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BRIEF

The Climate Technology Progress Report 2023

Speed and Scale for Urban Systems Transformation

DISCLAIMERS

CITATION

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1. INTRODUCTION

The world is at a critical turning point in the battle against the triple planetary crisis of climate change, biodiversity loss and pollution, a crisis that knows no boundaries and has cross-generational impacts. The number of extreme weather events over the last 30 years has been staggering, and 2023 has been no exception. It is evident, though, that current levels of climate technology implementation are inadequate to address this challenge. Meeting national and international climate targets requires efficient and rapid scaling up of the implementation and use of climate technologies, which, in addition to climate objectives, also have significant co-benefits.

In line with the findings of the Global Stocktake process, the Technical Dialogue has suggested that to strengthen the global response to the threat of climate change, governments need to support system transformations that mainstream climate resilience and low greenhouse gas emissions development. Moreover, alongside the impacts of climate change, are several mega trends – including rapid urbanization, digitalization, and demographic changes among others, which have consequences for the current and future realities. Thus, system transformations to address climate change must operate against the context of these evolving and dynamic complexities and uncertainties and have a large degree of unpredictability.

The 28th UN Climate Conference, or the Conference of the Parties (COP), is a pivotal opportunity for the international community to scale up climate action. Climate finance, along with technology transfer and capacity-building, will be key issues and the COP Presidency has called for private and public-sector stakeholders to commit funding and technology for system transformations, in particular for food and agriculture systems. Beyond this, society needs to phase out existing high-emission systems and technologies, while scaling up low and zero-emission alternatives, and implementing both supply and demand-side measures, including technologies that enable mitigation pathways consistent with the Paris temperature goals as well as support adaptation and resilience to the projected risks.

To reach transformational change there is a need for system transitions, being the process of changing from one state or condition to another in a given period of time. The IPCC Sixth Assessment Cycle highlighted various key system transitions. These include energy, industry, urban and infrastructure, land, and ecosystems (including oceans) and societal systems. Collectively, and if appropriately guided, these transitions can enable faster and deeper adaptation and mitigation actions, while also advancing broader sustainable development. By bringing together mitigation, adaptation and sustainable development, system transitions can be key drivers for achieving low-carbon, climate-resilient, and sustainable development.

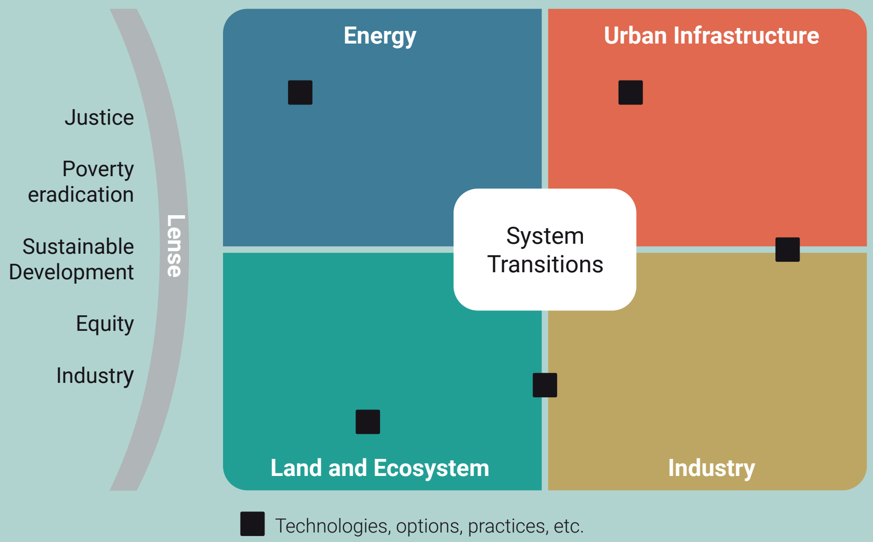
Box 1: System transitions

To achieve system transitions, technology development and transfer is one of the indispensable enabling conditions. It is hence essential to understand better the processes that shape technology development and transfer in general, and thereby to understand the factors that lead to successful outcomes as well as barriers that hinder such outcomes. An enabling environment for enhanced technology development and transfer consists of resources and conditions that are generated by different structures and institutions. In addition to focusing on enabling environments, this report also focuses on feasibility. 'Feasibility' indicates how likely it is that a mitigation or adaptation technology is implemented, based on how many barriers and enablers are in place. The feasibility for a technology, and enabling conditions for the same, are interlinked, such that feasibility increases when enabling conditions are strengthened.

Fig. 1 illustrates the enabling conditions needed for system transitions as a dynamic environment that enables change, and examples of lenses through which this can be approached. Technologies are embedded within or across systems.

Enabling environment

- Multilevel governance
- Technological innovation
- Behavior change
- Policy instruments
- Finance
- Institutional Capacity



Feasibility Assessment

- Geophysical
- Socio-cultural
- Ecological
- Institutional
- Technological
- Ecological-Environmental

The 2022 Climate Technology Progress Report (CTPR), set out a framework and approach for tracking and exploring trends in technology progress. While the 2022 edition applied the approach using data and cases from the Africa region, the 2023 CTPR continues to explore progress and sets out analyses and case studies focused on urban transitions in the context of Asia. Asia houses one of the fastest-growing urban populations and is highly vulnerable to extreme weather and climate change impacts. As an example, South-East Asia has an average urban population growth of around 2.21 per cent, while the rural population is declining at a rate of -1.3 per cent (United Nations Development Programme [UNDP] 2015). Moreover, while urbanization is taking place across the urban-rural divide, as well as in megacities, there is also an increase in growth in so called secondary cities.

While urbanization has provided economic opportunities and raised the standard of living for millions of people, there are also social and environmental costs. These include:

- an increase in urban sprawl,
- local governments being unable to provide adequate infrastructure that matches the rapid need for housing and public services, leading to informal settlements,
- increased water consumption, which is causing shrinking aquifers,
- problems with traffic congestion due to a rise in the ownership of cars and motorcycles, leading to air pollution and greenhouse gas emissions,
- a large amount of waste, with significant impacts on land, rivers and lakes.

As the share of population living in urban areas is significantly correlated with per capita income levels, the cases included in this report are selected to represent a variety of different types of cities, representing developed, emerging, and developing countries in Asia.

The Hive Nanyang Technological University in Singapore uses Nature-based Solutions to keep temperatures low ©Shutterstock

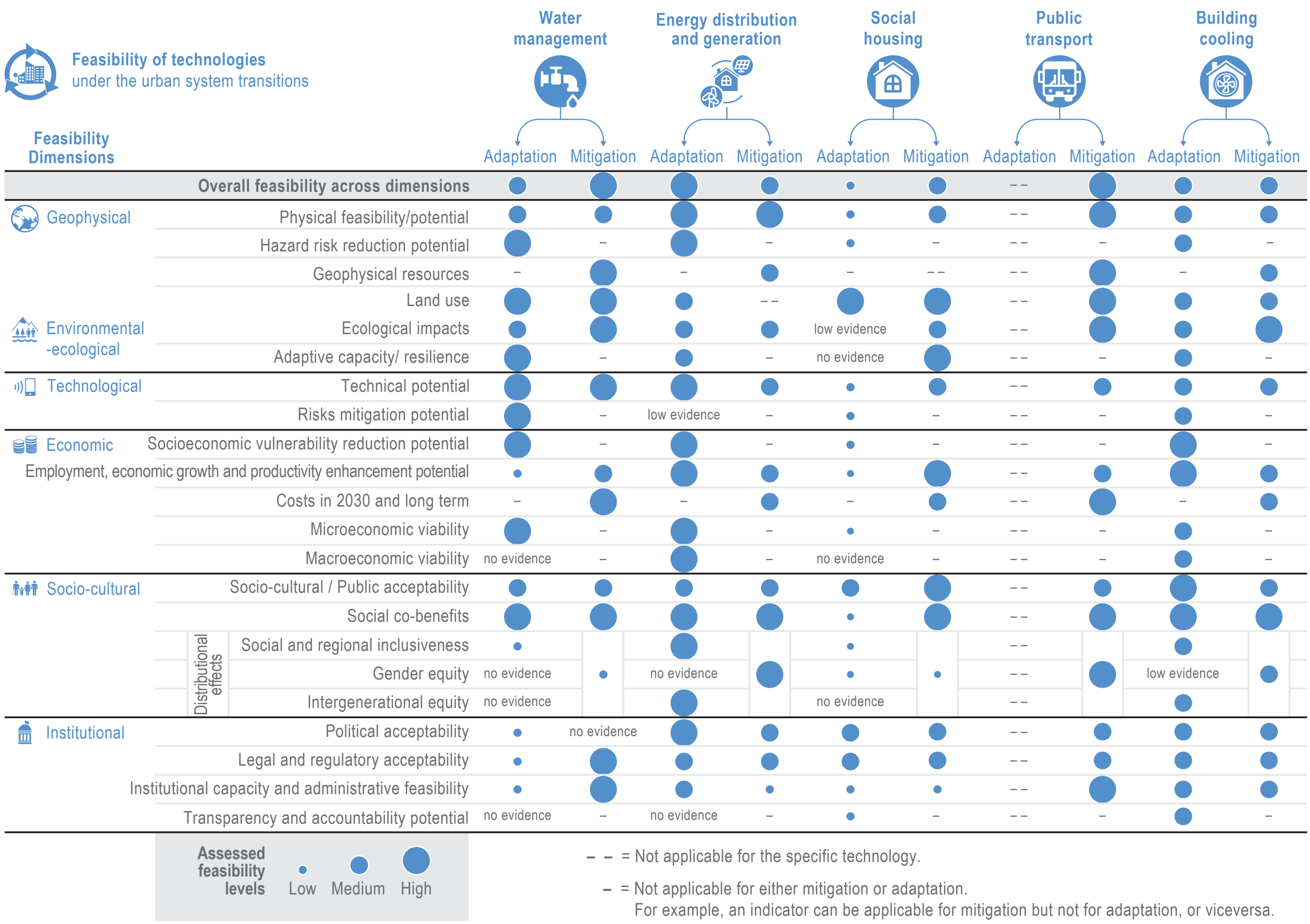
KEY MESSAGES

2. FEASIBILITY ASSESSMENT

The feasibility assessment was operationalized along critical dimensions, which are geophysical, environmental-ecological, technological, economic, sociocultural, and institutional factors that enable or constrain the implementation of a particular technology. This report assessed five technology groupings within the urban system, these include public transport, building cooling, water management, social housing, and energy distribution and generation. Moreover, a system transition framework was adopted for this assessment.

Figure 2.1 Feasibility of technologies for urban system transitions.

Panel A - Feasibility scores for water management, energy generation and distribution, social housing and public transport



Technology inclusive system transitions can generate benefits across different sectors and regions, provided they are supported by appropriate enabling conditions, including effective multi-level governance and institutional capacity, policy design and implementation, innovation, and climate and development finance.

Unlike a sectoral approach, a system transitions framework shifts the focus from evaluating single mitigation or adaptation technologies to emphasizing the relationship between technologies. Taking the urban transport system as an example, the more discrete, sectoral approach would focus on single policies such as new parking restrictions. The more integrated perspective provided by system transitions would emphasize clean public transport options that have more synergies and multiple co-benefits, which can support more comprehensive transformations towards sustainable mobility. By adopting a system transitions framework, this leads to a more holistic view of a group of technologies that can support transition and as a result, is consistent with the understanding that there is no "one-size-fits-all" technological solution or transition.

Collectively, these system transitions widen the solution space and accelerate and deepen the implementation of sustainable development, adaptation and mitigation actions by equipping actors and decision makers with more effective options that lead to climate-resilient development. Moreover, evaluating synergies and trade-offs of urban technologies through a systems transition framework helps create a better understanding of equity and justice and their roles in paving climate resilient development pathways.

3. TECHNOLOGY, INNOVATION AND SUPPORTING INFRASTRUCTURE

To drive a systemic and transformative urban transition, it is imperative to prioritize comprehensive technological innovations in critical domains, such as urban building, transportation, energy supply, water systems and urban planning.

Table 3.1 Technological progress, innovation requirements and contribution to urban mitigation and/or adaptation

Key area	Technology categories	Innovation requirement		Urban mitigation	Urban adaptation
Urban building system	Low-carbon and resilient construction material	Material performance	Alternative technologies	X	X
	Renewable energy integration	Energy conversion efficiency	Self-sustaining structures	X	
	Energy-efficiency technologies	System connectivity	Heat pump performance	X	
Urban transport system	Vehicle electrification	Next-generation batteries	Fast-charging stations	X	
	Intelligent transport system	Seamless integration	Interoperability	X	
Urban energy supply system	Urban energy management and optimization	Internet of Things technologies	Big data	X	X
	Smart grid and energy storage	Grid stability	Resilient supply	X	
Urban water system	Smart water management	Real-time data processing	Multi-parameter sensors	X	X
	Water recycling and reuse system	Energy efficiency	Energy recovery	X	X
	Stormwater management solutions	Optimal stormwater retention	Nature-based solution	X	X
Urban planning	Climate mitigation urban planning	Advanced modelling software	Participatory planning	X	
	Climate-adaptive urban planning	Durability	Predictive modelling		X
	Urban modelling and simulation	Climate projection	Virtual reality technology	X	X

Besides the technical barriers, the feasibility assessment has shown that the sociocultural and institutional dimensions are important challenges that can hinder further upscaling of technologies.

Many technologies, such as cooling technologies in the building sector, show high economic feasibility and large potential to reduce greenhouse gas emissions and/or to reduce climate vulnerability. However, sociocultural, and institutional challenges hinder further upscaling the implementation and use of these technologies. Identifying synergies between and co-benefits of technologies could increase perceptions of desirability and increase opportunities for economic benefits and enhanced equity. The feasibility assessment undertaken in the report, reveals strong evidence for highly feasible technologies for urban systems. It also reveals gaps between the desirability of technologies, such as nature-based solutions, which have high synergies on mitigation and adaptation, and the need to strengthen institutional dimensions, as well as highlighting more specific features such as the need for gender-responsive approaches. In this way, the work here could serve both to inform the immediate needs of decision makers and as a call for future assessments.

Technological advance depends not only on the technology's research and development but also on the support provided by urban infrastructure.

Urban infrastructure encompasses physical and organizational structures, facilities and systems that are crucial for the functioning and development of cities and urban areas. This includes transport systems (roads, bridges and public transport), water supply and sanitation networks, energy distribution systems, public lighting, communication networks, public spaces and buildings. The progress of climate technology is not exclusively reliant on research and development; instead, it is deeply contingent on the presence of robust urban infrastructure encompassing vital components such as transport systems, water supply and sanitation networks, energy distribution, communication networks, public spaces, and buildings.

Table 3.2 Typical urban infrastructure for urban facilities and services

Urban facilities and services	Type of urban infrastructure			
Transport	Sustainable public transport	Charging facilities	Non-motorized transport infrastructure	Carpooling and ride-sharing initiatives
Building	Green buildings	Energy-efficient systems	Waste management facilities	-
Energy	Renewable energy sources	Smart grid	Energy storage	-
Wastewater	Water treatment plants	Purification facilities	Interconnected pipelines	Reservoirs
Street lighting	Smart lighting	Lighting networks	Lamp posts	Security cameras

Recognizing the synergistic benefits of applying innovative climate technologies can help incentivize governments to further enhance the adoption of such technologies. These synergistic benefits include, but are not limited to, improving energy independence and flexibility, addressing local environmental pollution, fostering economic development, and inspiring innovation.

Region-specific climate technologies can play a significant role in facilitating the transition to low-carbon and sustainable practices in local areas, whether they are emerging or mature cities. Cases from the Global South highlight this fact.

4. INSTITUTIONAL SETTINGS AND GOVERNANCE

Flexibility, adaptability, and anticipatory governance systems is important, in times of complexity and uncertainty.
Future governance systems should prioritise being flexible, adaptable, and anticipatory to the ever-increasing complexity and uncertainty, that several mega trends bring as mentioned earlier. This entails, a combination of both hard and soft governance tools to inform policy, as well as creating spaces for open dialogue, building trust, plurality of perspectives, new narratives, and spaces for reflexivity. Thus, future governance inevitably requires new kinds of capacities to steer, coordinate, build partnerships amongst multi stakeholders in various spatial scales, and across sectors.

Box 2: Sustainable mobility in Cambodia: e-mobility

Traffic congestion is a problem in most cities in South-East Asia. Transport is a major contributor to greenhouse gas emissions, particularly as most transport is based on fossil fuels. Sustainable transport is needed to reduce greenhouse gas emissions, for example, by switching to low-carbon fuels.

In Cambodia, reliance on road transport has increased as the country's economy has developed. Cambodia relies mainly on fossil fuel vehicles, most of which are second-hand. With the increase in the number of vehicles on the road and the fuel composition of Cambodia's energy mix, concerns have been raised about emissions and deteriorating air quality in the country's urban areas.

In 2019, Cambodia requested technical assistance for the Climate Technology Centre and Network (CTCN) under the United Nations Framework Convention on Climate Change (UNFCCC) to help accelerate the transition to cleaner and more efficient mobility systems and contribute significantly to Cambodia's efforts to meet its Nationally Determined Contributions (NDC) targets. Throughout the period of technical assistance, the Policy Action Plan for the development of low-emission mobility policies was developed to support the implementation of Cambodia's Intended Nationally Determined Contributions (INDC) targets for the transport sector. The support was achieved through a review of Cambodia's INDC, relevant policies and regulations; the transport sector growth, emissions and business-as-usual scenario; an impact analysis of two alternative e-mobility scenarios, and barriers to e-mobility and e-mobility policies. Based on the technical, social, environmental and gender analysis and the barriers/gaps, action areas and enabling conditions identified, a recommendation was made to implement e-mobility in Cambodia. This recommendation will help ministerial policymakers in Cambodia to develop e-mobility policies in order to achieve the INDC target for the transport sector. A proposal for a Green Climate Fund (GCF) readiness project has also been developed for further action.

In 2022, based on the proposal developed above, the GCF readiness project entitled "Climate Technology Deployment Roadmap for an E-mobility Ecosystem in Cambodia" was successfully launched to support the deployment of e-mobility. Based on the roadmap, the country will focus on establishing the long-term strategy for the deployment of e-mobility technology in Cambodia by strengthening its readiness in terms of policies and regulations, institutions, its means of implementation such as technology, finance and infrastructure to create an enabling environment that will support the fulfilment of its NDC in the transport sector. The aim is to mitigate GHG emissions in the transport sector through policy instruments to promote low-emission modes of transport.

Transforming urban systems to mitigate and adapt to the impacts of climate change has become a central matter for municipalities and regional authorities.
While implementing climate technology solutions is critical in pursuing low-carbon, climate-resilient development pathways depend to a great extent on good governance, adequate resource mobilization and allocation, and institutional capacity-building to attract and finance them effectively. Governance arrangements should include better interlinkages between existing institutions and emerging actors to catalyse sufficient access to public and private resources and nurture partnerships for climate technology implementation, commercialization and scale-up at the city level.

Ensuring effective collaboration and communication can be challenging, especially when formal and informal structures are complex and overly bureaucratic. The implementation of climate technology solutions requires coordination among different government agencies, departments, and stakeholders. A whole government approach that includes both vertical and horizontal components of government that are fit to deliver services efficiently is needed. This is important because there are multiple policy levers that need to be pulled to access opportunities, which may exist at different scales and in different sectors. Often, there are power dynamics between vertical levels of government and horizontally across quasi-government and non-governmental organizations and actors.

Local leadership and stewardship play a key function in enabling the establishment of comprehensive policies that foster climate technology action as a key component of cities' sustainability agendas. The work of climate technology champions, for example a mayor or chief minister, is essential for supporting the process of integrating climate technology transfer priorities into long-term urban development and climate action plans, leading on clear target setting and milestones to measure progress and keeping systemic changes monitored and accountable for stakeholders, including public and private-sector financiers and international donors.

5. POLICIES AND REGULATORY FRAMEWORKS

Asian cities differ in terms of their development status, size (megacities to medium and small cities), level of infrastructure, cultural diversity, and presence of informality. In many large Asian cities, a significant share of the population still resides in informal settlements. For local governments, particularly in the Global South, the priorities of providing housing and basic infrastructure have greater significance than climate actions. Sustainable development is a key priority for all cities, especially for rapidly growing cities in Asia that have a high degree of informality. Policy implementation must carefully evaluate trade-offs with development priorities.

Electric mobility seems more skewed towards uptake in two and three wheelers in the urban transport mix in several Asian cities. For electric vehicles (EVs), most of Asia, except for China, the market share remains below 2%. Para-transit modes (e.g., motorcycle taxis, jeepneys and shared auto-rickshaws) compensates for a lack of available public transport infrastructure and has provided first and last mile connective in several Asian cities. However, their lack of integration into the system results in redundant and overlapping routes and adds a new dimension to public transport policy in Asia. There is an added co-benefit in encouraging electric mobility because this can address air pollution in Asian cities, given the predominant use of fossil fuels in most vehicles.

Box 3: Near-zero energy buildings in China

China has taken ambitious steps to scale up zero-energy buildings. National policies and targets with funding for the demonstration of pilot projects have been effectively supported by local design guidelines and incentives (Liu et al. 2019; Nascimento et al. 2022). These include the Near Zero-emission Buildings Standard China (2019), the Green and High-Efficiency Cooling Action Plan, 2019; the National Energy Conservation Law (amendment) China (2016); the Energy Efficiency Leader Scheme China (2015); the Strategic Action Plan for Energy Development China (2014); the Fuel Excise Tax China (2012); Demand-Side Management Implementation Measures China (2010); the Building Energy Efficiency Labelling Scheme (2008) and Energy Conservation in Buildings China (2006) (NewClimate Institute 2022).

China's Green Building Action Plan (2013) required 20 per cent of newly constructed buildings from 2015 to adhere to green standards, including public buildings and affordable housing funded by the government. Buildings achieving 2-star and 3-star green certifications will qualify for financial support from the state and will be given preference in the local urban planning process. Local governments must establish their own strategies to align with the overarching national plan (Nascimento et al. 2022; NewClimate Institute 2022).

A study reviewing 254 central and 1,175 local Green Building Plans in China between 2004 and 2021 showed that central policy had a key role in providing direction for investments and action. Local governments responded by improving their green buildings performance framework. Over time, targets became more efficient and generated better compliance and upscaling. The five key elements of China's green building policies were 1) reducing economic inequality and enhancing regional cooperation; 2) improving legal and regulatory systems, 3) policy innovation 4) information disclosure and 5) developing market-oriented green finance systems (Hu et al. 2023).

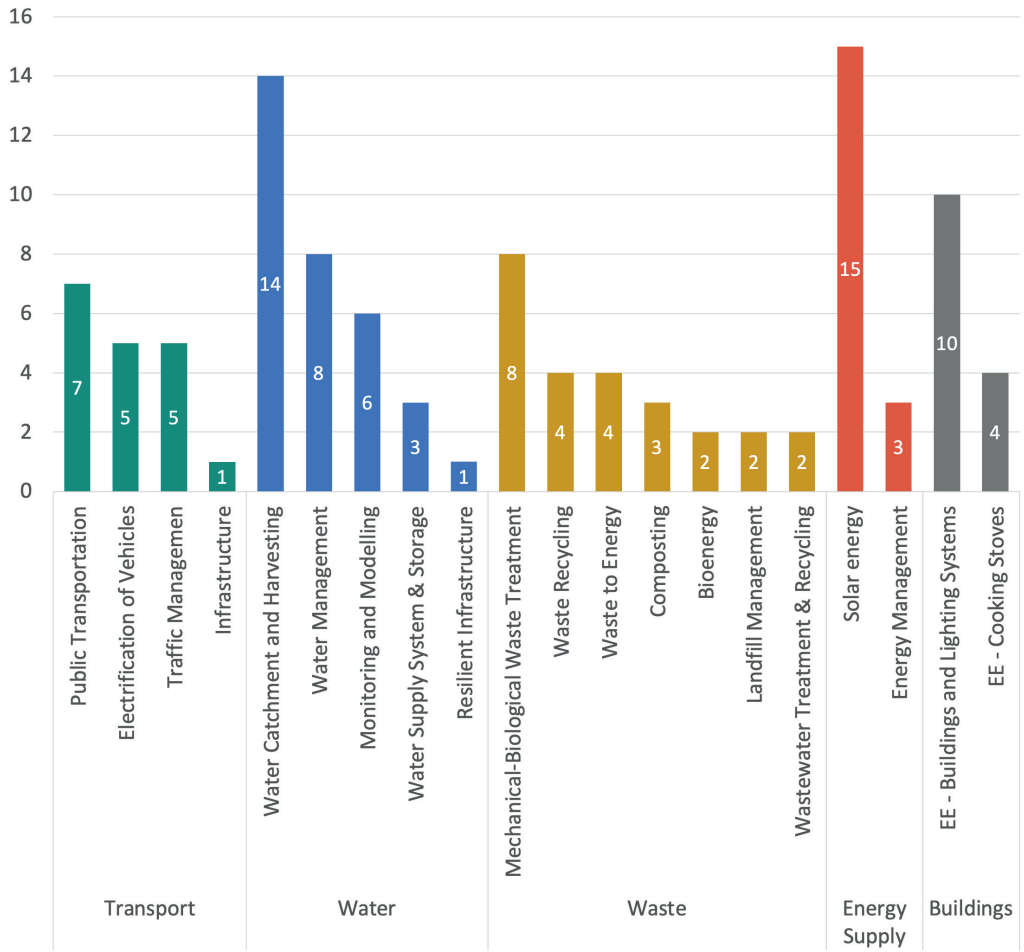
A multi-level inspection system ensures the enforcement of building energy codes and improves energy efficiency in the rapidly growing construction sector. Results show high compliance rates, yet these rates require careful interpretation due to factors such as limited sample size and potential data gaps, suggesting the need for refined criteria, better data access and a national information platform, but overall, China's unique approach demonstrates the efficacy of a well-designed compliance framework in advancing building energy code enforcement (Evans et al. 2010; Bin and Nadel 2012)

Barriers to wider technology adoption in Asian cities include high upfront costs, limited awareness and understanding of benefits, weak institutions, and a lack of autonomy for raising revenue and financing investments. Besides technology development, behaviour and lifestyle changes, and urban planning are important interrelated issues, which can facilitate avoiding carbon lock in especially in small and medium-sized cities.

Successful technology-inclusive initiatives at most times involve a range of policies and instruments at the national and sub-national level, which together with incentives spur replicability across cities.
It is evident that governments at all levels have a key role to play in technology development and transfer during the initial stages through clear policies, investments in research and development and through funding subsidies and other mechanisms. Both climate and development challenges can be addressed simultaneously, to maximize synergies and minimize tradeoffs. However, implementing integrated policies and approaches is challenging in practice and there is still too much of sectoral or supply-side actions to facilitate climate technology development and transfer, more is needed in terms of mainstreaming initiatives in overall city strategies.

An analysis of country **Technology Needs Assessment show varying climate technology priorities** in Transport, Water, Waste, Energy Supply, Building and Industry sectors for 20 countries in the Asia region (see below). This shows the various actions prioritized by countries under the GEF-funded Technology Needs Assessment project. The length of the bar indicates the number of countries that identified a given technology as a national priority. These priorities relate well with the recent IPCC report that identi¬fies the following key strategies for climate change mitigation and adaptation: energy efficiency or shift options (efficient buildings, appliances, and public transport); improvement options such as cleaner technologies (electric vehicles); avoidance options (waste management, circularity, and non-motorized transport (NMT)) and resilience and resource conservation (nature-based solutions and water management).

Figure 5.1 Sector-wise Asia Specific Technology Priorities.



Source: own analysis of country Technology Needs Assessment reports available at www.tech-action.org

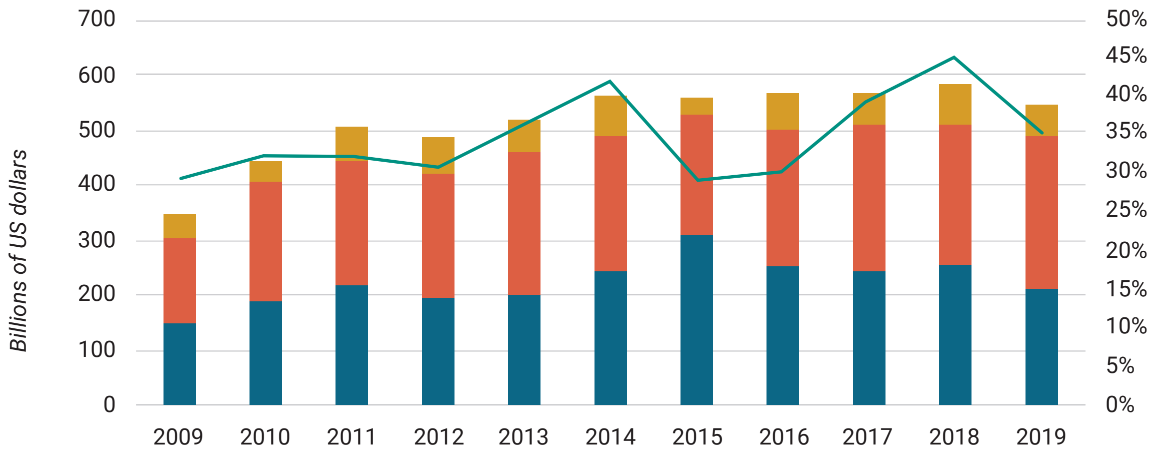
Urban development has led to the loss of green and blue spaces. A focus on nature-based solutions in urban planning and policies can address climate change and deliver a range of benefits.

Cities have limited control over development and transfer of many climate technologies, which are handled at the national level. However, local governments have an important role to play, for example by managing land and infrastructure required for technology adoption; allocating parking spaces for charging and making rooftops and land available for solar photovoltaic; demonstrating technologies and taking a lead, for example, by purchasing electric cars for their own use or being the first sites for solar photovoltaic; and by setting ambitious targets and regulations in line with national policies.

6. CLIMATE FINANCE FOR URBAN TECHNOLOGIES

Asia's cities are growing rapidly, and financing is being deployed to support a range of innovative and entrepreneurial solutions. From 2009 to 2019, foreign direct investment inflows

Figure 6.1 Foreign direct investment inflows to Asia and the Pacific and their global share, 2009 to 2019.



Source: (UNESCAP, 2021)

*Note: **China** includes Hong Kong, China and Macao, China; **A-P** stands for Asia and the Pasific; **Developing A-P** excludes China, Hong Kong China and Macao, China.*

into Asia and the Pacific grew gradually from about USD 350 billion to just under USD 600 billion annually. In 2019, about 40 per cent of foreign direct investment was in China, with most of the balance to developing countries in Asia and the Pacific.

Project-to-project approaches, that are determined by business odels and risks assessments, still dominate actions on technology development and transfer. Thus, the business-as-usual mindset prevails, and numerous challenges persist.
It is important for urban planners and political leaders to recognize that the problem is not so much a question of the supply in absolute terms since there is ample investment capacity in the global system. Rather, the problem lies in the ability to move large volumes of money and deploy it where it is most needed and where the social, environmental, and economic returns on investment are the highest. New kinds of coordination mechanisms and decision making are needed in both horizontal (among various stakeholders and across different departments and different functional areas) and vertical (at national, regional, and municipal levels). However, these add complexity to a project and overhead costs for investors, which are challenging to allocate, but are necessary in obtaining better overall economic outcomes and an increase in social and economic returns.

Several new approaches are emerging, such as bundling and aggregation, green and climate bonds, impact investment funds, blended finance, and gender lens investment. These ensure that finance is directed where it is needed most, and where it has the most impact.

Given the increasing complexity in investment approaches, project preparation and transaction management are even more important. This will provide critical support services for structuring deals and channelling finance flows. Project development and preparation facilities can play an important role in originating, developing and curating investor-ready pipelines and pushing the investor envelope by helping potential investors to understand and relate to urban development in the climate context.

7. CONCLUSION

System transformations open up many opportunities, but rapid change can be disruptive and therefore a focus on inclusion and equity is necessary. Narrow sectoral approaches are ineffective amid the social, economic, political, and climate crises. Both climate and development challenges can be addressed simultaneously, to maximize synergies and minimize trade-offs. However, implementing integrated policies and approaches is challenging in practice.

Sustainable development is a key priority for all cities, especially for rapidly growing cities in Asia that have a high degree of informality. Policy implementation must carefully evaluate trade-offs with development priorities. There is no one-size-fits-all technological solution or transition pathway, indeed, technical solutions need to be embedded within a local socio-political and institutional context, which are in turned influenced by cultural norms, attitudes and assumptions.

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