



FINANCING LOW-CARBON, CLIMATE-RESILIENT CITIES

COALITION FOR URBAN TRANSITIONS

A New Climate Economy Special Initiative

Financing Low-Carbon, Climate-Resilient Cities

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Executive Summary

In many parts of the world, urban development is becoming more inefficient, unsustainable, and carbon-intensive. Urban spatial expansion is outstripping urban population growth and the share of urban trips by private vehicles is increasing in all developing regions. Meanwhile, millions of urban residents lack access to risk-reducing infrastructure and services, such as sewers, piped water, drains, waste collection or healthcare.

A transition to low-carbon, climate-resilient cities will require both a substantial increase in the total quantity of urban infrastructure investment and a shift in the way that existing streams of finance are allocated. There is therefore a need for innovation, learning and scaling of financing instruments, financial architecture and governance structures. This paper outlines how cities and countries can enhance fundamental financial capabilities and systemically mainstream climate commitments into financial decision-making.

1.1 Demand for finance

To achieve the Paris Agreement, mature cities will need to refurbish existing systems and infrastructures, and fast-growing cities will need to shift towards lower-carbon development pathways. There is therefore a need for investment in new power generation technologies to decarbonise the electricity grid; energy efficiency in buildings, lighting and appliances; transport infrastructure that enables modal shift to public and non-motorised transport options; next generation mobility, particularly electric vehicles; and solid waste management. Urban form will have a major influence on the type and feasibility of different low-carbon measures, particularly through patterns of density, land-use mix, connectivity, and accessibility.

The scale of adaptation investment needed will depend on the scale of mitigation investment mobilised. In other words, the finance required to adapt cities to a 1.5°C increase in global temperatures are a fraction of those required to adapt to a rise of 4°C. Adaptation investment needs are a function of physical exposure to climate risk and adaptive capacity. This suggests three broad categories of adaptation investment: (1) reducing exposure to everyday hazards through the provision of basic infrastructure and services, such as sewers, piped water and healthcare; (2) managing new risks by integrating climate considerations into the design, implementation or retrofit of urban infrastructure; and (3) building new infrastructure and services specifically to respond to new climate hazards, such as sea level rise.

Low-carbon and climate-resilient urban investments are institutionally more complex than conventional urban investments and may entail higher upfront costs. Consequently, the financing and funding arrangements will generally be more sophisticated than existing systems.

1.2 Supply of finance

Domestic public finance has traditionally been a significant source of infrastructure investment, and is currently equivalent to about three per cent of global GDP. However, public budgets are often insufficient for larger and more complex

infrastructure projects, particularly in the context of limited own-source revenues, austerity or competing priorities. This is particularly true at the local level: many municipalities in sub-Saharan Africa and elsewhere have an annual planned budget of less than US\$20 per person, most of which is committed to operating costs such as salaries. Governments may also be constrained from near-term infrastructure investment by the need to pay attention to fiscal sustainability, which is necessary to ensure long-term access to private finance.

International public finance is also an important source of infrastructure investment, but it is not sufficient to fill the financing gap. There is therefore a need to use this finance strategically to develop an enabling environment for low-carbon, climate-resilient investment in urban areas. This could be through supporting the design of climate-sensitive policy frameworks and institutional arrangements; building local capacities to plan and deliver climate-compatible infrastructure; supporting early entrants in key markets, such as renewable energy technologies or energy-efficient appliances; and crowding in private investment through reducing project risk. Development and climate finance can also be used to promote inclusive decision-making processes and equitable project outcomes, thereby addressing some of the drivers of climate vulnerability.

Private investors could be drawn to sustainable urban infrastructure projects where a sufficient return on investment is forecast based on project income flows or low-risk government debt repayments. Bankability and creditworthiness are therefore prerequisites to attracting private finance. Commercial banks, investment companies, pension funds, insurance companies and sovereign wealth funds manage over US\$110 trillion of assets, much of which could be steered into sustainable urban infrastructure. It is important to recognise that these different investor types will have different risk-return expectations and investment horizons, and to identify and structure projects appropriately for these different sources of finance.

1.3 Connecting demand for, and supply of, finance

Governments have a range of financing and funding mechanisms available to secure investment. Equity involves contributing resources in return for a share in the ownership of a project. This typically means that the completed project must be operated as a company of some sort so that the equity can be placed. Debt involves contributing resources in return for repayment, typically on an agreed schedule with interest. Public financing entities may also use grants or risk mitigation instruments to reduce the costs or perceived risks to private investors. In addition, governments have access to a funding base of taxes, charges, fees and other revenues, and can additionally use asset-based instruments to secure private finance. Some of these instruments will be used routinely as part of a government's revenue-raising and steering efforts; others may be deployed to mobilise the investment for a specific project or sector.

There is scope to use or adapt many of these financing instruments to advance climate aspirations. For example, land and property taxes may be designed to incentivise more compact urban growth, while guarantees may be used to reduce the risks associated with emerging low-carbon technologies. Four instruments have particular promise to support investment in sustainable urban infrastructure at scale: pricing, regulation and standards, debt financing, land value capture and public-private partnerships.

A major barrier to financing low-carbon, climate-resilient infrastructure is the lack of robust implementing entities, particularly entities with a strong understanding of sustainability and resilience. Implementing entities need to be

capable of structuring projects to suit the diverse risk appetites, time horizons and expectations of returns of prospective investors. Such projects must have sufficient bankability, or such entities must have sufficient creditworthiness, to attract affordable capital. For maximum cost-effectiveness, implementing entities should be able to utilise a wide range of financing and funding models, and administer project design and procurement processes that can leverage private finance. Implementing agencies should also have clear responsibility for, and support to, integrate climate criteria into project design, implementation and evaluation.

1.4 Enhancing urban finance readiness

As a precondition for either low-carbon or climate-resilient urban development, governments need to raise sufficient resources or improve the efficacy of expenditure sufficiently to fill the financing gap. Their capacity to do so can be understood as their urban finance readiness.

The binding constraint in high-income countries is not the supply of finance, but the coherence and effectiveness of demand-side institutions. Given high per capita incomes, infrastructure such as renewable energy systems, water networks and building developments can generate revenue streams that provide private investors with attractive returns on investment. Governments can also raise revenue through taxation, fees, charges, tariffs and asset management. However, demand-side institutions vary in their capacity to package and structure investment projects to secure the necessary resources. Central governments in high-income countries will typically have sophisticated capabilities that allow them to deploy a range of financing and funding instruments. The effectiveness of subnational institutions is more varied.

In contrast, both the demand and supply sides of the urban finance market are often constrained in low- and middle-income countries. Low per capita incomes mean lower tax revenues and less ability to pay user fees and charges at a level that provides a sufficient profit margin for investors. It follows that poorer countries and cities are less likely to have access to the same range of financing mechanisms that are available to wealthy nations and cities. However, urban finance readiness is not just a function of per capita incomes, but also of the quality of relevant demand- and supply-side institutions. Institutional weaknesses may manifest as imperfect information; politicised decision making; corruption; lack of clarity or certainty around regulatory and legislative frameworks; poorly functioning land and property markets; poor collection and management of own-source revenue; or weak project management and technical capabilities.

Crucially, this analysis suggests that cities and countries do not need substantial increases in per capita incomes to improve their urban finance readiness. Governments have opportunities to raise and steer infrastructure investment through:

- 1. Strengthening fiscal and financial systems** by expanding the fiscal space through tax and expenditure measures, and tackling gaps in the availability and costs of long-term finance.
- 2. Providing a stable, enabling policy environment** by developing detailed urban spatial plans and infrastructure strategies, and by clarifying regulations and legislation to reduce investment risks and transaction costs.
- 3. Improving project development and implementation** systems by clarifying agency mandates and funding sources, and by supporting project preparation activities.

1.5 Mainstreaming climate considerations into urban finance systems

Climate-compatible urban development will require fundamental reforms to urban finance systems to make good practice ubiquitous, and to improve on good practice. The reform priorities can be grouped according to the three opportunities identified above.

There are large opportunities to mainstream climate considerations into fiscal and financial systems through pricing, accounting and procurement mechanisms. Pricing climate-related externalities appropriately offers huge potential to steer investment towards more sustainable forms of investment. Governments should prioritise eliminating pervasive fossil fuel subsidies and adopting carbon pricing. Accounting for physical, liability and transition risks can also steer help to shift investment away from projects with large carbon footprints or high exposure to climate impacts. Such accounting systems may be introduced by financial intermediaries, regulators or central banks. Looking beyond infrastructure investment, green public procurement policies are an effective means to establish markets for more sustainable goods and services. Central and local governments can introduce environmental standards into technical specifications, procurement selection and award criteria, and contract performance clauses.

The financial and fiscal architecture can also be used to reduce systemic vulnerability (including to climate risk) by creating space for low-income and other marginalised urban residents to influence the allocation of public resources and governance of private investment. Proven models exist, such as participatory budgeting or city development funds.

Policy frameworks, spatial plans and infrastructure strategies should clearly direct investment towards low-carbon, climate-resilient modes of development. This requires coordinated multi-level governance (across national, regional and city governments) and horizontal policy integration. For maximum effectiveness and legitimacy, such plans and strategies must also address other local priorities, such as housing affordability and air quality. Policy instruments can also tackle non-financial obstacles to low-carbon and climate-resilient investment, such as split incentives, inadequate access to finance and industry fragmentation. Such policies will need to be tailored to the local institutional, legal, economic and cultural context, and to target a range of prospective investors including households, small and medium enterprises, commercial banks and local authorities.

Lead agencies can adopt project appraisal and valuation systems that systematically capture environmental externalities over an asset's lifecycle, and apply rigorous and consistent environmental safeguards to planned investments. Optimising a project design across multiple criteria typically requires a professional and multidisciplinary team with legal, technical, scientific and financial expertise. An appropriate choice of shadow carbon price and discount rate can further ensure that the long-term, social costs of climate change are meaningfully accounted for when designing and delivering new infrastructure projects.

1.6 Research priorities

1. Strengthening the economic and financial case for climate-compatible urban development from the perspective of a range of different actors (including diverse investors).

2. Understanding the spatial allocation of productive assets, households and jobs relative to climate risk.
3. Identifying the components of urban finance readiness, and activities or reforms that can enhance readiness.
4. Assessing the different ways that climate goals can be mainstreamed into urban finance systems on both the supply and demand side.
5. Assessing the different ways that urban financial systems could enhance inclusion and equity, and thereby reduce vulnerability to climate change.
6. Determining best practice in engaging private actors in sustainable urban infrastructure projects of different kinds, and articulating the conditions or contingencies for success.
7. Evaluating the best actors and mechanisms to best support learning, replication and scaling on both the supply and demand side.
8. Accounting for flows of climate finance and improving the use of international public finance to achieve paradigm shifting potential.

1. Introduction

Today, more than half of the global population live in urban areas, which contribute over 80 per cent of global GDP (UN, 2015). The concentration of people and economic activity means that urban areas are responsible for a substantial share of resource use and waste production, with 67 to 76 per cent of global energy consumption and 71-76 per cent of carbon dioxide emissions from final energy use being attributed to urban activities (Seto *et al.*, 2014). The world's urban population is projected to increase by one billion in the next 15 years (UN DESA, 2015). The increase in urban populations, economies and carbon emissions will be the greatest in emerging and developing countries (*ibid.*). Recognising the growing proportion of global emissions associated with urban activities, 113 Nationally Determined Contributions (NDCs) under the Paris Agreement include urban-related content on adaptation and mitigation. This is most pronounced in the rapidly urbanising regions of Africa and Asia (UN-Habitat, 2017).

Unfortunately, in many parts of the world, urban development is becoming more inefficient, unsustainable, and carbon-intensive. Urban spatial expansion is far outstripping urban population growth (Angel *et al.*, 2011), and the share of urban trips by private vehicles is projected to increase in all developing regions by 2050 (OECD/ITF, 2017). Meanwhile, millions of urban residents lack access to risk-reducing infrastructure and services, such as sewers, piped water, drains, waste collection or healthcare. It is therefore urgent that urban development be designed and implemented in a way that mitigates and adapts to climate risks. A transition to climate-compatible cities will require both a substantial increase in the total quantity of urban finance and a shift in the way that existing streams of finance are allocated. There is therefore a need for innovation, learning and scaling of financing instruments, financial architecture and governance structures.

The methodologies used to calculate financial requirements for climate-positive urban infrastructure are, to date, very limited in their scope. While imperfect, existing estimates reveal that:

1. There is a huge gap between demand for, and supply of, urban infrastructure investments.
2. The financing gap is largest in emerging and developing countries.
3. Additional resources will be required to finance climate-compatible investments, which often have higher upfront costs or higher risks than conventional projects.

The next chapter considers demand for finance for sustainable urban infrastructure. This encompasses the agencies undertaking projects, the type of projects and the funding required to repay finance. Chapter 3 looks at the supply of finance for investment projects, mapping possible investors and their likely risk appetites, return expectations, liquidity needs and time horizons. Chapter 4 considers the financing and funding mechanisms that can be deployed on the demand side to raise and steer finance from the supply side, and at integrating climate considerations into the project preparation process. Chapter 5 presents the concept of urban finance readiness: the capacity of supply- and demand-side institutions to address the infrastructure financing gap. It assesses key opportunities to strengthen fiscal and financial systems, policy environments and frameworks, and project development and implementation processes. The chapter then explores how climate considerations can be mainstreamed into urban finance systems. Chapter 6 concludes with research priorities going forward.

2. Demand for finance for sustainable urban infrastructure

Global investment in core infrastructure is currently around US\$3.4 trillion per annum. However, to meet human and economic development needs over coming decades, a total of US\$5 to US\$6 trillion is required each year (Bhattacharya *et al.*, 2016). The annual deficit in infrastructure investment is therefore above US\$1 trillion a year. 70 per cent of the projected investment needs for sustainable infrastructure will be required in emerging and developing countries, with a particularly fast rate of increase in Africa where urban population growth rates are highest (Bhattacharya *et al.*, 2016).

To avoid dangerous levels of climate change and to adapt to existing risks, planned investment must be steered towards lower-carbon, climate-resilient options. For example, the global residential floor area is projected to increase from 164 billion square metres in 2012 to 354 billion square metres in 2050 (Dulac, 2014); it is essential that this new construction is energy efficient and located in areas with minimal exposure to environmental hazards. One estimate suggests that the total incremental financing needs associated with climate-compatible development are equivalent to around five per cent of total investment requirements (Bhattacharya *et al.*, 2016). The higher financing needs reflect the higher capital costs, technological substitution and technical risks associated with many sustainable infrastructure options.

Estimates of the scale of urban investment needs vary according to the different assumptions surrounding the sectors considered, choices around infrastructure and technology, rates of technological learning, the value of avoided investment costs, and the ambition of measures to reduce the environmental impact of infrastructure. Irrespective of the precise values involved, it is clear that there is an urgent need to scale up levels of infrastructure investment in cities around the world, particularly in those in the global South, and to steer investment towards more sustainable options.

While climate-positive approaches might have higher incremental investment needs, there is a growing body of evidence to suggest that they might generate a net financial return. Early analysis suggests that, although new green districts in urban areas cost 8 to 10 per cent more than 'brown' districts, lower operating costs of this infrastructure allow for payback periods of only three to five years (Bouton *et al.*, 2015). Another study finds that investing in sustainable urban infrastructure would have a net present value of US\$17 trillion of economic benefits globally by 2050, primarily from energy savings, within relatively manageable investment repayment schedules (Sudmant *et al.*, 2016). In other cases, the economic returns of climate actions may be even broader. For instance, avoided mortality through reductions in

air pollution has estimated health benefits worth US\$50-380 per tonne of carbon dioxide (West *et al.*, 2013). In impoverished neighbourhoods in temperate regions, the value of other health benefits from investments in insulation may be worth ten times as much as energy savings. These gains accrue to households, businesses and public health systems, and may therefore be difficult for prospective investors to recover (Gouldson *et al.*, 2018).

There is already substantial demand for finance to adapt urban infrastructure to environmental risks, which will increase with the severity and intensity of climate change. Many cities are located in areas that are very exposed to the effects of climate change, such as extreme weather conditions, sea-level rise, and storm surges. As of 2007, an estimated 13 per cent of the world's urban population lived in low elevation coastal zones (less than 10m above sea level), and the share was higher in Least Developed Countries (21 per cent), where there are greater infrastructure deficits than in OECD countries (11 per cent) (McGranahan *et al.*, 2007). The World Bank estimates that US\$11-20 billion is needed annually to 2050 to ensure urban infrastructure is adapted to climate risks (Hughes *et al.*, 2010), while UN Environment calculated that the requirements were US\$120 billion to 2030 (CCFLA, 2015). These estimates arguably understate the need for investment in basic infrastructure, such as drains, sewers and piped water supplies, which are important preconditions for urban resilience. When accounting for this 'adaptation deficit' (which is mostly a development deficit), the financing gap is much greater (Parry *et al.*, 2009). Quite apart from the moral imperative to meet and climate-proof human development goals, there is a long-term economic case for such adaptation investment as articulated in 'The Stern Review' (Stern, 2006). But this can be difficult to translate into near-term investments that satisfy the risk-return criteria of financiers.

2.1 Investments in low-carbon urban development

The Paris Agreement aspires to limit the global temperature rise this century to no more than 1.5°C above pre-industrial levels. This will require greenhouse gas emissions to reach net zero in the second half of the century, with net negative emissions thereafter (Rogelj *et al.*, 2016).

Urban form has a major influence on the type and viability of low-carbon investments and strongly influences levels of greenhouse gas emissions, particularly through patterns of density, land-use mix, connectivity, and accessibility (Seto *et al.*, 2014). Integrated land-use, housing and transport planning can steer investment towards more compact and connected modes of urban development, which are more carbon-efficient than urban sprawl (Rode *et al.*, 2017). Higher levels of population density can also improve the cost-effectiveness of more energy-efficient options such as mass transit, cycling, walking and district heating and cooling. Urban form (and the policies that drive it) therefore has a major influence on the carbon intensity of urban activities.

Mature cities will need to refurbish existing systems and infrastructures, and fast-growing cities will need to shift towards lower-carbon development pathways (Davis *et al.*, 2010; Müller *et al.*, 2013). Within the constraints of urban form, investments in four interconnected sectors arguably have the greatest abatement potential. These are:

2. Decarbonising the electricity grid
3. Energy efficiency in buildings
4. Modal shift and next generation mobility, and
5. Waste management.

Interventions in these sectors each require a defined set of investment types, which, in turn, require a set of institutional arrangements to implement. These institutional arrangements are not in place on a systemic basis, otherwise the required investments would be occurring. But prototypes and/or small-scale versions of all the elements needed for systemic arrangements are operating successfully – somewhere – in almost all these sectors. This section will define the key investments required in each of these sectors and some of the obstacles to unlocking the necessary finance.

2.1.1 Decarbonising the electricity grid

Major investments will be required in new power generation from renewable sources, whether through centralised or decentralised technologies. In some contexts, this will involve new capacity in response to unmet or new demand – particularly in fast-growing cities of the global South. In other contexts, this will involve replacing or refurbishing existing capacity to reduce the emissions associated with power generation. Action by national and regional governments is important, as the current institutional arrangements in many countries place cities in a relatively weak position to influence these investments (Cowell *et al.*, 2017). However, this is not to say that some effective influence cannot be exerted.

There are a few fundamental financing challenges associated with investments in renewable energy. While a growing array of renewable energy technologies are economically competitive in an increasing number of geographic contexts, some continue to be more expensive than fossil fuel alternatives. Even where the levelised cost of energy (LCOE) is competitive with current market prices, renewable energy technologies tend to have higher capital costs than conventional power generation options. This is particularly relevant for developing and emerging economies, where capital and financing costs tend to be higher than in rich countries (Hirth and Steckel, 2016). Lack of access to sufficient finance and the short time horizons of some potential investors can therefore constrain finance flows, particularly where there are significant opportunity costs to any public expenditure (Colenbrander *et al.*, 2016).

In addition to this direct financial barrier, low-carbon energy technologies are often perceived as more risky than conventional generation options due to – among other things – the relative capital intensity of the investment, complicated or unfavourable permit processes and financial and public institutions designed for different investment needs (Schmidt, 2014; Granoff *et al.*, 2016). In Indonesia, for example, geothermal power could be economically attractive, but investment has been constrained by unfavourable tender processes, artificially low electricity prices, and the technical risk associated with establishing a new plant (Smith, 2012). By comparison, coal power generation has been indirectly subsidised through a national policy, setting the price of domestic coal below international rates (Chattopadhyay and Jha, 2014). Local firms and investors may also be deterred by lack of awareness or familiarity with new technologies, or with the financing mechanisms required to support their deployment (Kennedy and Basu, 2013). Again, poor information about different options is more likely in lower-income contexts, although (as seen in the US), selective use of available information can be equally problematic.

Distributed generation has many of the same financing/funding issues as large power plants. There are also additional challenges related to consumer awareness and cost recovery. For example, high rates of property turnover mean that individuals who buy rooftop solar panels may not enjoy much of the return on their investment (unless their investment manifests in higher house prices).

2.1.2 Energy efficiency in the buildings sector

Major investments will be required to improve the efficiency of the building envelope and of heating and cooling systems. Recent technological developments and improved knowledge allow the construction of very low- and zero-energy buildings, often at comparable costs to conventional buildings. Where there are higher upfront costs, these may have payback periods as short as five years (IEA, 2013a). In principle, new building stock could all be constructed to high energy efficiency standards through regulation and the extension of existing financing/funding systems. The challenges are not financial, but relate to awareness and enforcement – particularly in contexts such as China and India where the majority of new building construction is anticipated.

In contrast, the issue of retrofitting existing buildings is fraught with difficulty. Substantial energy savings (50-90 per cent of total energy consumption) have been achieved in individual buildings throughout the world through deep retrofits. However, even where measures are cost-effective, there are strong barriers to uptake, including imperfect information, split incentives, lack of awareness, transaction costs, inadequate access to financing, and industry fragmentation (Lucon *et al.*, 2014). There is therefore a need for innovative finance mechanisms and business models, particularly if energy utilities, businesses, and financial institutions are to successfully aggregate multiple small projects and overcome first-cost hurdles (Veeraboina and Yesuratnam, 2013). There are a number of systematic performance-based financing models emerging from energy service companies (ESCOs) in China (Kostka and Shin, 2013), the UK (Hannon *et al.*, 2013), and the USA (Stuart *et al.*, 2014), although their success is varied. One of the particularly sensitive issues relating to retrofit will be sharing the funding burden, as low-income households are more likely to rent (meaning that the incentives of tenants and owners do not align) or live in lower-quality housing (which requires more substantive and therefore costly retrofits).

2.1.3 Low-carbon transport

The nature of low-carbon transport infrastructure investments will vary depending on population size, rates of population growth, levels of income, technical and financial capabilities, and established infrastructure stock. Mitigation pathways vary among regions, with the largest opportunities to shape transport systems and infrastructure around low-carbon options arguably in rapidly urbanising countries of the global South (Sims *et al.*, 2014). Transport projects that are likely to need financing and funding are outlined in Table 1.

Table 1: Opportunities to decarbonise urban transport networks through an avoid-shift-improve approach.

	Strategy	Activities / projects
AVOID long and unnecessary trips.	Dense and mixed-use development	Renovation of historic districts and downtown areas; master plans, integration of land use and transport planning.
	Use of information technologies to reduce trips	Teleworking, virtual meetings through improved connectivity and internet access; digital journey planning and ticketing.
SHIFT the movement of goods and people to more carbon-efficient modes	Improved facilities for biking and walking	Recovery of invaded sidewalks and public spaces; rehabilitation of waterfront sidewalks with adequate design, urbanism and furniture; bikeways and bike lanes, safe bike parking.
	Improved public transport systems	Bus networks (including Bus Rapid Transit), cable cars, ferries, passenger trains, metro, trams.
	Disincentives to individual motor vehicle use	Administrative restrictions (using plate numbers), congestion pricing, taxes on fuels and registration, urban tolls.

IMPROVE the efficiency of vehicles, fuels and energy carriers, as well as the operational management of transport services.	Clean and low-carbon fuels	Electrification of transport; elimination of lead content, reduction of sulphur content, use of biofuels; support for Compressed Natural Gas (CNG) and Gas to Liquid (GTL).
	Clean and low-carbon vehicles Safe cars and roads	Fuel economy standard, hybrids (internal combustion engine-electric), road inspection programmes.
	Command and control improved management	Technical inspection programs, including air pollutant controls; traffic control networks, centralised dispatch and control of transit services.

Source: Modified from Hidalgo and Huizenga (2013)

Many of these activities and projects can be implemented at relatively low cost; others can be financed by steering planned investments towards lower-carbon options (for instance, mandating that consumers purchase more efficient cars). However, some transport projects have high investment needs.

Redirecting funding from unsustainable transport (highways, overpasses) could increase the public finance available for funding sustainable transport (Sakamoto *et al.*, 2010). This can be constrained by wider political considerations and economic frameworks, such as job creation associated with the vehicle manufacturing industry. It is therefore necessary that investment in public and non-motorised transport is accompanied by proactive demand management to discourage the use of private vehicles; for example, by increasing parking costs and reallocating car lanes for buses and bicycles.

Even where these barriers can be overcome, large transport infrastructure projects will likely still exceed the capacity of public budgets. This means that decision makers must seek to create a 'package' of financial sources, often blending public finance with private finance to reduce the total cost of capital or perceived investment risk. Leveraging private finance is critical: in 2011, foreign direct investment in the transport sector exceeded overseas development assistance and climate finance combined (ITC, 2013). Land-based taxes and fees are increasingly recognised as a promising mechanism to unlock private investment, notably in Indian cities (Newman *et al.*, 2013). Land value capture instruments enable the state to secure a proportion of the higher values associated with investments in public transport infrastructure.

Technological and institutional innovations are creating new opportunities to decarbonise the transport sector. Product innovation (such as transport electrification and autonomous cars) creates opportunities to reduce the carbon intensity of fuel or the total number of cars on the road. The carbon implications of new forms of shared mobility (such as e-hailing and car/bike sharing schemes) are unpredictable (Canales *et al.*, 2017). The ease and low cost of e-hailing systems such as Uber, OlaCabs and Didi Chuxing, for instance, might either shift public transport users into cars or create a feasible alternative to private vehicle ownership.

2.1.4 Low-carbon waste management

Waste collection, processing, recycling and disposal are priorities for municipalities, particularly those in the global South. In the absence of effective waste management systems (including municipal solid waste, wastewater and sewage), the higher density of people living in urban areas leads to significant health costs that are mostly borne by children and the poor. The economic costs of healthcare, lost productivity, flood damage, tourism and clean-up costs are estimated to be five to ten times greater than the financial costs of proper waste management (Wilson and Velis, 2015). Yet it is common for municipalities in the global South

to spend up to 50 per cent of their municipal budget on solid waste management (Aleluia and Ferrão, 2017), often while serving less than half their population.

There is a range of ways that cities can manage solid waste, including landfill, recycling, composting and waste-to-energy technologies. These may be used together in different combinations. Emissions from landfills can be reduced through landfill gas flaring and utilisation. Waste-to-energy can be particularly carbon-effective, as energy generated from waste can displace fossil fuel alternatives. Waste-to-energy options include incineration, gasification, pyrolysis, anaerobic digestion and refuse-derived fuel. There are also opportunities to reduce waste upstream through measures to reduce waste in the manufacturing and packaging phases. There is evidence that some of these waste management strategies can generate a commercial return, subject to the policy environment and market for specific energy products (Papargyropoulou *et al.*, 2015).

Financing and funding waste management is now fairly routine, even if best practice is no longer universal. Improving access to capital finance will be essential in low- and lower-middle income countries. Recycling, composting and waste-to-energy systems offer some prospect for returns on investment, and therefore opportunities to leverage private finance. The Clean Development Mechanism played an important role in building the technical capabilities and financial case for investment in low-carbon waste technologies (Agamuthu *et al.*, 2009). However, the geographical spread of CDM projects and other loans for solid waste management has been very uneven: between 2003 and 2012, the top ten recipients were all middle-income countries, which accounted for over two thirds of the total value of grants and loans (Lerpiniere *et al.*, 2014). There is therefore an urgent need for donors to reorient towards low-income countries, which commensurately involves a renewed focus on building local capacities, rather than just project preparation.

5.1 Investments in climate-resilient urban development

The more the global temperature increases, the more severe the impacts of climate change. Therefore, the scale of adaptation investment needed will depend on the scale of mitigation investment mobilised. In other words, the finance required to adapt cities to a 1.5°C increase in global temperatures are a fraction of those required to adapt to a rise of 4°C. This section will explore the relationship between development and adaptation investments, some of the barriers to mobilising these investments, and some of the institutional arrangements and financing mechanisms that might be deployed to fill the financing gap.

Adaptation investment needs are a function of physical exposure to climate risk and adaptive capacity. Adaptive capacity is in turn significantly dependent on the level of 'development' of a community, resulting in a continuum of needed interventions (see Figure 1). This suggests three broad categories of adaptation, which each need different approaches to financing:

1. **Addressing drivers of vulnerability.** At the development end of this spectrum, there is a need for investment in basic urban infrastructure and services: sewers, piped water, drains, all-weather roads, waste collection, healthcare and emergency services. Although clearly an important part of conventional 'development', these are essential investments to reduce urban residents' exposure and sensitivity to a range of climate-related risks, such as flooding (World Bank, 2015). These investments need to factor in likely increases in climate impacts. This is a priority for cities and communities with low levels of development and, accordingly, low adaptive capacity.

2. **Building response capacity and managing climate risk.** All urban infrastructure should be resilient to the impacts of climate change, which may involve additional finance to enhance its robustness, create redundancy or introduce fail-safe systems (Dodman *et al.*, 2017). Urban planning should also be informed by climate change projections to minimise land development in hazardous areas, such as low-lying coastal zones or floodplains:
 - a. New infrastructure must be designed and built to be climate compatible. This is a priority for cities with rapid population/economic growth and with significant infrastructure deficits.
 - b. Existing infrastructure must be modified or retrofitted to be resilient to climate impacts, or replaced with climate-compatible infrastructure. This is a priority for cities with an established infrastructure stock.
3. **Confronting climate change.** At the adaptation end of this spectrum, there is a need for investment in new infrastructure and services specifically to respond to new climate hazards, such as sea level rise, water scarcity and more frequent and intense storms. Relevant measures could include grey, green or blue infrastructure, such as sea walls, emergency warning systems, canals, levee dykes or green spaces that serve as floodplains. A priority for cities and communities with high physical exposure to climate risks.

There is a need for the institutions allocating climate finance to recognise the development-adaptation continuum. Low-income urban residents and cities face everyday risks associated with inadequate basic infrastructure and poverty, and these risks will be exacerbated rather than necessarily caused by climate change (Pelling *et al.*, 2018). A preoccupation with ‘additionality’ – the principle that adaptation finance should only be allocated in response to risks that can be explicitly linked to climate change – makes it more difficult to integrate development and adaptation investments effectively (Fankhauser and Burton, 2011). Rather than focusing narrowly on climate adaptation or other hazards, this underscores the need for holistic policymaking and demand-led planning to achieve resilient urban development – enabled by appropriately flexible and responsive urban finance systems.

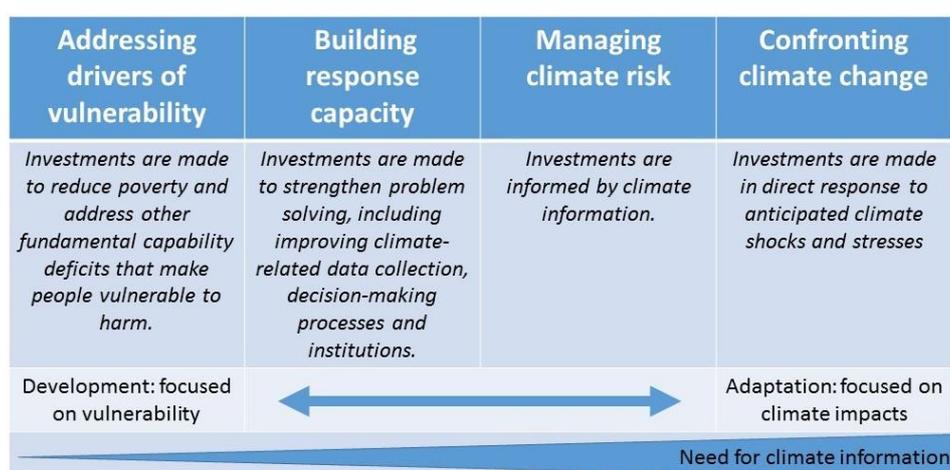


Figure 1. The development-adaptation investment continuum.

Source: Modified from McGray *et al.* (2007).

In each category of investment above, there is a need for investment in ‘soft’ infrastructure (such as human capital and institutions) as well as the ‘hard’ infrastructure that comprises

the built environment. Soft infrastructure might include the provision of education and healthcare, establishing participatory decision-making processes, or designing and enforcing regulatory frameworks that contribute to public health and safety (such as traffic management or pollution control). Investments in soft infrastructure may be more cost-effective than hard infrastructure, and can also enhance the effectiveness of other types of adaptation investment (Fankhauser and Burton, 2011).

The focus on vulnerability and soft infrastructure highlights an important challenge with respect to financing adaptation. The bulk of adaptation investment is required in low-income cities of the global South, and in low-income neighbourhoods within cities. These actors typically have limited capacity to raise or attract capital, as is evident from current infrastructure deficits. City governments in low-income countries, particularly smaller cities, are likely to have a small revenue base combined with weak revenue collection and management systems. This limits their access to sources of finance, such as capital markets (Floater *et al.*, 2017a), that could enable investment in development or adaptation. Within cities, low-income communities lack access to finance. These urban residents are also often systematically excluded from public services, due to processes that favour the formal sector over the informal, and higher-income groups over lower-income groups. For example, urban residents living in informal settlements may not have a legal address, which in turn means that they cannot open a bank account, obtain insurance, connect to utilities, send children to school, receive healthcare, or register on the electoral roll (Satterthwaite *et al.*, 2018).

Adaptation investment in low-income cities and neighbourhoods will therefore require fundamental reforms to political and financial structures to successfully engage with powerful, and often entrenched, political economic interests (Chu *et al.*, 2017). Municipal governments need to establish decision-making processes that are accountable and responsive to urban residents who are vulnerable to climate change, such as low-income groups, women, children, the elderly, persons with disabilities, and others. Although there are few documented examples of sustained engagement, there are many promising experiments focused on encouraging public participation and building civic capacities for urban climate adaptation (Sarzynski, 2015). Where local governments are accountable to their citizens, resourcing and empowering these administrations can reduce vulnerability by enhancing incentives to produce services and infrastructure that meet the SDGs and reduce exposure to climate risk (Colenbrander *et al.*, 2017). Fiscal risk must be contained at the same time.

A second challenge concerns achieving satisfactory risk-return ratios for both development and adaptation investments in urban settings. In the long term, there are substantial economic returns associated with climate-resilient development, and substantial costs can be avoided through investments in adaptation. But these are often non-monetised, indirect returns with high degrees of uncertainty, so they need to be financed with public resources.

However, there are opportunities to steer private investment towards climate-resilient forms of investment (and deter private investment in maladaptation) through information, regulatory or fiscal instruments. Particularly large opportunities exist with respect to (World Bank, 2011):

1. Privately-held infrastructure that provides public services, such as transport, electric power networks, water systems, and solid waste. Governments can use regulation and procurement policies to require private constructors and operators to ensure the resilience of these systems.
2. Private properties that have a direct incentive to enhance their adaptive capacity, such as downtown buildings that could be renovated with green roofs to minimise the urban heat island effect.

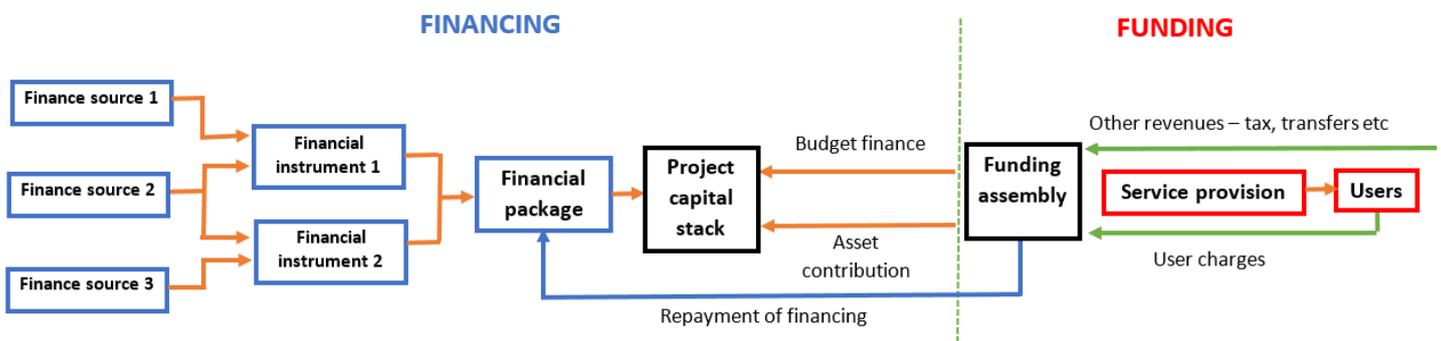
3. Insurance and other risk management instruments that provide protection in the event of high-severity, low-frequency events, and can incentivise more climate-compatible behaviour.

In summary, climate-positive urban investments are institutionally more complex than historical and current urban investments. They may also entail higher upfront costs, if they are not all together more expensive by conventional economic and financial metrics. Consequently, the financing and funding arrangements will generally be more sophisticated than existing systems.

3. Supply of finance for sustainable urban infrastructure

Although the **financing** needed to get a project built and running can come from a wide variety of sources, the **funding** for climate-related and other infrastructure must ultimately come from users and other stakeholders (Figure 2). Sometimes national and municipal governments will be able to draw on their own funds to finance large infrastructure projects, but even cities with relatively large own-sources revenues and access to intergovernmental transfers will generally require additional financing. Cities must examine all options carefully when structuring a project to ensure its financial sustainability over the long term. In this chapter, we explore possible sources of financing and funding.

Figure 2. Financing and funding urban infrastructure.



Source: Authors.

3.1 Domestic public finance

Government infrastructure investment is equivalent to about three per cent of global GDP (Standards and Poor's Rating Service, 2014). Governments have traditionally financed a significant proportion of infrastructure investment, but sourcing sufficient urban infrastructure finance is a challenge. Higher-income countries have reduced infrastructure spending due to various austerity measures and reprioritisation of other public services (WWF and Z/Yen Group, 2015). Emerging and low-income countries have been increasing their public expenditure on infrastructure and a large part is directed to urban areas (Bhattacharya *et al.*, 2016). However, many governments are constrained in their spending on infrastructure due to competing priorities and the need to manage existing debt. Larger and more complex projects may also be beyond the capacity of public budgets (with a few notable exceptions, such as China). Additionally, countries that do not pay sufficient attention to fiscal

sustainability in the medium term also tend to suffer balance of payments crises and loss of access to private sector financing or credit that can constrain future investment. Balancing near- and long-term financing needs is therefore important.

The responsibility for funding and financing urban infrastructure has increasingly shifted away from national governments towards municipalities and cities. Poor own-source revenues can turn these spending assignments into unfunded mandates. Many local authorities, particularly those in sub-Saharan Africa, have an annual planned budget of less than US\$20 per person (Cabannes, 2015), most of which is committed to operating costs, such as salaries. Local revenue collection is often inefficient, and local governments frequently have little or no control over rates or bases at the margin. Opportunities for land-based financing may be constrained by poor market information, incomplete or inaccurate land and property registries, and undue influence on the decision-making process by vested interests (Berrisford *et al.*, 2018). Additionally, few low- and lower middle-income countries have the enabling multi-level governance arrangements in place that could equip local authorities to act effectively on climate change (Gouldson *et al.*, 2015; Kithia, 2011). Only 42 per cent of countries worldwide are recorded as devolving fiscal or legislative powers to subnational governments (IADB, 2015), and of these, the depth of revenue-raising powers is highly variable.

3.2 International public finance

Multilateral, regional and bilateral development organisations are able to provide significant financing and funding (including in the form of grants). Development banks alone have provided up to US\$160 billion for urban infrastructure (Bhattacharya *et al.*, 2016). Many, although not all, development banks and agencies have committed to ensure that their investments are compatible with the Paris Agreement. In addition, international public climate finance is projected to play an increasingly prominent role in leveraging and enabling private investment in sustainable infrastructure. Some of this will be distributed through established development banks and agencies, but ultimately, the Green Climate Fund (GCF) is intended to be the main channel for mobilising US\$100 billion of climate finance by 2020, of which half is committed to mitigation and half to adaptation. To date, difficulties translating donor pledges to well-capitalised funds with a viable project pipeline have resulted in relatively limited impact from multilateral climate funds.

While national governments may choose to work with these agencies to finance urban infrastructure, few agencies are permitted or willing to work directly with city governments. For example, many climate funds can only allocate resources to central governments or require a sovereign guarantee to allocate resources to sub-national governments (Paulais and Pigey, 2010; van Kerkhoff *et al.*, 2011). This can constrain city governments' capacity to respond to locally identified priorities where there is poor coordination or political differences with national agencies. Where development agencies are able to allocate resources to sub-national governments, local authorities rarely have structural relationships with such bodies and often speak a different technical language. Such information can be supplied by specialised consultants, but cities have limited budgets to commission such expertise. Many donors prefer large-scale projects, which are perceived to have lower transaction costs than small-scale ones (van Kerkhoff *et al.*, 2011). Local governments (particularly in smaller areas) may lack the capacity to implement large-scale projects, absorb large sums of money or leverage co-financing. The lending criteria of many development banks and climate funds indicate a preference for investments in 'hard' infrastructure, such as solar farms and sea

walls, which are typically the responsibility of national government agencies, rather than 'soft' infrastructure, such as capacity building and raising awareness, which tend to be delivered (and required) by local organisations (Fankhauser and Burton, 2011). The long lead times and approval processes may further frustrate local efforts to secure international public finance. Therefore, control of climate-related projects and opportunities for capacity development may remain concentrated at the national level.

The GCF and the Adaptation Fund have introduced a number of relatively new institutional features with the aim of channelling a larger share of climate finance to the local level, including direct access modalities and fit-for-purpose organisational accreditation and project approval processes. These are intended to reduce the transaction costs for local governments and civil society. To date, however, these have been little utilised. As of March 2017, only 36.2 per cent of resources committed by the Adaptation Fund and only 6.2 per cent of those committed by the GCF were to National Implementing Entities; the remainder has been or will be disbursed through International Implementing Entities, such as United Nations agencies, multilateral development banks, international financial institutions and regional institutions (Colenbrander *et al.*, 2017). This means that some of the same social, political and economic processes that create and sustain inequalities within a country will be the same processes that determine how adaptation finance is used. Well-meaning interventions therefore risk consolidating inequality and exclusion by concentrating assets in the hands of a few. The climate finance architecture therefore risks entrenching differential access to public resources, and continuing the political exclusion that contributes to climate vulnerability (Barrett, 2013).

3.3 Private finance

Commercial banks and investment companies manage nearly US\$70 trillion of assets, while pension funds, insurance companies and sovereign wealth funds (which tend to have lower risk appetites and longer-term investment horizons) represent nearly US\$44 trillion more (McKinsey, 2016). These investors could be drawn to public infrastructure investments where a sufficient return on investment is forecast based on project income flows, or low-risk government debt repayments based on sensible fiscal sustainability criteria. Bankability and creditworthiness are therefore prerequisites to attracting private finance into sustainable urban infrastructure (Floater *et al.*, 2017b). However, these finance sources have not been successfully steered towards climate-positive urban investments. For example, pension funds remain mostly untapped with only about one to three per cent directed at sustainable infrastructure (Liebreich and McCrone, 2013).

Unpacking the constituent elements within these pools of public, private and institutional capital is important, given the differing factors such as risk-return expectations and investment horizons of various investor groups. For example, private equity and infrastructure funds seek the greatest return and will make equity investments in projects with strong growth potential. These funds are often willing to invest in relatively unproven markets and technologies over the medium term (5-15 years). In contrast, pension funds and life insurance companies search for investments that provide predictable income streams to meet long-term obligations such as pensions or insurance claims, but need relatively high liquidity to meet claims. Public capital sources and private investor profiles will therefore suit different types and life-cycle stages of public infrastructure projects, and the largest capital pool in terms of assets under management may not necessarily be the most promising source of finance (Floater *et al.*, 2017b). Public finance and development assistance can play an important role

in improving the risk-adjusted returns associated with different infrastructure projects and in catalysing private and institutional sector participation.

Table 2. Potential sources of private finance for sustainable urban infrastructure, and barriers faced by each investor type.

Finance source	Key barriers					
	Lack of upfront public capital	Institutional inertia	Institutional capacity	Risk	Low returns	Imperfect information
Commercial banks and investment companies		e.g. National lending caps on banks for infrastructure financing (e.g. in India)	e.g. Lack of experience with project finance and municipal bond issues	e.g. Political risks and regulatory changes that impact income flows leading to non-performing loans	e.g. High capital requirements constrain long term investments (e.g. Basel III)	e.g. Lack of commercial knowledge in emerging markets for loan syndication
Developers and infrastructure operators		e.g., Better profit-making opportunities in servicing existing assets than new asset development		e.g. Local currency variability in project income against foreign currency denominated debt	e.g. High local market interest rates make projects unattractive	e.g. Lack of familiarity with operating partners in emerging markets
Private equity and infrastructure funds		e.g. Investors lack trusted relationships with partners and counterparties in 3C infrastructure		e.g. Risk that government guarantees could be reversed	e.g. Private equity hurdle rates unsuited to infrastructure investments	e.g. Lack of information on value potential of new technologies
Pension funds and insurance		e.g. Appetite for very large investments may miss smaller urban-scale opportunities			e.g. Liquidity requirements limit long-term investments (e.g. Solvency II)	e.g. Lack of knowledge in infrastructure
Sovereign wealth funds		e.g., Fund prohibitions from investing in infrastructure		e.g. Uncertainty with asset performance in new technology	e.g. Numerous small projects mismatched with large capex strategy	e.g. No clear partner strategy in unfamiliar emerging markets

Source: Modified from Floater *et al.* (2017a).

4. Connecting supply and demand to deliver sustainable urban development

5.2 Financing and funding instruments

This section explores financing and funding mechanisms available to national and local governments. Some of these will be used routinely as part of a government's revenue-raising and steering efforts; others may be deployed to mobilise the investment for a specific project or sector.

There are a few broad categories of financing instruments. Governments have a **funding base** of taxes, charges, fees and other revenues, and can additionally use **asset-based instruments** to secure private finance. **Equity** involves contributing resources in return for a share in the ownership of a project. This typically means that the completed project must be operated as a company of some sort so that the equity can be placed. **Debt** involves contributing resources in return for repayment, typically on an agreed schedule with interest. Public financing entities may use **grants** or **risk mitigation instruments** to reduce the costs or perceived risks to private investors. Specific instruments within each of these categories are listed in Table 3.

Table 3. Possible financing and funding mechanisms available to leverage finance from different sources.

<i>Sources of finance:</i>	<i>Internal</i>		<i>External</i>
	<i>Domestic public finance</i>	<i>International public finance</i>	<i>Private finance</i>
<i>Relevant institutions</i>	<ul style="list-style-type: none"> - National governments - National development banks - Municipal development funds - Subnational governments 	<ul style="list-style-type: none"> - Multilateral development banks - Bilateral development agencies 	<ul style="list-style-type: none"> - Commercial banks and investment companies - Developers and infrastructure operators - Private equity and infrastructure funds - Pension funds - Sovereign wealth funds - Philanthropic foundations
<i>Funding base</i>	<ul style="list-style-type: none"> - Intergovernmental fiscal transfers 		<ul style="list-style-type: none"> - Property taxes - Betterment levies or value capture taxes - Tax increment financing - Fees, tariffs and charges - In-kind contributions
<i>Asset-based instruments</i>	<ul style="list-style-type: none"> - Sale of land - Lease of public land assets - Sale of development rights 		
<i>Debt</i>	<ul style="list-style-type: none"> - Specific purpose concessional loans 	<ul style="list-style-type: none"> - Loans - Concessional loans - Subordinated debt and mezzanine loans - Sukuk and Sharia compliant finance 	<ul style="list-style-type: none"> - Bank loans (including syndicated bank loans) - Subordinated debt and mezzanine loans - Project bonds - General obligation bonds - Sukuk and Sharia compliant finance - Securitisation and asset-backed securities

<i>Equity</i>		<ul style="list-style-type: none"> - Public-private partnerships - Project equity - Yieldcos 	<ul style="list-style-type: none"> - Crowdfunding - Public-private partnerships - Project equity - Listed infrastructure corporates and funds - Preferred shares - Yieldcos - Trusts - Co-investment platforms
<i>Grants</i>	<ul style="list-style-type: none"> - Specific purpose grants 	<ul style="list-style-type: none"> - Grants 	<ul style="list-style-type: none"> - Philanthropic grants
<i>Risk mitigation instruments</i>	<ul style="list-style-type: none"> - Credit guarantee - Credit insurance 	<ul style="list-style-type: none"> - Credit guarantee - Credit insurance 	<ul style="list-style-type: none"> - Business insurance - Credit insurance

Source: Authors

There is scope to use or adapt many of these financing instruments for specifically green or climate purposes. In debt-based financing, for example, the total value of 'green bonds' reached US\$156.7 billion in 2017 (Climate Bonds Initiative, 2018). Such green bonds may be tied to specific, environmentally positive projects such as public transport, renewable energy or solid waste management. Alternatively, governments may issue general obligation green bonds (as the cities of Johannesburg, Mexico City and Ottawa have done) to raise finance for environmental projects without clear revenue streams, including adaptation initiatives. Similarly, fees, taxes and charges may be designed to steer investment towards climate-compatible forms of urban development. Carbon pricing is arguably the most economically efficient way to accelerate a low-carbon transition (Stiglitz *et al.*, 2017). Otherwise, the design of land/property taxes or additional interventions such as congestion pricing can be used to incentivise more carbon-efficient modes of urban growth. Development financing institutions already widely use risk mitigation instruments and grants to crowd in private investment for low-carbon infrastructure projects, but this could be accelerated and scaled (Bhattacharya *et al.*, 2016). Out of the diversity of mechanisms set out in Table 3, some have particular promise to support investment in sustainable urban infrastructure at scale (Floater *et al.*, 2017a).

Pricing, regulation and standards can drive investments into sustainable urban infrastructure. Economic efficiency points to the advantages of a common global carbon price, with emissions reductions taking place wherever the marginal costs are lowest (Stern, 2006). By 2017, 42 national and 25 subnational jurisdictions were pricing carbon (Stiglitz *et al.*, 2017). In the absence of a carbon price or where additional externalities must be considered (such as air pollution or technological learning), additional pricing schemes can further spur investment. For example, incentives for electric cars and rooftop photovoltaic panels have played a major role in growing those markets in China and Europe.

Regulatory measures are particularly powerful for creating a shift from infrastructure investment that locks in high-carbon pathways to new green technologies in the urban economy. Policies regarding the entry, treatment and protection of different investors are important to create an enabling environment, but financial regulation can go further to encourage or mandate investment in green projects. Governments can also regulate developers and operators (such as utilities) to preferentially invest in climate-compatible options. Renewable energy portfolio standards, for instance, can mandate that utilities provide a certain fraction of renewable energy, which increases investors' certainty about the size and value of future markets. Minimum energy performance standards or voluntary labelling codes

for appliances, buildings, lighting and vehicles can encourage businesses and households to choose more efficient options.

Governments can:

- Create efficient and effective regulatory frameworks and standards that steer investment into sustainable infrastructure projects and investments. This is particularly important in sectors characterised by small investment sizes and where consumer choices are key investment drivers, such as energy efficiency, distributed energy, non-motorised and electric mobility, shared mobility, and green buildings.
- Work with commercial banks, banking regulators, and capital market authorities on green finance voluntary practices and mandatory measures, including new market and finance product development, environmental impact reporting, and green secondary market rules.
- Establish pricing systems (whether negative pricing, such as emission trading schemes, or positive pricing, such as feed-in tariffs) to steer investment into sustainable infrastructure investments. Again, this is particularly important in sectors where firm and household choices are key investment drivers, or where sustainable infrastructure options have higher costs than conventional options without government intervention.

Debt financing is an important tool for raising upfront capital to finance sustainable urban infrastructure. Debt capital can be raised in the form of a bank loan, syndicated loans (with multiple lenders) or bonds. In most countries, bank lending tends to predominate early in a city's financial development with bond transactions emerging later (although bank lending will likely persist to cater to different elements of the market). This trend is explained by the generally lower transaction costs and complexity associated with bank lending compared to bonds. Loans can be further differentiated between short-term 'project finance' used to pay the cost of project construction, and longer-term 'permanent finance' used to support assets during their operational life. Permanent finance typically has lower interest rates as the risks are more predictable than for project finance. Labelling and standards can also ensure that debt finance is used for green investments, which are typically cost-effective for the issuer (Ernst and Young, 2016).

Debt financing may be secured at the national or city level. As a prerequisite to debt financing, governments need budgetary, accounting and financial management capabilities and sufficient sources of funding for making repayments. This is a major constraint for urban infrastructure in low-income countries, where users may be unwilling or unable to pay high enough charges to allow full cost recovery plus a return on investment (Bielenberg *et al.*, 2016). Asset-backed securities can also help to reduce risk for private and institutional investors, but could shift liabilities to central government. Even when a city has achieved an investment-grade credit rating, sound financial management is essential to minimise the risk of future default and to provide headroom for future investments while debt repayments of older projects are still ongoing. In the absence of fiscal decentralisation or as a complement to municipal debt financing, creditworthy national governments can collaborate with cities to identify investment priorities and structure bankable projects or national bond issues to support them.

Governments can facilitate debt financing by:

- Reforming national regulations to allow local borrowing and clarify the conditions for bank lending or bond issuance. This could include liberalising regulations dictating whether cities (and/or utilities) can borrow and how much, borrowing procedures,

whether they can borrow in a group, what currencies they can borrow in, the type of collateral that they may pledge to secure borrowing, and action in cases of default.

- Building the capacity of subnational governments to improve budgetary planning, accounting and financial management in local governments. This can reduce the costs of borrowing either through bank lending or bond issuance. They could also help to build local governments' experience with borrowing through joint projects or credit guarantees.
- Developing project pipelines, either via national borrowing or with support for project preparation. This could include the use of pooling instruments to aggregate similar small projects, for example through a national fund for energy efficiency, decentralised renewable and other same-type infrastructure investments across secondary and tertiary cities.
- Participating in programmes focused on enhancing (municipal) creditworthiness, e.g. those run by Climate KIC and the World Bank. They could also promote standards and labelling to encourage preferential issuance of green bonds at both national and subnational level.

Land value capture (LVC) includes a range of instruments by which the public sector can capture a proportion of rising land prices to fund large urban infrastructure projects. Investments in water, sanitation and transport infrastructure can lead to increased land and property values nearby. This uplift in value can be used as a source of revenue. At the same time, land-based financing can be used to drive more compact urban development.

The effectiveness of LVC can be increased where governments integrate spatial planning policies and infrastructure investment strategies. This can underpin nodes and corridors of managed urban growth, enhancing land values within close proximity. A transparent land and property market and an effective tax system can further enhance the efficacy of land value capture approaches. National governments can provide strong regulatory frameworks and guarantees that enable municipalities to capture land value uplifts, though cities will need significant technical capacities for successful implementation. Where land is owned by national agencies (as in China or Ethiopia), they can directly influence or capture the gain related to land sales or ground leases.

Governments can facilitate wider deployment of LVC instruments through:

- Developing national LVC regulatory frameworks that outline whether cities can sell and trade development rights, land leasing systems and the rules governing rights exchanges. They could additionally create best practice guidance for local co-investment based on local-level LVC.
- Coordinating spatial plans and infrastructure strategies across different scales, and align them with LVC mechanisms.
- Investing in more efficient property markets, for example by systematising valuation practices, registration and titling, and introducing transparent transaction registries. This also creates opportunities to improve public land and built asset registries and condition assessments to determine where there is investment potential and uncaptured value in government holdings.
- Multi-level collaboration to identify projects suited to LVC (recognising there are several specific LVC instruments available with different finance raising/repayment characteristics) and identify bridge financing sources (for example, concessional finance from development finance institutions) if needed so that projects can be initiated in advance of LVC revenue flows.

Public-private partnerships (PPPs) are contracts which allocate risks between public and private entities, and often play a role where governments face technical, institutional and financial constraints (UNCTAD, 2013). There are many forms of PPP, but their potential is typically limited to projects that involve commercial returns on revenue-generating assets. Energy and road infrastructure projects have attracted the vast majority of global PPP finance, subject to market regulations and thanks to clear income streams from these assets (ibid.).

PPPs are complex structures. Asymmetric information between levels of government, and between the public and private partners, can lead to rent-seeking behaviour. Without tight monitoring and public expenditure management, PPPs can effectively create hidden liabilities for government agencies. Therefore, PPPs are a particularly important instrument in middle and high income countries with mature financial systems, as the effectiveness of this mechanism depends heavily on appropriate project identification, structuring, contractual arrangements and government capacity.

Governments can enable greater use of PPPs through:

- Evaluating the asset types and prospective investments that are suited to PPPs and contribute to sustainable urban form and infrastructure development. This can be used to prepare a long list of feasible pilot or exemplar projects.
- Establishing regulation and legislation outlining the ability of cities/utilities to enter into PPP transactions, and detailing the corporate framework for entities which may be established to do so, the way in which tariffs are set, and the mandate of regulatory oversight processes and agencies.
- Establishing national PPP units that can support project preparation and tendering, drawing on international technical assistance as required to ensure the feasibility, accountability, transparency and competitiveness of the process.

5.3 Developing financially-viable climate-positive projects

Central and city governments often have to deploy a range of instruments to accumulate different sources of finance to develop, construct and operate a project. This can be depicted as the 'capital stack' (Figure 3).

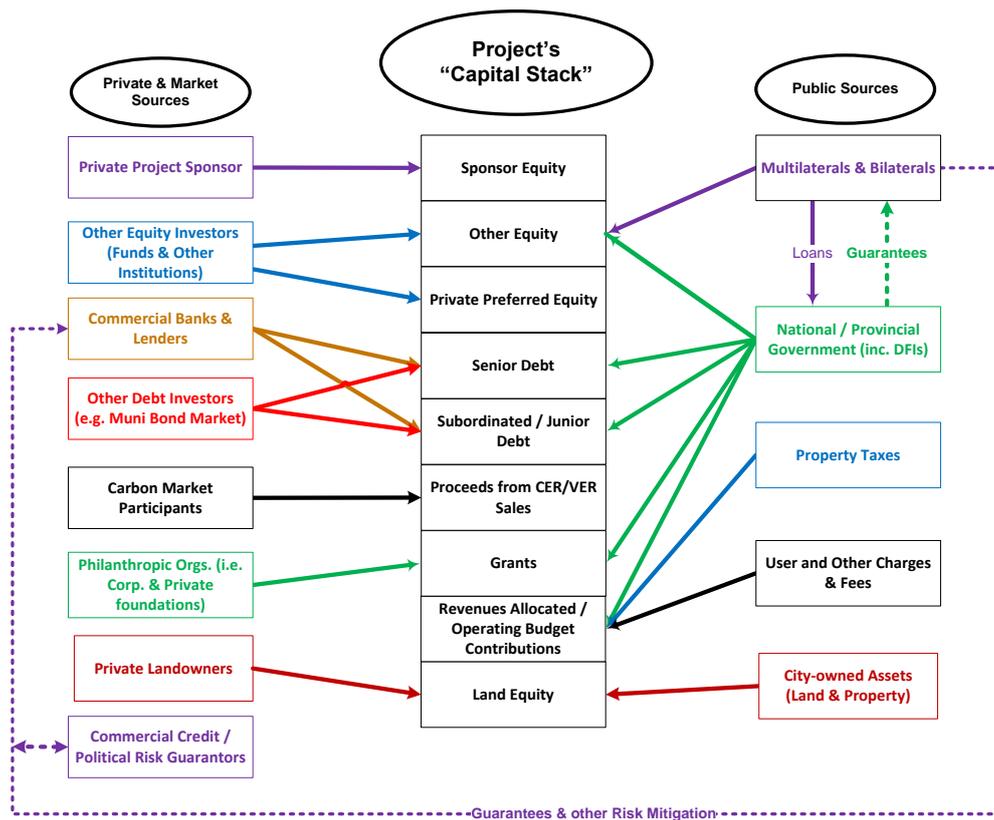


Figure 3. Illustrative capital stack showing how different sources of finance can be combined by deploying a range of instruments. Sources of private finance are on the left and public finance on the right. Each of these prospective investors will have different risk/return profiles. A range of financing instruments is therefore deployed, each with different terms and conditions to suit a particular investor type.

Source: Authors.

In the near term, there is scope for a rapid growth in climate-positive infrastructure investment by strengthening the project development and structuring systems in public and private institutions, and by building their familiarity with urban and climate opportunities. Focusing attention on these issues could enable national and local governments to develop pipelines of viable, bankable climate-focused investments to realise some mitigation potential and build some adaptive capacity immediately. Prioritised programmes and projects should be designed to meet both sectoral and climate objectives.

On the demand side, there is a lack of organisational structures that can address the unique challenges of climate investments set out in Chapter 2. There is a need to develop robust implementing entities capable of structuring projects to suit the diverse risk appetites, time horizons and expectations of returns of prospective investors. Such projects must have sufficient bankability, or such entities must have sufficient creditworthiness, to attract affordable capital. This might require the establishment of special purpose vehicles with segregated funding and accounting that are able to undertake long-term contracts, particularly to mobilise finance for cities in low- and lower middle-income countries. For maximum cost-effectiveness, these implementing entities must also be able to utilise and combine a wide range of financing and funding models. This will require the development of the skills base of local governments, and of their counterpart national and regional agencies. In many cases, it also implies the need for a review of intergovernmental fiscal relations, revenue raising powers and cost-sharing arrangements.

On the one hand, such entities benefit from clarity and specificity regarding governance arrangements. National, regional, metropolitan and local level plans need to be mutually consistent and fully legitimate from the perspective of all stakeholders, and with sufficient base information to enable the efficient development of concept designs. The responsibilities of different sectoral agencies and levels of government also need to be clear and agreed so that there is neither overlap nor gap in implementation of an agreed urban climate investment plan. On the other hand, implementing entities benefit from flexible planning and implementation mandates rather than detailed, technical prescriptions of projects. A performance-based approach to financing (and indeed, other aspects of designing and implementing urban infrastructure projects) offers space for efficiencies and innovations.

These implementing entities need to be able to administer project design and procurement processes that can leverage private sector resources, and encourage good quality bids offering value for money. A deeper understanding of how available finance sources can suit different projects and markets can create better targeting between investment needs and capital resource. For example, private equity and infrastructure funds seek the greatest return and will make equity investments in projects with strong growth potential. These funds are often willing to invest in relatively new or unproven markets and technologies. In contrast, pension funds and insurance companies search for investments that provide predictable income streams to meet long-term obligations, such as pensions or insurance claims.

It is also important to recognise that structuring projects to appeal to private investors is a rigorous process, and resulting structures can be more complicated than purely public financing. While the private sector can bring important technical and managerial capabilities as well as finance, there is a need for effective public oversight to balance social and private returns.

Important characteristics of the project development processes include:

- Concept development should be done in the context of a comprehensive assessment of how a prospective project will contribute to human and economic development goals.
- Pre-feasibility assessments should identify and evaluate a range of financing/funding options against a range of criteria, including climate implications.
- Bid processes should be efficient and effective, ensuring competition but allowing for physical and financial innovation in order to meet both sector and climate objectives. Calls to tender should recognise that the owners of private capital or their fund managers will seek the highest returns commensurate with risk and other investment objectives, and structure investment opportunities so as to be attractive in a competitive market.
- Bid assessments should be transparent and based on pre-defined criteria. These criteria should incentivise projects that minimise life-cycle costs (rather than just initial investment costs) and that encourage private and community participation. This can both leverage funding from non-government sources and increase public acceptance of climate-related projects.
- Projects must offer options for appropriate consideration of changes in ownership and financing structures after construction has been completed. Equity and debt investors often require some level of liquidity, and therefore need ways to withdraw or recover their money (for example, through property sales).

5. Financial institutional structures

5.1 Conceptualising urban finance readiness

Governments need to raise sufficient resources or improve the efficacy of expenditure sufficiently to fill the urban infrastructure financing gap. Their capacity to do so can be understood as their urban finance readiness, a concept initially introduced in *Financing the Urban Transition: Policymakers' Summary* (Floater *et al.*, 2017b).

High-income countries are likely to have sophisticated financial capabilities, which allow them to deploy a range of financing instruments. Central and sometimes subnational governments are likely to have well-developed land and property registries to enable land-based financing; investment-grade credit ratings to enable access to affordable debt finance; and effective contracting and procurement processes to enable the structuring of public-private partnerships. Appropriately designed mechanisms can both expand public budgets and secure or steer private investment. Additionally, given high levels of income per capita, infrastructure such as renewable energy production and distribution, water networks and building developments can generate consumer revenue streams that incentivise private investors to purchase equity as a long-term investment. The binding constraint in high-income countries is therefore not the supply of finance, but the coherence and effectiveness of demand-side institutions.

In contrast, many low- and middle-income countries face severe constraints to accessing finance. Low per capita incomes can limit the levels at which government can mobilise urban investment (although China is an obvious exception). Lower incomes mean lower tax revenues and less ability to pay user fees and charges at a level that provides a sufficient profit margin for investors (even for potentially revenue generating assets such as electricity and water supplies) (Bielenberg *et al.*, 2016). This means that governments have less scope to use public finance and public services to leverage private investment.

However, levels of urban finance readiness are not just a function of per capita incomes. Institutional weaknesses on both the demand and supply side may mean that governments are less capable of raising and steering finance towards sustainable infrastructure options. Institutional weaknesses may manifest as imperfect information; politicised decision making; corruption; lack of clarity or certainty around regulatory and legislative frameworks; poorly functioning land and property markets; poor collection and management of own-source revenue; or weak project management and technical capabilities. These conditions contribute to perceived and actual risks that may deter commercial and institutional investors. To illustrate, a one to two per cent reduction in financing costs could be achieved through greater policy predictability, and could be worth up to US\$100 billion per year (Bhattacharya *et al.*, 2015). Thus, in low- and middle-income countries, both the demand and supply sides of the urban finance market are often constrained. It follows that poorer countries and cities are less likely to have access to the same range of financing mechanisms that are available to wealthy nations and cities.

Credit ratings can be a useful proxy for a government's financial readiness. Credit ratings of countries (and the cities within them) capture some important aspects of urban finance readiness, such as the availability, diversity and reliability of revenue sources, debt levels and management of public finances. The concept of urban finance readiness is illustrated in Figure 3 (Floater *et al.*, 2017b), which shows that sovereign credit ratings correspond to average levels of income. However, outliers such as the Philippines or Thailand have achieved a sovereign credit rating that is much higher than might be predicted based on their per capita GDP. This is due to better institutional performance across at least some of the factors that influence credit ratings.

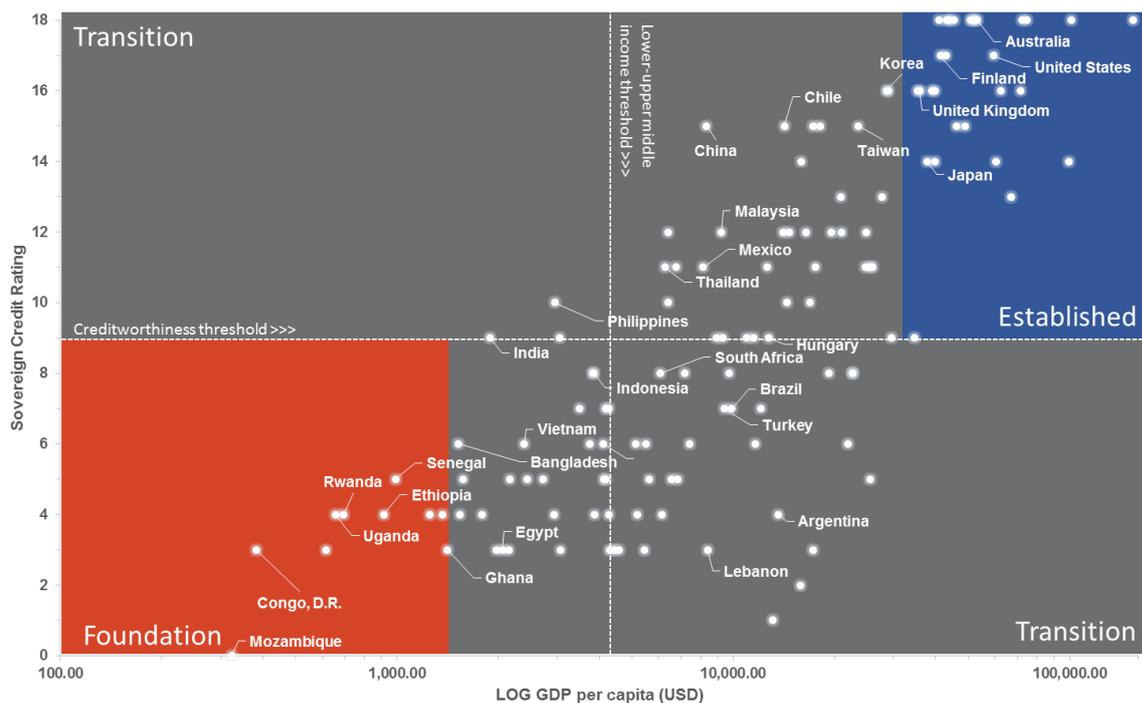


Figure 4. The relationship between average per capita GDP and sovereign credit ratings (as graded by Standard and Poor's) in selected countries. Many countries have clearly developed good financial management capabilities relative to their levels of economic development, and therefore have greater capacity to raise and steer finance for climate-compatible urban infrastructure. The foundation, transition and established stages are defined by three thresholds: the cut-off between investment grade and 'junk' credit ratings (BBB-); and the lower and upper bounds of the World Bank middle-income band (US\$1,025 to US\$12,475 per capita).

Source: Floater *et al.* (2017b).

The legal and regulatory environment, particularly at the national scale, is arguably an especially important determinant of levels of urban finance readiness. National policies comprise the 'rules of the game' that guide both supply and demand aspects of urban finance. For example, national governments may impose lending caps that limit commercial investment in certain asset classes or liquidity mandates to ensure that banks can meet short-term customer obligations. These regulations may change the attractiveness of different types of investments.¹ Policy and regulatory certainty is also important, as this affects perceptions of risk. Investors in large-scale, longer-term capital projects demand certainty about the legal basis of regulatory regimes, their ability to be amended, a country's track record of adjusting or replacing legislation and whether this is planned and transparent, and the impact of a change of political party in government (BNEF *et al.*, 2016).

Although national policies are of primary importance, the quality of subnational institutions is also important and may vary within countries. Capitals and financial centres often perform better than smaller cities, leading to asymmetric quality of infrastructure and access to public services.

Urban finance readiness is therefore determined by the quality of the institutions that determine the amount and sources of finance and funding that might be available to

¹ Although introduced for legitimate reasons, lending caps and liquidity mandates may create a mismatch between investor needs and investment opportunities. The impact on the supply of finance is significant for infrastructure projects, which are typically long term and relatively illiquid. The mismatch is most pronounced in countries with shallow capital markets and chronic balance of payments constraints.

governments. Those with greater capabilities not only have more public finance to invest, but also greater scope to crowd in finance by creating an enabling environment for private investment and structuring specific projects in a way that is commercially attractive. Further, the above analysis suggests that cities and countries do not need substantial increases in per capita incomes to improve their urban finance readiness. Key opportunities include (Bhattacharya *et al.*, 2016):

- 4. Strengthening fiscal and financial systems.** In particular:
 - a. *Expanding the fiscal space through tax and expenditure measures.* Both central and subnational governments have scope to improve their revenue structures, rationalise spending and tackle tax avoidance and evasion. This offers greater scope to use government balance sheets to directly finance investment, as well as improving access to debt financing while lowering its cost.
 - b. *Tackling gaps in the availability and costs of long-term finance.* Infrastructure investments offer steady long-term returns and opportunities for risk diversification across sector and countries. This should be attractive to institutional investors, if governments can support the development of bank lending and markets for bonds, equity, and asset-backed securities.
- 5. Providing a stable policy environment and strengthening investment frameworks.** In particular:
 - a. *Clarifying and reforming regulation.* Creating an enabling policy environment for infrastructure investors can reduce myriad risks and transaction costs, allowing both public and private sector organisations to develop a pipeline of viable investment projects. On the supply side, for instance, governments can reform investment limits, capital adequacy, reserve requirements, the valuation of assets and liabilities, and limits on foreign investment to encourage investors to make longer-term and cross-border investments.
 - b. *Developing national and city-scale urban infrastructure strategies and plans.* Infrastructure strategies should be used to develop a clear pipeline of projects on the demand side, with lead agencies clearly identified. These projects should include coherent financing and funding strategies, and have transparent tendering processes. Infrastructure strategies should be closely integrated with spatial plans and align with NDCs.
- 6. Improving project development and implementation systems.** In particular:
 - a. *Clarifying agency mandates and funding sources.* Agencies need appropriate mandates and resources to design, finance, implement and operate urban infrastructure. National governments need to clearly articulate who is responsible for specific types of projects and activities, and provide those agencies with sufficient resources and capacities. The ability to plan and undertake long-term contracts is particularly important for cost-effective financing. Where investments are multi-sectoral, lead agencies should be clearly identified and appropriate mechanisms for consultation and collaboration must be established.
 - b. *Supporting project preparation activities.* Many public bodies struggle to structure projects in a way that satisfies the criteria of prospective financiers, whether central line ministries or private investors. National governments and international agencies can provide dedicated support for project preparation to overcome this barrier, particularly for new or complex financial instruments. There are many PPP units around the world, for example, that specifically support the design and procurement of PPPs.

In summary, more functional and cohesive urban finance systems will be necessary if government agencies are to mobilise the additional resources necessary to fill the infrastructure financing gap. Directing finance towards climate-positive investments will prove a related but additional challenge, as outlined in the next section.

5.2 Mainstreaming climate considerations into urban finance systems

The urban climate literature widely recognises the need for transformational change towards climate-positive forms of development. This will require fundamental reforms to urban finance systems to make good practice ubiquitous, and to improve on good practice. The reform priorities can be grouped according to the three opportunities identified in Section 5.1.

5.2.1 Fiscal and finance systems

Governments can mainstream climate goals into fiscal and financial systems. Effective enabling legislation, targeting criteria, and monitoring, reporting and validation systems can help to embed climate considerations into private and public financial decision making. Few countries have established coherent policies in this area, although China offers an example (The People's Bank of China *et al.*, 2016).

As a first step, governments should seek to eliminate pervasive fossil fuel subsidies and adopt carbon pricing. Pricing climate-related externalities appropriately offers huge potential for additional public and private revenues that could be used more appropriately, including to fill the financing gap for sustainable infrastructure. The IMF estimates that fossil fuel subsidies cost US\$5.3 trillion in 2015, or 6.5 per cent of global GDP (Coady *et al.*, 2015). There is progress on this front; more than 30 countries have reduced or phased out fossil fuel subsidies since 2013. However, there is a need for further reform to address implicit subsidies (for example, for extraction of fossil fuels). Where national governments have failed to act, many cities and regions have adopted carbon pricing at subnational scales.

Financial systems further need to address the three ways in which climate change creates financial risk: **physical risk** whereby climate impacts such as sea level rise and more severe storms damage property and disrupt trade; **liability risks** whereby parties who have suffered loss and damage seek compensation from those that they hold responsible; and **transition risks** whereby structural adjustment to a low-carbon economy results in repricing of assets and commodities (Farid *et al.*, 2016). Accounting for such risk should shift investment away from sectors and projects where risks are highest and into sustainable infrastructure options. To be effective, accounting for climate risks needs to be done by all relevant actors, including financial intermediaries such as banks, securities markets and institutional investors, as well as by those actors and institutions regulating financial markets, including credit ratings agencies, regulatory and supervisory bodies and central banks (Bhattacharya, 2016).

Looking beyond urban infrastructure projects, public procurement (the purchase of goods and services by government) accounts for a substantial share of Gross Domestic Product. Greening public procurement can demonstrate demand for more sustainable goods and services, creating an incentive for prospective suppliers to build key capabilities and innovate in this space. Governments can introduce environmental standards into technical specifications, procurement selection and award criteria, and contract performance clauses. Establishing green procurement processes requires ongoing consultation with stakeholders and suppliers

to assess available green solutions; it may also require manuals, training and guidance to professionalise public sector procurement strategies (OECD, 2015).

The urban finance architecture can also reduce systemic vulnerability to risk (including climate risk) if it creates space for low-income and other marginalised groups to influence the allocation of public resources and governance of private investment. Proven models exist. For example, in Southeast Asian cities, city development funds have facilitated collaborative decision making by grassroots organisations of the urban poor, local authorities and private landowners (Boonyabancha and Kerr, 2018). In Latin American cities, participatory budgeting has proven capable of improving citizen-state linkages so that public resources are allocated in ways that address the priorities of low-income groups (Cabannes and Lipietz, 2018). These structures provide a conduit for information between local government and residents, which is an important way of building adaptive capacity (Williams *et al.*, 2015). In both cases, relatively small-scale financial systems have ensured that an increased share of public funds are allocated in ways that reduce the vulnerability of urban residents, as well as creating a platform for low-income groups to collaborate and negotiate with public agencies on issues such as tenure security, infrastructure provision and regulatory reform (Archer *et al.*, 2014). These efforts in turn shape wider patterns of investment and development at the city scale.

5.2.2 Policy and planning systems

Policy frameworks, urban plans and infrastructure strategies should clearly direct investment towards climate-compatible forms of development. Tax policies and urban plans, for example, might promote sprawling patterns of urban growth through single land-use zoning or tax incentives for single-family dwellings and private cars (Godfrey and Zhao, 2016). This mode of development is less carbon efficient than urban forms with higher density, mixed land use and better connectivity or accessibility (Seto *et al.*, 2014). There is therefore a need for coordinated multi-level governance (across national, regional and city governments) and horizontal policy integration to effectively support the planning, implementing and financing climate-positive investments within sustainable urban forms. Urban plans and infrastructure strategies should articulate a coherent vision that is fully sustainable, whereby planned investments minimise greenhouse gas emissions and take into account projected climate conditions. For maximum effectiveness and legitimacy, such plans and strategies must also respond to other local priorities, such as access to affordable housing and air quality.

Careful design of policy instruments may also help to address non-pricing barriers that constrain investment. Effective project packaging and structuring (see Chapter 4.2) can help to improve incentive structures to attract private finance. However, this will not resolve problems such as imperfect information, split incentives, inadequate access to finance, capacity deficits and industry fragmentation (IEA, 2013b). Political economy barriers may prove even more significant, such as opposition from local industries (Cragg *et al.*, 2013; Jenkins, 2014). Such factors may manifest as financial hurdles, but they cannot necessarily be overcome through pricing mechanisms. To mainstream climate considerations across all urban investment, there is a need to design policy instruments that specifically tackle these non-financial obstacles. Such policies will need to be tailored to the local institutional, legal, economic and cultural context, and to target a range of prospective investors including households, small and medium enterprises, commercial banks and local authorities (Colenbrander *et al.*, 2017).

In low- and middle-income countries, international public finance could better support the development of an enabling environment for financing climate action in cities, for example through the design of climate-sensitive policy frameworks and participatory institutional structures. It could be used to build local capacities to deliver climate-compatible urban

infrastructure, for example by training urban planners, architects and construction workers in the design of carbon-neutral buildings. It could also be used to support early entrants to climate-positive markets (for example, in renewable energy technologies or energy-efficient appliances) and reduce barriers to subsequent investors, developers and financial intermediaries. Lastly, public finance could be systematically used to crowd in private investment by reducing project risk through (for example) the use of subordinated debt or guarantees (Sierra, 2011).

5.2.3 Project development, structuring and implementation

Cities do not typically function as investment vehicles; climate-relevant urban projects may be the provenance of multiple levels of government, multiple sectoral agencies and multiple local jurisdictions. Coherent green infrastructure projects require coordination across these demand-side entities to identify and manage environmental externalities. The lead agency or investment vehicle can adopt project appraisal and valuation systems that systematically capture environmental externalities, and apply rigorous and consistent environmental safeguards to planned investments (Qureshi, 2016). Optimising a project design across multiple criteria typically requires a professional and multidisciplinary team with legal, technical, scientific and financial expertise.

When selecting or designing infrastructure projects, it is important that agencies assess value for money over an asset's life cycle. This can be difficult with new technologies and systems, as lack of data on financial and risk performance complicates evaluation. Additionally, rapid rates of technological change can make historical performance data outdated (Bielenberg *et al.*, 2016). Where data are available, two factors that can affect this lifecycle analysis are the choice of shadow carbon price and discount rate. The shadow carbon price should theoretically approximate the social cost of greenhouse gas emissions, although some analyses suggest that this would require investment in all technically feasible mitigation potentials (Ackerman and Stanton, 2012). The choice of discount rate should reflect public perceptions of distributive justice over generations, as the benefits of low-carbon, climate-resilient infrastructure will largely be felt in the long term (Dasgupta, 2008). One option is to use a declining discount rate for larger projects with longer lifespans, as adopted in the United Kingdom (Guo *et al.*, 2006).

Multilateral development banks could play a catalytic role by pioneering new sustainable infrastructure investments. However, they will likely need to make changes to strengthen their individual and collective roles and garner deeper support from shareholders and private actors. Possible measures include: (i) increases in paid-in capital; (ii) increases in callable capital; (iii) greater flexibility in using balance sheets, including securitising existing loans, exchange of assets and standardising/scaling the green bond market; (iv) more effective use of guarantee instruments, including creating or supporting new investment vehicles; and (v) more effective targeting of blended finance instruments, especially for low-income countries (Bhattacharya *et al.*, 2015).

6. Research priorities

- 1. Strengthening the economic and financial case for climate-compatible urban development from the perspective of a range of different actors (including diverse investors).**

A detailed economic and financial case for low-carbon, climate-resilient cities can change the political economies of decision making and galvanise a range of critical actors, including Ministries of Finance, development banks, commercial banks and investment companies. The limitations and gaps in this evidence base are clearly documented (Gouldson *et al.*, 2018). In particular, there is a paucity of research on smaller cities in low- and lower-middle income countries; indeed, there is a paucity of financial data to enable better decision making. There is therefore a need to strengthen the economic and financial case for climate action. Where possible, research should identify synergies between climate action and local priorities (such as air quality, congestion or job creation) in order to build political and public buy-in.

2. Understanding the spatial allocation of productive assets, households and jobs relative to climate risk.

Different urban neighbourhoods and different cities vary in their exposure to diverse climate impacts, including extreme temperatures, flooding, sea level rise and storms. Understanding the value of productive assets, homes and jobs that are at risk can help make the case for climate action to decision makers. Micro-level spatial analysis is important to engage specific companies and agencies, while the aggregated conclusions can help to make the macroeconomic case for investment in mitigation or adaptation.

Access to local climate projections is also important for prospective investors so that they can minimise exposure to future risk. Climate funds also require this information as a precondition for disbursing adaptation finance. There is therefore a need for detailed, locally specific projections of future climate risk at the neighbourhood level or lower. This information should be prepared and published in ways that are accessible and meaningful to different users, ranging from large public tenders (e.g. for transport infrastructure) to private developers (e.g. for new commercial buildings) to grassroots organisations (e.g. for slum upgrading).

3. Identifying the components of urban finance readiness, and activities or reforms that can enhance the readiness of different departments and agencies.

One of the primary barriers to climate action in many cities is lack of finance. There is therefore a need to address fundamental weaknesses in urban finance systems. Many public agencies are experimenting with fiscal and planning processes, regulatory and legislative frameworks and institutional arrangements to strengthen urban finance systems and mainstream climate considerations into planning and investment. Many of these initiatives have not been documented in detail, let alone rigorously evaluated beyond narrow financial metrics. A comprehensive collection of comparative and longitudinal studies focused on demand-side institutions (rather than project finance) could inform the development of integrated, extensive investment programmes that systematically mobilise and direct finance. One example is the recent analysis of sub-national project preparation facilities in Asia and Latin America, published by the Cities Climate Finance Leadership Alliance (Oberholzer *et al.*, 2018).

4. Assessing the different ways that climate goals can be mainstreamed into urban finance systems on both the supply and demand side.

Increasing levels of urban finance is no guarantee that cities will transition to lower-carbon or more climate-resilient paths. Policy and regulatory reforms will be required to break organisational lock-in and steer investment towards climate-compatible options. Researchers can generate the evidence base necessary for national and local governments to design urban climate frameworks that take advantage of synergetic effects and improve policy coherence; avoid blind spots, inefficient duplication and redundancy; overcome poor sequencing; enhance social learning; and escape institutional inertia and enable innovation (Rode *et al.*, 2017). Nor will not be sufficient to merely improve financial returns through – for example – carbon pricing. Policies must mandate sustainability criteria into all investments, or be designed to tackle non-financial obstacles to climate-positive investment, such as capacity deficits or split incentives. The reforms and activities required to embed climate considerations into financial decision making will vary among countries, so there is a need for local political and policy analysis.

5. Assessing the different ways that urban financial systems could enhance inclusion and equity, and thereby reduce vulnerability to climate change.

Vulnerability to climate change is not just a function of increased exposure to environmental risks, but also of existing social, economic and political processes (Khan and Roberts, 2013). Adaptation must therefore involve engagement with the drivers of vulnerability: exclusion, marginalisation and inequality. The financial architecture can serve to perpetuate exclusion; for example where banks require a formal address to open an account; or facilitate inclusion, for example where a proportion of public budgets is allocated through participatory processes. There is a need for further research on financial inclusion (going beyond just access to savings and credit, although these are important) and the implications for urban resilience.

6. Determining best practice in engaging private actors in sustainable urban infrastructure projects of different kinds, and articulating the conditions or contingencies for success.

There is a growing number of low-carbon and/or climate-resilient projects around the world, including in cities in the global South. This creates opportunities to understand what financing sources and instruments are appropriate for different project types to more efficiently match demand for, and supply of, urban finance. There is a particular need to understand how to stimulate private sector participation in these projects, and the conditions and contingencies for accountable, effective collaborations. As outlined above, neither domestic nor international public finance is sufficient to fill the investment gap. There is therefore a need to raise and steer private finance, but also to balance social and private returns. Future research could evaluate project approaches and outcomes in individual sectors (e.g. renewable power generation, public transport), by particular institutions (e.g. utilities or commercial banks), or with specific financial instruments (e.g. land value capture or public-private partnerships).

7. Evaluating the best actors and mechanisms to best support learning, replication and scaling on both the supply and demand side.

A huge range of low-carbon and climate-resilient urban projects have been financed successfully, but have not achieved scale. There is therefore a need for horizontal replication (the reproduction of proven approaches through multiple, small initiatives) and/or vertical mainstreaming (integrating proven approaches into dominant institutional policy and

practice) (Pelling, 2011). Future research could usefully evaluate how learning can be disseminated among and within both supply- and demand-side institutions: for example, the relative importance of individual change agents; formal training, shadow networks; or reforming decision-making processes. Where organisations are primarily dedicated to such knowledge sharing (for example, city networks), there is greater scope to document and evaluate different strategies to enable other organisations to emulate best practice.

8. Accounting for flows of climate finance and improving the use of international public finance to achieve paradigm shifting potential.

Accounting for climate finance flows is difficult and often contested. There is a need for clear methodologies to estimate the scale of: (a) domestic public climate expenditure; (b) private investments in mitigation, especially relating to energy efficiency, transport and land use; and (c) adaptation finance, particularly private and domestic public investments (Buchner *et al.*, 2017).

Because international climate finance is ultimately limited, it must be used to catalyse transformative change. The GCF articulates its role as supporting “a paradigm shift to low-emission and climate-resilient development”. There is a need for detailed empirical research to understand how climate and development finance can systemically change the way that other investment is allocated. This might involve measures to increase local ownership, improve economic competitiveness, facilitate knowledge and learning, create an enabling investment environment, or develop critical capabilities to allow deployment and scaling of climate-compatible options.

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