THE SUMMARY FOR URBAN POLICYMAKERS OF THE IPCC'S SIXTH ASSESSMENT REPORT

VOLUME III

WHAT THE LATEST SCIENCE ON CLIMATE CHANGE MITIGATION MEANS FOR CITIES AND URBAN AREAS

SUMMARY FOR URBAN POLICYMAKERS

The Summary for Urban Policymakers (SUP) Initiative is a series of three summary reports: *What the Latest Physical Science of Climate Change Means for Cities and Urban Areas*, distilled from the IPCC Working Group I report; *What the Latest Science on Impacts, Adaptation and Vulnerability means for Cities and Urban Areas*, distilled from the IPCC Working Group II report; and *What the Latest Science on Climate Change Mitigation Means For Cities and Urban Areas*, distilled from the IPCC Working Group III report.

This is Volume III of the series and all three are available here: https://supforclimate.com

This report should be cited as:

Babiker, M., Bazaz, A., Bertoldi, P., Creutzig, F., De Coninck, H., De Kleijne, K., Dhakal, S., Haldar, S., Jiang, K., Kılkış, Ş., Klaus, I., Krishnaswamy, J., Lwasa, S., Niamir, L., Pathak, M., Pereira, J. P., Revi, A., Roy, J., Seto, K.C., Singh, C., Some, S., Steg, L., Ürge-Vorsatz, D. (2022). *What the latest science on climate change mitigation means for cities and urban areas*. Indian Institute for Human Settlements. https://doi.org/10.24943/SUPSV310.2022

SUP PARTNERS

The SUP series is supported by a partnership of the Global Covenant of Mayors for Climate & Energy (GCoM) alliance for city climate leadership, the Resilience First business network, the Indian Institute for Human Settlements, the German Federal Ministry for Economic Affairs and Climate Action in collaboration with the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), and led by Resilience Rising.

SUP VOLUME I

What the Latest Physical Science of **Climate Change** Means for Cities and Urban Areas

SUP VOLUME II

What the Latest Science on **Impacts, Adaptation and Vulnerability** Means for Cities and Urban Areas

SUP VOLUME III

What the Latest Science on **Climate Change Mitigation** Means for Cities and Urban areas

CONTENTS

AUTHORS

Mustafa Babiker (Saudi Arabia)
Coordinating Lead Author, Chapter 12, IPCC AR6 WGIII
Lead Author, Chapter 4, IPCC Special Report on 1.5°C
Saudi Aramco

Amir Bazaz (India)
Contributing Author, Chapter 4, IPCC Special Report on 1.5°C
Indian Institute for Human Settlements

Paolo Bertoldi (Italy)
Lead Author, Chapter 9, IPCC AR6 WGIII
Lead Author, Chapter 4, IPCC Special Report on 1.5°C
European Commission

Felix Creutzig (Germany)
Coordinating Lead Author, Chapter 5, IPCC AR6 WGIII
Mercator Research Institute on Global Commons and Climate Change

Heleen De Coninck (Netherlands)
Coordinating Lead Author, Chapter 16, IPCC AR6 WGIII
Coordinating Lead Author, Chapter 4, IPCC Special Report on 1.5°C
Eindhoven University of Technology

Kiane De Kleijne (Netherlands)
Chapter Scientist, Chapter 12, IPCC AR6 WGIII
Contributing Author, Chapter 4, IPCC Special Report on 1.5°C
Radboud University

Shobhakar Dhakal (Thailand)
Coordinating Lead Author, Chapter 2, IPCC AR6 WGIII
Asian Institute of Technology

Stuti Haldar (India)
Indian Institute for Human Settlements

Kejun Jiang (China)
Lead Author, Chapter 3, IPCC AR6 WGIII
Coordinating Lead Author, Chapter 2, IPCC Special Report on 1.5°C
Energy Research Institute

Şiir Kılkış (Turkey)
Lead Author, Chapter 8, IPCC AR6 WGIII
The Scientific and Technological Research Council of Turkey

Ian Klaus (USA)
Series Editor of the SUP Series
Chicago Council of Global Affairs

Jagdish Krishnaswamy (India)
Coordinating Lead Author, Chapter 7, IPCC Special Report on Climate Change and Land
Indian Institute for Human Settlements

Shuaib Lwasa (Uganda)
Coordinating Lead Author, Chapter 8, IPCC AR6 WGIII
Lead Author, Chapter 6, IPCC Special Report on Climate Change and Land
Global Center on Adaptation

Leila Niamir (Iran/Austria)
Chapter Scientist and Contributing Author, Chapter 5, IPCC AR6 WGIII Report
International Institute for Applied Systems Analysis

Minal Pathak (India)
Scientist, IPCC WGIII Technical Support Unit
Ahmedabad University

Joana Portugal Pereira (Brazil)
Lead Author, Chapter 4, IPCC AR6 WGIII
Coordinating Lead Author, Annex C, IPCC AR6 WGIII
Universidade Federal do Rio de Janeiro

Aromar Revi (India)
Coordinating Lead Author, Chapter 18, IPCC AR6 WGII
and Chapter 4, IPCC Special Report on 1.5°C
Indian Institute for Human Settlements

Joyashree Roy (India/Thailand)
Coordinating Lead Author, Chapter 5, IPCC AR6 WGIII
and Chapter 5, IPCC Special Report on 1.5°C
Asian Institute of Technology

Karen C. Seto (USA)
Coordinating Lead Author, Chapter 8, IPCC AR6 WGIII
Yale University

Chandni Singh (India)
Lead Author, Chapter 10, IPCC AR6 WGII
Author, Cross-Chapter Paper 2, IPCC AR6 WGII
Indian Institute for Human Settlements

Shreya Some (India)
Contributing Author Chapter 17, IPCC AR6 WGIII Report
and Chapter 5, IPCC Special Report on 1.5°C
Scientist, IPCC WGIII Technical Support Unit
Asian Institute of Technology

Linda Steg (Netherlands)
Lead Author, Chapter 6, IPCC AR6 WGIII
Lead Author, Chapter 4, IPCC Special Report on 1.5°C
University of Groningen

Diana Ürge-Vorsatz (Hungary)
Vice-Chair, Working Group III, IPCC
Central European University

REVIEW EDITORS

Priyadarshi R. Shukla (India)
Co-Chair, Working Group III
IPCC

Jim Skea (UK)
Co-Chair, Working Group III
IPCC

CORE TEAM

Debra Roberts (South Africa)
Co-Chair, Working Group II,
IPCC

Seth Schultz (USA)
Lead Author, Chapter 4, IPCC Special Report on 1.5°C
Resilience Rising

Amanda Eichel (USA)
Lead for the SUP Initiative
Resilience Rising

Aromar Revi (India)
Coordinating Lead Author, Chapter 18, IPCC AR6 WGII
and Chapter 4, IPCC Special Report on 1.5°C
Indian Institute for Human Settlements

Ian Klaus (USA)
Series Editor of the SUP Series
Chicago Council of Global Affairs

THE SUP SERIES

The 6th Assessment Report cycle (AR6) of the Intergovernmental Panel on Climate Change (IPCC) comes at a turning point in history. Human influence has warmed the planet, and widespread and rapid impacts are occurring to both natural and human systems in all regions of the world. In response, immediate action is needed if there is to be any hope of limiting global warming close to 1.5°C or well below 2°C below pre-industrial levels, as well as preparing for and adapting to current and future risks. AR6 is composed of the three main reports: *The Physical Science Basis*; *Impacts, Adaptation and Vulnerability*; and *Mitigation of Climate Change*, as well as a *Synthesis Report*. It also includes three additional publications: the *Special Report on Global Warming of 1.5°C*, the *Special Report on the Ocean and Cryosphere in a Changing Climate*, and the *Special Report on Climate Change and Land*. Together they offer the most current and comprehensive scientific understanding of the climate crisis.

The Summary for Urban Policymakers (SUP) series distils the IPCC reports into targeted summaries to inform action at the city and regional scale. Volume I in the series, *What the Latest Physical Science of Climate Change Means for Cities and Urban Areas*, identified the ways in which human-induced climate change is affecting every region of the world, and the cities and urban areas therein. Volume II, *What the Latest Science on Impacts, Adaptation and Vulnerability means for Cities and Urban Areas*, assessed the feasibility and effectiveness of different adaptation options. To achieve climate resilient development, synergies between policies and actions for climate change adaptation, mitigation, and other development goals are needed.

This third volume in the series, *What the Latest Science on Climate Change Mitigation Means for Cities and Urban Areas* offers a concise and accessible distillation of the IPCC Working Group III Report for urban policymakers. The 21st century is characterised by a rapidly growing urban population, urban land expansion and associated rise in demand for resources, infrastructure, and services. These trends are expected to drive the growth in emissions from urban consumption and production through 2100, although the rate of urban emissions growth will depend on the type of urbanisation and the speed and scale of mitigation action implemented. Aggressive and ambitious policies for transition towards net zero greenhouse gas (GHG) emissions can be implemented in cities and urban areas, while contributing to sustainable development. Ultimately, mitigation action and adaptation are interdependent processes, and pursuing these actions together can promote sustainable development.

Gwangju, South Korea

1. THE SCALE OF THE PROBLEM, AND SOLVING IT

The urban share of global GHG emissions, including those linked to the consumption of goods and services, is high and continues to increase. In 2015, the urban share of global emissions was about 62%. By 2020, just five years later, the urban share of emissions had increased to between 67-72% of global emissions. These emissions are not equally distributed across urban areas: about 100 of the largest emitting cities account for about 18% of the global carbon footprint. [1]

While the drivers of urban GHG emissions are complex and vary across geography, income levels and economies, there are opportunities for all cities and urban areas to reduce emissions and further develop without significant emissions growth. Population size, state of urbanisation, and city form all play a part in defining options for cities. Developing countries, in particular, present opportunities to shift development pathways toward sustainability and implement climate resilient development.

A substantial share of the population in low-emitting countries lack access to modern energy and mobility services. Eradicating energy poverty and providing decent living standards in the context of achieving sustainable development objectives can be achieved while simultaneously reducing global energy demand and without significant global emissions growth.[2] Low-emission urbanisation can improve well-being; however, such urbanisation can still result in increased global GHG emissions through increased emissions outside of city boundaries.

Within the larger story of urbanisation in the 21st century, a number of global trends will shape our ability to limit global warming:

- The size of the global urban population is large and growing, currently totalling 4.5 billion and projected to be 7 billion by 2050;
- With ongoing urbanisation in the Global South, cities in those regions currently at early stages of urban development will require significant new infrastructure build-up, whereas established cities will need to replace or rebuild ageing infrastructure. In all cases, the associated demand for materials comes with potentially high levels of embodied emissions, heightening the need to decarbonise and dematerialise such work;
- There are a large number of cities with inadequate institutional, financial, and technical capacities to plan, enact, and implement local climate change actions;
- The growing preponderance of megacities and extended metropolitan areas present unique challenges for governance as well as energy and carbon efficiency; and
- Reinforcing interactions among urban infrastructures and technologies, institutions, and individual and collective behaviours could create inertia and path dependency, also known as carbon lock-in.[3]

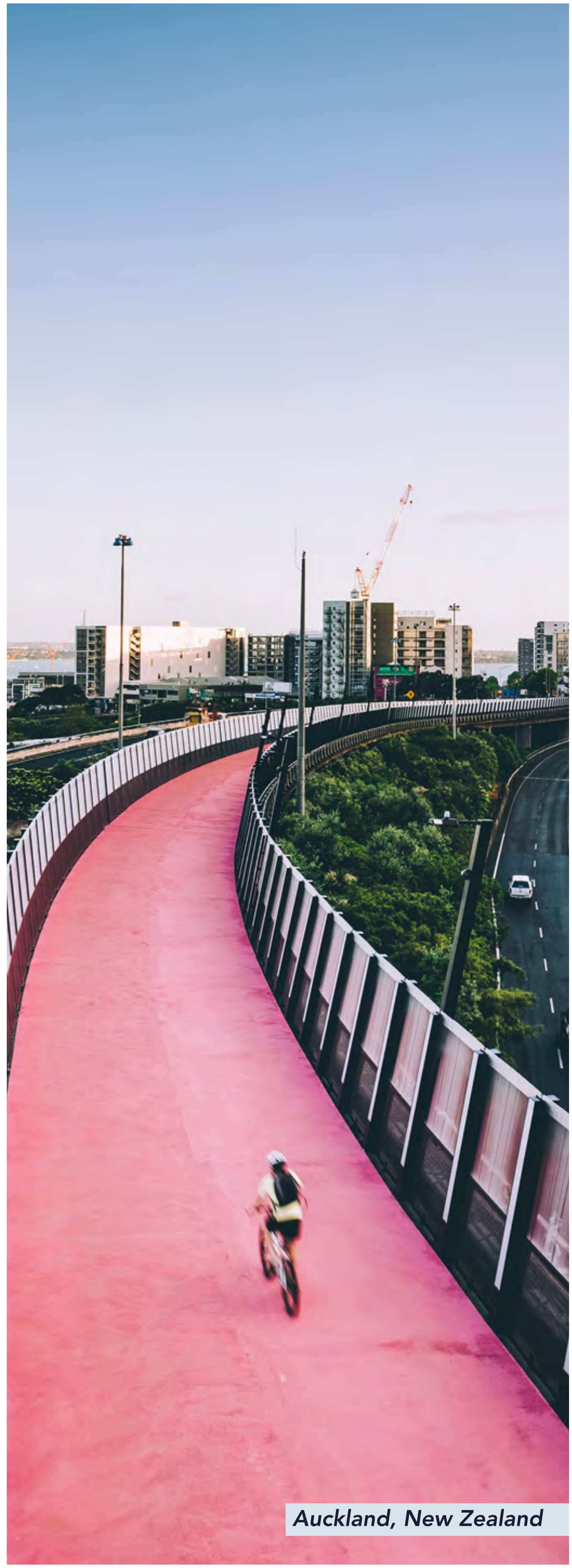
Los Angeles, USA

Mitigation of climate change in cities and urban areas has a crucial role in determining the future of the global climate. Cities and urban areas are often more energy efficient than non-urban areas, but the manner in which cities are designed, built, retrofitted, and powered will greatly impact current and future emissions.

Under scenarios with stringent mitigation efforts, peak emissions may be reached as soon as possible. Even with immediate stringent CO_2 emissions reductions, decreased emissions will continue to add to the planet's cumulative CO_2 budget. This will lead to warming above 1.5°C in the next 20 years. However, without immediate deep reductions in GHG emissions, global warming will exceed 2°C by around 2050. The stark differences between possible outcomes will rely on widespread and sustained mitigation efforts that surpass any sector-by-sector approach alone, tackling the mitigation opportunities in the urban system as a whole while providing other co-benefits.

If cities and urban areas are to aggressively pursue low- and net-zero pathways, they will need to integrate an Avoid-Shift-Improve (ASI) framework into their actions and choices. An ASI framework can support climate mitigation strategies and actions within sectors but also across urban and other systems, emphasizing demand-side climate mitigation. The ASI framing includes actions that help in avoiding emissions by behavioural and lifestyle changes, and redesigning service provisioning systems; shifting choices to already existing competitive low-carbon technologies and service-provisioning systems; and improving efficiency of technologies in end-use sectors.

Continuing with sectoral-based approaches and along existing development pathways will not achieve rapid and deep emissions reductions. Instead, shifting development pathways towards sustainability offers opportunities to broaden the range of enablers, policies, and instruments that a society can use to accelerate mitigation, while increasing the likelihood of making progress on development goals.[4] For example, promoting walkable urban areas, when combined with electrification using clean renewable energy as well as green and blue urban infrastructure that limits local warming, can deliver several co-benefits to human health and well-being as well as climate change mitigation and adaptation.[5] While the appropriate set of policies to shift development pathways depends on national and local circumstances and capacities, cities and urban areas will be focal points for mitigation actions and systemic transitions.


Auckland, New Zealand

2. GOALS AND POTENTIAL FOR MITIGATION

The magnitude, pace and patterns of urbanisation in the coming decades will significantly impact emissions while offering a window of opportunity to decarbonise and dematerialise.[6] The science is clear: we have the technology and know-how to build net- or near net-zero cities and to make them livable, resilient and vibrant.[7] Furthermore, mitigation actions within cities affect GHG emissions outside of urban boundaries through urban consumption, production and supply chains. Therefore, urban climate action can have positive cascading effects in other sectors and regions, including beyond administrative boundaries of cities.[8] The biggest challenges to delivering on such opportunities are in the areas of governance, finance, technology, planning and consumption. Territorial strategies to deliver net-zero cities must embed mitigation targets and approaches within a broader context of social, economic and human well-being that includes connections between rural and urban.

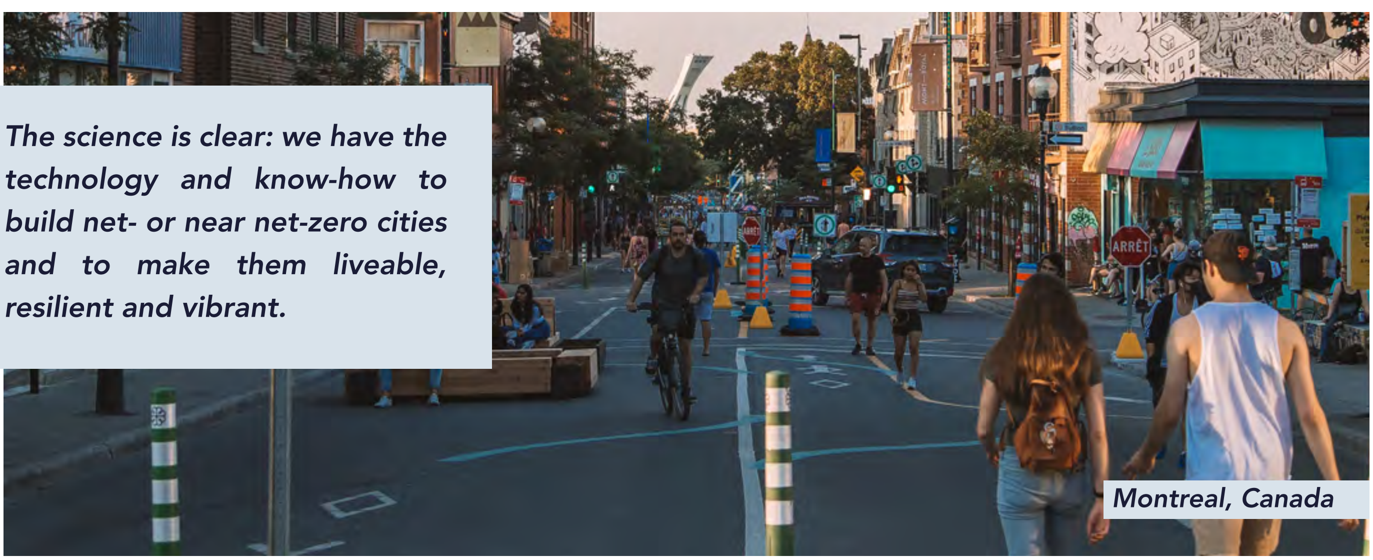
The energy, transportation, housing and food requirements of urban residents offer significant demand-side mitigation options, and can have cascading effects on other sectors, such as land use, and thereby reduces GHG emissions within cities as well as beyond urban territorial boundaries. Such options can be developed and delivered through low-carbon infrastructures, granular and efficient end-use technologies and strategies that avoid higher demand for materials and energy. Many of the tactical steps to such reduction are explicitly urban, including the use of electric vehicles (EVs), active transportation like walking and cycling, and shared pool mobility. In the built environment, they also include the development of compact urban planning, energy efficiency measures, passive design, active measures like heat pumps, and low-energy intensity and consumption buildings.[9]

An integrated approach to urban mitigation must bring together strategies to:

- Reduce or change energy and material use towards more sustainable production and consumption, including through urban planning for more accessible and walkable urban areas with more compact urban form;
- Increase adoption of electrification of urban energy systems while switching to low-emission energy sources and renewable energy; and
- Enhance carbon uptake and storage in urban environments.

There are multiple ways that these broad mitigation strategies can be integrated across established, rapidly growing and emerging cities.

The science is clear: we have the technology and know-how to build net- or near net-zero cities and to make them liveable, resilient and vibrant.



Montreal, Canada

Mitigation and urban typologies

The characteristics of cities vary greatly. They have different geographies, climates, economies, demographics, resource endowments, and dependencies on ecosystems and regions. As a result, effective and feasible mitigation strategies also vary across cities. One immediate way to consider diverse mitigation strategies is by using urban typology. Typologies are classifications based on a shared feature or characteristic. Examples of features or characteristics which may be used to establish city typologies include population size, urban form, and geography.

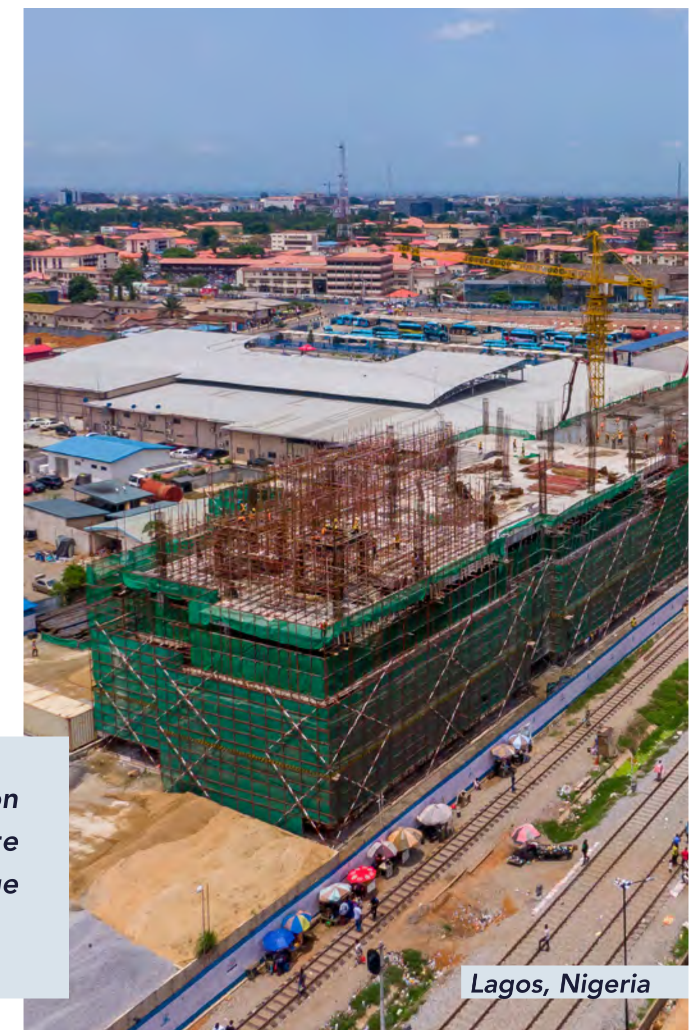
It is possible to bundle urban mitigation strategies according two key urban characteristics, both of which are also important emissions drivers: urban form and stage of urban development. Completed in 2014, the IPCC Fifth Assessment Report (AR5) established that the spatial form of cities is a major driver of urban emissions. Compact and walkable cities where destinations and origins are in close proximity are generally correlated with low per capita GHG emissions.[10] In contrast, cities with dispersed and automobile-centric urban form, characterised by low densities of housing and employment as well as separation of uses, generally have higher per capita GHG emissions.

The AR6 completed in 2022 and covered in the SUP series built on this work and further assessed that the stage of urban development affects the demand for infrastructure and carbon lock-in. Settlements that are in early stages of urbanisation with relatively low levels of infrastructure deployment have large opportunities to pursue low- or net-zero urbanisation pathways, whereas established cities with mature infrastructure generally have more locked-in energy behaviours. A key innovation in AR6 is the conceptualisation of three key city typologies as entry points for urban mitigation: an established city, a rapidly growing city, and an emerging city. These three general typologies occur along a continuum across a national or territorial urban system, made up of many interconnected urban areas and cities of various sizes and types. A single city can have neighbourhoods that are established, other districts that are rapidly developing, and an emerging periphery.

All cities have significant opportunities to implement mitigation strategies; the city typologies provide a roadmap for the approaches that are most feasible and effective for each type of city. With the city typologies as the frame, urban mitigation strategies are clustered into four categories:

- Reducing energy and material consumption through spatial planning;
- Decarbonising the urban energy system through electrification while simultaneously switching to net-zero emissions sources;
- Sequestering and storing carbon in cities; and,
- Changing urban demand and energy behaviours.[11]

Settlements that are in early stages of urbanisation with relatively low levels of infrastructure deployment have large opportunities to pursue low- or net-zero urbanisation pathways.



Lagos, Nigeria

Accelerating demand-side mitigation actions through Avoid-Shift-Improve strategies

The acceleration and scaling up of mitigation actions in urban areas requires a focus on the demand side. Demand-side actions may reach beyond the choice of an individual to include broader choices in infrastructure and technologies. Individual action, while important, must be supported by large structural changes.

Demand-side actions can be broadly understood through the ASI frame introduced in section 1. Within the ASI frame, it is helpful to think of actions in three domains: the socio-behavioural, especially important for avoid strategies, where social norms, culture, and individual choices play an important role; infrastructure, which provides underlying cost-benefit justification and is particularly relevant for shift options; and the technological, which is especially important for improve options.

Avoiding energy use and related emissions is possible through behavioural changes reflected in altered product consumption choices or through more efficient product designs. Teleworking is another important opportunity with significant mitigation potential, particularly if one ongoing impact of the COVID-19 pandemic includes a structural shift toward more remote work. Enhanced electrification of certain key sectors can contribute to demand-side mitigation by avoiding incremental electricity demand, which reduces the decarbonisation burden on the electricity supply side.

Shift measures are most relevant for transport and food, including: modal shift to shared pooled mobility; safe, comfortable public transport systems; and a shift towards balanced, less water-intensive, sustainable, and healthy diets. These options would need to be underpinned by adequate low-carbon physical infrastructure and other mechanisms that support shifting individual and societal choices towards low-carbon and less water-consuming profiles, such as safe and convenient transit corridors and desirable and affordable plant-based diets.

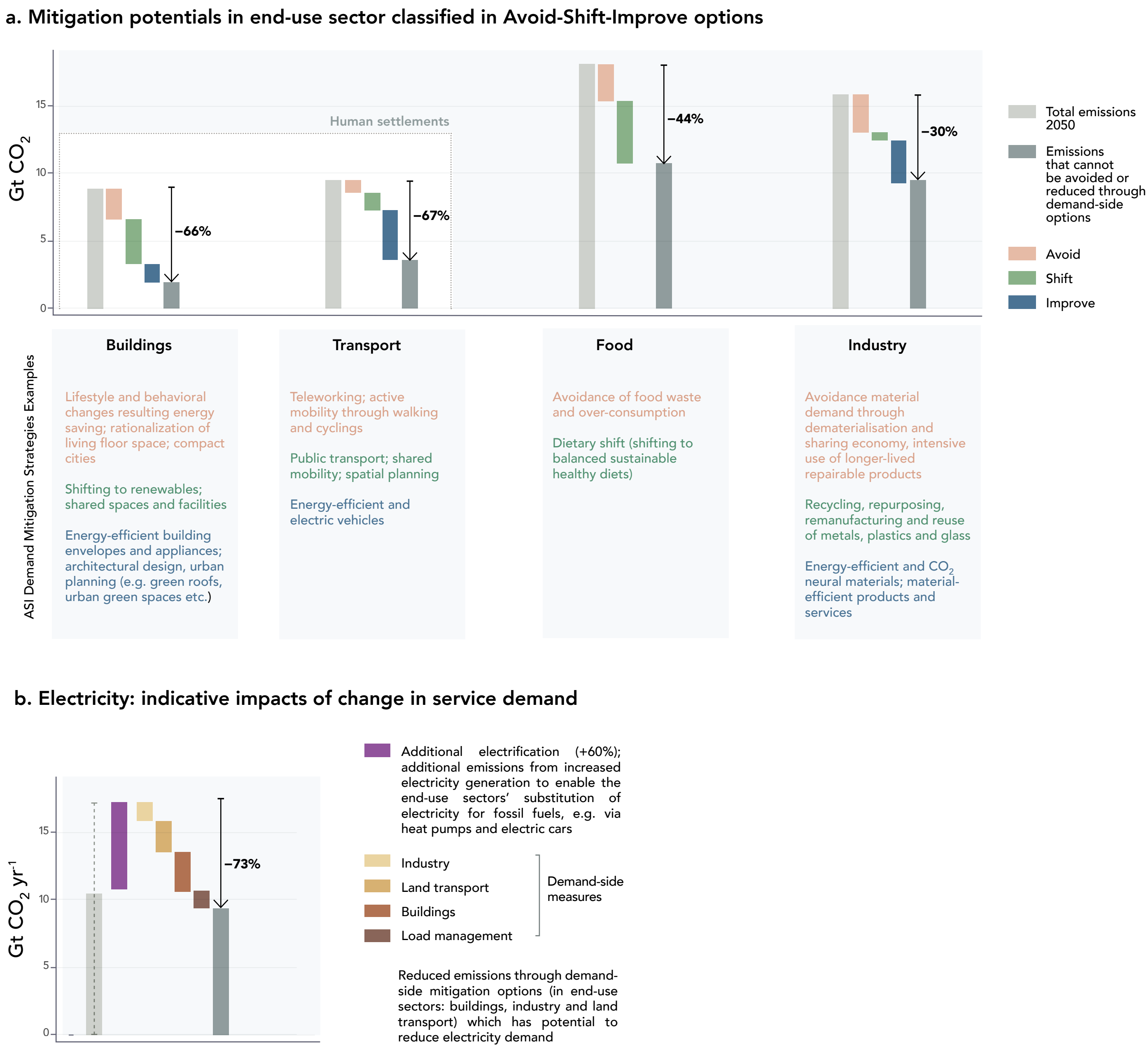
Improvements provide significant impact on the building, transport, and industrial sectors. Notable examples here include: the design of energy efficient building envelopes, improved household appliances, wider use of electric cars, and more efficient material and energy use in industrial production.

Importantly, ASI strategies are found to be consistent with high levels of well-being most notable in health due to improved air quality and enhanced energy use. In some cases, the co-benefits of a reduction strategy can even go beyond the associated mitigation benefits.[12] Food, mobility, and water are additional categories where well-being is improved. For example, mobility-linked enhanced well-being outcomes are found in compact cities that emphasise teleworking and have a system (or cross-sectoral) orientation towards mitigation approaches.

Box 1.

Hangzhou, China

Figure 1: Mitigation potential of demand-side options by 2050.



Source: A re-interpretation of data underlying the Figure SPM.6, Summary for Policymakers, IPCC AR6 WGIII

Deep and accelerated emissions reductions across urban systems, regardless of city type, require a territorial approach that integrates mitigation and sustainable development strategies across space. It will be very difficult for a city to achieve deep emissions reductions without accounting for its peripheral, regional, and global reach and influence.[13] A territorial orientation towards emissions reductions is thus crucial. A large number of cities have adopted net-zero emissions targets. In some cases, the scope of these targets extends beyond the boundary of the city to include upstream and downstream emissions. In most cases, realising these stringent emissions reduction targets would involve some form of carbon offsetting for residual emissions through enhancing carbon uptake. In the case of established cities, for example, investments in urban green and blue infrastructure could offset residual emissions that cannot be reduced.[14]

3. SYSTEMS TRANSITIONS

Although much of the scientific literature on mitigation focuses on individual sectors, cities offer the opportunity for systemic responses. As such, urban mitigation actions have the potential to reach across sectors and beyond urban boundaries concurrently. This section outlines elements of the five key interconnected systems: urban, rural, and infrastructure systems; energy; land and food systems; industry; and societal transitions.[15] To the degree that it is possible and relevant, each transition pathway integrates ASI options as well as city typology analysis.

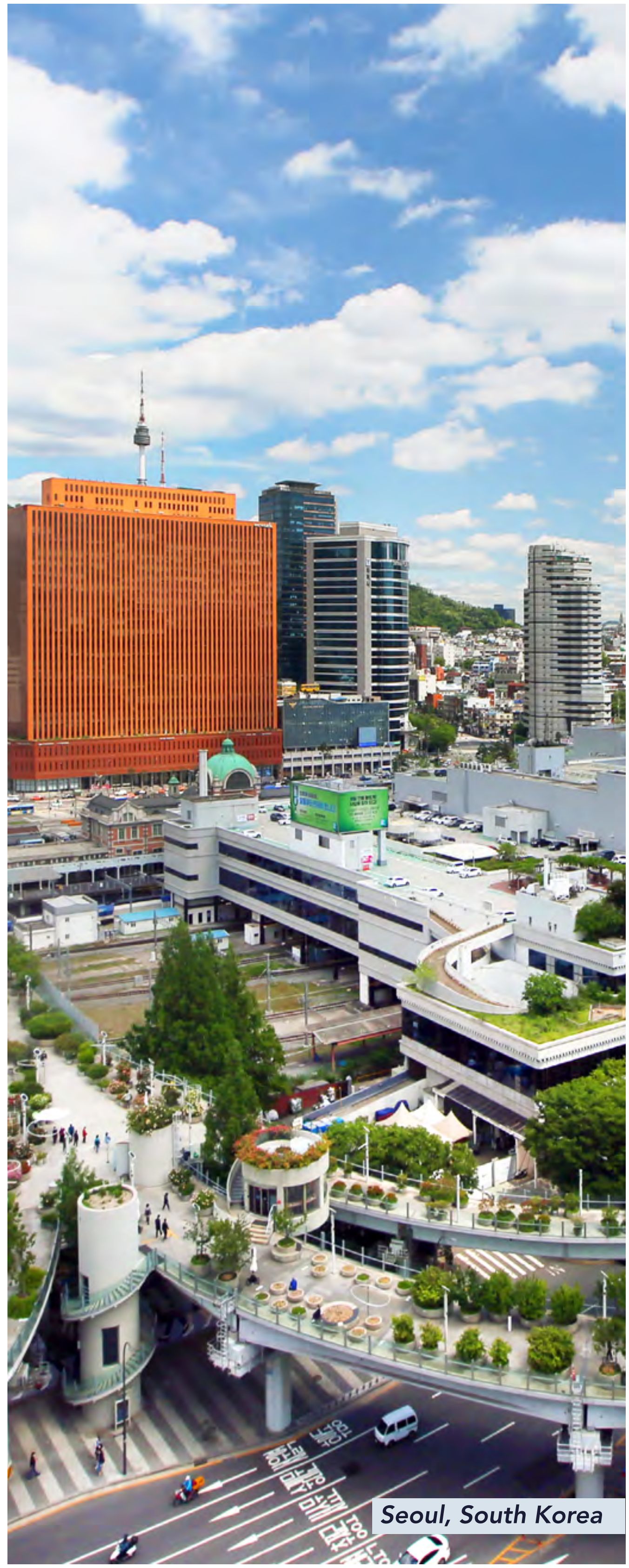
A number of mitigation options can be acted upon, with significant impact, in the near term. Many of these actions can be implemented in buildings and mobility, including; thermostat adjustments, direct feedback of energy uses in buildings, reduced speed limits, teleconferencing, and rapid street space reallocation. Importantly, short-term actions can be a starting point for setting up and enabling system transitions. A change in choice architecture or decision-making ability aimed at reducing energy and material input, for example, can be a starting point towards more energy efficient mobility via an increase in use of shared pooled mobility that can reduce the need for highly-resource and energy-intensive automobile production.

The Systems transitions

The *urban and infrastructure systems* transition brings together energy, buildings, transportation, and land-use options within cities and urban areas.[16]

For the energy sector, options focusing on ASI strategies (Box 1 and Figure 1) can reduce the demand for energy and materials, while on-site renewable energy can meet the remaining energy demand with low- or zero-carbon energy. Cities can retrofit existing buildings, in particular in developed countries with limited population growth and largely established cities as well as construct new buildings according to building codes that mandate net-zero energy at the building or district level and, gradually, the use of low-emission construction materials.[17]

For the building sector, particular attention is needed to maintain human comfort without dramatically increasing the demand for cooling, owing in part



Seoul, South Korea

to urban heat island effect. In addition to efficient mechanical cooling systems with climate-friendly refrigerants, passive and traditional cooling techniques such as natural ventilation, shading and evaporative cooling should be promoted.

For the transportation sector, changes in urban form, behaviour change programs, the circular economy, the shared economy, energy sufficiency and efficiency, and digitalisation can support systemic changes that lead to reductions in demand for transport services or the use of more efficient transport modes. For example, cities can reduce their transport-related fuel consumption by around 25% through combinations of compact land use and the provision of less car-dependent transport infrastructure.[18] Disruptive, hybrid, largely non-networked technologies have significant potential for low-emissions development in urban areas of developing countries.[19] Ultimately, the best strategies for pursuing urban and infrastructure system transition will depend on a given city's typology, including its current and future land use, spatial form, and state of urbanisation.

Energy systems transitions

Urban areas must play a key role in the energy systems transition on both the demand side as well as the supply side. A city that is walkable and designed around people rather than cars, for example, can reduce energy demands, while demand management and demand response can increase the flexibility of energy systems to accommodate larger shares of variable renewable energy sources.[20] Electrification at the urban scale, including large-scale options based on electrified public transport, heat pumps, and renewable-energy-based district heating and cooling networks, provide entry points to realise the energy systems transitions.[21]

On the supply side, roofs, walls, and balconies in cities and urban areas offer a large potential area for solar photovoltaic (PV) installations. Despite falling PV prices, there is still the need for policy to enable this potential.[22] Local energy communities at urban or district scale are important sites for promoting renewable energy systems and fostering citizens' participation and engagement. Urban residents can become active prosumers[23] by offering demand flexibility, energy storage, and renewable energy generation.[24] Coupling energy planning and citizen engagement can boost the share of renewable energy.

Istanbul, Türkiye

Land and food systems transitions

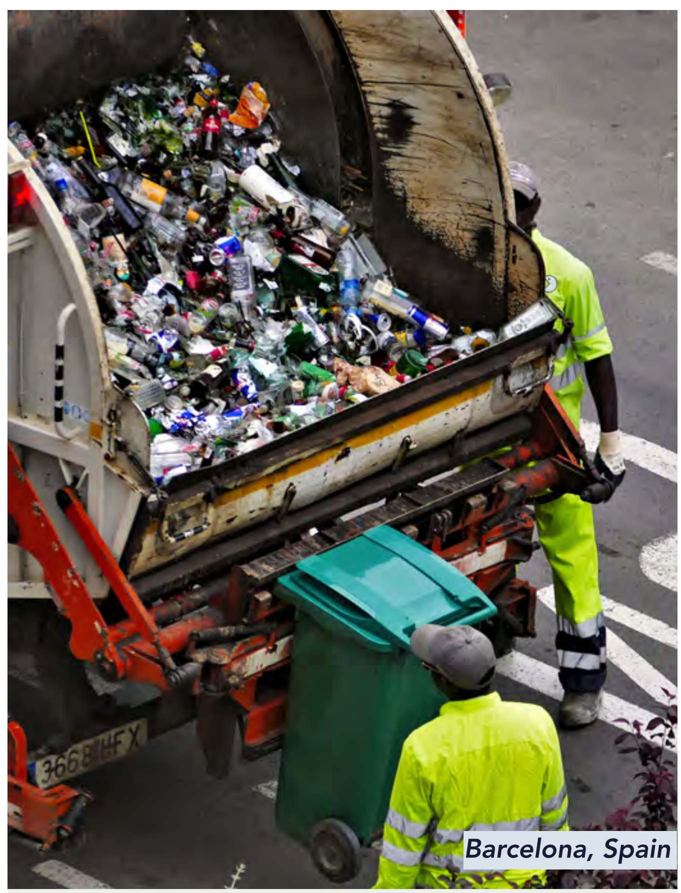
Land-based demand-side measures are relevant in the urban context. The land and food systems transition, sustainably implemented, offers an essential opportunity to reduce emissions as land-use change accounts for about 13-21% of total GHG emissions. Cities are major users of land- and water-based resources, and urban residents can significantly reduce overall emissions by shifting to sustainable healthy diets, reducing water use and food waste, recycling wastewater, conserving green areas that serve as water catchments, and building with wood and biochemicals.[25] Enhancing carbon uptake and storage in the urban environment, including through nature-based solutions such as permeable surfaces, green spaces, trees, rivers, ponds, and lakes would be equally important to facilitate emissions reductions.[26] Most of these measures can be implemented in the short term, do not require additional land, and can potentially support sustainable development. However, if poorly implemented and governed, land-based measures can result in trade-offs with livelihoods and ecosystem services.

In the context of national or local net-zero GHG emissions targets, carbon dioxide removal may be necessary to neutralise residual GHG emissions from hard-to-abate sectors, such as those from some industrial activities, long-distance transport, or methane and nitrous oxide from agriculture and polluted water bodies.[27] Finally, the land use sector can also be a carbon sink if properly managed. In city environments, urban green and blue infrastructure, including retained local ecosystems, green areas, parks, and urban farming, can play a significant role in GHG emissions reductions while also delivering ecosystem services co-benefits.[28]

Industrial systems transition

Buildings, infrastructure, and transport all require materials such as cement and concrete, iron and steel, glass, bricks, plastics, and other chemicals. Increased basic materials extraction and production have caused industrial emissions to grow faster than emissions in other sectors over the last decades.[29] Modelling suggests that in developed countries, per capita material stocks are levelling off, while in developing countries the construction of new infrastructure and growing demand for products still drives global material demand. Climate action may also spur material demand, like steel for windmills, building insulation materials for heating/cooling systems, and EVs.[30]

Mandaue City, Philippines



Barcelona, Spain

Historically, mitigation efforts in industry have focussed on incrementally improving existing manufacturing processes, for example by increasing efficiency to limit energy demand and material inputs, therefore limiting direct and indirect emissions associated with the extraction of resources. While important, incremental changes alone are insufficient to realise net-zero emissions from the industrial sector. Additional transformational changes are needed, such as low- to zero-GHG intensity production processes in the longer term, switching to alternative energy carriers and feedstocks, and capturing and storing remaining CO_2. Reducing primary production is also key, and can be achieved through a lowered demand for materials, increased material efficiency, and circularity.[31]

Cities can play an important role to facilitate the industrial systems transition through: spatial planning that limits material demand, implementation of improved design standards, and building codes. Additional strategies include: promoting circularity through dedicated policies for recycling and waste and developing urban-industrial symbiosis to use waste from cities as fuel, feedstock, and construction material, including creating a demand for bio-based building materials.[32] In every case, coordinated action throughout value chains to promote all mitigation options is a prerequisite for reaching net-zero CO_2 emissions in industry.[33]

In addition to incentivising the industrial system transition, cities may also be affected by it. Some industrial sectors are growing while others are shrinking. Furthermore, the potential for generating wind and solar power is not distributed evenly across the world, neither are geological formations suitable for storing CO_2. Energy-intensive industries requiring renewable electricity, hydrogen produced through electrolysis, or captured CO_2 storage sites to reduce emissions may relocate to those regions where this is available.[34] Such changes in global supply chains will have global distributional effects on employment and economic structure, and would require socially inclusive emissions phase-out plans within the context of just transitions.[35]


Mannheim, Germany

Societal systems transition

Finally, one of the important developments of the AR6 cycle is the emphasis on societal transitions encompassing demand, services, and social aspects of mitigation. Demand-side strategies, spread across all sectors, offer the potential to reduce emissions by 40-70% by 2050. Within the ASI framework, the greatest 'Avoid' potential comes from reducing long-haul aviation and providing short-distance, low-carbon urban infrastructure alternatives.[36] Demand for passenger and freight services can be reduced through combinations of teleworking, digitalisation, dematerialisation, supply chain management, and smart and shared mobility.[37] Transport demand management incentives are likely necessary to support such systemic changes.

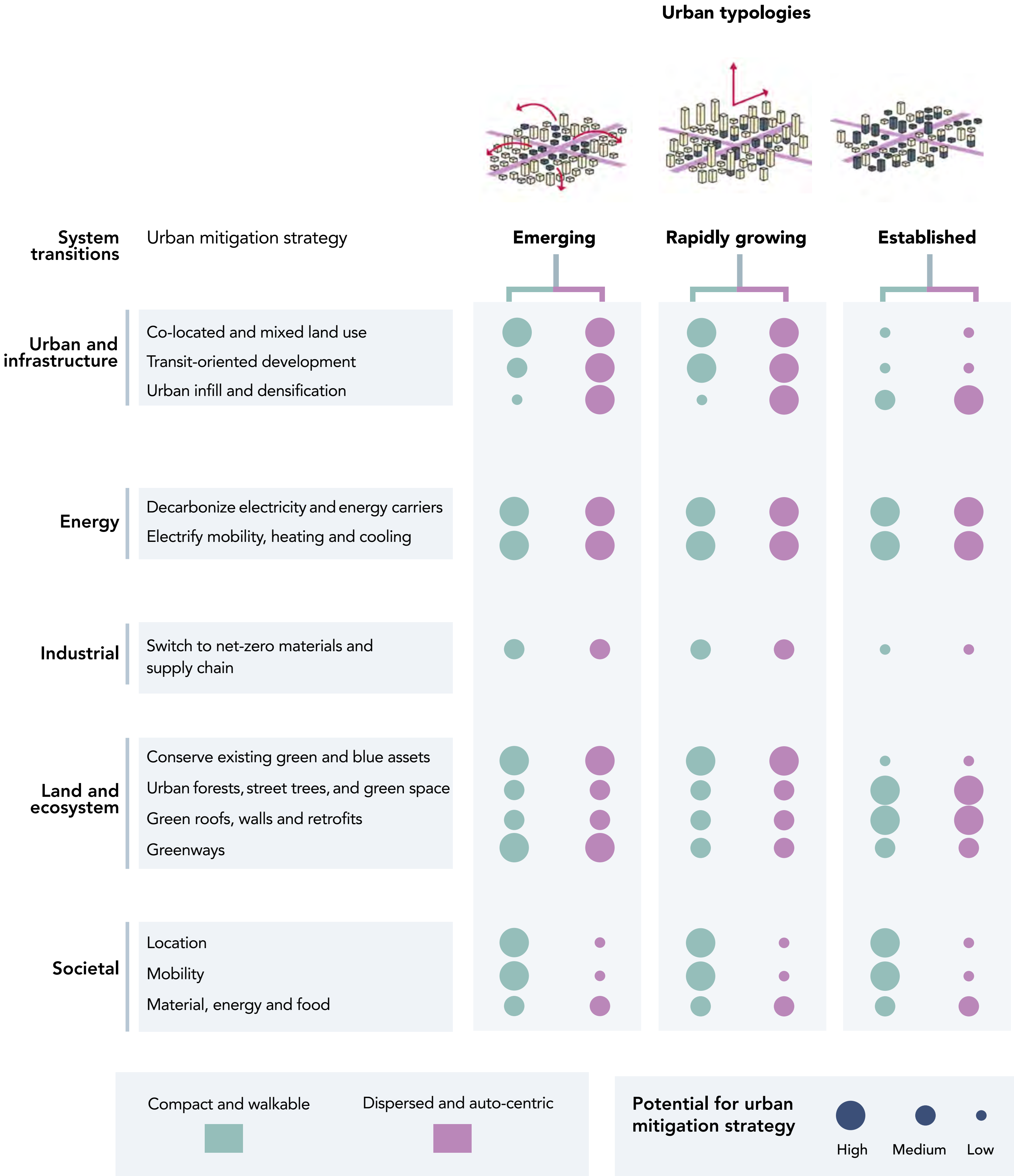
Collective social change over the longer term, including towards less resource-intensive lifestyles, depends on building a social mandate through public participation and deliberation, as well as effective communications campaigns that adequately explain and incentivise alternative options. Individuals are capable of reducing their GHG emissions and may become role models in a broader, collective effort to normalise and prioritise low-carbon lifestyles, invest in low-carbon businesses, and advocate for strong climate policies.[38]

Finally, urban consumption patterns and supply chains have regional and global implications. As such, the full potential for reduction of consumption-based urban emissions will be achieved only when emissions beyond cities' administrative boundaries are also reduced. Such a territorial approach requires cooperation and coordination between national and sub-national governments, as well as with industry and civil society.[39]

Mitigation interventions, which are by design large and complex and cut across multiple urban scales, are often beyond local budgetary and institutional capacity. Innovative partnerships are needed across multiple local, regional, national, and international institutions and stakeholders, particularly to mobilise financial resources and identify innovative governance structures, processes, and mechanisms.[40]

Turin, Italy

Figure 2: : Potential of urban mitigation strategies across urban typologies (growth x form) and systems transitions.



Source: Derived from IPCC AR6 WGIII, Chapter 8, Figure 8.20, Figure 8.21.

Feasibility

The feasibility of mitigation options depends on a wide array of factors, including the geophysical, environmental-ecological, technological, economic, socio-cultural, political, and institutional. As Figure 2 illustrates, these factors are key to accelerated implementation.[41] Almost all mitigation options face institutional barriers that must be addressed to enable their application at scale.

Feasibility also differs across regions. The institutional capacity to support deployment of options, for example, varies across countries, while spatial planning has a higher potential of impact at early stages of urban development. The feasibility of demand side responses, meanwhile, depends on capacities as well as socio-cultural and local conditions. The speed and scale of implementation also affects feasibility: most options face barriers when they are implemented rapidly at a large scale. The feasibility of mitigation options can increase when synergies with adaptation options are leveraged.[42]

Options, synergies and trade-offs

Mitigation options in urban areas can have synergies across a range of SDGs, and in some cases can result in both complementarity and trade-offs within the urban application as well as through dependencies on other ecosystems and regions elsewhere. These interactions vary depending on the scale and the development context.

Figure 3: Overall feasibility of mitigation options and synergies and trade-offs between sectoral mitigation options and the SDGs.

Sector	Mitigation Response Options	Overall Feasibility	1	2	3	4	5	6	7	8	9	10	11	12	14	15
Energy	Solar Energy	High	+	★	+			★	+	+	+		+	★		★
Energy	Wind energy	Medium	+	★	+			+	+	+	+		+	★	★	★
Energy	Geothermal	Low	+		★			★	+		+		+			
Energy	Energy storage for low-carbon grids	Low														
Energy	Demand side mitigation	Medium	+	+	+		+	+	★	★	+	+	+			
Energy	System integration	Medium														
Urban	Urban land use and spatial planning	Medium	+	★	+	+	+	+	+	+	+	★	+	★	★	★
Urban	Electrification of the urban energy system	High	+	★	+	+	+	+	+	+	+	+	+	★	+	★
Urban	District heating and cooling networks	Medium	+	−	+				+	+	+		+	+		+
Urban	Urban green and blue infrastructure	High	+	+	+	+		+	+	+	+	★	+	+	+	+
Urban	Waste prevention, minimization and management	Medium	+	+	★			+		★	+					+
Urban	Integrating sectors, strategies and innovations	Medium	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Building	Building design and performance	Low	+	+	+			+	+	★		+	+	+		+
Building	Change in construction methods and circular economy	Medium			+			★	+	★	+		+	+		
Building	Envelope improvement	Low	★	+	★	+		+	+	★	★	★	+	+		
Building	Heating, ventilation and air conditioning (HVAC)	Low	★	+	+			+	+		★	★	+	+		
Building	Efficient Appliances	Medium	★	+	+	+	+	+	+	★	−	★	+	★		+
Building	Change in construction materials	Low			+			★	+	★	+			+	+	
Building	Demand Side management (active management operation, digitalization and flexible comfort requirements)	Low	★	★	+	+	+	★	★	★	★	★	+	+		+
Building	Renewable energy production	Low	+		★	+	+		+	+	+	+	+	+		
Transport	Demand reduction and mode shift	Medium	+		+	+	+		+	+	★	+	+	+		
Transport	Biofuels for land transport, aviation, and shipping	Low		★	★				+	+	+		+		★	★
Transport	Electric vehicles for land transport	Low				★				★	+	+	★	+	★	

Related Sustainable Development Goals:

- 1 No poverty
- 2 Zero hunger
- 3 Good health and wellbeing
- 4 Quality education
- 5 Gender equality
- 6 Clean water and sanitation
- 7 Affordable and clean energy
- 8 Decent work and economic growth
- 9 Industry, innovation and infrastrcuture
- 10 Reduced inequalities
- 11 Sustainable cities and communities
- 12 Responsible consumption and production
- 13 Climate action
- 14 Life below water
- 15 Life on land
- 16 Peace, justice and strong institutions
- 17 Partnership for the goals

+ Synergies
− Trade-offs
★ Synergies and trade-offs
Blanks represent no assessment

Overall Feasibility: High, Medium, Low

Source: Derived from IPCC AR6 WGIII, Summary for Policymakers, SPM.8

As Figure 3 illustrates, there are multiple near-term sustainable development benefits that result from mitigation actions. There are synergies between sustainable development and mitigation actions that promote, among other benefits: energy efficiency and renewable energy; urban planning with more green spaces; reduced air pollution; and demand-side mitigation strategies such as shifts to balanced, sustainable healthy diets. Zero- or low-emission electrification and shifts to public transport can enhance health and employment benefits, enhance energy security goals, and improve equity. In industry, low- or zero-emission electrification can contribute to reduced environmental pressures, as well as increased economic activity and employment. Notably, enhanced mitigation and broader actions to shift development pathways towards sustainability can have distributional consequences within and between countries, potentially shifting income and employment profiles and generating new employment opportunities.[43]

Mitigation actions can also contribute towards adaptation and community resilience; indeed, mitigation remains essential to effective adaptation and climate resilient development. Opportunities for synergies between mitigation actions and adaptation needs exist in sustainable urban planning and infrastructure design, including green roofs and facades, permeable urban surfaces, urban agriculture, and water-sensitive design. These options can reduce flood risks and pressure on urban drainage systems, improve infiltration and ground-water recharge, alleviate urban heat island effects, enhance urban biodiversity, and enhance health and well-being benefits from reduced air pollution and improved aesthetics. In general, measures promoting walkable urban areas that are combined with low- or zero-emission electrification can create health co-benefits from cleaner air.

In certain instances, mitigation options also come with trade-offs. Increasing urban density to reduce travel, for example, can also increase vulnerability to heat waves and flooding. Air pollution control techniques can involve trade-offs with waste management strategies, especially if incineration is involved. Trade-offs can also arise if food systems are coupled with bioenergy, electricity, and heat. Electrification of urban energy systems can negatively impact freshwater aquatic, coastal, and marine ecosystems if delivered through enhanced hydropower development and biofuel cultivation. Material demand due to enhanced electrification may increase, so appropriate policy design becomes especially important.[44] Many of the potential trade-offs between mitigation and sustainable development could be minimised through appropriate policies, as well as enhanced attention to social equity, particularly through participatory processes of decision-making.


Queenstown, Singapore

4. ENABLING CONDITIONS FOR SYSTEMS TRANSITIONS AND TRANSFORMATION

Enabling conditions are the policies, investments, and engagement strategies that must be in place in order to realise, promote, or advance systems transitions and ultimately transformation. They play a critical role in determining the scalability and efficacy of mitigation efforts by both creating the legal frameworks for action, but also engaging the specific actors that must ultimately implement change. These enabling conditions relate to urban policy and planning, governance, finance, lifestyle and behaviour change, innovation, and technology. Crucial elements of each are outlined below:

Urban policy and planning

Urban policies and spatial planning are necessary to establish targets and guidelines for the key attributes of cities that drive urban emissions through interventions at multiple geographic scales. For instance, metropolitan policies and integrated strategic spatial planning can facilitate compact urban areas, restructure urban regions, and shape and reduce energy demand and transportation patterns. Similarly, cities can facilitate a shift to sustainable healthy diets through food procurement policies that promote local production and reduce vehicle use. Through building codes, cities can regulate material and construction standards for buildings, including requirements for efficient heating and cooling techniques and appliances.

Some interventions involve decisions beyond the administrative boundaries of cities and require cooperation with other levels of government. For instance, upscaling EVs involves a range of policies, incentives, and regulations complemented across local, state, and national levels. Coordination mechanisms for urban policy within a nested governance framework can join fragmented policymaking and enable the implementation of cross-sector policies beyond a single-sector focus, teaming up multiple institutions to increase capacity for low-carbon transitions.[45]

Although spatial planning provides a unique opportunity to envision low- or net-zero cities, especially through the integration of land use and transport planning, the implementation of such visions requires a broad approach to urban policy that includes a range of policies and investment approaches across administrative and territorial boundaries, partnerships between public and private sectors, and vertical integration of local, regional, and national policies that affect urban space.

Governance and institutions

While many cities have set ambitious goals, and in many cases achieved significant outcomes for carbon reduction to date, none are capable of realising the necessary impact alone: implementing ambitious climate action in cities requires the involvement of governance at multiple levels. Further, regional, national, and international climate goals are most impactful when local governments are involved alongside higher levels as partners, rendering urban areas key foci of climate governance more broadly. Cities will also need to create engagement avenues with multiple local stakeholders and actors, including the private sector and civil society, particularly grassroots and front-line organisations that capture indigenous and locally-lived expertise and experience.[46] Climate mitigation responses that integrate considerations of all relevant communities from a perspective of justice and equity can cultivate widespread support for expanding the scope and scale of action.[47]

Ensuring focus on governance creates a legal basis to respond systemically to the mitigation agenda.[48] Cities have the ability to implement policies across a range of sectors, but such an ability is contingent upon their institutional capacities to develop, coordinate, and integrate sectoral mitigation strategies within their context and with intentional involvement from the local community. These institutional capacities are influenced by incumbent political context, governance and regulatory regimes, and budgetary considerations. Such institutional constraints are more pronounced in the developing world.[49]

Ultimately, a transformative reimagination across governance and institutional frameworks is needed to enable climate mitigation in cities and regions. The reimagined configuration must be responsive to the stage of development, city size and typologies, and incumbent institutional capacities.[50]

Financing urban mitigation

Availability and access to finance is a crucial dimension of urban climate mitigation action and also a substantive barrier, mostly due to limited financial capacity and lack of creditworthiness among city governments, particularly for intermediate cities in emerging markets. Current mitigation finance across all sources, sectors, and regions is in the range of 16-33% of the average need up to 2030 for scenarios that limit temperature rise to 2°C. Crucially, mitigation investment gaps are the highest for developing countries.[51] Policy action is effective when matched by long-term and consistent financial support for implementation.[52] Yet at an aggregate level, progress on aligning climate finance with low-emission pathways has been slow, reflecting a serious and persistent misallocation of financial resources.[53] Cities, along with international institutions, national government, and local stakeholders, will play an important role in mobilising climate finance across key sectors and, increasingly, by aligning cross-sectoral considerations to enable upscaled financial flows.[54] For example, the mobilisation of financial resources to leverage cross-sectoral mitigation opportunities requires both a combination of public and private capital as well as new business models, including community-led bottom-up mitigation action.[55] For example, green municipal bonds offer significant potential to expand sources of finance but more importantly, enable cross-sector collaboration and cooperation.[56] In addition to new business models, it is crucial to ensure sustainable and predictable intergovernmental transfers to city governments that enable financing of mitigation action. Predictable transfers can help facilitate, for example, access to low-concession large infrastructure finance. Large low-carbon infrastructure projects are often beyond the capacity of local municipal budgets, jurisdictions, and institutions and thus, calls for innovative partnerships across a range of actors, such as international institutions, national and regional governments, transnational networks, and local stakeholders.[57]

Current mitigation finance across all sources, sectors, and regions is in the range of 16-33 percent of the average need up to 2030 for scenarios that limit temperature rise to 2°C.

Austin, USA

Lifestyle and behavioural change

Behavioural change is an important and underutilised driver that can be cultivated to rapidly mitigate climate change.[58] Such change can be encouraged and supported by policy and system changes, including energy pricing policies, providing sustainable technology, and making the low-carbon choice the default option.[59] Urban infrastructure investments can also enable low-carbon lifestyles through, for example, compact urban layouts and accessible electric transit systems. The numbers with regards to the built environment are striking. Between 5-30% of global annual GHG emissions by 2050 can be limited by a combination of new and repurposed infrastructure and compact cities, co-location of jobs and housing, more efficient use of floor space and energy in buildings, and the reallocation of space for active mobility.[60] Finally, the process of policy development and implementation matters. Public support for policy and implementation, including system changes, improves when benefits and costs are shared, and when decision-making processes encourage trust.[61]


São Paulo, Brazil

Innovation and technology

Significant progress has been made in climate change mitigation technologies and innovation in recent years. Innovation, together with other enabling conditions, has the potential to support system transitions and to shift development pathways to limit warming. For instance, widespread technological innovation in combination with public policy can advance the implementation of clean energy options, such as feed-in tariffs. Additionally, innovation can enhance human wellbeing through developing new and improved ways of service delivery. Mobility apps, for example, that offer mobility-as-service can also encourage active and healthy lifestyles.[62] However, innovation can also result in negative externalities, such as rebound effects leading to lower net emissions reductions and increased dependence on foreign knowledge and technology, especially in developing countries. Effective policy and governance can minimise negative externalities and avoid trade-offs between innovation and sustainable development.[63] Regulatory and economic instruments can stimulate innovation and support emission reductions. Gaps in innovation cooperation remain, which need to be addressed through improved financial support for international technology cooperation and enhanced capacities in developing countries across innovation value chains.[64]


Paris, France

CONCLUSION

Addressing warming in an urban world requires urgent and ambitious action. Yet importantly, the ambitious actions cities and urban areas must take to continue the transition towards net-zero GHG emissions do not exist outside of geography and history. Instead, mitigation strategies must be intertwined with climate resilient development, with policymakers pursuing synergies with adaptation options. While cities and urban areas may differ in essential ways—from populations, to the built environment, to level of adaptation preparedness, to the onset of climatic impact drivers—the underlying fact remains: emissions must be reduced in all cities, urban areas, and linked peripheral regions, and this must happen now. The necessary steps and strategies needed to advance systems transition, and the urban and infrastructure transition in particular, can provide the beginning of a wider transformation, one in which people reconsider their relationship with each other, with nature, and with the material world.

Mumbai, India

ANNEX

Essential Principles and Concepts

Clarity in some essential principles can further the understanding of current climate science and the development and implementation of associated policies. This annex provides IPCC definitions from Working Group II and Working Group III on concepts central to understanding, and taking action around, cities and climate change. So as to maintain consistency, these definitions, while shortened at times, are drawn directly from AR6 WGII and WGIII.[65]

Adaptation in human systems is the process of adjustment to actual or expected climate and its effects to moderate harm or take advantage of beneficial opportunities. In natural systems, it is the process of adjustment to actual climate and its effects; potentially facilitated by human intervention.

Choice architecture describes the presentation of choices to consumers, and the impact that presentation has on consumer decision-making.

Climate Resilient Development refers to the process of implementing GHG mitigation and adaptation measures to support sustainable development for all.

Co-benefits are positive effects that a policy or measure aimed at one objective has on another objective, thereby increasing the total benefit to society or the environment. Co-benefits are also referred to as ancillary benefits.

Dematerialise refers to the reduction in the quantity of the materials used in the production of one unit of output. It is a circular economy principle that can affect the operations and emissions of the transport sector, as reductions in the quantities of materials used reduces transport needs, while reductions in the weight of products improves the efficiency of transporting them. Dematerialisation can occur through more efficient production processes but also when a new product is developed to provide the same functionality as multiple products. e.g. smart phone, which provides the service of at least 22 other former devices.

Impacts are the consequences of realised risks on natural and human systems, where risks result from the interactions of climate-related hazards (including extreme weather and climate events), exposure, and vulnerability. Impacts generally refer to effects on lives; livelihoods; health and well-being; ecosystems and species; economic, social, and cultural assets; services (including ecosystem services); and infrastructure. Impacts may be referred to as consequences or outcomes, and can be adverse or beneficial.

Mitigation is a human intervention to reduce emissions or enhance the sinks of GHGes.

Prosumer is a consumer that also produces energy and inputs energy to the system, for which it is an active agent in the energy system and market.

Rebound effects are phenomena whereby the reduction in energy consumption or emissions (relative to a baseline) associated with the implementation of mitigation measures in a jurisdiction is offset to some degree through induced changes in consumption, production, and prices within the same jurisdiction. The rebound effect is most typically ascribed to technological energy efficiency improvements.

Resilience is the capacity of social, economic, and ecological systems to cope with a hazardous event, trend, or disturbance, responding or reorganising in ways that maintain their essential function, identity, structure, and capacity for adaptation, learning, and transformation.

Risk is the potential for adverse consequences for human or ecological systems, recognising a diversity of values and objectives associated with such systems. Key risks have severe consequences for humans and social-ecological systems from the interaction of climate related hazards with the vulnerabilities of societies and systems exposed.

Transformational adaptation is adaptation that changes the fundamental attributes of a social-ecological system in anticipation of climate change and its impacts.

Urban share refers to total urban emissions based on consumption-based accounting.

Vulnerability is the propensity or predisposition to be adversely affected and encompasses a variety of concepts and elements, including sensitivity or susceptibility to harm and lack of capacity to cope and adapt.

ADVISORS: CITY OFFICIALS

Hamidou Baguian
City of Bobo-Dioulasso, Burkina Faso

Zach Baumer
City of Austin, USA

Lia Cairone
City of New York, USA

Yoonjin Cho
City of Seoul, Republic of Korea

Leticia Clemente
City of Baguio, Philippines

Ricardo Cofré
City of Peñalolén, Chile

Tiffany Crawford
City of Melbourne, Australia

Nisreen Daoud
Municipality of Greater Amman, Jordan

Manuel de Araújo
City of Quelimane, Mozambique

Johan De Herdt
City of Antwerp, Belgium

Gillian Dick
City of Glasgow, United Kingdom'

Sharon Dijksma
City of Utrecht, The Netherlands

João Dinis
City of Cascais, Portugal

Roshanie Dissanayake
City of Colombo, Sri Lanka

Tamsin Faragher
City of Cape Town, South Africa

Yann Françoise
City of Paris, France

Erika Alejandra Fregoso Cuenca
City of Guadalajara, Mexico

Natalia Garay
Metropolitan Region of Santiago, Chile

Katrina Graham
City of Hobart, Australia

Solape Hammond
State of Lagos, Nigeria

Leonardo Herou
City of Canelones, Uruguay

Bridget Herring
City of Asheville, USA

Patricia Himschoot
City of Buenos Aires, Argentina

Bryan Ho-Yan
City of Guelph, Canada

Ivan Ivankovic
City of Zagreb, Croatia

Jonas Kamleh
City of Malmö, Sweden

Kunal Khemnar
City of Pune, India

Sonia Knauer
City of Belo Horizonte, Brazil

Felipe Mandarino
City of Rio de Janeiro, Brazil

Carolina Manriquez
Metropolitan Region of Santiago, Chile

Sri Maryati
City of Palembang, Indonesia

Daniela Mastrángelo
City of Rosario, Argentina

Anna Mitchell
City of Sydney, Australia

Ahmad Zabri bin Mohamed Sarajudin
City of Seberang Perai, Malaysia

Rosli Nordin
City of Kuala Lumpur, Malaysia

Joseph Oganga
City of Kisumu, Kenya

Herman Padonou
National Association of Municipalities of Benin

Diana Porlles
City of Lima, Peru

Agnes Schöenfelder
City of Mannheim, Germany

Mohamed Sefiani
City of Chefchaouen, Morocco

Mariusz Skiba
City of Katowice, Poland

David Smart
City of Bo, Sierra Leone

Katrin Stjernfeldt Jammeh
City of Malmö, Sweden

Çağlar Tükel
City of Izmir, Turkey

Risto Veivo
City of Turku, Finland

Paola Vela
City of Lima, Peru

Irma Ventayol i Ceferino
City of Barcelona, Spain

Anthony Xenon Walde
City of Makati, Philippines

Fernand Yapi Cocody
City of Abidjan, Cote d'Ivoire

ADVISORS: BUSINESS LEADERS

Per Boesgaar
Arup

Brodie Boland
McKinsey & Company

John Carstensen
Mott MacDonald

Carlo Castelli
Jacobs

Bruce Chong
Arup

Henning Diederichs
Institute of Chartered Accountants in England and Wales

Callum Ellis
Marsh

Siobhan Gardiner
Deloitte

Björn-Olof Gustafsson
WSP

Peter Hall
Wood

Alex Jimenez
Arup

Katherine Maxwell
WSP

Amanda May
National Grid

Dhiren Naidoo
Wood

Emily Ojoo-Massawa
Mott MacDonald

Diego Padilla-Philipps
WSP

Kirtiman Pathak
McKinsey & Company

Graeme Riddell
Marsh

Heather Rosenberg
Arup

Kaitlin Shilling
Arup

Ben Smith
Arup

Stephanie Tseng
Mott MacDonald

Stephane Villemain
Ivanhoé Cambridge

Christine Wissink
Wood

David Wright
National Grid

Daniela Zuloaga
Arup

ENDORSEMENTS

TEAM

Madhurya Balan
Indian Institute for Human Settlements

Amir Bashir Bazaz
Indian Institute for Human Settlements

Beena Chester
Resilience First

Gemma Cowan
Resilience Rising

Andy Deacon
Global Covenant of Mayors

Sarah Grumulaitis
Arup

Nicola Iezza
ICLEI – Europe

Amy Leitch
Arup

Marni McGregor
Global Covenant of Mayors

Malavika Navale
Indian Institute for Human Settlements

Prathijna Poonacha Kodira
Indian Institute for Human Settlements

Giorgia Rambelli
Global Covenant of Mayors

Chandni Singh
Indian Institute for Human Settlements

Debabrat Sukla
Indian Institute for Human Settlements

Swati Surampally
Indian Institute for Human Settlements

Padma Venkatraman
Indian Institute for Human Settlements

ENDNOTES

[1] IPCC, 2022. ***Climate Change 2022: Mitigation of Climate Change***, Technical Summary, TS. 5.2; Chapter 8, 8.1.6, 8.3.3; Carbon footprint refers to combined global CO_2 and CH4 emissions through the production and consumption of goods and services
[2] Ibid., Summary for Policymakers, Figure SPM.2; Chapter 1, Figure 1.2; Chapter 2, 2.2, 2.4, 2.6; Chapter 3, 3.7; Chapter 4, 4.2; Chapter 6, 6.7; Technical Summary, Figure TS.4, Figure TS.5
[3] Ibid., Chapter 8, 8.1.4, 8.1.5, 8.1.6
[4] Ibid., Technical Summary, Box TS.3; Chapter 4, 4.3,Figure 4.7, Cross-Chapter Box 5 | Shifting development pathways to increase sustainability and broaden mitigation options
[5] Ibid., Chapter 8, 8.2, 8.4; Chapter 4, 4.4.1
[6] Ibid., Chapter 8, Cross-Working Group Box 2 | Cities and Climate Change; Chapter 5, 5.3; Chapter 10, 10.2, 10.8
[7] Refers to GHG emissions. These estimates include all CO2 and CH4 emission categories except for aviation and marine bunker fuels, land-use change, forestry and agriculture.
[8] Ibid., Summary for Policymakers, C.6; Chapter 8, 8.2, 8.3, 8.4, 8.5, 8.6, Figure 8.21; Chapter 13, 13.2
[9] Ibid., Summary for Policymakers, Figure SPM.6, C.8.2; Chapter 11, Table 11.4, Box 11.2, 11.3, 11.4; Chapter 5.3, Chapter 10, 10.2, 10.8
[10] Ibid., Chapter 8, 8.2, 8.3.4, 8.4, 8.6
[11] Ibid., Chapter 5, 5.1, 5.3, Table 5.1, Figure 5.6, Figure 5.7, Figure 5.8, Figure 5.10 , 5.6.2, Table 5.5, Table 5.7; Technical Summary, Box TS.12, TS. 5.8, TS. 6.3
[12] Ibid., Chapter 5, 5.2.3
[13] Ibid., Technical Summary, TS.5.2
[14] Ibid., Chapter 8, 8.6.1, Box 8.4
[15] As the AR6 cycle moved from the Special Reports and Working Group I to Working Groups II and III, a fifth systems transition, societal transition, was added to the four originally described in the Special Report on Global Warming of 1.5ºC.
[16] Ibid., Chapter 8, Fig 8.4.7
[17] Ibid., Chapter 9, 9.6, 9.9; Chapter 8, 8.4, Box 8.4, 8.5; Chapter 13, 13.5, 13.9
[18] Ibid., Chapter 10, Executive Summary
[19] Ibid., Chapter 8, 8.3.2
[20] Ibid., Chapter 8, 8.4.3
[21] Ibid., Chapter 8, 8.4.3
[22] Ibid., Chapter 9, 9.9
[23] IPCC, 2022: Annex I: Glossary [van Diemen, et al. (eds)]. In IPCC, 2022: ***Climate Change 2022: Mitigation of Climate Change***. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [P.R. Shukla, et al. (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA. doi: 10.1017/9781009157926.020
[24] IPCC, 2022. ***Climate Change 2022: Mitigation of Climate Change***, Chapter 9, 9.9.5
[25] Ibid., Chapter 7; Chapter 5, 5.3.6.1; IPCC, 2019: Climate Change and Land: an IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems [P.R. Shukla, et al. (eds.)]. In press.
[26] IPCC, 2022. ***Climate Change 2022: Mitigation of Climate Change***, Summary for Policymakers, C.6.2
[27] Ibid., Chapter 12, 12.3
[28] Olsson, L., et al., 2019: Land Degradation, 4.9.1. In: ***Climate Change and Land***: an IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems [P.R. Shukla, et al. (eds.)]. In press
[29] IPCC, 2022. ***Climate Change 2022: Mitigation of Climate Change***, Chapter 11, 11.2.2
[30] Ibid., Chapter 11, 11.3.1
[31] Ibid., Chapter 11, 11.3
[32] IPCC, 2022. ***Climate Change 2022: Mitigation of Climate Change***, Summary for Policymakers, C.6.2; Chapter 5, 5.3, Figure 5.7; Chapter 8, 8.2, 8.4, 8.6, Figure 8.21; Chapter 9, 9.4, 9.6, 10.2
[33] Ibid., Chapter 11, 11.3.1, 11.3.2, 11.3.3, 11.4.3
[34] Ibid., Chapter 11, Box 11.1, 11.2.3
[35] Ibid., Chapter 11, 11.6
[36] Ibid., Technical Summary, Figure TS.20, Figure TS.21; Chapter 5, 5.3.1, 5.3.2, Figure 5.7, Figure 5.8, Table 5.1
[37] Ibid., Chapter 5, 5.3; Chapter 10, 10.2, 10.8
[38] Ibid., Chapter 5, 5.4.1, 5.4.3, 5.4.4, Figure 5.14
[39] Ibid., Chapter 8, 8.4, Box 8.4, 8.5; Chapter 9, 9.6, 9.9; Chapter 13, 13.5, 13.9
[40] Ibid., Technical Summary, TS.5.2; Chapter 8, 8.4, 8.5
[41] Ibid., Technical Summary, Figure TS.31, Box TS.15; IPCC, 2022: Annex II: Definitions, Units and Conventions [Al Khourdajie, et al. (eds)]. In IPCC, 2022: ***Climate Change 2022: Mitigation of Climate Change***. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [P.R. Shukla, et al. (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA. doi: 10.1017/9781009157926.021
[42] IPCC, 2022. ***Climate Change 2022: Mitigation of Climate Change***, Chapter 6, 6.4; Chapter 7, 7.4; Chapter 8, 8.5; Chapter 9, 9.10; Chapter 10, 10.8
[43] Ibid., Summary for Policymakers, D.3.2; Chapter1, 1.4, 1.6; Chapter3, 3.6; Chapter 4, 4.2; Chapter 5, 5.2; Chapter 11, Box 11.1; Chapter 14, 14.3; Chapter 15, 15.2, 15.5, 15.6
[44] Ibid., Chapter 8, Figure 8.4, Supplementary Material SM8.1; Chapter 17, Figure 17.1
[45] Ibid., Chapter 8, 8.5.1, Box 8.3; Chapter 13, 13.7; Cross-Chapter Box 9 | Case studies of integrated policymaking for sector transitions

[46] Ibid., Chapter 8, 8.5.1
[47] Ibid., Chapter 13, 13.2, 13.6, 13.8, 13.9
[48] Ibid., Chapter 13, 13.2, 13.5, 13.7, 13.9
[49] Ibid., Chapter 8, 8.4, 8.5, 8.6; Chapter 13, 13.3, 13.4
[50] Ibid., Technical Summary, Box TS.13; Chapter 13, 13.6; Chapter 9, 9.9
[51] Ibid., Summary for Policymakers, Figure SPM.9; Chapter 14, 14.4; Chapter 15, 15.1, 15.2, 15.3, 15.4
[52] Ibid., Chapter 7, 7.6
[53] Ibid., Chapter 15, 15.2, 15.3
[54] Ibid., Chapter 12, 12.6.4
[55] Ibid., Chapter 12, 12.6.4; Chapter 15, 15.2, 15.3, 15.4; Chapter 9, 9.9
[56] Ibid., Chapter 8, 8.5.4
[57] Ibid., Chapter 8, 8.4, 8.5
[58] Ibid., Chapter 4, 4.4; Chapter 5, Figure 5.14; Chapter 13, 13.9; Chapter 14, 14.5; Chapter 15, 15.6; Chapter 16, 16.3, 16.4, 16.5, Cross-Chapter Box 12 | Transition Dynamics
[59] Ibid., Summary for Policymakers, Figure SPM.6; Chapter 2, 2.4.3, 2.6.2; Chapter 4, 4.2.5; Chapter 5, 5.1, 5.2, 5.3, 5.4, Figure 5.4, Figure 5.10, Table 5.2, Table 5.2; Chapter 7, 7.4.5; Chapter 8, 8.2, 8.4; Chapter 9, 9.4; Chapter 10, 10.2; Chapter 12, 12.4; Technical Summary, Figure TS.20
[60] Ibid., Summary for Policymakers, Figure SPM.6; Chapter 5, 5.3.1, 5.3.3, 5.4, Figure 5.7, Figure 5.13, Table 5.1, Table 5.5, Table 5.2; Chapter 8, 8.4; Chapter 9, 9.5; Chapter 10, 10.2; Chapter 11, 11.3, 11.4, Table 11.6; Technical Summary, Box TS.12
[61] Ibid., Chapter 6, 6.7.6
[62] Ibid., Chapter 9, 9.9; Chapter 16, 16.1, 16.3, 16.4, 16.6; Chapter 16, Cross-Chapter Box 11 | Digitalization: efficiency potentials and governance considerations
[63] Ibid., Chapter 16, 16.2, 16.3, 16.4, 16.5, 16.6
[64] Ibid., Chapter 4, 4.4; Chapter 14, 14.2; Chapter 16, 16.5.3
[65] Ibid., Summary for Policymakers, C.10.4; IPCC, 2022: Annex I: Glossary [van Diemen, R., et al. (eds)]. In IPCC, 2022: ***Climate Change 2022: Mitigation of Climate Change***. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [P.R. Shukla, et al. (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA. doi: 10.1017/9781009157926.020; IPCC, 2022: Annex II: Glossary [Möller, V., et al. (eds.)]. In: ***Climate Change 2022: Impacts, Adaptation and Vulnerability***. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [H.-O. Pörtner, et al. (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA, pp. 2897–2930, doi:10.1017/9781009325844.029

IMAGE CREDITS

Cover page: Getty Images https://www.gettyimages.in/detail/photo/solar-panel-on-the-top-of-building-royalty-free-image/1339826733?adppopup=true
Content page: Rahul Chakraborty / Unsplash, https://unsplash.com/photos/Y-jzNrG-_60
Pg 3: ASIA CULTURECENTRE / Unsplash, https://unsplash.com/photos/v4hGTtEtm2U
Pg 4: Wei Zeng / Unsplash, https://unsplash.com/photos/DjuWIrmsEog
Pg 5: Dan Freeman / Unsplash, https://unsplash.com/photos/m4-wkz4GV04
Pg 6: Jamshed Khedri / Unsplash, https://unsplash.com/photos/R41BlweGsLU
Pg 7: Ademola Olaniran
Pg 8: Paul Starkey / Ashden, https://cutt.ly/CBQfU1i
Pg 10: Seoul Metropolitan Government
Pg 11: Kamil Kalkan / Unsplash, https://unsplash.com/photos/JYQOiiPQIEc
Pg 12: Mark Linel Padecio / Climate Visuals Countdown, https://cutt.ly/eBQhYRA; zibik / Unsplash, https://unsplash.com/photos/iR4mClggzEU
Pg 13: The City of Mannheim
Pg 14: Mael BALLAND / Unsplash, https://unsplash.com/photos/Ft-PrGvzXZ4
Pg 16: Sander Crombach / Unsplash, https://unsplash.com/photos/pWTLOFDhx-c
Pg 18: CHUTTERSNAP / Unsplash, https://unsplash.com/photos/th19OsUf3mE
Pg 20: City of Austin
Pg 21: Dennis Siqueira / Unsplash, https://unsplash.com/photos/TqSVEKceq3Q; Thierry Grun / Alamy, https://cutt.ly/ZBQkkkC
Pg 22: Vaishnav Chogale / Unsplash, https://unsplash.com/photos/509aAyMoMtQ

THE SUMMARY FOR URBAN POLICYMAKERS OF THE IPCC'S SIXTH ASSESSMENT REPORT

VOLUME III

WHAT THE LATEST SCIENCE ON CLIMATE CHANGE MITIGATION MEANS FOR CITIES AND URBAN AREAS

SUMMARY FOR URBAN POLICYMAKERS