, the New York Green Bank, established in 2014, follows a similar model and has also achieved significant success in driving private investment into clean energy projects. Several countries are currently looking at replicating these models.

Conclusion

Much greater mobilization of financing is needed to meet investment costs for resilient and low-carbon cities. The mobilization of funding is no less critical: It is the bedrock of financing, providing the necessary returns for financiers, supporting operation and maintenance costs, and bridging gaps in project viability where monetizable benefits are insufficient. Different resilient and low-carbon urban investments present different opportunities for financing and funding. Some generate relatively robust direct revenues and savings or indirect benefits, which can be monetized to attract private finance given an

otherwise enabling environment. Others create more dissipated externalities that are monetizable only at national or global levels or generate only small direct revenues or savings relative to costs, hence requiring more substantial cross-subsidies from the public sector.

Notes

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SPOTLIGHT 2: CAPE TOWN, SOUTH AFRICA

Summary

- Cape Town, South Africa, has made significant progress in integrating climate change considerations into its planning and has received global recognition for its efforts, continuously monitoring and reviewing its Climate Change Action Plan to ensure effective implementation.
- The city of Cape Town is dedicated to achieving climate resilience and carbon neutrality by 2050 through its comprehensive Climate Change Action Plan.
- The city faces significant challenges in implementing its carbon neutrality plan, including dependence on coal-intensive grid electricity, the need for substantial spatial transformation in public transport, and financial constraints because of high upfront costs for adaptation interventions.
- For the 2023–24 financial year, Cape Town has allocated a substantial budget toward infrastructure, focusing on areas such as wastewater management, road transport, and renewable energy.

Introduction

Cape Town, a coastal city located in South Africa's Western Cape province at the southwestern tip of Africa, is at the forefront of regional climate action. With a population of 4.7 million and an average annualized population growth rate of 2.4 percent, the city's population is projected to grow to between 7.0 and 7.7 million by 2050. Cape Town faces a range of climate risks that demand urgent and comprehensive mitigation and adaptation strategies. These risks include significant reductions in mean annual rainfall, altered rainfall seasonality including increased risk of urban flooding, notable increases in mean annual temperature, more frequent high heat days and intense heat waves, increased wind strength, and rising sea levels coupled with enhanced coastal erosion. These climatic changes pose substantial threats to the city's infrastructure, economy, and the well-being of its residents (City of Cape Town 2021).

Commitment to carbon neutrality

In response to the pressing climate challenges, the city of Cape Town has committed to achieving climate resilience and carbon neutrality by 2050. To realize this vision, Cape Town has developed a comprehensive Climate Change Action Plan that encompasses 10 strategic focus areas. These areas include resilience, economic inclusiveness, embedded sustainability, carbon neutrality, health and well-being, collaboration and integration, climate-responsive urban development, equitable service delivery, the precautionary principle,[1] and innovation and transformational planning. Each of these focus areas outlines specific goals and actions required for effective implementation. For example, the resilience area aims to strengthen the city's capacity to endure and recover from climatic shocks. The economic inclusiveness area ensures that all residents benefit from climate action initiatives. Embedded sustainability integrates sustainable practices into all aspects of city operations, and the carbon neutrality area focuses on achieving net-zero greenhouse gas emissions (City of Cape Town 2021).

Implementation challenges

The implementation of the Climate Change Action Plan is fraught with challenges that the city has identified:

- **Energy dependence:** The city's reliance on coal-intensive grid electricity necessitates a transformation of its energy supply. Achieving carbon neutrality hinges on procuring or generating renewable electricity, supported by a functional regulatory, transmission, and system operating framework.
- **Public transport:** Cape Town's partial mandate in public transport and the need for significant spatial transformation to make mass transit economically viable present additional hurdles. The transition to electric vehicles will only be effective if low-carbon or carbon-neutral electricity is available.
- **Financial constraints:** High upfront costs for adaptation interventions, particularly those requiring substantial infrastructure development or upgrades, pose significant barriers. Although long-term cost savings are anticipated, these initial financial outlays can impede implementation.

City finances

Cape Town uses a combination of own-source revenues, debt, and fiscal transfers to fund its capital investments and aims to further diversify its revenue streams. For the 2023–24 financial year, the city of Cape Town had an operating budget of nearly ZAR 60 billion (US$3.2 billion) and a capital budget of approximately ZAR 11 billion (US$595 million). The funding sources for capital expenditures included the following:

- Internally generated funds: ZAR 4.9 billion (US$265 million)
- Borrowings: ZAR 3.5 billion (US$189 million)
- Fiscal transfers: ZAR 2.8 billion (US$151 million)
- Public contributions and donations: ZAR 94 million (US$5 million).

Infrastructure spending for this period was ZAR 6.6 billion (US$357 million), with a strong focus on wastewater management, road transport, energy sources, and water management. However, the city experienced financial strain, in particular because of reduced electricity revenues, which are traditionally used to cross-subsidize the municipal budget. This is because of challenges posed by load-shedding (temporary controlled power outages) and the increased adoption of small-scale generation units by businesses and homeowners. To address these financial challenges, the city is focusing on diversifying its income streams, enabling international funding, and attracting investment. Ongoing priorities include enhancing operational efficiencies, adjusting spending priorities within the available operating budget, and maximizing available grant funding. Looking ahead, Cape Town is continuously working to extend its planning horizons. The city has made significant progress, particularly in integrating climate change considerations into its 10-year capital plan. Cape Town's planned infrastructure investments for the next decade (2024–25 to 2033–34) will focus on critical areas such as renewable energy, water and sanitation, public transport, and urban development (City of Cape Town, n.d.-a, n.d.-b).

Although Cape Town successfully issued a municipal green bond in 2017, it is reluctant to issue further green bonds because of high costs related to certification and reporting. Prompted by increasingly frequent droughts, Cape Town issued its first municipal green bond in 2017 to help invest in

climate change mitigation and adaptation. The issuance was a success, earning a high rating from Moody's and being four-times oversubscribed. The bond raised ZAR 1 billion (approximately US$76 million at the time), which the city used to finance low-carbon transport, water management, coastal protection, and energy efficiency projects. However, the city has not issued any green bonds since then, opting instead to issue nongreen municipal bonds even while using the proceeds for green projects. This is because the green bond did not bring with it either a pricing discount or a more diverse pool of investors than a traditional transaction, although it did come with higher costs related to green certification, expertise, and reporting (World Bank and UNCDF 2024).

Progress toward Cape Town's vision

The city of Cape Town has made progress toward achieving its vision along several fronts, which are highlighted below.

Water and sanitation business model reform

The city of Cape Town continues to execute its water strategy, approved by the city council in 2019, which aims to secure new water supplies and enhance resilience by addressing gaps in national infrastructure investment. The city is overhauling its delivery model, focusing on sanitation and the inclusion of advanced technologies. This includes a digital water solution with advanced metering infrastructure and 74 pressure sensors at pump stations for real-time network monitoring. Upgraded telemetry infrastructure enhances digital capabilities, whereas refined maintenance strategies use real-time condition-based monitoring to reduce costs and asset failures.

Revenue model and tariff structure reform

Appropriate tariffs are crucial to ensure that water and sanitation services are effectively managed, balancing economic, environmental, and social goals. The current tariff structure comprises an inclining four-block tariff for domestic services and uniform tariffs for nondomestic customers. A two-part water tariff system is being considered for potential implementation with respect to sanitation services, with reviews beginning in 2022–23.

Climate change strategy and action plan monitoring

The city monitors its Climate Change Action Plan through an annual progress review. Actions in this plan are closely tied to programs identified as climate

priority programs in the Integrated Development Plan, ensuring seamless integration with the city's overarching strategy. The city reports annually to CDP-ICLEI Track, a global climate change reporting platform, and has maintained an A rating since the inception of the new rating system for cities in 2018. Only 13 percent of 930 cities scored globally achieved this rating in 2023, and Cape Town was the only African city to be recognized.

Collaboration and climate finance

Ongoing collaboration with networks such as C40 and the Resilient Cities Network has enabled Cape Town to secure climate finance and technical assistance for projects that address climate challenges. This includes work on green infrastructure for flood risk reduction and renewable energy in municipal buildings, funded through the German Agency for International Cooperation and the C40 Cities Finance Facility. Climate finance-related support was also secured through the Gates Foundation for an alternative sanitation pilot.

Integration of climate risk into project management

In the year in review, steps were taken to integrate climate risk into Cape Town's project management and budget planning. This involved an assessment of both short-term and long-term capital projects to identify current climate investments and pinpoint areas needing further attention. Project managers have been issued a guidebook to strengthen the integration of climate response into future service delivery and projects.

Annual implementation review

Cape Town's annual implementation review of the Climate Change Action Plan tracks progress against the actions contained in the plan and monitors trends in indicators associated with the plan's goals. The 2022–23 review revealed that 54 actions (more than 50 percent of the plan) were categorized as "in implementation." This signals a positive trajectory, considering the long-term nature of the plan.

Infrastructure and climate risk integration

Various initiatives integrate climate risk into planning processes. Climate considerations are included in the city's spatial development frameworks at municipal, district, and local levels, as well as in the project management system.

A resilience assessment has been conducted for the city's 10-year capital project portfolio to identify areas requiring further intervention. A climate budget tagging exercise has also been done for the 3-year capital budget, setting the stage for tracking future spending on climate change initiatives (World Bank and UNCDF 2024).

Conclusion

Cape Town has demonstrated a clear commitment to climate action. It has developed and implemented a robust climate action plan and outlined a comprehensive 10-year investment strategy. The city's plans and intentions are well defined, reflecting a proactive approach to sustainable development and climate resilience. In June 2024, Cape Town earned global recognition at the World Cities Summit in Singapore, receiving a special mention for the Lee Kuan Yew World City Prize. This distinguished biennial award celebrates cities that excel in creating vibrant, sustainable, and livable urban environments.

Note

1. The "precautionary principle" is a risk-averse and cautious approach that acknowledges the limitations of current knowledge regarding the consequences of decisions and actions. It is applied in decision-making processes in which there is uncertainty about whether a decision may negatively affect climate resilience, expose an area or group of people to increased climate risk, or reduce the adaptive capacity of an area or group of people. Furthermore, the precautionary principle asserts that uncertainty should not be used as a justification for delaying measures aimed at reducing climate risk.

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CHAPTER 5

Recommendations

Summary

- **Local governments** can improve their funding flows, investment efficiency, and financing readiness to make investments in resilient, low-carbon urban development more achievable. They can
  - Improve the capture of direct revenues (for example, user fees) and indirect benefits (for example, increased land values and monetized emission reductions) from resilient and low-carbon investments.
  - Integrate resilience and low-carbon goals into investment planning and build technical capacity to prepare investments.
  - Raise investment efficiency by using data to target and optimize investments, aligning private incentives with climate goals, and steering efficient spatial growth through investment location decisions and land use policies.
  - Enhance their creditworthiness and build their financial expertise.
- **Groups of local governments** can pool their smaller infrastructure projects to leverage economies of scale to make investments more attractive to private financiers.
- **National governments** have a critical role to play.
  - National technical assistance can enable cities to prepare, implement, fund, and finance climate-smart investments effectively.

    - National governments can ensure that cities receive adequate and predictable fiscal transfers to cross-subsidize investments with wider economic benefits and support long-term planning and financing with predictable funding flows. Structuring fiscal transfers as performance-based grants can improve incentives.
    - By setting the regulatory and policy frameworks, national governments both empower local governments to raise funds and engage in sustainable financing and establish incentives for resilient and low-carbon action by third parties.
    - National institutions can also offer credit enhancements, such as viability gap funding and sovereign guarantees, to make urban projects more attractive to investors and may deliver some investments directly.
- Although resilience is often a priority in low-income cities, many low-carbon investments also have important local benefits, making them appropriate even where emissions are low.
- Whereas large, higher-income, high-capacity cities have greater access to finance, low-income, low-capacity cities can develop their funding streams, financial management, and project preparation and implementation, to improve readiness for financing in the long term and reap gains for funding and efficiency in the short or medium term.

Overview

Although the estimated costs of the investments identified in this report are high, improving efficiency and access to funding and financing can help bridge the investment gaps. As discussed in chapter 2, resilient and low-carbon urban investments in low- and middle-income countries (L&MICs) could cost between 0.8 and 2.6 percent of their combined GDP (2.5 to 4.4 percent when including operations and maintenance costs). When low-income countries are considered separately, their investment costs could be as high as 8.4 percent of GDP (and 17.4 percent when operations and maintenance costs are added in the high scenario). The largest costs are in the sectors of flood protection, energy improvements in buildings, and low-carbon transportation. Chapter 3 discussed how cities can achieve greater efficiency through spatial coordination, the integration of mitigation and

adaptation into investments, targeting of investments, and accountability. Chapter 4 introduced a framework for funding and financing resilient and low-carbon urban investments; it presented opportunities for raising direct revenues and monetizing indirect benefits of the investments in each sector, which can be used to fund the investments or raise repayable financing through borrowing and public-private partnerships (PPPs). This chapter provides key recommendations, aimed primarily at local and national governments, although they are also relevant to multilateral development banks (MDBs) and other international development partners, private investors, and others.[1]

Recommended actions to improve efficiency, funding, and financing

This section outlines recommendations for local and national governments to achieve four high-level objectives. These four objectives are discussed in the following sections.

OBJECTIVE 1: IDENTIFY AND PREPARE RESILIENT AND LOW-CARBON URBAN INVESTMENTS

Local Governments

- **Develop capital investment plans that integrate resilience and low-carbon urban development goals.** Cities should develop capacity, incentives, and processes to mainstream resilience and mitigation into investment planning—including capital investment plans—and project design. Aligning these plans with the country's nationally determined contributions and national adaptation plans can help attract support from national governments.
- **Build technical expertise in the preparation and implementation of resilient and low-carbon investments.** Understanding the impact of investments on climate change risk and greenhouse gas (GHG) emissions requires specialized expertise beyond traditional sectoral expertise.

National Governments

- **Offer technical assistance to local governments to support project preparation.** National governments can provide technical assistance, or

build local capacity, to prepare climate-smart capital investment plans; integrate mitigation and resilience considerations into infrastructure, service delivery, buildings, and land-use plans; and select, target, and design high-impact investments in resilience and mitigation. Some of this support may be delivered via national development banks.

- **Develop a national strategy for subnational climate action, operationalized through a national platform and technical working groups, to help cities identify and prepare investments.** National governments can develop and implement country-led subnational climate action (Samuels and Maehara 2025). These can be operationalized through platforms that coordinate between government entities, development partners, and the private sector.

OBJECTIVE 2: INCREASE EFFICIENCY TO REDUCE INVESTMENT COSTS

Local Governments

- **Use available policy, administrative, and investment levers to promote efficient spatial growth.** As discussed in chapter 3, urban form has important implications for the cost of infrastructure and service provision. Zoning and enforcement, investments in transport and amenities, revenue instruments, and others can promote more spatially efficient and coordinated land use, lowering long-term costs while reducing emissions.
- **Use data to target and optimize investment decisions.** Data analysis and modeling can help cities derive the greatest benefits from limited resources and investments. For example, it can guide cities to build public transportation where it will maximize accessibility to users, GHG reductions, opportunities for fare collection, and land value capture; choose the most cost-effective flood protection measures for a given location; prioritize flood and heat risk measures in locations with the greatest projected risks; and so on.
- **Align the incentives of private firms and households to support mitigation and adaptation to reduce the need for public investment.** These can include design regulations, user fees, and other policies to incentivize resilient and low-carbon behavior on the part of private firms (including contractors providing public services) and households, which in turn reduces the need for public investment to meet resilience and emission goals.

National Governments

- **Build the capacity of local governments to enhance efficiency.** National governments should build the capacity of, and provide technical assistance to, local governments to realize efficiency gains across key elements of urban planning and investment.
- **Ensure national institutions incentivize and enable urban efficiency.** National policies should incentivize resilient and low-carbon behavior in cities, such as through appropriate fuel pricing, road taxes, national building regulations and infrastructure standards, and others. National institutions should pursue efficiency gains in areas of urban planning and investment that fall under national jurisdiction (such as national transport infrastructure or national land administration) while empowering urban local governments to take appropriate actions to improve efficiency.

OBJECTIVE 3: INCREASE ACCESS TO FUNDING

Local Governments

- **Identify and capture the funding generated directly and indirectly from each investment.** Cities can identify and capture direct revenues (user fees, fares, sales, savings, and others) and indirect benefits (land value increments, emission reductions that can be monetized as carbon credits, and others) from low-carbon and resilient investments.
- **Develop efficient and transparent land markets and revenue administration to facilitate the use of land value capture instruments.** Well-functioning land administration systems, up-to-date property assessments, and efficient property tax collection support the financing of investments through land value capture.

National Governments

- **Ensure that fiscal transfer systems provide adequate, timely, and predictable disbursements to cities.** Predictable revenues are essential to enable local governments to attract investment, make and execute capital plans, and perform essential operations and maintenance, and for many cities, central transfers are a critical source of these revenues. Performance-based grants with climate criteria can enable and incentivize cities to achieve climate-related targets.

- **Dedicate appropriate fiscal resources to low-carbon and resilient urban investments that fall under the mandate of national institutions.** This can be achieved while realizing efficiency gains and mobilizing funding to ensure their financial sustainability.

OBJECTIVE 4: INCREASE ACCESS TO FINANCING

Local Governments

- **Build technical expertise in securing finance.** Local governments can develop or hire expertise to design commercial transactions, liaise with investors, and streamline project bidding processes to enhance cities' capacity to attract finance.
- **Enhance creditworthiness through improved public financial management systems and performance.** Sound, transparent public financial management systems are a precondition for investor engagement and sustainable financing. This should be complemented by enhancing fiscal sustainability and space, including monetizing and recapturing the benefits of urban infrastructure and services.
- **Where possible, pool smaller projects, including across multiple local governments, to leverage economies of scale to attract financiers.**

National Governments

- **Offer technical assistance to enhance local government creditworthiness and project bankability.** National governments can provide technical assistance and build local capacity (for example, on public financial management, project preparation, and compliance with green finance requirements).
- **Provide funding and financing support to enhance project bankability.** This can include viability gap funding and sovereign guarantees to reduce perceived risks.
- **Strengthen institutions and the enabling environment for commercial municipal borrowing, private sector participation, and innovative financing activities.** General measures include updating regulations and institutions to support subnational borrowing and PPPs for low-carbon and resilient investments, establishing credible public counterparties and dispute resolution mechanisms to reduce investors' risk perception,

and providing viability gap funding. Measures specific to low-carbon and resilient investments include establishing incentives and regulations to encourage or require more climate-smart private investments (for example, building codes, vehicle emission regulations, landfill quotas, energy efficiency certification, and others) and supporting accreditation and certification (for example, through development of green bond frameworks, and supportive institutions for measurement, reporting, and verification of emission reductions).

- **Develop and use national development banks (and funds) to channel local-currency climate finance to cities.** Governments can enhance the role of national development banks as providers or mediators of subnational financing, require that all financed investments meet certain criteria for resilience and mitigation, and create dedicated windows within national development banks and climate funds for urban climate-smart projects. National institutions should prioritize financing or funding for investments that are less likely to attract private finance, to ensure that private finance is not crowded out.
- **Aggregate subnational projects from several cities to enhance bankability.** Coordinating and aggregating climate-related investments across cities can help meet the requirements of financiers, including MDBs and private lenders. This is particularly important for small projects and those in secondary cities.[2]

Tailoring the approach to the context

TAILORING TO NATIONAL INCOME LEVELS

Because low-income countries tend to have low GHG emissions and high climate vulnerability, their investment priority is typically urban resilience rather than emission reductions. However, building infrastructure in a spatially efficient manner, promoting energy-efficient building techniques, connecting spaces via public and nonmotorized transport, and using other low-carbon measures offer substantial local benefits—including reductions in costs, air pollution, and congestion—making them important even in low-income contexts. Within each sector, low-carbon investment strategies need to be tailored to ensure financial feasibility; for example, buses usually take precedence over metros in low-income contexts.

Whereas concessional international sources such as MDBs and bilateral aid may take precedence in smaller or lower-income countries, upper-middle income countries with large cities, and in which national governments have adequate fiscal capacity, may particularly benefit from the support of national development banks in catalyzing urban investments.

TAILORING TO SUBNATIONAL FISCAL CAPACITY

Within a single country, cities tend to diverge considerably in their fiscal capacity, with higher capacity typically found in larger and capital cities. Larger cities with strong financial capability may be able to raise own-source revenues commensurate with their main investment needs, enter into PPPs, implement complex forms of land value capture, issue bonds, and aggregate carbon credits. Other cities may be too small or lack the staffing and technical capacity to raise funding and financing in these ways. Cities with low fiscal capacity will require more transfers from national governments or donors in the short term, but they can work toward improving their fiscal capacities, such as improving efficiency and breadth in the collection of taxes and fees, improving land and property records in support of property taxation and land value capture, and so on. By developing their funding streams, financial management, and capacity for project preparation and implementation, these cities can improve readiness for financing in the long term while strengthening funding and efficiency in the short to medium term.

TAILORING TO CITY SIZE

Small cities can achieve economies of scale by pooling their investments. For example, neighboring municipalities can share waste and wastewater treatment facilities or flood-resilient infrastructure, which would not be feasible to finance separately. Cities can also pool projects to attract private investors (for example, a multicity PPP) or jointly procure goods and services to attract providers by offering larger contracts.

TAILORING TO POPULATION GROWTH TRAJECTORIES

The populations of many cities in L&MICs are projected to grow rapidly in the coming years, particularly in South Asia and Sub-Saharan Africa.

These cities can build infrastructure in resilient and low-carbon ways at the outset. However, many other cities in Europe and Central Asia and parts of the East Asia and Pacific, Latin America and the Caribbean, and Middle East and North Africa regions are unlikely to grow substantially in the coming years, with some even experiencing population decline. These cities will need to retrofit existing infrastructure and buildings and, where possible, find ways to adapt them to new uses as economic needs and demographics change. Adaptive reuse of existing infrastructure is often a low-cost and low-carbon alternative to demolition and reconstruction.

Conclusion

The resilient and low-carbon investments needed in L&MICs globally will cost hundreds of billions of dollars a year. However, "climate" investments are not a separate category of investments, because most resilient and low-carbon investments also deliver necessary local benefits. Similarly, "climate" finance is not a separate category of finance; although some financial sources are climate specific, most sources of funding and financing that need to be mobilized to make resilient and low-carbon investments are not. Closing the investment gap involves identifying sources of funding and financing relevant to each investment and reducing costs through efficiency improvements. This presents critical roles for both local and national governments to close the urban investment gap.

Notes

1. Recommendations in this chapter draw on World Bank and UNCDF (United Nations Capital Development Fund). 2024. *Local Governments Climate Finance Instruments—Global Experiences and Prospects in Developing Countries*. Washington, DC: World Bank.
2. See note 2.

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Many policy makers in developing countries want to invest in urban infrastructure that meets the service delivery needs of growing cities while enabling climate resilience and lowering emissions. But the costs involved and the challenges of mobilizing the necessary resources are significant. This report offers a primer for city governments to better understand urban climate infrastructure investment requirements and climate finance options available to help implement necessary investments.

— *Hugh Cole, Director, Policy & Strategy, and Chief Data Officer, City of Cape Town, South Africa*

Banking on Cities is built on sophisticated and comprehensive technical analysis, but it focuses on what the results mean for cities in practical terms. It will be a useful resource to our cities around the world as they take urgently needed climate action.

— *Andy Deacon, Managing Director, Global Covenant of Mayors for Climate and Energy*

BMZ welcomes this World Bank report that will serve as a valuable guide to those of us in the international community who are supporting the Global South by investing in resilient, sustainable urban development on our pathway to net-zero societies. Cities are facing severe challenges caused by climate change. Investment in resilient and socially just infrastructure is urgently needed, especially in the Global South. We need more cooperation among stakeholders, including the private sector. This report will add value by elaborating on the relevance of different types of investment and funding options.

— *Dirk Meyer, Director General, German Federal Ministry for Economic Cooperation and Development (BMZ)*

City Climate Finance Gap Fund

Federal Ministry for Economic Cooperation and Development

Federal Ministry for Economic Affairs and Climate Action

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