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CLIMATE CHANGE AND FINANCE

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Abstract

This paper is essentially a literature review of the interaction of climate change and finance through the lens of financing low-carbon urban infrastructure. The financial implications of climate change risks are still under-explored in the finance literature. The transition towards a low-carbon economy requires a broad array of financial instruments and innovations that will have far-reaching implications for markets, corporations, intermediaries, and investors.

This paper proposes some potential links between some seminal theories in finance and the climate-economy literature. It reviews the demand side for urban infrastructural finance as well as the supply side.

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 (investment decisions).

The paper also reviews 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 and how climate considerations can be mainstreamed into urban finance systems.

Key Words: Climate risk, Urban Infrastructure, Urban Finance, Finance.

Introduction

Financial decisions worldwide are increasingly influenced by the scarcity of resources and climate. The extent of the environmental impact from climate change is still uncertain but the recent scientific evidence is increasingly worrisome as documented by the Intergovernmental Panel on Climate Change (IPCC, 2018) and many governments are taking decisive steps to avert a catastrophe. The transition towards a low-carbon economy requires a broad array of financial instruments and innovations that will have far-reaching implications for markets, corporations, intermediaries, and investors. The financial implications of climatic change risks - in a context of evolving climate policies - are still understudied.

This exploratory paper draws substantially from the insights of Colenbrander, Lindfield, Lufkin, Quijano (2018) by reviewing the interaction between climate change and finance through the lens of financing low-carbon urban infrastructure around the world. The urban infrastructures under spotlight are buildings, electricity, transport systems and waste management.

Today, more than half of the global population live in urban areas, which contribute over 80 per cent of global GDP (UN, 2019a, 2019b). The concentration of people and economic activities 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 11 years (UN, 2019b). The increase in urban populations, economies and carbon emissions will be the greatest in emerging and developing countries. Recognizing 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.

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 and the share of urban trips by private vehicles is projected to increase in all developing regions by 2050. 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 (Colenbrander, Lindfield, Lufkin & Quijano, 2018).

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.

Some emerging research areas include the use of capital markets to create market-based emissions trading systems (Nordhaus (1994, 2013, 2015, 2016, 2017a, 2017b), Stern, 2013, Golosov, Hassler, Krusell, & Tsyvinski, 2014)), the efficiency of the market pricing of climatic risks (Cohen & Frazzini, 2008, Bansal, Ochoa, & Kiku, 2016), the role of venture capital and alternative finance to develop new low-emissions technologies (Aglietta & Espagne, 2016), the climate risks assessment and disclosure for banks and non-financial companies (Battiston, Mandel, Monasterolo, Schütze, & Visentin, 2017), the contribution of project finance and private equity to building clean energy projects (Steffen, 2017; Colenbrander, Dodman, & Mitlin, 2018), the financial management decisions affected by climate risks and policies, the corporate governance conflicts and incentives in addressing climate risks, and the design of investment strategies to hedge climate risks and liabilities.

Some scholars have attempted to investigate the interaction between climate change risk and efficient market hypothesis. The efficient market hypothesis is the hypothesis that market prices reflect all relevant information so that market participants cannot design trading rules based on such information to earn superior returns. Roll (1984), Campbell & Diebold (2005), Deschenes & Greenstone (2007), Schlenker & Roberts (2009) and Dell, Jones & Olken (2014) examine the impact of short-term fluctuations in weather on the pricing of weather derivatives. Hong, Li & Xu (2019) consider the impact of drought on the pricing of food industry stocks across 31 countries to determine if market prices efficiently discount drought risks across the selected countries. Hong, Li & Xu (2019) develop and test their hypothesis in three steps. First, they measure time trends in droughts across countries with publicly traded equities in the food industry and categorize countries into those with negative (or adverse trends) versus those with nonnegative (or in some instances even positive trends) by using publicly available data up to a given year *t*. Second, they then document that these trend rankings, measured using data only up to year *t*, can forecast the relative performance of food industry cashflows (in years *t+1*, *t+2*, . . .), i.e., the food industries in countries with negative trends experience subsequently poor profit growth relative to the food industries in countries with positive trends. Using asset pricing models such as the Sharpe (1964) CAPM, Carhart (1997) four-factor model

(utilized empirically by Fama & French (2012)) or the currency factor model of Lustig, Roussanov & Verdelhan (2011), the authors find significant underreaction effects of climate risks on market prices. In other words, their analysis suggests that climate risk information is incorporated into stock prices with "significant delay". This evidence is not conclusive in the empirical literature (Barro, 2015).

Understanding the role of financial markets in pricing climate risks is a natural one, though work is limited at this point with some notable exceptions. Bansal, Ochoa, & Kiku (2016) argue that long-run climate risks as captured by temperature are priced into the market. Giglio, Maggaiori, Stroebel & Weber (2015) and Daniel, Litterman & Wagner (2018) show how stock and real estate market might help guide government policies assuming market efficiently incorporates such climate risks.

The purpose of this proposal is to link some of the emerging issues on climate change to seminal theories in finance. Traditionally, climate change is usually considered as negative externality against which society can insure itself through a carbon tax or an emission trading market. But except under the efficient market hypothesis (EMH) whereby climate risk effects are adequately incorporated into market prices, there is little chance that such a simple approach to climate policy succeeds in mitigating climate damages. In other words, there is a strong possibility that financial and climate fragility reinforce each other. Some of the seminal theories upon which modern finance is founded are: (1) utility theory, (2) state-preference theory, (3) mean-variance portfolio theory, (4) capital asset pricing model (**CAPM**) and its various extensions (including the arbitrage pricing theory, **APT**), (5) option pricing theory, (6) agency theory, (7) efficient market hypothesis, and (8) the Modigliani-Miller (**MM**) theorems. Their common theme is "How do individuals and society allocate scarce resources through a price system based on the valuation of risky assets?" Utility theory establishes the basis of rational decision making in the face of risky alternatives such as a trade-off between incurring a carbon tax and reputational damage on one hand and profitability on the other hand in a firm's production and operating decisions. Or in the aggregate case, the trade-off between industrial activities that generate employment opportunities for the populace at the cost of a warmer or polluted environment for the society. In mainstream finance, the objects of choice are described by state-preference theory, mean-variance portfolio theory, capital asset pricing model, and option pricing theory. When the theory of choice is combined with the objects of choice, such fusion yields the model for valuing risky alternatives. When correctly assigned, the efficient market hypothesis posits that market prices provide useful signals to the economy for the necessary task of resource allocation. Finally, the Modigliani-Miller theory asks the question "Does the method of financing have any impact on the value of the firm?" The answer to this question has important implications for the firm's choice of capital structure (debt-to-equity mix) and dividend policy (Modigliani & Miller, 1958; Miller & Modigliani, 1961). Some of the analytical framework utilized at the micro-firm level

have been extended to the analysis of economic aggregates of capital structure of firms, debt policy of nations and agency theory at both firms- and economy wide-level (Modigliani & Miller, 1958; 1963; Jensen & Meckling, 1976; Jensen, 1986; Miller, 1977; Miller, 1988; Miller, 1998; Miller, 2000; Copeland, Weston & Shastri, 2005; Miller, 2005; Stulz, 2005; Bolton, 2016; Bolton & Huang, 2018).

The rest of this proposal is structured as follows. Section I covers the demand for finance for sustainable urban infrastructure. This encompasses the agencies undertaking projects, the type of projects and the funding required to repay finance. Section II considers the supply of finance for investment projects, mapping possible investors and their likely risk appetites, return expectations, liquidity needs and their time horizons. Section III 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. Section IV 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. Section V further explores how climate considerations can be mainstreamed into urban finance systems. Section VI concludes with fertile grounds for future research.

1.0 The 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$1.5 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. 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, 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. 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. 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 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). The World Bank estimates that US$11-20 billion is needed annually to 2050 to ensure urban infrastructure is adapted to climate risks (Hughs, Chinowsky & Strzepek, 2010), while UN Environment calculated that the requirements were US$120 billion to 2030. 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. 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 various studies. But this can be difficult to translate into near-term investments that satisfy the risk-return criteria of financiers (Colenbrander, Lindfield, Lufkin & Quijano, 2018).

1.1 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. 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. Within the constraints of urban form, investments in four interconnected sectors arguably have the greatest abatement potential. These are:

1. Decarbonizing the electricity grid
2. Energy efficiency in buildings
3. Modal shift and next generation mobility, and
4. 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.

Decarbonizing 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 & 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. 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. 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 issues as large power plants. In addition, there are 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).

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. 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 most of the 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. 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. There are a few systematic performance-based financing models emerging from energy service companies (ESCOs) in China, the United Kingdom, and the United States, although their success is varied (Colenbrander, Lindfield, Lufkin & Quijano, 2018). 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).

Low-carbon Transport Infrastructure

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 decarbonize 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: Colenbrander, Lindfield, Lufkin & Quijano, 2018, pp.12-13.

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. 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. Land-based taxes and fees are increasingly recognised as a promising mechanism to unlock private investment, notably in Indian cities. 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.

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. 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.

Financing and funding waste management is now 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 (CDM) played an important role in building the technical capabilities and financial case for investment in low-carbon waste technologies 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. 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.

1.2 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 is 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 mobilizing 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. 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. 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 minimize 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 recognize 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. 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.

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. 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, Anguelovski, & Roberts, 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. 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, Lindfield, Lufkin, & Quijano, 2018). 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:

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 minimize 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 incentivize more climate-compatible behaviour.

In sum, 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.

2.0 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. 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.

2.1 Domestic Public Finance

According to Standards & Poor's, government infrastructure investment is equivalent to about three per cent of global GDP. 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. 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, 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, Cirolia & Palmer, 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. Only 42 per cent of countries worldwide are recorded as devolving fiscal or legislative powers to subnational governments, and of these, the depth of revenue-raising powers is highly variable.

2.2 International Public Finance

Multilateral, regional, and bilateral development organizations can 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 mobilizing 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-capitalized 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. 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 can 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 specialized 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. 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 organizations. 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 several 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 organizational 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 utilized. 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.

2.3. 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 (Colenbrander, Lindfield, Lufkin, & Quijano, 2018).

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 catalyzing private and institutional sector participation.

Table 2: Potential Sources of Private Finance for Sustainable Urban Infrastructure, and Barriers faced by each Investor Type.

	KEY BARRIERS				
Finance Source	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		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

	in 3C infrastructure.				
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

Sources: Floater, *et al* (2017a), Colenbrander, Lindfield, Lufkin, & Quijano (2018).

3.0 Connecting Demand and Supply to Deliver Sustainable Urban Development

3.1 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. Under perfect market conditions, the Modigliani-Miller theorem would imply that each financial instrument is as good as another so that there are no net benefits to borrowing. However, in the presence of information, agency and tax-induced frictions, financial structure may matter for addressing infrastructural investments. Specific instruments within each of categories are listed in Table 3.

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

Sources of Finance / Instrument	Internal	External	
	Domestic public finance	International Public Finance	Private Finance
Relevant institutions	-National governments	-Multilateral development banks	- Commercial banks and investment companies

	-National development banks -Municipal development funds -Subnational governments	-Bilateral development agencies	- Developers and infrastructure operators - Private equity and infrastructure funds - Pension funds - Sovereign wealth funds -Philanthropic foundations -University endowment funds
Funding base	- Intergovernmental fiscal transfers		-Property taxes -Betterment levies or value capture taxes -Tax increment financing -Fees, tariffs, and charges
Asset-based instruments	- Sale of land -Lease of public land assets -Sale of development rights		-In-kind contributions
Debt	-Specific purpose concessional loans -Green Bonds	-Loans - Concessional loans - Subordinated debt and mezzanine loans - Sukuk and Sharia compliant finance	- 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

			-Crowdfunding
Equity		-Public-private partnerships - Project equity - Yieldcos	-Public-private partnerships - Project equity -Listed infrastructure corporates and funds - Preferred shares - Yieldcos - Trusts -Co-investment platforms -Crowdfunding
Grants	- Specific purpose grants	- Grants	-Philanthropic grants
Risk Mitigation Instruments	- Credit guarantee - Credit insurance	- Credit guarantee - Credit insurance	- Business insurance - Credit insurance

Source: Modified from Colenbrander, Lindfield, Lufkin, & Quijano (2018)

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 incentivize 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 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. 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:

1) 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.
2) 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.
3) 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 (Steffen, 2017, Colenbrander, Lindfield, Lufkin, & Quijano 2018).

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. 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 minimize 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 decentralization 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:

1) Reforming national regulations to allow local borrowing and clarify the conditions for bank lending or bond issuance. This could include liberalizing 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.
2) 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.
3) 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, decentralized renewable and other same-type infrastructure investments across secondary and tertiary cities.
4) 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 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:
1) 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.
2) Coordinating spatial plans and infrastructure strategies across different scales and align them with LVC mechanisms.
3) Investing in more efficient property markets, for example by systematizing 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.
4) Multi-level collaboration to identify projects suited to LVC (recognizing 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:

1) 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.
2) Establishing regulation and legislation outlining the ability of cities/utilities to enter 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.
3) 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.

3.2 Developing Financially Viable Climate Positive Projects

Central and sub-national governments often must deploy a range of instruments to accumulate different sources of finance to develop, construct and operate a project.

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 realize some mitigation potential and build some adaptive capacity immediately. Prioritized programmes and projects should be designed to meet both sectoral and climate objectives.

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 mobilize finance for cities in low- and lower middle-income countries. For maximum cost-effectiveness, these implementing entities must also be able to utilize 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 recognize 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 to meet both sector and climate objectives. Calls to tender should recognize 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 to be attractive in a competitive market.

 Bid assessments should be transparent and based on pre-defined criteria. These criteria should incentivize projects that minimize 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).

4.0 Financial Institutional Structures and 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).

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; politicized 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.

5.0 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 marginalized 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. Optimizing 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 (Barro, 2015).

6.0 Conclusion

This paper has attempted a review of the demand and supply sides for financing urban infrastructure to address risks posed by climate changes. The demand for finance side encompasses the agencies undertaking projects, the type of projects and the funding required to repay finance. The supply side of finance maps possible investors and their likely risk appetites, return expectations, liquidity needs and their time horizons. Next, 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 were reviewed. The concept of urban finance readiness was described as the capacity of supply- and demand-side institutions to address the infrastructure financing gap. Urban finance readiness is an assessment of key opportunities to strengthen fiscal and financial systems, policy environments and frameworks, and project development and implementation processes and exploration of how climate considerations could be mainstreamed into urban finance systems. There exist fertile grounds for incorporating the analytical frameworks from corporate finance into the climate-economy literature especially the interaction of investment (demand side) and financing decisions in bridging the infrastructural financing gap around the world. Mandatory projects may not yield positive net present values (NPV) to modern corporations but the incorporation of real options analysis of the climate (or environmental) viability of such projects - via assessment of social benefits and accrued prestige to "environmentally compliant" corporations – means that infrastructural projects can be appraised on financially grounds especially in a public-private partnership (PPP) arrangement of urban infrastructure provision. As usual, the financing of such projects will be driven by the capacity to map possible institutional investors and their likely risk appetites, return expectations, liquidity needs and their time horizons.

The asset pricing implications of climate risks can be studied by examining the transmission of risks to the market prices of the underlying securities issued by the companies most affected by specific climate conditions.

Fertile grounds for future research exist and include the following:

- Strengthening the economic and financial case for climate-compatible urban development from the perspective of a range of different actors (including diverse investors).
- Understanding the spatial allocation of productive assets, households, and jobs relative to climate risk.
- Identifying the components of urban finance readiness, and activities or reforms that can enhance readiness.

- Assessing the different ways that climate goals can be mainstreamed into urban finance systems on both the supply and demand side.
- Assessing the different ways that urban financial systems could enhance inclusion and equity, and thereby reduce vulnerability to climate change.
- Determining best practice in engaging private actors in sustainable urban infrastructure projects of different kinds and articulating the conditions or contingencies for success.
- Evaluating the best actors and mechanisms to best support learning, replication and scaling on both the supply and demand side.
- Accounting for flows of climate finance and improving the use of international public finance to achieve paradigm shifting potential.

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