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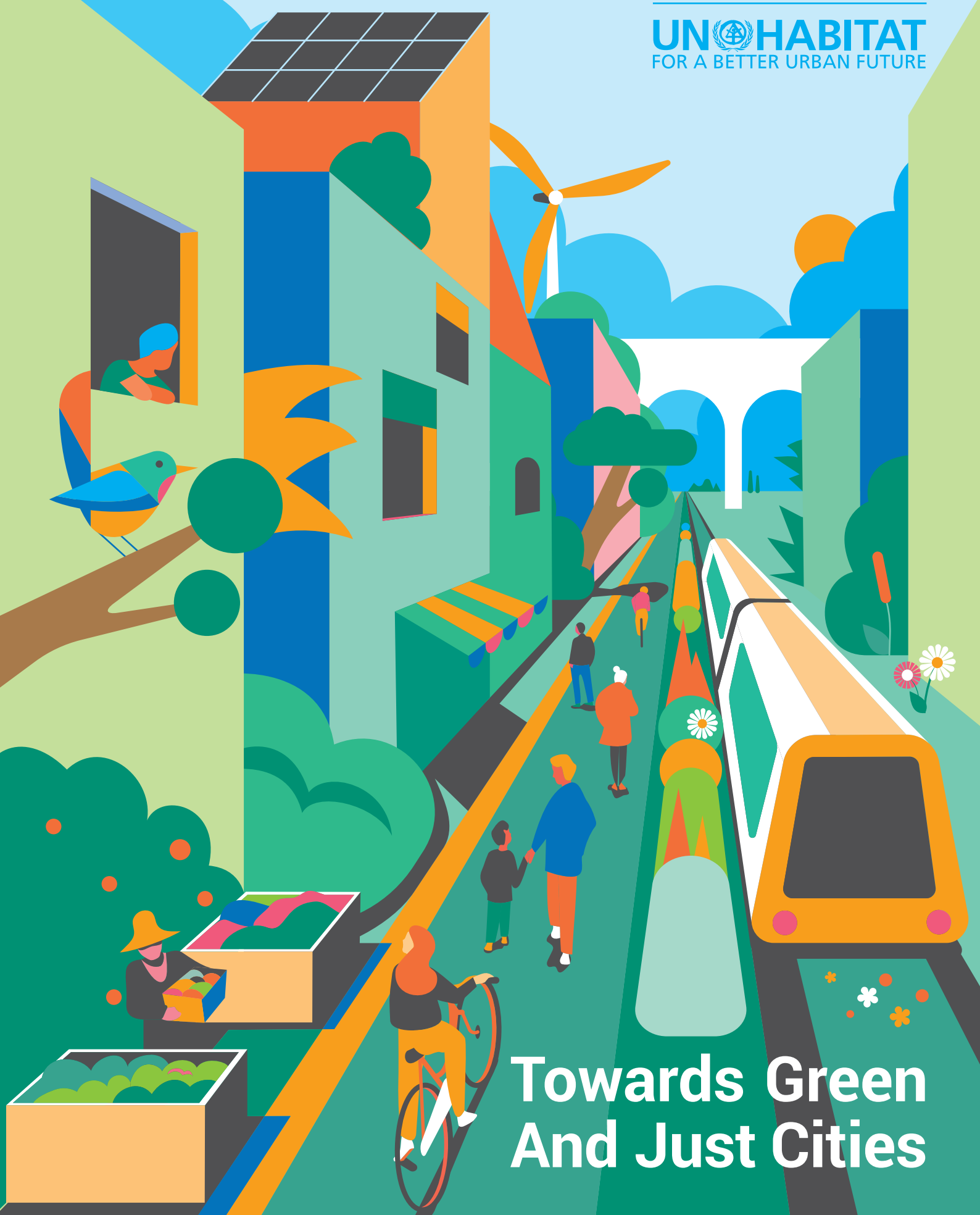

Towards Green And Just Cities

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ISBN No: 978-92-807-3889-6
Job No: DEW/2387/NA

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Suggested citation: United Nations Environment Programme and United Nations Human Settlements Programme (UN-Habitat) (2021). *Global Environment for Cities-GEO for Cities: Towards Green and Just Cities.* UNEP, Nairobi.

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GLOBAL ENVIRONMENT OUTLOOK FOR CITIES
GEO FOR CITIES
TOWARDS GREEN AND JUST CITIES

Acknowledgements

The sixth Global Environment Outlook (GEO) for Cities report is a product of the generous dedication and extraordinary investment of numerous individuals. Their knowledge, expertise and insight have helped shape this important publication. A complete list of reviewers can be found at the end of this publication. Special thanks are extended to:

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Strategic Agenda

GEO-6 funding and technical support
The following organizations provided funding and technical support directly or indirectly to the Global Environment Outlook for Cities (GEO for Cities): the Government of Norway, together with the United Nations Environment Programme Environment Fund and Regular Budget supported this project, while technical assistance was provided by GRID-Arendal and CASEarth. These generous contributions made the production of GEO for Cities possible.

Norwegian Ministry of Climate and Environment

GRID ARENDAL
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Executive Directors’ Foreword

(Forthcoming)

Co-chair's Foreword

The GEO for Cities journey began in May 2019, when the Advisory Committee was convened to discuss how this publication could cover environmental trends; the diversity of cities ; resource constraints and inequality in cities and across the world; visions for transformation; and the potential of cities to be transformative. While we were focused intensely on the future and the next five, 10, 20 and even 50 years – especially in terms of urbanization and cities and environmental impact and sustainability – none of us could have foreseen the turbulence of the immediate future.

Since work started on GEO for Cities, approximately 70 billion tons of carbon dioxide have been emitted into the atmosphere, the world's urban population has grown by 159 million people, 20 million hectares of forests have been lost and 16 million tons of plastic have been dumped into the ocean. We have also seen the global COVID-19 pandemic sweep across the planet, widespread protests for racial justice in cities and towns around the world, people facing job losses, cities grappling with cuts to municipal budgets, devastating forest fires spreading in urban and peri-urban areas in Australia and the western United States, catastrophic flooding in cities in Indonesia, India and Europe, a record hurricane season in the Atlantic and crops and livelihoods destroyed by a locust plague in East Africa.

From the global to the individual level, our world is changing at a rapid pace and we need inspiration and solutions more than ever at this critical juncture. We hope this report rises to these challenge and that its careful consideration of the current situation can catalyse and contribute to action and better outcomes for cities, people, the planet and the environment.

Some of the questions explored here concern the past and present. What are the urban dynamics that have resulted in environmental degradation and inequality? How can we overcome barriers to create a more sustainable future in different types of cities? How are cities affecting fresh water, land, biodiversity, the oceans and air? And how are changes in these dimensions of the environment affecting cities?

Other parts of the report address the future: What are innovative, ground-breaking visions for an environmentally sustainable and just future in cities for both people and nature? What are some of the pathways for transformative actions in cities and where can we find stories of success and hope?

The report covers a wide range of environmental, social and economic issues while providing key starting points to take action and convert transformative visions into reality. Given how diverse cities are, different aspects of the report may resonate in some places more than others. For some cities, the inequality highlighted in chapter 2 and the air pollution issues described in chapter 3 may be the most

pressing issues. Here, the equitability and urban mobility of the second and third dimensions of the vision in chapter 4 may provide the best starting point. In other cities, where the COVID-19 pandemic may be a catalyst, the case study on Cape Town in chapter 5 provides an example of how a severe shock can lead a city to create institutions focused on long-term and inclusive urban resilience.

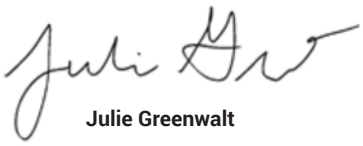
The report addresses different urban stakeholders. For young people, the problems caused by the current political economy and limited job opportunities (chapter 2), combined with acute concerns about climate change and marine plastics pollution (chapter 3) may point to a focus on circular cities and decarbonization (dimension one in chapter 4). Inspiration may be found in case studies on integrated policies for decarbonizing different sectors in Toronto, Canada, and on redesigning material flows in a circular way with social justice and job creation integrated as end goals in Alappuzha, India.

This document has not been produced in isolation, disconnected from other assessments, efforts and initiatives. Instead, it builds on many valuable and insightful reports on cities and climate change and the growth of cities that have come before it. It also acts as a bridge to other GEO reports, including the GEO-6 comprehensive assessment of environmental trends and pathways, GEO for Youth, which is focused on youth engagement and action for tackling environmental crises, and GEO for Business, which highlights the role of business in building a better future for all.

The past two years have affected us all: at the global level, with restrictions on movement and changes in priorities and attention; at the national level, with economic and logistical struggles; and also at the city level, with changes to the urban fabric and rhythms of life. The pandemic has affected us as individuals too, impacting the way we work, causing our personal and professional lives to intersect, requiring us to deal with loss and suffering, and changing our view of what matters most and how we connect with our cities and our environment.

Given these are challenges that we all face, we would like to acknowledge the contributions of and express our gratitude to everyone who has been involved in the GEO for Cities process, particularly the expert authors for their dedication, commitment and willingness to engage; the Advisory Committee for their flexibility and guidance; and the United Nations Environmental Programme Secretariat for steering this ship through the difficult and unpredictable waters of the past two years.

We hope this publication informs and inspires you to discuss, observe, plan and take action for a just and environmentally sustainable future for our cities, people, nature and the planet.



Julie Greenwalt

Diego Martino

Summary for city-level decision makers

It is clear from the analysis provided in this second edition of GEO for Cities that cities have the potential to drive progress towards the 2030 Agenda and its Sustainable Development Goals. To achieve this, cities must be designed or redesigned to use resources in an environmentally sustainable way and become more resilient, inclusive and just places. This potential can be fulfilled by adopting the transformative visions and pathways towards implementation presented in this report, to make cities beacons for others to follow.

Cities are diverse places of exchange, continuously interacting both internally and with other places. It is through these interactions that urban innovation is possible. In this process, cities can significantly transform their own environments and societies while also impacting places beyond their immediate urban environment.

Urbanization continues to increase across the globe, but growth and prosperity are unequally distributed. While megacities remain economically, socially and ecologically important, growth is also accelerating in small and medium-sized cities, especially in developing countries. Inequality within and between cities affects human health and well-being, as well as the environment. The COVID-19 pandemic has exacerbated this inequality.

However, all cities have difficulty managing these interactions and challenges sustainably. They are faced with multiple dimensions of ecological, social and economic dynamics that reinforce unsustainable trajectories. Several factors "lock" cities into an unsustainable status quo, including:

1. the prevalence of the static political economy, often leading to capture of governance systems by vested interests;
2. the dominance of business-as-usual models of urban planning that tend to focus on controlling, taming or exploiting nature; and
3. the complex and multi-level governance systems to which cities belong and within which they operate. These factors vary across cities but have slowed transformational progress to date.

Global environmental challenges are affecting cities. The conditions under which cities have developed and currently function are changing. Global changes (for example, climate change, biodiversity loss and pollution) have direct impacts at the city level. There is an urgent need to consider the implications of these transformations in urban contexts. Global environmental challenges also affect the value of essential city infrastructure and the quality of life of urban residents. Environmental changes in air, fresh water, biodiversity, oceans, coasts and land, even in far-flung but connected places, affect human aspects such as health, equity and food security at the city level.

Cities also impact all three environmental crises: climate change, biodiversity loss and pollution. Urban activities contribute to current environmental degradation, both within and beyond their boundaries. These environmental impacts primarily result from energy and material use in cities (particularly in transport and buildings), increasing consumption patterns, including for food, and the generation and management of waste. Although enough data and information currently exist to allow cities to take important actions, gaps in data quantity and quality could be filled that would help refine urban planning and environmental management at the city level. Urban environment planning and management needs to consider ecological processes and nature-based solutions for all city inhabitants, both human and non-human.

Some cities are using various governance processes to build more environmentally sustainable and equitable futures. These approaches are built on

1. inclusive, publicly engaged decision-making;
2. partnerships and coalition-based governance; and
3. institutionalization for longevity and scaling up. The success of these approaches depends on time- and place-specific factors.

Using these approaches, urban planning and overall city management become important tools for changing the sustainability performance of cities. Urban planning and city management need to consider the complexity, diversity and interconnections within and beyond cities in order to change the current trends and simultaneously achieve multiple Sustainable Development Goals.

GEO for Cities presents a vision of environmentally sustainable and just cities that recognizes the diversity of cities and will help guide these urban transformations. The goals in the vision and the associated dimensions presented in this report are consistent with global conventions and agreements related to development, sustainability, disaster prevention, resilience, reducing biodiversity loss and pollution and addressing climate change. Linked to this future urban vision and its dimensions are transformation pathways tailored to local and regional specificities, priorities and capacities; these are presented in the form of a set of proposed transitional actions associated with each dimension.

Cities must be part of the solution to environmental and climate crises. If it is implemented quickly, the broad, flexible vision for environmentally sustainable and just cities will allow cities to lead the transformation called for in the United Nations Environment Programme's Sixth Global Environmental Outlook (GEO-6) and help avoid irreversible tipping points. This vision is based on strong scientific evidence, case studies, and forward-looking ideas about how changes in policy, practice and behaviour could lead to environmentally sustainable and just cities. With this vision, we identify three main areas of urban action – or urban dimensions – involving

1. low carbon, energy and material efficiency as well as circularity;
2. resilience and sustainability; and

(3) social inclusion and multispecies justice as core areas for advancing sustainability.

Together, these dimensions cut across city and regional land uses and sociotechnical systems alongside biophysical features and ecologies; power relationships, governance systems and institutions; energy, materials and information flows; and cultural practices, social behaviour and multispecies interactions.

Shared understanding, commitment and desire for deep, strategic and substantial urban change to tackle interconnected environmental and development challenges are needed to transform the vision into a reality in cities around the world.

Making progress towards environmentally sustainable, just and inclusive urban transformation requires pathways to build urban circularity, achieve deep decarbonization, design for urban resilience and support social inclusion and justice in cities. Injecting a justice perspective across all these pathways is crucial to ensure that the whole is greater than the sum of its parts.

Designing and implementing pathways towards environmentally sustainable and just outcomes requires simultaneous strategies to overcome the deep-seated lock-ins that prevail in many cities, particularly in relation to their political economy, business-as-usual urban planning approaches and at times exclusionary and technocratic governance models.

While most cities pursuing transformative change are only achieving a fraction of the potential outcomes required to ensure that urban development is headed in the right direction, many such experiences show that the successful restructuring of fundamental processes of governance can eventually achieve and sustain these transformational outcomes in the longer term.

The pathways presented in this report are often complex, and they must be so if they are to solve the interlinked problems of social equity and environmental sustainability. An overarching lesson is that it is unrealistic to expect any one actor to play a transformational role alone. Working together is the key.

To achieve these transformation pathways, several important actions will need to be taken, including:

- **Designing urban infrastructure for more equitable, resilient, and environmentally sustainable living, production and consumption:** Because urban infrastructure is long-lasting, it can 'lock-in' and shape resource needs and service inequities for decades to come.

- **Investing in mechanisms for cross-sectoral and multi-jurisdictional collaboration, governance, and implementation:** Systemic, transformative action requires cross-sectoral integration as well as coordination between jurisdictions both within urban and peri-urban regions and between local, subnational, and national authorities.

- **Seeking equity and justice across all local environmental action and programming:** Equity and justice should not be seen as sectoral considerations to be addressed as an afterthought. They require strategies to shift the multiple structural drivers of inequity that are commonly found in cities. For example, in the case of informality, the everyday activities and livelihoods of ordinary women and men need to be recognized and supported, rather than viewed as a burden.

- **Building reciprocal rural-urban linkages:** A range of flows and interactions between urban and rural areas can serve as entry points to develop interventions with reciprocal benefits. These include the two-way movement of people, capital, information, nutrients, ecosystem services and more.

- **Incorporating insights from data and science into decision-making processes:** Many of the insights needed to guide long-range planning and transformational pathways require specialist expertise that often does not sit within local governments. Expert guidance is often needed, for instance, to gather, process and interpret the data required for material flow analyses, greenhouse gas emissions and biodiversity baselines and resilience assessments, among others.

- **Fostering inter-city exchange and co-learning:** Most cities face a combination of challenges that need to be identified and resolved in line with their own development pathways, instead of implementing strategies that may have been externally prescribed. However, although urban agendas need to be adapted to their own contexts, geographies and histories, there is enormous value in sharing experiences with other cities.

As stated by Maassen and Galvin (2019):

> *"[r]eal world examples of deep urban transformations are hard to come by."*

Fortunately, there is a rich history of progress towards the changes we need. Collectively, we must identify what works and what does not, and come up with ethical principles for locally adapted solutions for transformative action from existing experiences and projected trends. Doing so will allow us to develop a collective knowledge and experience base on how cities, citizens, local authorities and their networks are co-producing pathways towards progressive and forward-looking urban agendas while inspiring others to do the same. The responsibility and opportunity to take on this challenge lies with us all so that everyone can live in the kinds of cities that we deserve.

Chapter 1

Why GEO for Cities, Why Now?

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Coordinating lead authors: Her Worship Maria-Helena Jose Correia Langa (Mayor, Mandlazaki, Mozambique), David Miller (Former Mayor of Toronto, Canada; Director of International Diplomacy, C40 Cities Climate Leadership Group)

Welcome to the second edition of the Global Environment Outlook (GEO) for Cities![1] This analysis of urban and environmental trends, combined with innovative visions and pathways for an environmentally sustainable future, led by cities large and small from around the globe, draws on the analysis of the main report for GEO-6 (UNEP 2019) and was developed using the GEO participatory, expert-led process. With the world still in the grip of the COVID-19 pandemic and many of our biggest and most vibrant cities still affected by this terrible virus, the need for transformational action for a healthy planet, healthy people and healthy cities has never been more critical. The pandemic holds an important message: a healthy planet is essential for our own health. It is time to take stock of our relationship with nature and learn how to build back better and greener,[2] placing nature at the heart of how cities function and thrive in the future.

As present and former mayors of two very different cities – Mandlazaki, a small city in Mozambique and Toronto, a large city in Canada – we want to share how this publication relates to our own experiences in Africa and North America. We see this document as a powerful reference for mayors from cities of all sizes when redesigning cities to support a healthy, safe, and low carbon future for people and nature (Locke *et al.* 2020) and healthy spaces for humans. We also want this publication to guide urban experts in the public and private sectors so that cities continue to make a positive contribution to a world with restored biodiversity, a stable climate and the near-zero waste economies of the future.

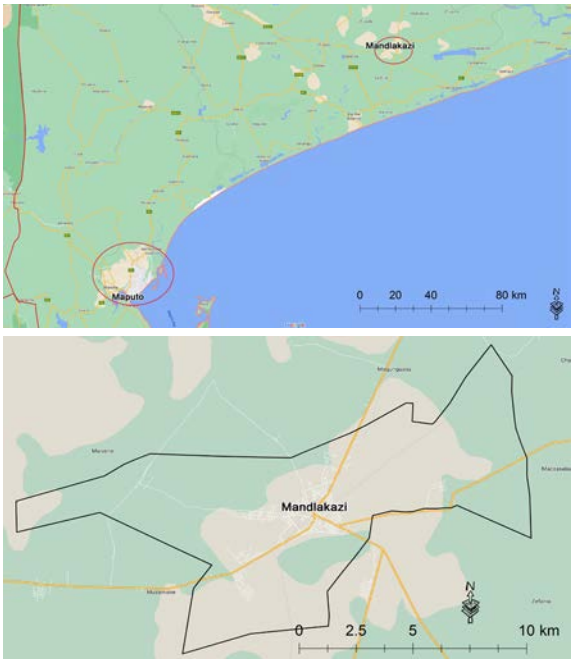
We will use our conversation in this first chapter to set the stage.

David Miller: Maria-Helena, it is a pleasure to work with you on this first chapter to introduce the GEO for Cities publication. I am keen to learn more about your city of Mandlakazi and what you are seeing in Mozambique.

Maria-Helena Jose Correia Langa: Thank you, David. The Municipality of Mandlakazi Village is a vibrant, green city located in the province of Gaza, about 260 km from the capital, Maputo. It covers just under 100 km^2 and has a population of 51,000 people who live in a mixture of urban and peri-urban areas. Just 20 km out of a road network of 240 km is paved. This means that road access in peri-urban neighbourhoods is difficult, reducing the quality of services provided for residents of the municipality.

The issues we face in Mandlakazi are similar to those facing Mozambique as a whole as it undergoes a process of urbanization. We are seeing a surge in informal settlements that are poorly served by basic services, lack adequate housing and suffer from poor mobility and transport systems and a shortage of public spaces. By 2025, Mozambique will

Figure 1.1: Location and boundaries for Mandlakazi, Mozambique



be the fourth most urbanized country in sub-Saharan Africa, with the highest concentration of people living in urban areas. Moreover, about three-quarters of the population work in the informal sector, where they lack job security and labour rights. The situation is further complicated by a severe lack of infrastructure, equipment and services throughout the country: 42 per cent of urban households do not have a water source inside their compounds; 13 per cent do not have a latrine or toilet; 39 per cent share improved sanitary facilities; and 28 per cent do not have a connection to the electricity grid or a connection to their home.

David, how similar is this to your city, Toronto, and North American cities in general?

David: In the last 40 years, Toronto has grown in size and prominence. Today it is the fourth largest city in North America, with a surface area of 630 km^2 and a metropolitan population of about 6.4 million. It is also recognized as one of the most multicultural and cosmopolitan cities around the world.

Despite its larger population and size, Toronto has a high urban density, concentrated property and ageing infrastructure. These challenges increase the city's vulnerability to extreme climate events, which have impacted it over the last decade. Toronto is also located on one of the Great Lakes, Lake Ontario, which makes the city particularly susceptible to flooding and extreme weather. In 2013, there was major city-wide flooding in July and an extreme ice storm in December. Similarly, in 2017, the Toronto Islands were flooded in spring, and a major heatwave hit the city in late summer. The risk we face is that these extreme climate events are becoming more variable, frequent and intense. This is causing Toronto to experience hotter, wetter and wilder weather.

1 GEO-5 for Local Governments can be found at: https://www.unep.org/resources/geo-5-local-government

2 The title of this second edition of GEO for Cities is 'Towards green and just cities'. Throughout this publication the term 'green' is synonymous or the same as 'environmentally sustainable' to ensure better understanding. This helps link the findings of the report to the environmental dimension of the Sustainable Development Goals and the environmental pillar of sustainable development, more broadly.

Figure 1.2: Location and surroundings of Toronto, Canada

This situation is typical of North American cities. Climate change means they are likely to experience more coastal flooding, droughts, intense heat waves, more intense rainfall, higher storm surge levels and hurricane wind speeds.

As in every city in North America, certain groups in Toronto – referred to as "climate vulnerable populations" – are at risk of being more severely affected by extreme climate events, partly due to increasing income inequality. Although Toronto is prosperous and growing, the city is also economically divided: higher-income neighbourhoods are better served with more access to essentials like housing, transit and public services, resulting in less poverty and better health outcomes for residents.

But enough about Toronto. Besides undergoing a process of urbanization both within Mandlakazi and across Mozambique, what are some of the particular challenges you face, Maria-Helena, especially those related to the environment and the climate emergency?

Maria-Helena: The biggest challenges holding the city of Mandlakazi back are budgetary constraints, poverty, infrastructure conditions, poor housing and weak solid waste management. Like many small and medium Mozambican cities, the city suffers from governance issues, including a lack of transparency and accountability.

Due to its geographic location, Mozambique is very exposed to natural hazards and the impacts of climate change, such as floods, cyclones and rising sea levels. However, changing rainfall patterns are also likely to reduce the flow of rivers in Mozambique, in turn leading to a decrease in the availability of surface water and soil water recharge, impacting groundwater resources and the water table of wells.

If the city's population grows in line with forecasts, Mandlakazi will continue to face a range of climate-related challenges over the coming decades. Some of these will undermine its ability to address the impacts of climate change and rapid urbanization. Our challenge will be working with different stakeholders to establish public and public–private partnerships to secure long-term investment with strong returns and public benefits, such as land tenure security, resilient social and critical infrastructure, and improved access to basic services and housing.

But what about the global pandemic, David? How has COVID-19 affected and changed your city?

David: The pandemic has laid bare the stark inequality in North American cities. COVID-19 has brought to the surface the deep vulnerabilities and inequities that exist in our urban ways of life. Across North America, the issues of systemic racism, sexism, inequality and unequal access to basic health care are all driven by the same institutional and economic failures. Moreover, these drivers of social injustice are the same as those behind pandemics and environmental breakdown. They underscore the extent to which we are all connected, dependent on each other and on a safe and healthy planet.

When the pandemic is over, we need to rethink urban design, planning and management and our relationships to urban systems. I am excited that this new GEO for Cities report will show city decision makers how economic stimulus responses to COVID-19 at all levels of government must be focus on green and just solutions and promote sustainable and resilient urban planning, focusing on areas such as upgrading slums, clean energy, energy efficiency and healthier mobility, including mass transit, walking and cycling. Of course, all this can only be achieved if we stop investing public money in fossil fuel technologies and redirect it to renewable energy plans and projects.

I really hope that the innovative action we take now to recover from the COVID-19 crisis will be guided by the long-term goal of building thriving, inclusive and environmentally sustainable communities. Now more than ever, we need to upskill and reskill workforces to promote access to good jobs in the growing green economy and lift up and support city workers to deliver resilient and sustainable public services for all, especially to our most vulnerable. Prioritizing a green and just recovery that is consistent with limiting the average global temperature increase to 1.5°C could create 50 million quality green jobs by 2025, prevent 270,000 premature deaths from poor air quality and save $1.4 billion in health costs from reduced hospital admissions for cardiovascular and respiratory diseases across all C40 cities between 2020 and 2030. Economic stimulus packages and investments must point the way to cities in which all citizens have access to security and opportunity, and they must put health at the heart of urban life.

Tell me, Maria-Helena, how has the global pandemic affected Mandlakazi?

Maria-Helena: The pandemic also aggravated many of the disparities and problems in Mandlakazi. Informal settlements and poverty in Mozambique are a clear indication of the vulnerabilities and inequities stemming from poor housing, water, sanitation and hygiene, including limited access to health services. There are also challenges because of our socioeconomic situation: it is hard to encourage people without jobs and income to follow measures like regular hand washing, social distancing, self-isolating when sick and other recommendations issued by the World Health Organization. As the virus spreads in Mozambique, we will see more people suffering from severe health consequences, not just because of limited access to health care and basic services like water and sanitation but also as a result of being forced to prioritize economic needs over health. We have seen that preparedness and early action by local governments and communities is essential. Once an outbreak occurs, it can escalate rapidly, leaving little room for further planning.

City leaders in Mandlakazi and across sub-Saharan Africa face the challenge of recovering from COVID-19 in parallel with the existing pressures of climate change, resource depletion and continued socioeconomic inequalities. To achieve this, the city has been promoting participatory governance from a gender perspective and has created several tools for participation. These include the Municipal Children's Forum, the Municipal Youth Forum, the Municipal Women's Forum and the Municipal Citizen Forum. Mandlakazi's successful experience in engaging with communities through participatory approaches and gender empowerment is also critical for increasing the resilience of the city and its communities. The systematic efforts in disaster risk reduction and climate change adaptation have been enhanced by community engagement in the planning process. The focus on these two aspects, together with empowering women, is one of the biggest goals when it comes to achieving sustainable development.

What about you David? Tell me about some of the efforts in Toronto and other cities to address climate change and achieve sustainable development?

David: Well, Maria-Helena, during my time as mayor, we set out to cut Toronto's greenhouse gas emissions by 30 per cent by 2020, compared to the 1990 baseline. As a result, this plan, which was introduced in 2007, and the closure of a coal-fired power plant by the Ontario government, we have managed to exceed this target, reducing emissions by 33 per cent below 1990 levels. In 2017, The Toronto City Council declared a climate emergency, unanimously endorsing the TransformTO plan. Building on its predecessor from 2007 (Change is in the AIR), the new plan provides a blueprint for longer term low-carbon goals, including a 65 per cent reduction of greenhouse gas emissions by 2030 and carbon neutrality by 2050 or sooner. The plan aims to simultaneously grow the city's economy and address the links between environmental degradation and growing urban inequality. Mayors across North America are all aware of their responsibility to protect all residents from climate risks, especially people living in vulnerable communities and climate risk zones. Working collaboratively through global and regional city networks such as C40, the Global Covenant of Mayors, United Cities and Local Government, ICLEI Local Governments for Sustainability and the Metropolis global

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network of major cities and metropolitan areas, as well as private-sector partners, mayors have made great progress in fostering equitable, resilient and environmentally sustainable urban pathways. However, mayors and city governments could do even more to achieve their climate ambitions with the active support of national governments and international institutions. This is why cities are calling for more collaboration with regional and national governments to deliver ambitious and transformative climate action plans.

As mayors of very different cities, we hear the resounding message of young activists, urban development scholars and policymakers that we must use the recovery from the global pandemic to forge a new normal and build a better future for all, protecting our planet before it is too late. Not only would a return to the status quo be a monumental failure of imagination, it would continue to embed the inequities laid bare by the pandemic. Moreover, it would lead to more carbon lock-in, loss of biodiversity and greater pollution, resulting in more disastrous crises brought on by the breakdown of nature.

Initiatives, such as local Green New Deals or the launch of the C40 mayors' agenda for a green and just recovery, are showing that environmental degradation and rising inequalities are increasingly approached as intertwined challenges. The twenty-first century requires a new social contract based on a green and just recovery that addresses these issues together and embeds a firm commitment to the preservation of the planet and its people.

1.1 What you will find in this report

This second edition of GEO for Cities is an extension of the main GEO-6 report, presenting and explaining the findings of the United Nations Environmental Programme (UNEP) flagship environmental assessment in a way that helps city decision makers take clear action. Chapter 2 of this report examines how cities function and the challenges and barriers to action they face, as well as some opportunities for catalysing change. Chapter 3 then examines how the environmental challenges of today are affecting cities and how cities are contributing to these environmental issues. Chapter 4 examines the types of future cities that will help address the environmental, economic and social challenges we currently face. City decision makers may see themselves in the dimensions set out in the chapter, alongside areas where their cities could improve. Finally, chapter 5 explores the pathways that need to be followed to reach the vision of "ideal" cities that is presented in chapter 4.

The environmental and urban challenges outlined in this report require urgent and sustained attention from everyone involved in cities. To achieve Sustainable Development Goal (SDG) 11, we must make cities and human settlements inclusive, safe, resilient and environmentally sustainable. UNEP, UN-Habitat, the GEO for Cities Advisory Committee, its co-chairs and the expert authors hope that this report will lead to the urgent action needed for cities to become the beacons of environmental excellence that help their citizens lead productive, prosperous and equitable lives. Enjoy and take action!

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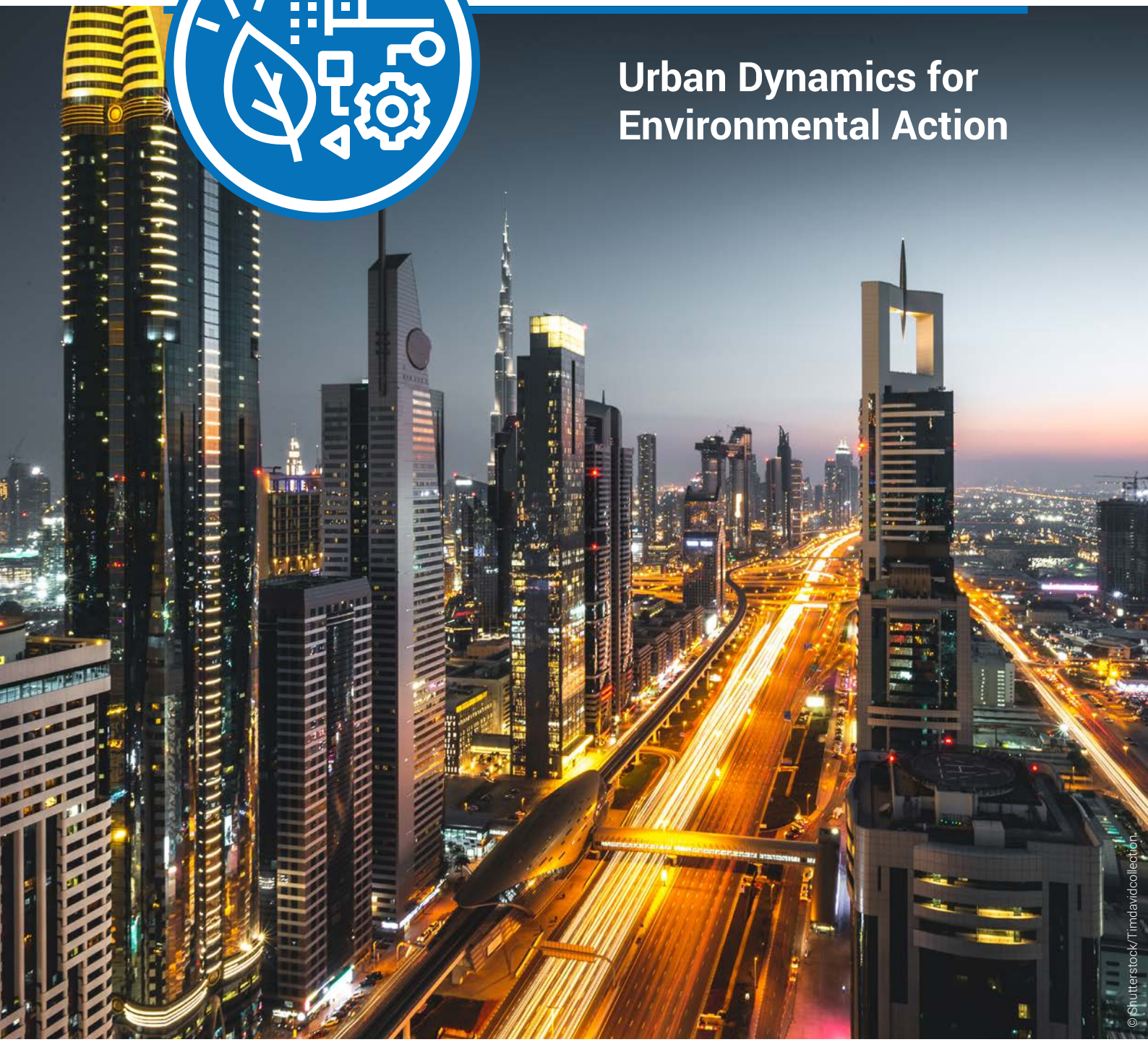
Chapter 2

Urban Dynamics for Environmental Action



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2.1 Introduction

Urban growth and urbanization processes have accelerated globally, especially in the last 45 years (United Nations Population Fund [UNFPA] 2007; United Nations 2019a). This has improved the quality of life of many people. Urban life provides some groups with access to better jobs, better services like drinking water and sanitation, better education, housing and health care, resulting in longer life expectancies (Vardoulakis and Kinney 2019). For others, however, urban life is characterized by the challenges of poverty and inequality, congestion, poor health and feelings of isolation or dislocation. Significant portions of the urban population still struggle to access the basic services required for a dignified human life (Satterthwaite *et al.* 2020) and feel trapped within harsh living conditions. At the same time, urbanization, along with biodiversity loss, ecosystem degradation and pollution, are central drivers of environmental change (United Nations 2019b and see chapter 3). As highlighted in the GEO-6 report, urban inequality and environmental sustainability are deeply intertwined. This report argues, so are their solutions.

This chapter, along with chapter 3, sets out the context through which deep urban transformation objectives and pathways can be understood. It outlines the deeply rooted and persistent challenges of inequality, pollution, environmental degradation, resource depletion and biodiversity loss faced by the majority of cities. All these problems have intensified in recent decades, despite global, national and local efforts to facilitate sustainable urban transitions. Rising to the challenge of necessary urban transformations first requires us to identify and understand these persistent challenges, referred to here as "lock-ins". For the purposes of this chapter this term is defined as ***complex, structural barriers that are deeply rooted in the political economy and the governance web particular to each city and that, combined, contribute to "business-as-usual" urban planning visions and practices***. Effectively, lock-ins refer to sociopolitical and behavioral processes that lead to physical lock-ins of energy use and carbon emissions in built infrastructure and urban form, biodiversity loss, ecosystem degradation and pollution. This interconnected set of lock-ins is ultimately slowing down the pace of urban transformation.

This account of the systemic failures to deliver transformation – or at the very least to slow the pace of change in most cities (section 2.3) – is developed after a description of larger global urbanization trends (section 2.2). These trends include the diversity of cities and urban areas in terms of population, size, urbanization, their relationship to the environment and ecosystems, and their varying capacities to respond to the growing and interconnected challenges of urbanization in the twenty-first century. In particular, many of the rapidly urbanizing cities of the Global South are poorly equipped to deal with these challenges. They are also the most affected by deepening inequality, the impacts of climate change and environmental degradation. Most cities are currently on unsustainable trajectories. This contributes to multiple dimensions of ecological, social and economic damage, although this can take different forms, with different impacts and in ways that are yet to be fully grasped.

Finally, the chapter explores ways in which a growing number of cities are already experimenting with transformative actions to overcome intersecting socio-political, behavioural and physical lock-ins, positioning them as drivers of environmentally sustainable, low-carbon, resilient, healthy and inclusive futures (section 2.4). This section shows that disruption to "business as usual" can occur on different scales, can come from multiple sources and agents, and is often pioneered by singular, even small catalytic actions, as is explained in more detail in chapter 5. However, for the large-scale systemic change that is urgently called for and described in chapter 4 to happen, local authorities and urban communities will need support and must share risks beyond their boundaries. Setting and maintaining cities on transformative pathways will mean reinforcing networks of learning and support, from the level of key communities all the way to national governments.

2.2 The state of cities

There is great diversity within and between cities. Cultures, economies, environments, infrastructure and histories are in many ways unique to each urban setting. There are also key linkages between cities and ecosystems that have placed many cities on a shared trajectory of urban environmental and socioeconomic unsustainability. The relationship between cities and the environment works in both directions: on the one hand, cities, their people and their infrastructure affect natural environments within, around and outside their boundaries; on the other, cities are vulnerable to environmental degradation. This two-sided relationship between cities and the environment is analysed in the following chapter (chapter 3). This chapter focuses on the human systems and built environments that shape cities and serve as potential entry points for transforming them in ways that prioritize justice and environmental sustainability.

2.2.1 Rapid but varied urban growth

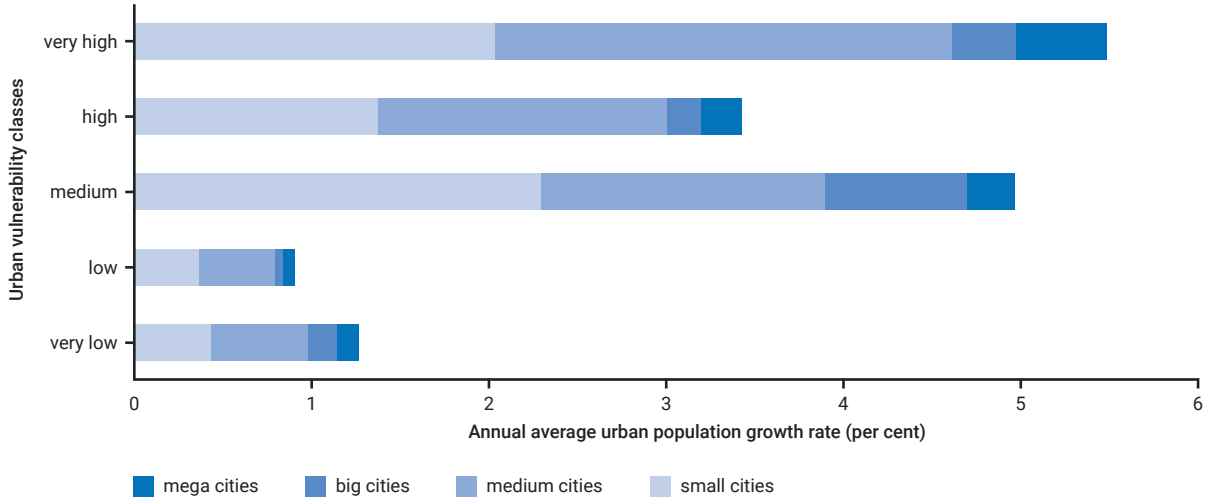
The period between 1975 and 2015 saw tremendous growth in global urban population: the global rural population increased by 488 million, while the global urban population grew by almost 2.4 billion. This meant that the urban share of the world's population grew from 38 per cent to 54 per cent. By 2050, this urban share is forecast to reach nearly 70 per cent (United Nations 2019b).[1] The staggering pace of global urban population growth over the past decades is now well understood. However, there are sharp regional variations within these broad trends and future projections. Many parts of Europe and North America are already almost fully urbanized. Going forward, 90 per cent of urban growth is expected to take place in low-income and middle-income countries (United Nations Environment Programme [UNEP] 2019a), with more than half of the growth (approximately two billion people) expected to take place in Africa. Asia's urban population is expected to grow by 650 million and Latin America's by 180 million. In contrast, Europe's population is expected to decline over the next 30 years (United Nations 2019a).

1 Global urban share of total population is nationally defined and often includes suburban and exurban areas (low-density, segregated, car-centric) that form part of a statistical metropolitan area.

The geographic shift that has accompanied this "second wave of urbanization" (UNFPA 2007) arguably puts the cities of Asia and Africa at the heart of the sustainability agenda for the coming decades (Simone and Pieterse 2017). Given the infrastructure deficits and limited fiscal base of local authorities in many of these settings, rapid urbanization is likely to create more "slum urbanism", with city governments and housing markets unable to keep pace with rapid growth (Pieterse 2014; United Nations Human Settlements Programme [UN-Habitat] 2016, p. 37). In cities where urban growth far outpaces economic growth, governments and other urban stakeholders struggle to respond to socioeconomic stress, let alone multiple environmental crises.

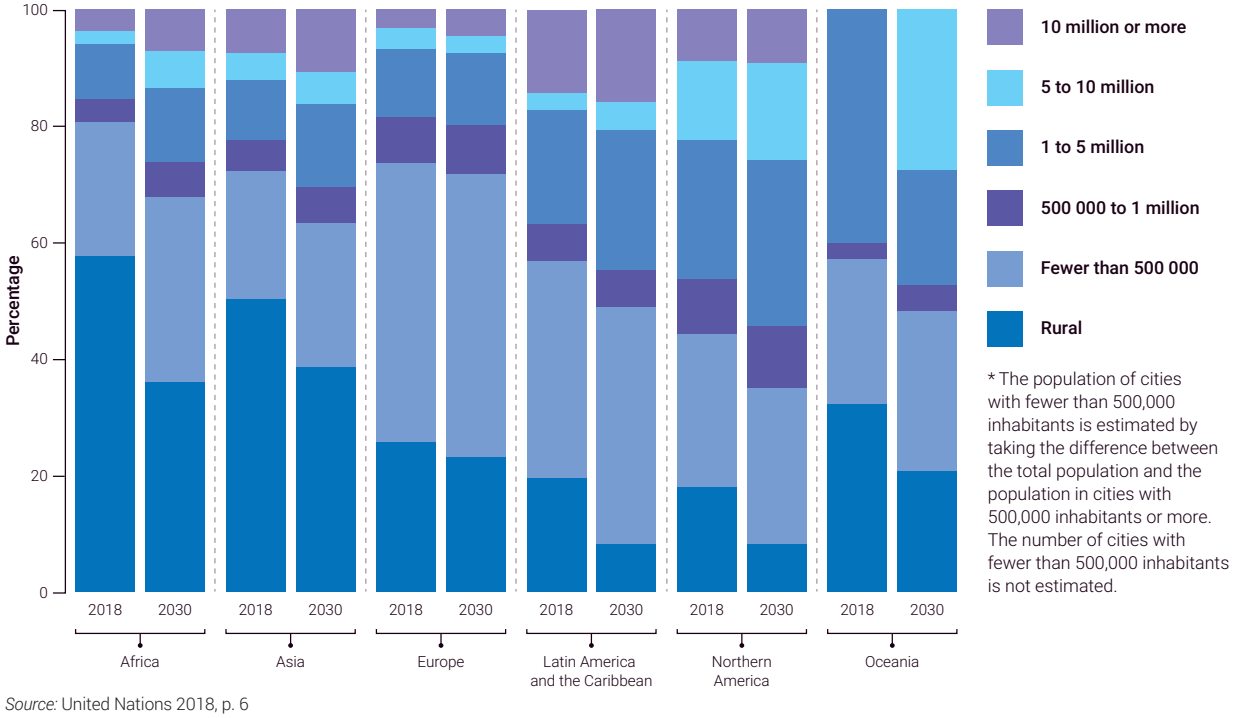
Beyond these regional differences, this second wave of urbanization is also characterised by the growing importance of medium-sized cities and peri-urban areas. While megacities often receive more political and media attention, small and medium-sized cities are among the fastest growing urban areas (**Figure 2.1**), albeit with variations between regions (**Figure 2.2**). By 2025, population gains in small and medium-sized cities in emerging-market countries will outpace the combined increase from developed economies and emerging-market megacities (McKinsey Global Institute 2011). In rapidly urbanizing contexts, small and medium-sized cities often capture growth from rural-to-urban migration (UN-Habitat 2015a). However, future trends show that these cities tend to be

Figure 2.1: City growth rates



Source: UNEP 2019a, p. 32

Figure 2.2: Population distribution by size and class of settlement and region, 2018 and 2030



* The population of cities with fewer than 500,000 inhabitants is estimated by taking the difference between the total population and the population in cities with 500,000 inhabitants or more. The number of cities with fewer than 500,000 inhabitants is not estimated.

Source: United Nations 2018, p. 6

more vulnerable to natural hazards and climate change than large cities and megacities (Birkmann *et al.* 2016) and tend to have a lower capacity for recovery (UNEP 2019a).

Size, however, is not the only measure of the diversity of cities and the processes by which they change. For instance, the growth of sprawling suburban and peri-urban regions – a significant trend spanning several decades in both higher-income and lower-income countries (UN-Habitat 2016) – can be linked to multiple processes, including:

- evolving rural–urban linkages;
- land markets;
- the absence of a regulatory environment for development;
- lifestyle preferences.

Such factors are locally specific and connected to both long-term urban growth dynamics and its environmental consequences.

Population density is another key feature of urbanization, with environmental implications. In 75 per cent of countries, both the urban population and the spatial extent of the built environment have grown. In others, however, urban population growth and built environment growth are decoupled (Pesaresi 2016). In regions like Europe, built-up areas have doubled, while the population has remained stable (Pesaresi 2016, p. 6). In 2015, 65 per cent of the global built environment was concentrated in high-income countries, around 30 per cent in middle-income countries, and just 6 per cent in low-income countries (Pesaresi 2016, p. 35). This is in stark contrast to the distribution of global urban population changes. Meanwhile, the increase in high-rise developments on the outskirts of cities in China, India, Turkey and Brazil means suburbanization is no longer characterized by low population densities. Moreover, the spatial configurations and lifestyles of the suburbs are developing independently of city centres (Keil 2018).

While these trends vary, the net effect is that cities with a higher population density tend to have lower per capita environmental impact within the city's boundaries.

The COVID-19 pandemic is likely to influence these trends, albeit in ways that are yet to be understood. The pandemic may accelerate the expansion of suburban and peri-urban patterns of urbanization in some regions, as remote working makes residential settlements more independent from workplaces in urban cores (Sharifi and Khavarian-Garmsir 2020). This has a potential impact on biodiversity loss (Rastandeh and Jarchow 2020; Connolly, Ali and Keil 2020). However, the pandemic may also do little to diminish the attractiveness of city centres in the long term (Price Waterhouse Coopers 2020). Regardless of the outcome, the pandemic is generating new conversations and prompting us to reassess many of our assumptions about the dynamic relationship between cities and environmental sustainability.

2.2.2 Escalating inequality and implications for the environment

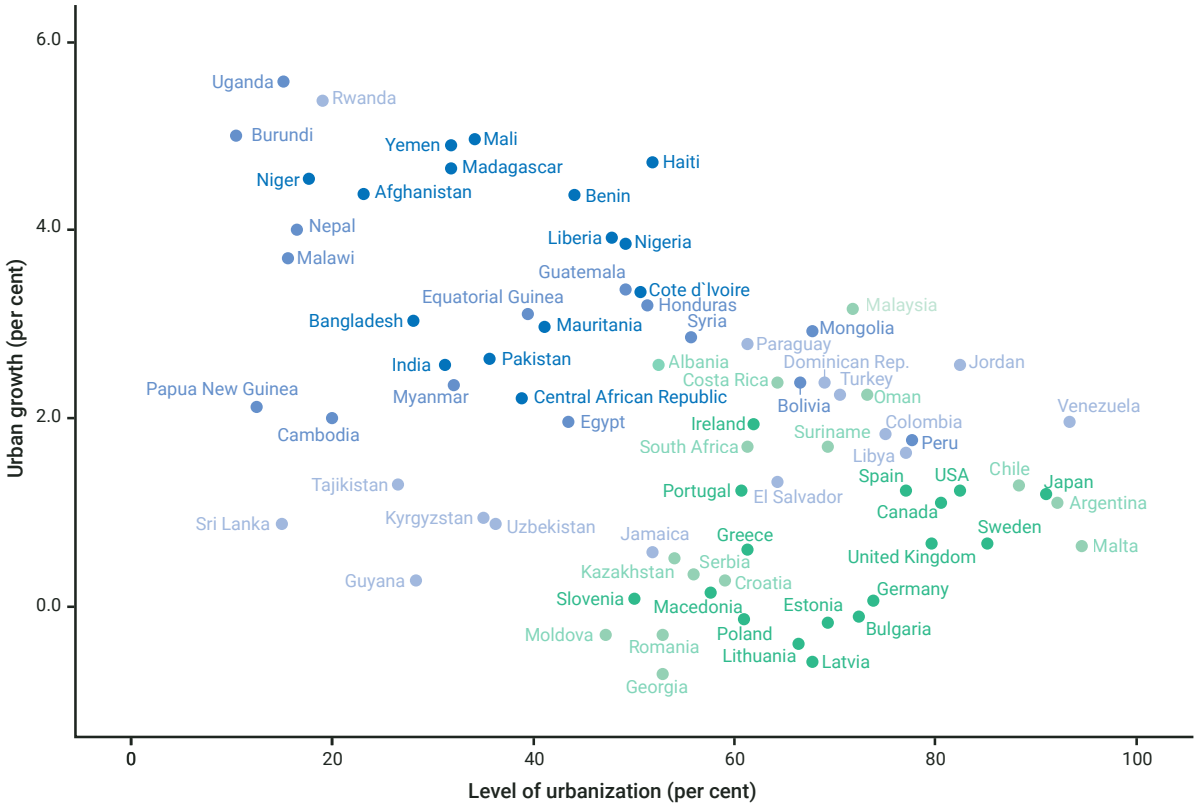
While there is no single urban growth projection or dominant urbanization pattern, across the world there is a consistent pattern of growing inequality, both within and between cities. In many places, the pandemic has shone a spotlight on these inequalities. For two-thirds of people who live in cities, income inequality increased between 1980 and 2010 (UN-Habitat 2015b). This social inequality is reflected spatially: many cities have neighbourhoods with contrasting infrastructure, services and amenities (Graham and Marvin 2001; International Resource Panel [IRP] 2018). Urban inequality operates through multiple and intersecting factors such as race, class, gender, ethnicity and caste. It is reflected in highly unequal access to opportunities, such as education, jobs and material goods, including housing, city services and infrastructure.

Inequality also contributes to environmental degradation within cities and beyond, affecting the potential or success rate of environmentally sustainable responses to urbanization (see also chapter 3). GEO-6 notes that the current unsustainable pattern of urban growth is "the result of population growth happening with the current consumption and production patterns", where "unsustainable consumption and production are each largely fuelled by heightened inequality" (UNEP 2019a). Inequality within and between cities remains one of the highest barriers to achieving environmental sustainability globally (Chancel and Piketty 2015; Oxfam 2015; UNEP 2019a) and is a key concern of the global Sustainable Development Goals (SDGs) (United Nations 2020a) and the New Urban Agenda (United Nations 2017).

The consequences of inequality are particularly obvious in regions that are at high risk of natural hazards like earthquakes and cyclones and the impacts of climate change, such as rising sea levels and increasing severity of flooding and droughts. These risks, alongside the capacities for mitigating or adapting to them, are not equally distributed across cities. For example, half a million people living below sea level in both Lagos and Dhaka are extremely vulnerable to rising sea levels and flooding (Martino *et al.* 2016, p. 65). In contrast, the city of New York is financing a seawall to protect the affluent district of Manhattan. These contrasting situations illustrate a broader trend whereby the cities of the Global North, which have contributed the most to climate change and biodiversity loss (through historical and ongoing energy use and consumption patterns), are often able to buffer themselves from some of the consequences. Meanwhile, the wide range of cities in the Global South often bear the brunt of climate change impacts and have disproportionately fewer resources to adapt and transform (Intergovernmental Panel on Climate Change [IPCC] 2018; African Development Bank, UNEP and United Nations Economic Commission for Africa [UNECA] 2019; UNEP 2019a) (**Figure 2.3**).

The burden of adapting to climate change is also shared unequally within cities. In some cases, affluent households have been able to retreat and relocate from at-risk coastal areas, often taking with them valuable tax revenue, which is needed to finance adaptation to a changing climate. In contrast, poorer communities are

Figure 2.3: Where rapid growth faces vulnerability



Classes of urban vulnerability	Level of urbanization	Growth rate 2000-2015
Very low	75.80	0.71
Low	69.19	0.92
Medium	56.07	2.36
High	43.51	2.89
Very high	38.59	3.71

Source: UNEP 2019a, p. 34

disproportionately vulnerable to and affected by climate change and less able to relocate away from these areas (Satterthwaite *et al.* 2020).

Urban inequality is also becoming further entrenched through climate change mitigation activities, both in urban cores and peri-urban areas. For instance, emerging "green enclaves", such as Masdar in Abu Dhabi, and upmarket green suburban estates that promote low-carbon urban living, often experiment with sustainability innovations such as ecosystem service schemes. However, they often do so without considering the affordability of housing, reinforcing existing inequalities. Similarly, improvements to local air quality and the installation of energy-efficient housing in certain neighbourhoods can have a perverse effect on urban wealth divisions as they can lead to increases in real estate prices. This is what some researchers have called "green gentrification" or the growing phenomenon by which environmental projects are contributing to the displacement of low-income – and often racialized – communities (Checker 2011; Gould and Lewis 2017).

A policy focus on pro-environmental behaviour and building design can help limit the environmental impacts of affluent lifestyles. When consumption patterns are included in greenhouse gas emissions accounting, affluent citizens contribute most to the climate crisis (Kartha *et al.* 2020). In Germany, for example, household income is a better predictor of carbon footprint than environmental awareness and behaviour (Moser and Kleinhückelkotten 2017). In wealthy urban communities, the many sustainability and climate change benefits derived from higher densities can be undermined by high levels of consumption (Meirelles *et al.* 2021; Paravantis *et al.* 2021). Greenhouse gas accounting methods that include both direct and indirect sources of urban emissions can help policymakers design solutions that deliver the greatest reductions, but new approaches and significant behavioural changes will ultimately be required to decouple economic growth and greenhouse-gas-intensive consumption in cities (Meirelles *et al.* 2021).

In light of these findings, organized groups, activists and academics are calling for the integration of a housing justice and global rights agenda into urban climate action plans (Rice *et al.* 2019; Office of the United Nations High Commissioner for Human Rights 2000; Habitat International Coalition 2021) (Global Platform for the Right to the City 2021). When inequality and climate change are inextricably linked, their solutions must also go hand in hand. Coordinated local, subnational and national policies are needed to address structural drivers of greenhouse gas emissions and the intersecting environmental crises. In turn, addressing urban inequalities presents a key opportunity for environmental sustainability. While business-as-usual urbanization disconnects ecosystem functions from urban structure, equitable cities can be engines for rapid positive change and have the potential to provide access to education, income, information, health care and culture, all of which can greatly advance environmental and most other sustainable development goals (IRP 2018). Reducing inequality can also help reduce consumption levels (Samaniego *et al.* 2014; Shin, Lees and López-Morales 2015).

Equitable and environmentally sustainable cities can generate resource efficiencies, promote ecosystem restoration, curb biodiversity loss and promote sustainable resource use, due to their population concentration and economic potential. Yet, we continue to build and govern cities in ways that perpetuate inequalities without properly considering the impact this has on finite planetary resources and the healthy ecosystems on which they depend (IRP 2018). In the following section, we examine some of the key forces that lock cities into environmentally unsustainable and unequal urbanization trajectories.

2.3 Unpacking city "lock-ins"

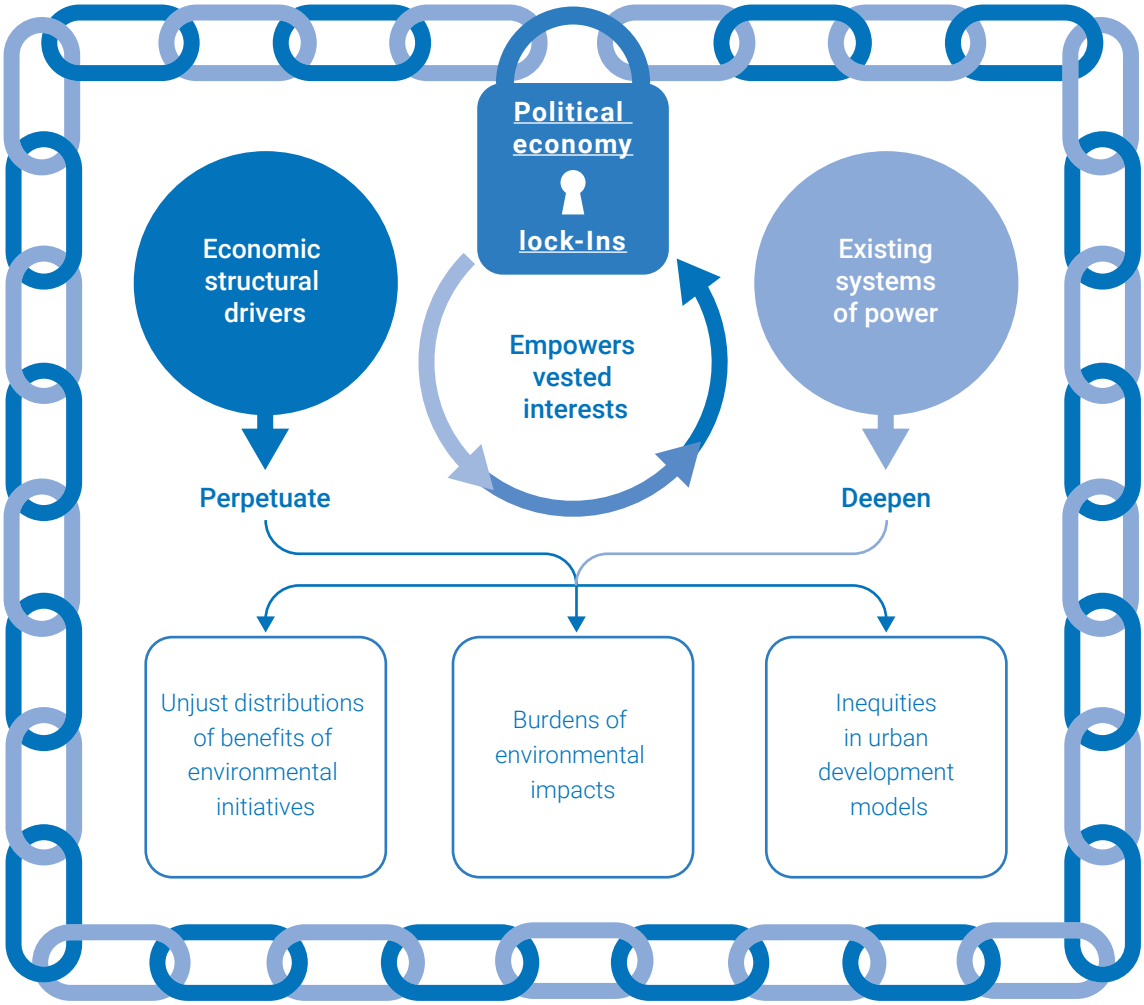
Despite increasing scientific evidence on the economic costs of inaction on the environment (IPCC 2014; IRP 2018; ADB, UNEP and UNECA 2019), the majority of cities and urban areas appear stuck on unsustainable "business-as-usual" models, defined by interconnected and deepening environmental and social crises. Notwithstanding the difficulties inherent to steering cities towards the net-zero, resilient, inclusive and just pathways outlined in chapters 4 and 5 of this report, this section analyses some of the key processes that hinder change or cause further deterioration. It does so by examining three key aspects of this problem, namely: the structural drivers or the political economy of cities that underpin unequal and environmentally unsustainable development practices; the dominance of business-as-usual urban planning visions and practices, including infrastructure systems; and the multiple governance webs within which cities operate. Together, they constitute city "lock-ins".

2.3.1 The political economy of cities

The business-as-usual models discussed above are underpinned by a series of structural drivers that tend to lock cities and urban areas into environmentally unsustainable urban forms and development patterns. These lock-in processes broadly fall into two areas: economic structural drivers, and existing systems of power that cut across gender, race, ethnicity, age, sexuality, migration status and other markers of difference. In different cities, these markers of difference intersect with vested interests to reproduce inequalities (Levy *et al.* 2017; Sultana 2020). As described below, both dimensions work together to perpetuate urban systems that maintain unjust distributions of the benefits of environmental initiatives and the burdens of environmental impacts, while deepening extractive urban development models (Agyeman, Bullard and Evans 2003).

A majority of cities and urban areas remain locked into pathways defined by resource-intensive development models, with little consideration given to natural resource constraints or environmental protection and vital, yet fragile, ecosystems (UNEP 2019a). Whether dominated by the service sector, manufacturing or raw material extraction, these development models tend to rely on continually boosting local and international production and consumption of individual and collective goods. These models are a far cry from the nature-positive and zero-

Figure 2.4: Effects of political economy lock-ins



carbon aspirations described in chapter 4. Crucially, this general trend applies as much to informal economies as it does to the "recorded" or formal economy, which means it affects the broad economic base that underpins most cities. Examples ranging from just-in-time production processes in the fashion industry, to the dependence of technology firms on essential – and often rare – minerals, illustrate the strong interdependence between urban and peri-urban informal economies and the global economic processes and financial drivers at work in international value chains (Kelly 2019; Chen and Carré eds. 2020).

People living in and managing cities are not solely responsible for perpetuating these environmentally unsustainable economic models. In fact, the transformational work of actors at the city level is often hindered by economic processes at national and international levels that measure success in terms of gross domestic product (Shehabi 2020) and are bound up with the resource-extractive logic of global trade and the imperative of shareholder profit (Kavanagh and Veldman 2020). The growing allure of urban land for global capital flows also means that many cities feel trapped in "there is no alternative" growth scenarios. Changing these conceptions and practices to fully include the notions of finite planetary resources, and cities and urban areas as common goods, is therefore a multi-actor, multi-scale, endeavour that goes beyond the sole remit of city actors. However, many cities and city-based actors play an active role in such processes. They proactively participate in global economic competition and adopt or maintain approaches based on the intensive use of resources, entrepreneurship and real estate development that contribute to the increasing commodification of urban life (Shin, Lees and López-Morales 2015; Shatkin 2017). Such approaches contrast with long-standing evidence of their environmental costs (Revi *et al.* 2014; UNEP 2019a) and their impact on deepening social, infrastructure and spatial divides in urban settings (Sassen 1991; Graham and Marvin 2001).

Structural drivers of environmentally unsustainable urbanization also affect the many cities that play a smaller role in the global economy. These include cities bypassed by evolving global demand, such as the rust-belt cities of Europe and North America, small and medium-sized cities in parts of Latin America, Africa, the Middle East and Asia, and cities like Havana that are purposefully excluded for geopolitical reasons. Cities and urban areas on the margins of global economic networks face major barriers to just transformations. These are often rooted in weak or even

eroding economic and tax bases, in addition to limited resources and capacity to address deep inequalities, chronic poverty and inadequate infrastructure, let alone unforeseen impacts such as extreme weather events and the COVID-19 pandemic. In these contexts, broadening the base of the economy while simultaneously protecting and rebuilding vulnerable ecosystem services and natural resources and habitats presents a major challenge (Pieterse 2011; Swilling and Annecke 2012).

Environmentally unsustainable economic drivers are compounded by the power relationships that vary by local context but tend to reinforce inequalities within cities. Despite often being the product of long-standing historical relationships, such power structures often still shape the access to, and control over, resources of urban communities. This is true of material resources such as land and housing, as well as intangible resources such as "the right to the city", livelihood opportunities or education. Crucially, these embedded power structures are a key determinant of the ability to participate in, and influence fundamental decision-making processes pertaining to a just distribution of goods, services and opportunities in urban areas (Agyeman, Bullard and Evans 2003; Levy *et al.* 2017). The exclusion of large segments of urban populations from these decision-making platforms can shape the contours and possibilities for change and represents a major lock-in that helps maintain the status quo.

The COVID-19 pandemic has highlighted on many of these deeply rooted conditions of urban inequality. All across the globe, ethnic minority groups, indigenous populations, women, the elderly, young people, the homeless and the unemployed, as well as informal workers have suffered disproportionately from its effects. The same inequality is reinforced by policy responses such as 'social distancing' and 'work from home' requirements. (Aldridge *et al.* 2020; United Nations 2020; United Nations Entity for Gender Equality and the Empowerment of Women [UN-Women] 2020; Women in Informal Employment: Globalizing and Organizing 2020; Turok and Visagie 2021). Commentators have been quick to point out how these disproportionate effects are linked to pre-existing inequalities when it comes to housing, access to services (including water, sanitation and health), job types and exposure to pollution. These factors are all material manifestations of unequal social relations in cities. Strikingly, they are the very same markers of vulnerability to "everyday" disaster risks, whose extent and ramifications are being amplified by the effects of climate change, biodiversity loss and pollution (Bull-Kamanga *et al.* 2003; Satterthwaite and Bartlett 2017; Bahn *et al.* 2020; see also chapter 3).

However, the response to the pandemic has yet to take into account these inequalities. In particular, calls to "build back better" have not seen calls from organized community groups to "building back fairer" (Pérez and Mannan 2020), a call that is closely related to racial justice and equity in many parts of the world. From past experience, existing power structures have proven particularly resistant to change, and have the support of many social institutions, such as education systems. The media, social media and significant parts of cultural life (pop culture, film and television) have often sustained unequal and unsustainable urban systems through the promotion of highly consumerist aspirations and general adherence to the status quo. In the political sphere, recent populist movements across the globe seem to be reinforcing long-standing policy paradigms and, in many places, indigenous populations and environmental protectors are seeing their very existence challenged (Greenfield and Watts 2020). The parallel rise of small but vocal "radical" movements in favour of climate action – in some cases articulating a link to major agendas for socioeconomic transformation – appear to support different visions of shared urban futures. However, it is still too early to assess their long-term impact on shifting the political economy within cities.

In the meantime, the deeply rooted structural forces outlined above manifest in urban planning visions and practices that tend to perpetuate business-as-usual practices and behaviours that operate, consciously or unconsciously, in the interests of certain well connected urban and global actors, at the expense of environmentally sustainable urban approaches.

2.3.2 Business-as-usual visions and practices in urban planning

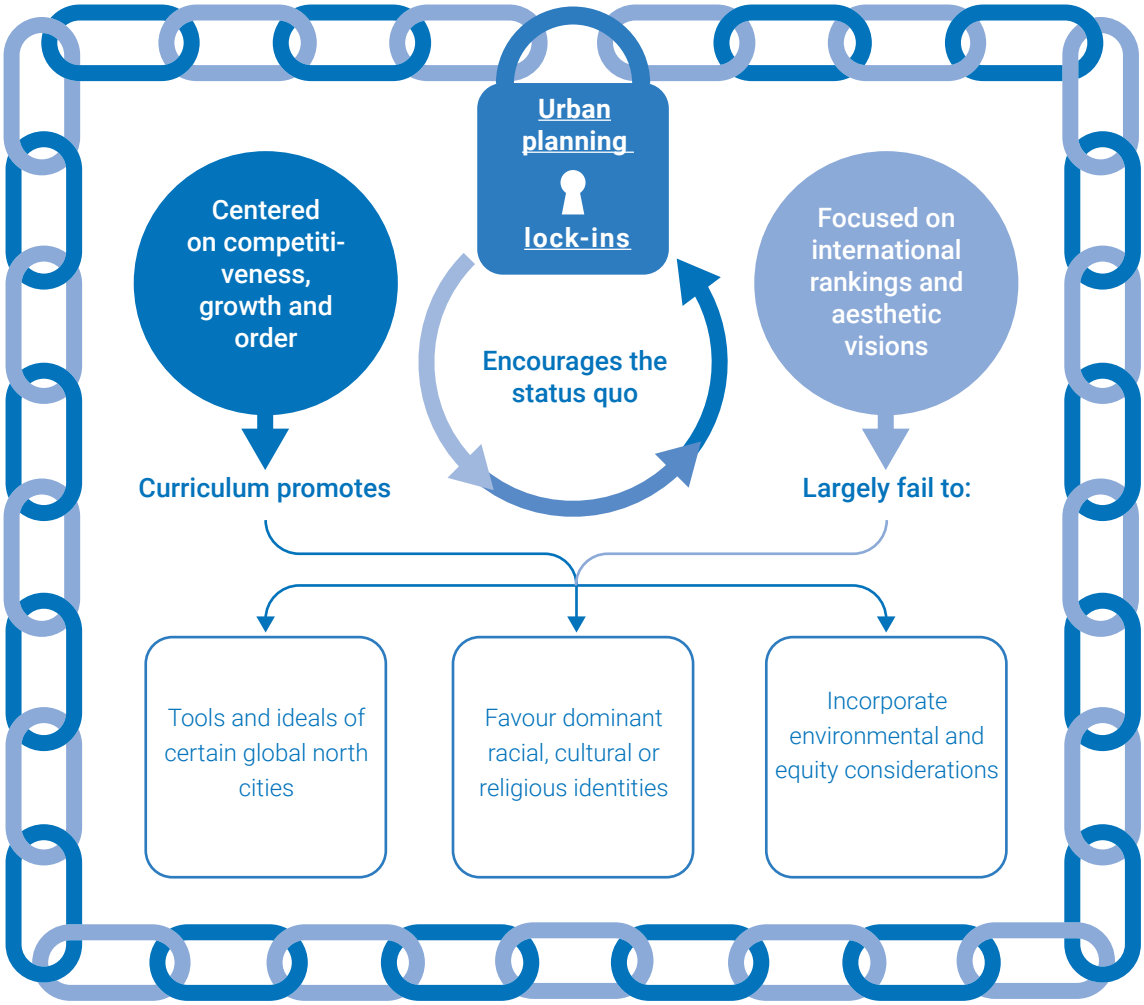
Addressing the deep-seated social and environmental challenges and tensions linked to urbanization requires considering the interconnected nature of the built form, culture, ecosystems, and natural habitats of cities (Chimhowua, Hulmeb and Munroc 2019; United Nations Economic and Social Commission for Asia and the Pacific [UNESCAP] 2019). In practice, however, urban planning priorities are influenced by complex and conflicting trade-offs. In such instances, the political economy of cities, combined with inertia, often act as barriers to planning's transformative potential.

Urban planning visions

Moving cities towards resilient, socially just, zero-carbon and nature-positive pathways partly relies on visions of urban futures that put environmental and socio-economic sustainability at their core. Yet the process that enables the shift from mainstream urban planning visions to those outlined in chapter 4 remains elusive in practice.

Many cities of the twenty-first century are produced and reproduced through urban visions centred on competitiveness, growth and order as key aspirations. Only passing reference is made to environmental sustainability and equity considerations. The imagery of "global" and "world-class" cities, in particular, still drives many cities worldwide, encouraged by international rankings and the aesthetic skylines of cities like Dubai and Singapore (Roy and Ong 2011). Similarly, modernist city visions remain widespread, even though they are often very different from urban realities, where large numbers of inhabitants live, work and access urban services through informal or self-help processes (Watson 2014). In other contexts, urban planning visions based on ideas of maintaining order are invoked to favour dominant racial, cultural or religious identities under the guise

Figure 2.5: Effects of urban planning lock-ins



of the public interest. This is especially the case in ethnically divided or post-war cities, where these visions can result in the creation of "ethnocratic" regimes (Yiftachel 2009).

While business-as-usual visions can and have been amended to include environmental sustainability principles, this piecemeal approach is usually insufficient and is often detrimental to ecosystems. One example is the inclusion of sustainability concepts, to boost competitive visions through "smart" transport solutions, such as the promotion of electric cars. These "adjustments" may help decrease air pollution in cities, however, the continuing promotion of car ownership and use in cities fails to address congestion and perpetuates inequity, safety issues and inefficiency. In contrast, a transport planning vision based on the universal provision of high quality public transport, which prioritises safe and reliable accessibility for low-income settlements, and disincentivizes private car use, offers the kind of planning shifts capable of disrupting the "high-consumption" cultures of many cities (see chapter 4).

Failure to imagine more transformative visions of equitable and environmentally sustainable cities, exposes many inhabitants to the darker side of the "world-class-eco city" aesthetic, a 'sustainability-adjusted vision which often exacerbates existing social and spatial inequalities. For example, based on several case studies in boroughs of New York, Gould and Lewis (2017) demonstrate how urban greening initiatives, justified in terms of promoting environmental sustainability, have often lead to the displacement of marginalised groups and individuals, deepening social and environmental inequality in the city through a process referred to as "green gentrification". Greening, without taking into account social resistance movements and without insisting on policies that promote equity, surrenders consideration of social justice (for example, the right to housing) to market forces (Checker 2011; Gould and Lewis 2017).

The persistence of city visions based on maintaining order, growth or competitiveness result from a variety of processes. These include the dominance of urban planning curricula that have largely failed to consider citizen priorities and the worsening ecological, social, and economic crises. Most planning curricula continue to promote tools and ideals that rely on the experiences of certain cities perceived to be successful, still largely located in the Global North (Porter 2010; Sudaresan 2019). But a key factor is the adoption and support of such visions by well-connected urban and global actors, with a strong

preference for the status quo (or only slight variations of it). This typically translates into unsustainable planning practices and urban forms.

Unpacking planning practices

The tools and processes used by planners to design, demarcate and develop cities have significant potential to help move cities on to more just and environmentally sustainable pathways. However, at present, the political-economy of most cities tends to position planning as a barrier to transformation, with the planners' toolkit largely promoting business-as-usual urban visions. Three areas of practice are particularly worth unpacking as critical for unlocking the potential of cities and catalysing transformative change: the management and expansion of urban land; broadening the scope of infrastructure decisions; and addressing economic development as part of planning practices.

Urban land management

Land use regulation and management are critical tools in delivering on transformational objectives, such as the net zero circular, resilient, inclusive and just city dimensions described in chapter 4. In particular, there is an important potential in redefining the use of urban public land for achieving social equity and environmental sustainability goals (see chapter 5). Similarly, the spatial planning tool of land-use zoning, used by cities to manage the distribution of land and resources, has great potential to help protect natural ecosystems and improve the quality of life of urban residents. Yet, in many contexts, zoning regulations are embedded in complex histories that may include colonial, racial, ethnic or communally segregated pasts (Zenoua and Boccard 2000; Porter 2010; Agyeman 2020) and, as a result, they tend to deepen patterns of social, spatial and environmental injustices. In the United States, for instance, ongoing systemic underinvestment in some racially segregated neighbourhoods is directly related to the "redlining" practices of the 1930s that excluded certain communities in certain locations from inward investment and financial markets (Rothstein 2017). Over time, this process led to neighbourhood decline and, in some cases, abandonment. To this day, residents of formerly redlined neighbourhoods suffer from higher heat exposure, leading to the long-term health and social effects of this racialized zoning practice (Wilson 2020). In other locations, the absence of official zoning is used by city governments to create "grey spaces" (or zones of questionable legality) to the advantage of dominant social or higher-income groups, often at the expense of poorer or socially marginalized urban dwellers (Yiftachel 2009).

The darker side of zoning can also be visible in the planning and management of peri-urban areas of growing cities. Here, struggling to balance urban development pressures with environmental protection goals, planners often use zoning mechanisms to regulate rapid, often informal, growth patterns. Frequently taking the form of "green zones" or "eco-corridors" (as for example, in Lima, Peru), these exclusionary zoning instruments, typically designed to confine informal settlements to specific peri-urban areas, can be used to restrict access to urban services and reinforce the sense of impermanence and transience for these informal settlements (Allen 2014). Despite their branding as environmental protection mechanisms "in the public interest", many such instances of land-use regulation leave the peri-urban poor vulnerable to displacement and restrict their ability to act as active agents of environmentally sustainable and just approaches to city-building.

Infrastructure choices

Deciding which services and resources will be accessed by whom is critical to put cities on just and transformative pathways (see chapters 4 and 5). Infrastructure planning is influenced by many pressures and inputs, some of which are contradictory. Affordability, environmental sustainability, accessibility, distribution, risk and resilience must all be factored into decisions. In practice, however, the balance of these often ends up reproducing top-down, technocratic solutions, or solutions that only reflect the aspirations and worldviews of dominant urban actors. The result is continuing asymmetrical or fragmented urbanism (Graham and Marvin 2001). In extreme cases, this is reflected in enclaves with easy access to infrastructure and services rubbing shoulders with areas of extreme deprivation. This broad statement holds true for basic infrastructure such as water, waste and sanitation (Allen 2014; Björkman 2015), as it does for mass-transit networks (see section 2.2 for a discussion of differences within cities).

Admittedly, designing an infrastructure investment programme that addresses equity at the same time as taking into account environmental sustainability considerations is not easy. Research on the equity and inclusion indicators for bus rapid transit systems in cities, such as Bogotá, Lima, Mexico City, Ahmedabad, Johannesburg and Istanbul, has found that these sustainable mobility alternatives have a significant impact on environmental and economic (affordability) indicators but often struggle to improve access in the poorest neighbourhoods (Venter *et al.* 2018). This may be because the initial implementation phases of overall networks have limited spatial coverage (often focused on high-traffic corridors) or because of higher costs associated with travel distances that may exclude poor commuters in peri-urban areas (Venter *et al.* 2018).

That said, climate-related grey infrastructure can act as a barrier to just transformations. As highlighted by the example of Mandlakazi, Mozambique (chapter 1), in many cities of the Global South, poor communities often live in areas prone to flooding and other hazards (Mitlin and Satterthwaite 2013), such as along canals and rivers or on marshlands and coasts. In the context of increasing climate variability and the frequency of extreme weather events, these communities are at increasing risk of disasters. However, cities' infrastructural responses can further increase the risk to these communities. In cities like Manila, in the Philippines, for instance, disaster risk mitigation measures have been used as slum-clearing measures in some instances (Alvarez and Cardenas 2019). Generally, increased political attention on climate change resilience,

especially in flood-prone cities, has led to the adoption of mega-infrastructure solutions, such as sea walls, dykes and levees, instead of nature-based solutions, such as planting mangroves (Jongman 2018). These grey infrastructure projects are cost intensive and often harm the relationship of vulnerable communities with their city and with nature. In the fishing communities of southern India, for example, breakwaters and seawalls have been built along almost 60 per cent of the coast of Kerala, increasing the risk of soil erosion in villages along the northern coast and reshaping people's relationship with the sea (Abraham 2018).

The scope and vision of infrastructure decisions – currently dominated by grey infrastructure projects – must be broadened to include blue-green systems as hybrid solutions for risk mitigation and adaptation (Alves *et al.* 2020; Mulligan *et al.* 2020), based on ecologically and socially restorative approaches (further discussed in chapters 4 and 5). Some cities in Latin America and the Caribbean are integrating natural capital thinking in their road design and development process to counter dependencies and impacts on associated ecosystems (Mandle *et al.* 2016). International coalitions and platforms like the UNEP Cool Coalition, the CitiesWithNature and Cities4Forests platforms enable cross-city learning and support cities to move away from traditional grey infrastructure plans, encouraging hybrid solutions to reduce ambient daytime temperatures (UNEP 2019b).

For cities to truly move onto more environmentally sustainable and socially just trajectories, it will be essential that our understanding of infrastructure expands beyond hard infrastructure to include the construction and maintenance of robust social infrastructure in our cities. Social infrastructure, including schools, hospitals and other health care facilities, public spaces that support social and physical well-being, and infrastructure to support cultural production, nurtures healthy communities and is a key to undoing city lock-ins. As the world battles the COVID-19 pandemic, infrastructure decisions have become even more critical. Millions of people who live in informal settlements and other forms of vulnerable neighbourhoods with poor access to basic services have been left most exposed (Du, King and Chanchani 2020). The lack of social infrastructure, particularly in the cities of the Global South, has created severe challenges for people who live in poverty in cities, and largely depend on informal social networks for livelihoods and basic services like water, electricity and health care (Roy 2020). Conversely, social welfare networks in several parts of the world have formally or informally organized to fill critical gaps in their cities' social and health infrastructure systems (Ajibo 2020; Menon *et al.* 2020). There is a clear need to learn from this experience, to nurture and extend these networks at the same time as developing robust social infrastructure to meet the needs of all urban inhabitants.

Economic development

Economic development has the potential to radically shift cities from deeply unsustainable approaches towards environmentally transformative and socially just pathways. However, economic priorities and budget allocations are frequently driven by national and state agendas that do not engage with the specific circumstances of cities (see section 2.3.3).

There is significant scope for cities to think about the connections between planning and economic development, paying greater attention to labour absorption, skills development and worker productivity. As the world's population becomes more urban, the share of informal labour in cities in developing countries is increasing substantially (UNEP 2019a). Informal employment represents roughly 60 percent of all global employment, and 90 percent of employment in developing countries (International Labour Organization [ILO] 2018). National

and local governments must reform legal and regulatory frameworks and integrate urban planning and design with measures that provide greater security to workers, especially those in the informal sector (UN-Habitat 2020). This is particularly relevant in the context of COVID-19, when many workers and workers in the informal economy have been severely affected, leading to a sharp growth in poverty levels (WIEGO 2020) Cities can leverage the momentum of transitions towards 'post-pandemic' recovery and environmental sustainability to support informal economic activities such as waste recycling and informal food provision, and develop training and skills development schemes to absorb labour (including new migrant labour) into green jobs (see chapter 5). An important first step here, in many contexts, involves recognising the contribution of these informal economic processes to long term urban equity and environmental sustainability.

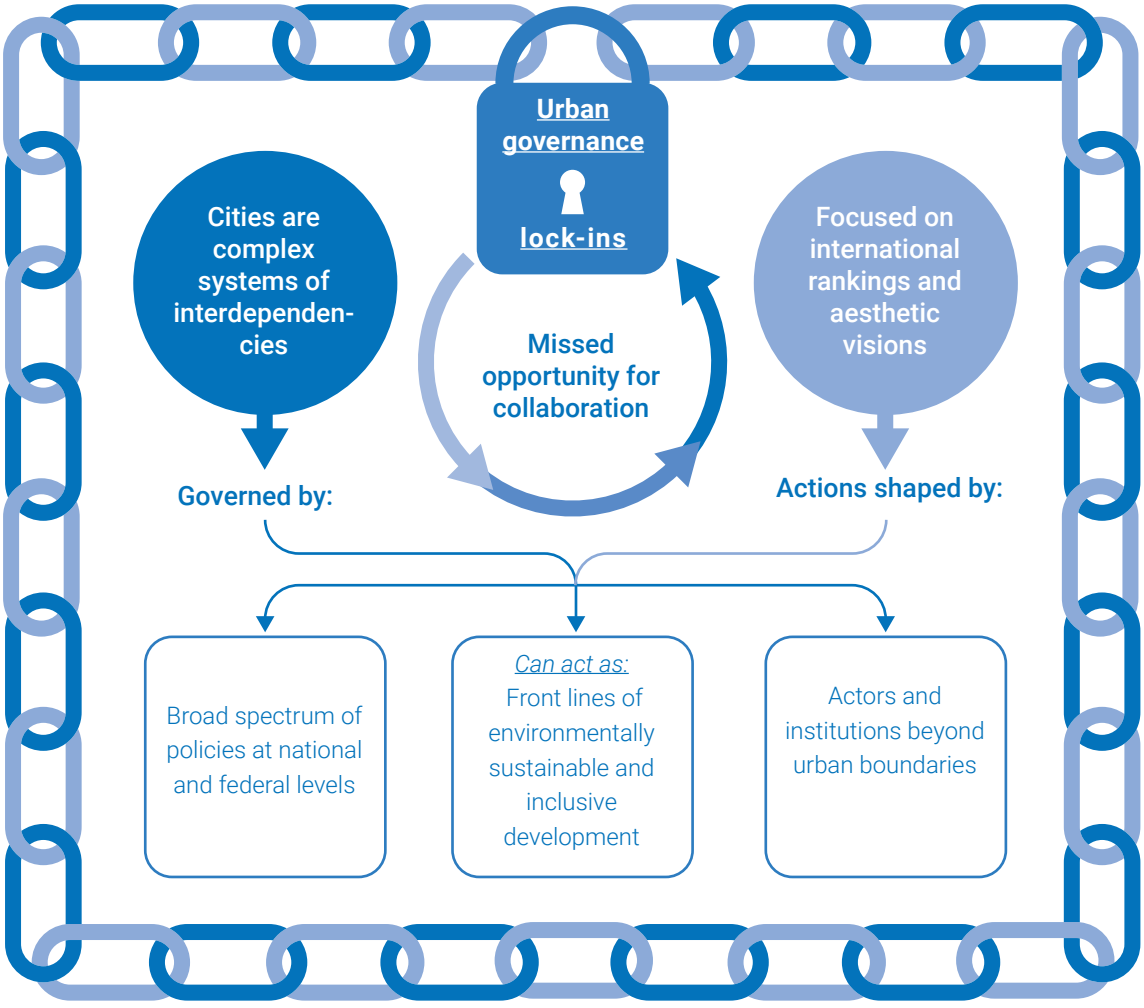
Cities and city administrators can benefit from tools that help evaluate the different social and environmental benefits of changing planning priorities and practices to be more sustainable. However, this is not easy. It requires challenging the political economy of cities which tends to continue unequal and unsustainable business-as-usual development. Moreover, cities are restricted by several other factors beyond their control, including jurisdiction, national and international interests, capacity deficits and the lack of flexible finance. Such barriers all help lock in a city's political economy and these factors must be taken into account to catalyse transformative change.

2.3.3 Complex and fragmented urban governance

Cities are complex systems of interdependencies across geographic, institutional and governance scales, where numerous actors and processes interact (Bai *et al.* 2016). They are governed by a broad spectrum of institutions and policy instruments from local to national levels, including those shaped by international commitments to sustainable development and a better environment, such as the SDGs, the post-2020 targets of the Convention on Biological Diversity and Nationally Determined Contributions (NDCs) for the Paris Agreement on Climate Change.

Despite recent advances such as the Cities Race to Zero and Cities Race to Resilience initiatives alongside platforms such as CitiesWithNature, and the GEF Urban Shift program, the full potential of cities' contribution to an environmentally sustainable and just transition has not yet been fully recognized nor realized. With urban areas accounting for

Figure 2.6: Effects of urban governance lock-ins



three-quarters of emissions from energy consumption, a low-carbon, climate-resilient urban transition is an essential component towards achieving national targets and priorities and globally set goals and commitments (Coalition for Urban Transitions 2019).

Multiple levels of governance

The functions and responses of cities are shaped by decisions taken by actors and the institutions both within and beyond their boundaries, which may have contradictory and unsustainable goals. In practice, cities can act as the frontlines for environmentally sustainable and inclusive development (Guterres 2019) and local interventions are imperative to advance sustainable development not only at the city level, but also nationally and globally. When a city is nested within an environmentally unsustainable regional or national context and policy framework, with unclear or limited mandates to subnational governments, a city's capacity for transformation is limited. The role of national policymakers and policies in shaping urban development cannot be ignored. Urban leaders can take bold steps towards improving the planning and functioning of their cities, but decisions made by national governments can significantly affect progress. As a result, national governments will continue to play a decisive role in the environmental sustainability of cities with positive or negative impacts for cities and globally (Rode, Heeckt and Cruz 2019).

In many places, even if cities want to take positive action, unfavourable and centralized national policies can lock in environmentally unsustainable business-as-usual pathways at the local level. For instance, most cities rely on national or regional centralized energy systems based on fossil fuels that produce high emissions. These broader governance and institutional frameworks may limit cities' ability to take action, for instance to self-generate and provide clean energy, if inhibited by national policies.

Infrastructure systems and services are key for the functioning of cities and account for a significant share of emissions. However, many policies and decisions in this area are made at the national level. This means that national policies can play a crucial role in either locking cities into high-emission trajectories, for example, by building highways, rather than supporting public transportation options or enabling zero-carbon development within cities. Creating enabling environments nationally, especially if it comes with locally accessible funding options, can have an immediate and massive positive impact. For instance, in India, the national government has launched a National Electric Mobility Mission Plan to promote energy-efficient low-carbon development. The plan involves the introduction of electric vehicles for multimodal public transport in several cities, a measure that is aligned with promoting low-carbon and environmentally sustainable development in cities (Yenneti *et al.* 2019).

While many cities continue to function under the umbrella of centralized governance and institutional frameworks, some have tried to go beyond this. For example, in South Africa, where the energy supply is heavily reliant on fossil fuels (80 per cent of the energy supply depends on coal), the City of Cape Town has designed its Small-Scale Embedded Generation programme to accelerate the low-carbon transition by promoting local energy production. The programme empowers the city's leadership and promotes more environmentally sustainable and decentralized urban development through diversifying the energy mix and the resale of electricity (C40 Cities and Nordic Sustainability 2019). The city's adoption of an environmentally sustainable and more reliable alternative to meet its energy needs and reduce its dependency on fossil fuels is an example of an agent of change that can drive environmentally sustainable and just transitions. Recently, the South African government increased the allowable self-generation of electricity exponentially to 100MW, immediately driving the private sector and cities alike to work towards new, now economically viable clean energy solutions for a low-carbon future and more reliable supply of power.

Well-aligned, multi-level governance systems that include all levels of governments enable each level of government to work where it is best placed to implement sustainable development solutions.

Challenges at the city level

City-level implementation is essential for meeting most international commitments (SDGs, NDCs, NUA). Yet in most cases, cities are not fully invited and engaged in national and international agenda setting, decision-making, funding options and implementation strategies (UN-Habitat 2020). This is a missed opportunity, since including cities in the process enables and empowers them, providing additional capacity and enabling implementation at the local level.

Local governments are producing their own voluntary reviews to complement official voluntary national reviews of the implementation of the SDGs. This puts cities in the spotlight for implementation (International Institute for Sustainable Development [IISD] 2019). However, environmentally sustainable and equitable urban transformations will require substantial investment. For instance, even the largest and most capable city governments can only deliver a fraction of their emission reduction targets as part of their country's NDCs due to the lack of financial resources (UN-Habitat 2020). Most urban local governments are underfunded, especially for infrastructure, services and socially and environmentally responsible public projects. Most depend on centrally allocated funds from national policies, programmes and missions earmarked for urban development (Guha and Chakrabarti 2020). This fiscal dependence brings constraints, partly related to the priority of cities and urban regions in broader national development and environmental sustainability strategies. Access to financing remains a critical factor to enable cities to implement these global goals on the ground and new, innovative and blended finance options are critically needed by cities the world over.

In some cases, cities continue to play an ambiguous role in national priorities or are perceived as threats to national identity and power structures (UN-Habitat 2014). This situation is often reflected in ambivalent policies and attempts to curtail the autonomy of cities, leaving

power and resources remaining centralized in national governments. Addressing urbanization challenges in a just and environmentally sustainable way means adopting an integrated approach to urban policies, facilitating collaborative and collective action among all levels of government and relevant stakeholders. Developing national urban policies is key to an integrated approach to the challenges of urbanization and has played a significant role in Brazil, China and South Africa in aligning urban development from the national to local levels. UN-Habitat has supported the national urban development processes of Burundi, Malawi, Mongolia and Sri Lanka (UN-Habitat 2021).

Several countries have decentralized governance systems (e.g. Nigeria and India) where states have significant power and other countries are undertaking decentralization processes (Kenya), however this does not necessarily translate into improved city action. Even when cities function as autonomous entities, they grapple with limited financial resources and capacities. Many are under-resourced and lack mandates to raise funds for innovative projects. This is especially true of low- and medium-income cities in Africa and Asia, which are set to grow the most over the coming years (section 2.1). City governments are often unable to cope with the rapid urbanization from burgeoning urban population while resource limitations mean they can struggle to deliver basic urban services, such as water, sanitation, health care and waste management. The increasing rate of urbanization and rising population density can lead to a series of increasing risks, especially when urbanization is fast, poorly planned and occurs against the backdrop of poverty. The lack of basic services, housing and health care can compound the impacts of natural hazards and extreme weather events, resulting in widespread hardship. For example, in cases of extreme rainfall, poor solid waste management practices can clog storm water drainage systems, leading to waterlogging and flooding, which increases loss of property, assets and even life.

Capacity-building of the urban institutional framework to manage complex urban challenges and issues is crucial. Many cities in developing countries grapple with ensuring the provision of basic services due to severe resource constraints, including human resources with the required skills (Cities Alliance 2016). Some countries have very few educational institutions able to produce professionals like urban planners, data analysts and climate and environmental scientists that can be deployed at the local level to design and plan cities in accordance with cutting-edge, socially just and environmentally transformational approaches. Moreover, city decision-makers may be hesitant or lack the knowledge to tap into the informal knowledge-base of urban dwellers to fill these capacity gaps. Another compounding factor is the lack of well-designed and implementable business plans based on medium to long term city sustainable growth and income scenarios.

City governments typically have separate and specialized bureaucratic departments, each of which deals with a specific sector (for example, housing, transport and green and public spaces). Institutional silos and poor interdepartmental communication and coordination are challenges for mainstreaming just transition objectives, which require close collaboration across multiple departments. In many cases, the existing formalized city governance structure hinders the adoption of integrated responses to address environmental problems and inequalities in cities. However, there are also examples of cities that have adopted cross-sector governance models for sustainable development. In the United Kingdom, for example, the Greater Manchester Low Carbon Hub, housed by Greater Manchester Combined Authority, has developed a long-term vision and plan to be carbon neutral by 2038 (Greater Manchester 2019).

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Taking initiative and collaboration also matter at smaller scales. Neighbourhoods are opportunities for immediate action and adopting an integrated approach at this scale can help overcome barriers and ensure greater environmental sustainability. They can act as innovation labs, pursuing activities on a smaller scale that serve as proof of concept for replication at the city level. Neighbourhoods are big enough to aggregate interrelated social, environmental and economic components and provide the basis for a coherent urban model, but also small enough to reduce some of the complexities of systems integration and to allow results to be seen in a shorter time frame.

The need for more and better data

Another key barrier to sustainable and just urban development is the lack of adequate data and data systems for planning. Many cities have little or no data that can provide relevant information on basic services for urban residents living in poverty in informal settlements. In some cases, despite 30 to 60 per cent of the urban population living in such conditions, basic information like street names and addresses is unavailable or missing (Satterthwaite 2020a). This makes it hard to bridge gaps in basic services and reduce the inherent vulnerabilities of those affected. Part of the issue lies in the lack of disaggregated data: despite most countries having census authorities, this data primarily serves the national government. Disaggregated data that can be used by urban local bodies for planning and to meet international targets and goals like the SDGs and NDCs is often absent. The challenges of maintaining data are exacerbated by the lack of institutional capacity, funding and accountability. There are several examples of city governments that have responded to poor official data by developing their own common database, collecting and compiling all the relevant data housed in different departments (Satterthwaite 2020b). However, such an approach runs up against the additional challenge of dealing with the compartmentalization of government agencies and departments working in silos. Moreover, this situation is further complicated by the lack of knowledge and understanding of the coping mechanisms of people living in poverty and the ways in which everyday resilience is built or eroded by planned interventions.

Despite the challenges presented by all these lock-ins, there are examples of how cities are trying to overcome them by experimenting with key enablers (see section 2.4) and further ways to overcome them through the pathways explored in chapter 5.

2.4 Catalyzing environmentally sustainable and just transformations

The previous sections have shown how 'lock-in' forces limit people's access to the basic services that are so often taken for granted by more developed communities. They also reveal the embedded and interconnected systems of injustice that are produced by, and help to create, unsustainable trajectories for so many of the world's cities and their inhabitants.

'Shifting' such path-dependencies, or disrupting 'business as usual', requires not only reducing environmental impacts and restoring ecosystems. It also requires whole-of-society engagement with issues of social equity and justice and challenging current systems of distribution, recognition, and participation. It means addressing difficult trade-offs, working across silos and, most difficult still, shifting embedded power structures. This is no small task, which goes some way towards explaining the tendency towards inertia within current city structures. Certainly, the short-termism inherent in most current political systems tends to favour existing power structures and immediate political wins (e.g. jobs in carbon intensive industries), at the expense of uncertain long-term transformation processes.

However, there are examples of cities that are already taking steps toward environmentally sustainable and just transformations (C40 Cities and Arup 2015). These responses are often the result of collaborative processes at multiple scales. Below are three examples of governance strategies that have helped catalyze transformative change. These practices and 'ways of doing things differently' both enable and reflect shifts in the political economies of cities and have helped to address some of the capacity constraints and governance barriers that keep cities locked in to unsustainable trajectories.

2.4.1 Inclusive, Publicly Engaged Decision-Making

A key root cause of the 'lock-in' to environmentally unsustainable and unjust urban approaches is the exclusion of some (at times a majority) local voices and urban populations from policy and planning processes. Recognizing this and opening up the decision-making process to give voice to those who historically have not been able to inform urban policies and planning strategies, has helped cities address both inequity and environmental unsustainability. The goal here has been ensuring that those most affected by unsustainable 'business as usual' approaches are heard, that their needs are taken into consideration, but also, and crucially, that their knowledge of urban dynamics, and their capacity to partner in solution-finding and city-making, are taken seriously.

A good example of this is in Mandlakazi in Mozambique (see chapter 1), where the city has promoted participatory governance with particular attention to gender and youth perspectives, creating several participation platforms to this end, including the Municipal Children's Forum, Municipal Youth Forum, Municipal Women's Forum, and the Municipal Citizen Forum. The city's experience in engaging with communities through participatory approaches and gender empowerment has been critical to increasing resilience. In particular, community engagement in the planning process has helped enhance systematic linkages between disaster risk reduction (DRR) and climate change adaptation (CCA).

Inclusive and participatory strategies and practices such as the Mandlakazi experience highlight the benefit of bringing a broad range of voices to participate in decision-making. Such inclusive and publicly engaged processes, where they exist with intent, tend to prioritize local concerns and

wellbeing, local spaces and environmental values. They also tend to do so in ways that acknowledge working with informality and marginalized groups rather than against them. Moreover, studies on participatory budgeting experiments have shown how such governance innovations can lead to impressive 'inversion in priorities', even over short periods of time. 'Inversions' here refer to the shifts in spending towards previously disadvantaged areas (e.g., poor neighbourhoods, informal settlements, neglected peri-urban areas) and shifts in political participation (e.g., those who were previously excluded from decision-making can now participate in decisions on spending of public resources) (Cabannes and Lipietz 2018). Similarly, the emerging trend in city-level citizens' assemblies, set up to address diverse urban and sustainability concerns ranging from food to climate change adaptation strategies (Doherty *et al.* 2020), speaks to the importance of discussion and dialogue processes to foster the city as a 'collective actor' (Le Galès 2002), able to respond with the interest of citizens and nature in the face of growing environmental sustainability and inequality challenges.

Of course, participatory planning or participatory forms of city-making are not new approaches and are not, in and of themselves, sufficient disruptors of business-as-usual urban development approaches. In particular, these processes can be captured by dominant plans or discourses driven by powerful vested interests or well-organized stakeholders (Lipietz 2008). However, the examples above offer interesting and promising results. In particular, the ad hoc selection of participants in many citizen assemblies, coupled with careful facilitation of difficult discussions (e.g. on trade-offs related to climate change adaptation strategies) have been interesting innovations to help challenge existing power structures and create a public focus for deliberations. These are crucial for fostering open discussions where behavioural patterns (e.g. regarding individual car use, aspirations for large housing plots or other markers of success) can be confronted with their long-term and broader socio-spatial and environmental implications. Equally useful have been attempts to create opportunities for discussions that explore the full slate of environmental issues affecting city dwellers and the diverse pathways for change.

Deliberation, or open discussion, is also part of participatory budgeting experiments. The outcomes of such discussion and participation in the life of the city have been linked to immediate material transformation on the ground (e.g. the development of new cycle lanes, new lighting, new common food growing plots,), which have rekindled a sense of belonging and ownership for many who have been previously excluded from decision-making in their neighbourhoods and cities. In Seville (Spain), for example, assemblies of women, youth and migrant communities have been introduced to ensure excluded groups can overcome the structural conditions that make it difficult for them to participate in the life of the city. In other cities, approaches to improve the quality and transformative potential of participatory budgeting have included civic education on budget literacy, budget resources, the responsibilities of municipal/metropolitan governments (vis-à-vis other tiers of government), or the mechanisms for improved and respectful dialogue and debate. Importantly, as in Gunirulhos (Brazil), such training has targeted participatory budgeting delegates and local government officials (UN-Habitat 2004; Molina 2011; Cabannes and Lipietz 2018).

Inclusive and participatory decision-making processes, where they have been put in practice and developed, have enabled the renewed mobilisation of diverse city inhabitants and institutions. This has transformed the structural societal forces that have placed and kept cities on inequitable and environmentally unsustainable trajectories.

2.4.2 Partnerships and Coalition-Building

Coalitions, partnerships and organized city networks have been key opportunities for moving urban sustainability and equity agendas forward, allowing cities to navigate the gaps in capacity, information, authority, and resources presented earlier. In the face of growing complexity and uncertainty, there is a need to open up solution-finding to a variety of knowledge holders and resources. Partnership-based governance, ranging from ad hoc arrangements to formal authority sharing, have arisen as part of cities' efforts to respond to such challenges. Admittedly, such partnerships and coalitions can be difficult to establish, resource and maintain, and have presented their own political challenges. Their creation and maintenance have often been iterative and have required constant attention. Building the capacity of city governments to engage in such partnerships and lead coalition building has therefore been an important strategy for those cities that are already engaged in transformative change.

Partnerships, coalitions and city networks have been developed at a variety of scales, bringing together a diverse range of actors. At the global and regional level, city networks have worked for some time on a wide range of topics related to governance and environmental sustainability, with an increased focus on nature and climate change in the past decade. These platforms foster learning and capacity building targeted at local governments, allow cities to advocate for what they need and to influence the outcomes of international discussions. The networks also help cities to navigate these international and national fora to facilitate better connections between national governments and cities.

In 1990 ICLEI - Local Governments for Sustainability first established a network of large and small cities from across the globe that were committing to collective action on sustainability in the wake of the Rio Earth Summit. ICLEI has since been joined by a large variety of organizations and movements that work to provide a collective and widely diverse range of services and tools to cities. The Global Task Force, the Global Covenant of Mayors for Climate and Energy (GCOM) and the nature focused CitiesWithNature initiatives are examples of networks and initiatives coming together to provide integrated and enabling platforms to inspire cities to take bold and often ground-breaking efforts towards a more sustainable shared urban future. Similarly,

initiatives such as United Cities and Local Governments' Commission on Social Inclusion, Participatory Democracy and Human Rights (UCLG – CISDP), or Metropolis offer other forms of city networking and peer-to-peer learning geared towards promoting inclusive urban planning and development. Harnessing the innovative and supportive power of city networks at the global and regional scales for addressing multiple environmental crises must be understood to be as much an urban planning and governance challenge as an environmental/technical one.

Multi-actor coalitions and partnerships have also been key for moving urban environmental sustainability and social equity agendas forward, allowing cities to plug into a wide range of knowledge, capacities, technology, authority and resource gaps. Amongst these, coalition building with parastatals[2] and regional or national governments is a strategic imperative for cities, in order to address cities' bounded authority and remit, as well as their limited financial capacity for achieving environmentally sustainable and just transformations. For small and medium-sized cities in particular, building such partnerships has been instrumental given their limited fiscal resources and the difficulties faced in unlocking international funds and private sector investment.

Public transport infrastructure, with its large capital investment requirements, is a case in point. In Dar-es-Salaam, funding for the Bus Rapid Transit (BRT) system was facilitated by the National Government with a mix of a national budget allocation and international loans from the World Bank and African Development Bank (Krüger *et al*. 2021). Other large-scale infrastructure and housing programmes have also seen the benefit of multi-scalar government partnerships. In Thailand, the Baan Mankong programme, operating under the Ministry of Social Development and Human Security's Community Organizations Development Institute (CODI), has been providing decentralized funding for close to two decades, enabling the development of community-driven (and local government-supported) housing, informal settlement upgrading and community development at scale (Boonyabancha and Kerr 2018). It is worth noting that the Sustainable Development Goals and the New Urban Agenda both make explicit reference to the importance of national governments in achieving sustainability at the city scale.

Coalition building with non-state actors, including the business sector, civil society, NGOs, activists and scientists/researchers is also crucial as a strategy for expanding the capacity, resources and knowledge needed for urban sustainability transformations. In many situations, the private sector has been instrumental in delivering complex transition finance packages, as mentioned in the case of transport. But partnerships with diverse sectors and branches of the private sector have also been key in helping to build capacity, and in the transfer of technological know-how, product design and innovation in favour of environmentally sustainable and just transformations. Energy transitions have been a strategic entry point for private sector innovation, and businesses, communities and governments are continually exploring how to better engage small and medium-sized enterprises on resilience and nature-based urban solutions. Similarly, partnerships and coalition-building with civil society and community organisations have been critical to plug data and knowledge gaps on the key spaces and dynamics of cities. In particular, such partnerships have proven instrumental in ensuring that informal ways of living and working in the city are

2 A company or organization which is owned by a country's government and often has some political power.

recognised and form a key part of solution-building and planning, be it with regards to settlement upgrading, inclusive approaches to waste and water management, food security or disaster risk reduction strategies (Miranda and Baud 2014; Boonyabancha *et al.* 2019; Hofmann 2020). Meanwhile, partnerships with the academic and research communities – often in collaboration with other city actors - have also been important to help stimulate, and often facilitate, new ways of 'thinking and doing things' or the development of 'communities of practice', able to speak across different experiences and rationales, towards the goal of achieving equity and environmental sustainability transitions (Smit *et al.* 2021). At an international scale, a number of initiatives have attempted to stimulate the building of coalitions between the research community and urban practitioners and policymakers. For example, the Cities and Climate Change Science conference, co-sponsored by the IPCC, held in Edmonton, Canada in March 2018 brought together these various actors to create the Global Research and Action Agenda on Cities and Climate Change, setting out key priorities for action, collaboration, research and data gaps.

Coalition- and partnership-based modes of governance for urban sustainability and equity agendas – increasingly referred to as coproduction or co-creation (Watson 2014; Mistra Urban Futures 2020; Knowledge in Action for Urban Equality 2021) – have, in their diversity, shown their capacity to start addressing some of the city lock-ins mentioned in the previous section. However, ensuring that partnership-based governance acts as an enabler of environmentally sustainable and just transformations, and not the perpetuation of business-as-usual approaches, requires astute leadership, committed involvement and resourcing from all parties. Sharpening the understanding of notions such as urban 'publicness', or of the urban commons, is also critical to guide visions and principles. Partnerships that put environmentally sustainable and just transformations at the heart of urban planning processes require constant nurturing and particular attention to those partnership members traditionally excluded or undervalued. The Memoranda of Understandings signed by a number of municipalities with organised community groups such as members of the Slum Dwellers International (SDI) network or of the Asian Coalition for Housing Rights have been important milestones to ensure enduring recognition of, and material support for, such city-building partnerships.

2.4.3 Institutionalization for Longevity and Scaling Up

A key challenge for environmentally sustainable and just urban transformations is ensuring that successes and innovations (whether top down, bottom up or indeed co-produced) are embedded, scaled up and out and have longevity. Institutionalizing changes, initiatives and innovations or embedding them into institutional and organizational processes and structures can help to ensure continuity beyond the term of a particular mayor, a civil servant's tenure, or social innovator's leadership. Institutionalization helps to mainstream innovations and facilitate their uptake at scale, for example from a pilot project to a city-wide initiative; or from a city-based innovation to a regional or national process. In practice, for pilot projects to contribute to these transformations and shift 'business as usual' thinking and approaches, "they must, at some point, move beyond the initial test site or boundaries within which they were created" (Hughes, Yordi and Besco 2020).

Long term, cross sectoral, cross scale planning for change, developed with a diverse range of expertise is an important objective for these types of transformations. Key considerations for scaling up have included resourcing, incorporation into routine budgets and the ability to attract further resources and support from other levels of government. While some cities have managed to catalyse transitions to environmentally sustainable and just urban development on the back of city-level initiatives, progress and scaling up has been more sustained where such objectives have aligned with national policies and funding mechanisms. In some cases, linking city-level benefits with national level targets and commitments that contribute to global goals and targets such as SDGs and NDCs has been beneficial (Bai *et al.* 2016; Coalition for Urban Transitions 2019). National government support has also been critical for ensuring learning is exchanged for scaling-up initiatives to other cities, especially secondary cities.

Effective institutionalization or mainstreaming of change at the city scale has also required shifts in policy, in procedures, shifts in methodologies and ways of doing things, as well as staff development (Levy 1996 and see examples in chapter 5). Embedding equity and climate change considerations in annual staff reviews or requiring robust public engagement in policy making (as demanded by the Aarhus Convention) have been important steps that have served to broaden the reach of potentially transformative measures.

Scaling up and mainstreaming change is difficult to achieve and sustain and requires ongoing feedback loops and learning to maintain, deepen and adapt to evolving circumstances. There is a fine line, for instance, between institutionalization measures that risk stalling transformation dynamics on the one hand, and on the other, the failure to embed innovative, 'precedent-setting' approaches that point to new, environmentally sustainable and equitable ways of doing things (Boonyabancha and Kerr 2018). In practice, developing and fine-tuning approaches that support experimentation for environmentally sustainable and just transformations by a variety of actors, or through co-production platforms, has often been the result of iterative processes that are time- and place-specific (Bulkeley, Broto and Edwards 2015; IRP 2018). There is no one-size-fits all approach to scaling up and embedding such critical innovations, just as there is not one-size fits all catalyst for such transformative practices to take root.

Finally, the development of city-specific accountability mechanisms has also played a key role in ensuring that new inclusive governance mechanisms and partnership-based responses have kept to, and extended, their transformative objectives. Specifically, ensuring that those communities and residents most affected by unsustainable and unequal

development can play such a 'care-taker' role, in urban contexts marked by the kinds of inequalities sketched out earlier, has proven critical. Successful examples highlight the importance of local, regional and even international peer-to-peer networks (such as WIEGO or Slum Dwellers International), along with the role of critical progressive alliances (for example, the Global Platform for the Right to the City), in supporting the functioning of more equitable transition governance mechanisms.

2.5 Conclusion

While many of the challenges and barriers described in this chapter are not new, they take on new urgency in light of growing urbanization, combined with the vulnerabilities and inequalities associated with intensifying environmental and climate crises. This chapter has brought attention to factors that tend to lock a majority of cities in to environmentally unsustainable and unequal urbanisation paths. Many of these factors have become embedded over time and have exacerbated the unsustainable trends described in section 2.2 and further elaborated in chapter 3. Placing cities on environmentally sustainable and just transformation trajectories will require addressing deeply embedded power relations, as well as growth-oriented and extractive economic systems that underpin much of current 'business as usual' urban planning practices. It will also mean overcoming what are often fragmented, under-resourced, under-capacitated, and exclusive governance systems.

The challenge is daunting, but breaking up these lock-ins and barriers is still possible. Urban decision makers remain at the forefront of addressing the world's most complex and interconnected challenges. Many – both inside and outside the (local) state – are making ambitious pledges to address the intertwined challenges of equity, environmental sustainability and the unmet basic needs of urban communities; and taking steps to make it happen. Cities, their networks, urban communities and innovators at the forefront of this trend are inspiring many more to follow in their footsteps. Their commitments and actions show the formidable potential of urban transformations and provide examples of key practices with the potential to disrupt business-as-usual scenarios and catalyse new pathways for transformative urban action, outlined in chapter 5.

This chapter has highlighted three key governance strategies that have helped catalyze transformative change towards more sustainable and equitable futures: (1) expanding the breadth of city stakeholders involved in decision-making in a more meaningful and effective way; (2) building stronger coalitions and partnerships within and beyond cities; (3) consolidating those changes in institutions and fostering an enabling policy environment for long-term, widespread and lasting change. Chapter 5 elaborates on diverse pathways and strategies for disrupting the status quo and shifting cities towards key environmental sustainability and equity objectives: building net zero, circular, resilient, inclusive and just cities.

Transformation at the necessary scale while maintaining these positive gains requires leadership. This leadership – which needs to come from civil society, business and all levels of government – needs to be nurtured, enabled and supported within cities by city leaders such as mayors. It also requires the support and resources provided by enabling national policies, fiscal allocations, the private sector and the international community at large. Access to finance for cities, and city networks, most urgently needs to be addressed at global level by all role players, notably development banks, global funding mechanism and bilateral and multilateral partnerships. Existing initiatives that enable cities to leapfrog technologies and learn, inspire, commit, act and report together towards meeting national and international goals, ambitions and targets towards sustainability, need to be supported, strengthened and embraced by the international community. As part of these processes, national governments have a critical role to play in supporting a wide range of environmental sustainability and just transformation initiatives, especially by addressing gaps in finance, clarifying local and subnational mandates and full committing to multilevel governance.

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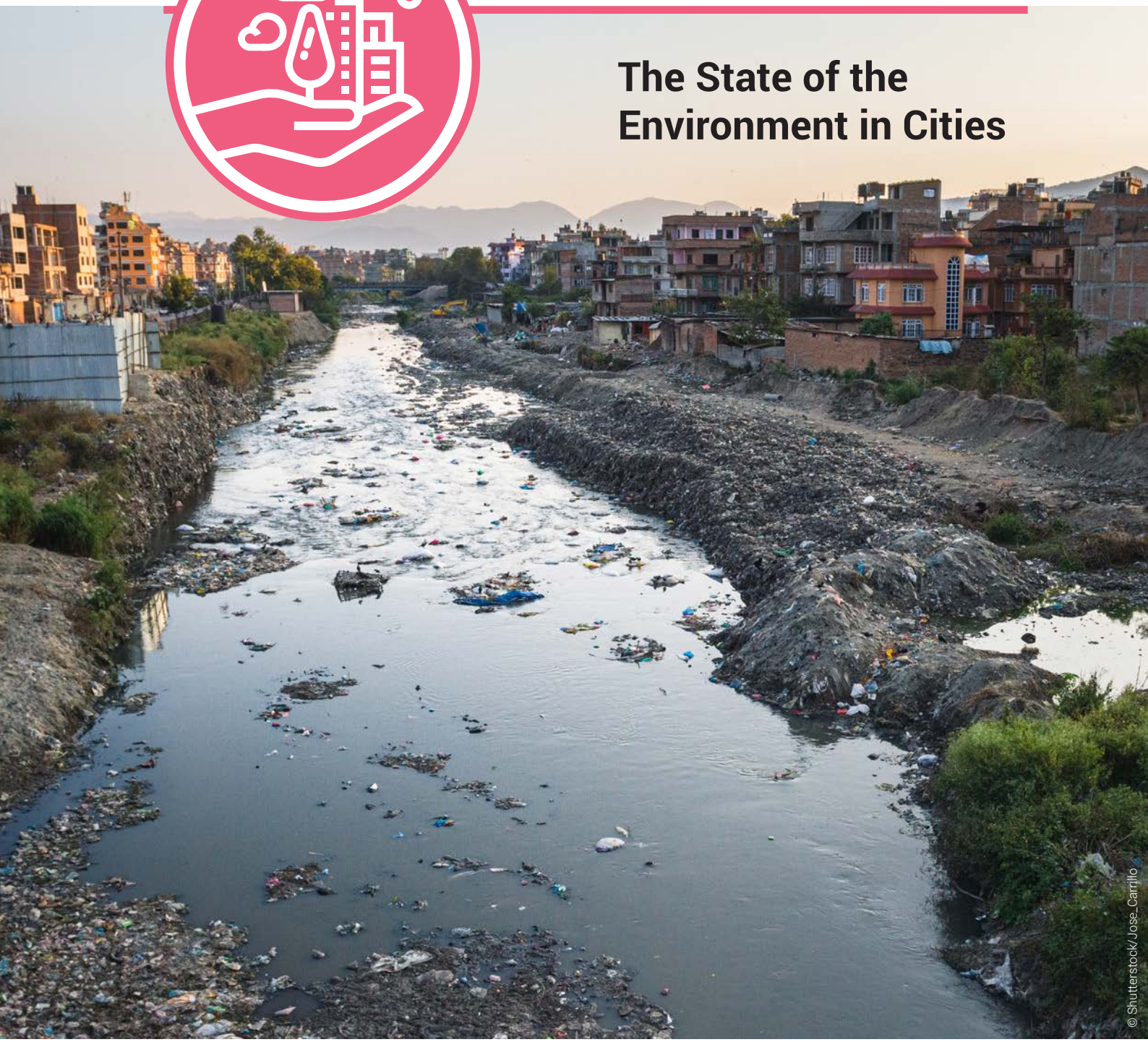
Chapter 3

The State of the Environment in Cities



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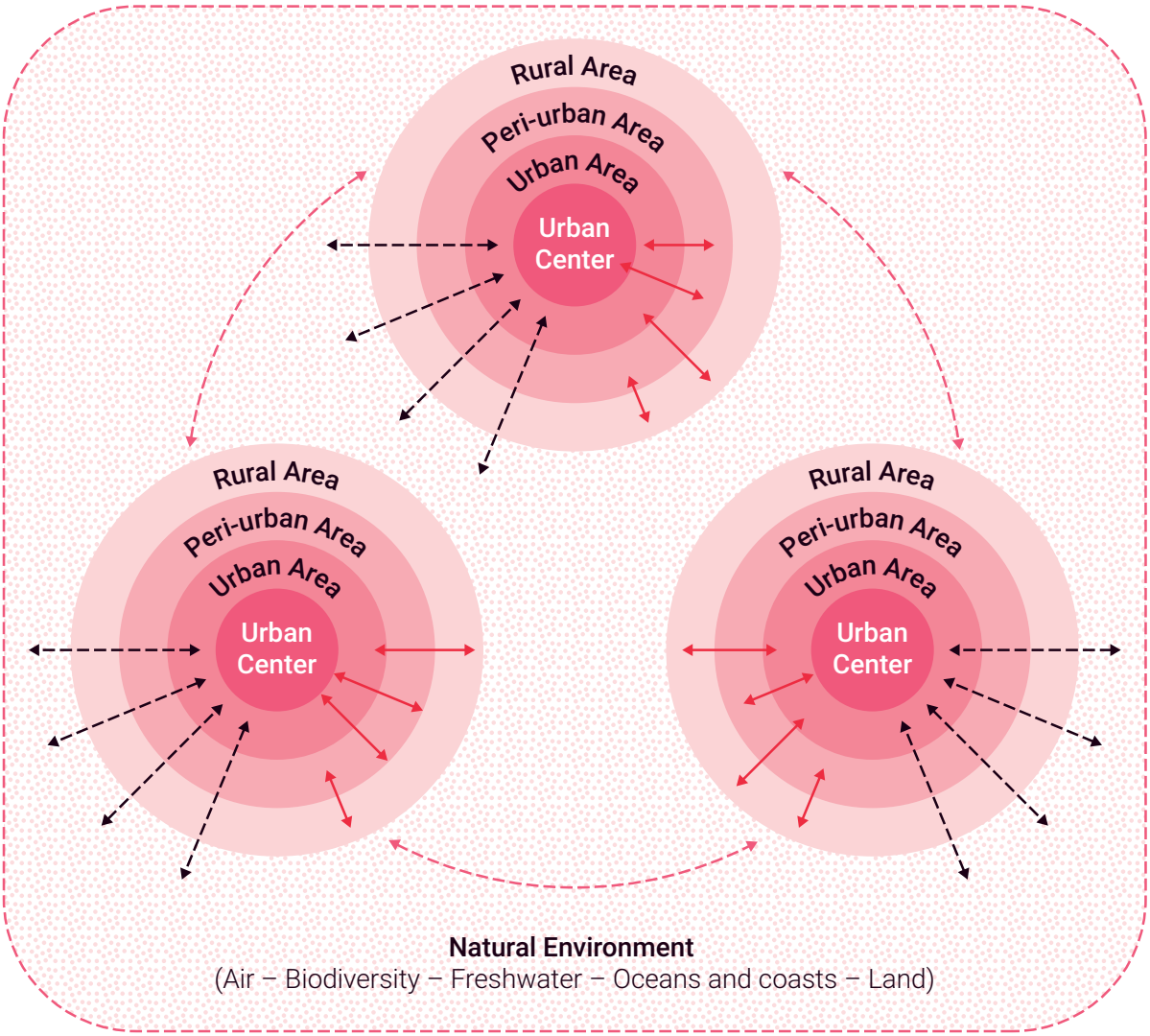
3.1 The city as a nexus of connections in time and space

An important feature of urban areas is that they continuously exchange people, goods, resources and information with other places (Seto *et al.* 2012; United Nations Convention to Combat Desertification [UNCCD] 2017). These interactions allow urban settlements to change in both space and time. Moreover, exchanges also transform other locations, either positively or negatively (Haase 2019). Cities cannot exist without these connections. These linkages with surrounding peri-urban and rural areas, as well as other distant cities and rural locations, create complementary and synergistic relationships (United Nations Human Settlements Programme [UN-Habitat] 2015). Although cities are embedded in their immediate environment, their footprint goes beyond jurisdictional boundaries, since food, water, waste disposal, sanitation, clean air and energy needs can seldom be satisfied within the city limits and people move temporarily or permanently between urban and rural areas (Haase 2019). These connections can be both local, with nearby spaces and places, or at the regional and global levels, with places that do not share a boundary with the city (also known as "telecouplings"[1]) (Liu *et al.* 2013; Seto and Reenberg 2014; Fragkias, Islam and Sprague 2017) (**Figure 3.1**).

Figure 3.1: Interconnections: how cities influence the environment and the environment influences cities



Urban Land Telecouplings (Flows and connections of people, goods, services and land-use changes)

Urban Land Telecouplings in contigious areas

Urban Land Telecouplings in multiple and distant locations

Urban – Environment nexus

Inputs – ecosystem services (food, water clean air, energy)

Outputs – emissions, organic and inorganic wastes

Source: Adapted from Seto *et al.* 2012; Ravetz, Fertner and Nielsen 2013

1 Telecouplings or teleconnections are linkages – both local, with nearby spaces and places, or at the regional and global levels – with places that do not share a boundary with the city.

Defining an urban settlement solely by its administrative boundary ignores the many connections and flows that make the city possible. Achieving Sustainable Development Goal (SDG) 11 on urban sustainability requires an approach that considers these telecouplings (Seto *et al.* 2012; Seto *et al.* 2017; Haase 2019). Changes in social, economic, environmental and political conditions will create new connections and remove, strengthen or weaken existing ones (Güneralp, Seto and Ramachandran 2013). In other instances, global investment, supply chains and consumption patterns in one area can change relationships in others (United Nations Environment Programme [UNEP] 2019, chapters 3 and 8). All this means cities can be thought of as nodes in a network, where the intensity of connections with near and faraway places changes with time and across space (Glaeser, Ponzetto and Zou 2016; Cities Alliance 2019).[2]

As cities grow, many dependencies with other areas may be overlooked and their environmental impact could increase at the expense of the city's needs and the well-being of its dwellers. The pressure of urban growth also affects inhabitants of other areas and nature's contributions to human well-being. City planners and practitioners need to be on the alert for signs of these trade-offs and must remember that the environmental dimensions of urban sustainability are tied to the areas connected to the city (section 5.4.2). Failing to consider these urban telecouplings makes it extremely difficult to achieve SDG 11 targets and many other SDGs, as pressures and impacts are also connected through these links between cities and rural areas, natural resources and other cities.

Urban settlements vary tremendously in their social, economic, environmental, political and technological contexts. All cities are already facing the impacts of climate change and its associated effects on human well-being. However, impacts – both present and future – depend on context and characteristics. For example, coastal cities may need to plan for rising sea levels, while cities in arid regions may experience water shortages due to changes in precipitation patterns. (Revi *et al.* 2014; C40 Cities Climate Leadership Group 2020; Grimmond *et al.* 2020). As discussed in chapter 2, size, institutional arrangements and income levels will determine the capacities of individual cities to cope with these challenges (Anguelovski, Chu and Carmin 2014; Reckien *et al.* 2015; Estrada, Botzen and Tol 2017; Paterson *et al.* 2017). Variations in urban conditions throughout the world mean there is no single silver bullet for city planners and managers (Brelsford *et al.* 2017). Unpacking the complexity of managing urban settlements is an urgent task, since urbanization is forecast to accelerate in all regions, albeit at different rates (United Nations 2019). Cities need to adopt integrated, synergistic, resilient and adaptive strategies for urban environments to meet the SDGs and other commitments, such as those related to the Intergovernmental Panel on Climate Change (IPCC) 2018 report on the impacts of global warming, the Paris Agreement and the Post-2020 Global Biodiversity Framework (Bazaz *et al.* 2018; Organization for Economic Co-operation and Development [OECD] 2020).

This chapter presents the most relevant issues of this urban–environment nexus, based on the five environmental themes of the Global Environment Outlook report: air, biodiversity, land and soil, oceans and coasts, and freshwater (UNEP 2019). However, we must acknowledge that the interconnected nature of cities and the environment means their impact on one area might also affect others. What may appear as repetitions in the text, in fact reflect the integrated nature of this nexus. Section 3.2 describes the main impacts of environmental change on cities, while section 3.3 emphasizes how they contribute to environmental change and how the interact with each other. Section 3.4 synthesizes the most important impacts at the city scale, provides possible global trends and reflects on gaps in the available data. Section 3.5 explores how changes in the city and the environment affect the health and well-being of urban residents. Finally, the chapter closes by highlighting the urgent need for more sustainable urban environments with more integrated and inclusive governance structures.

3.2 How are global environmental changes affecting cities?

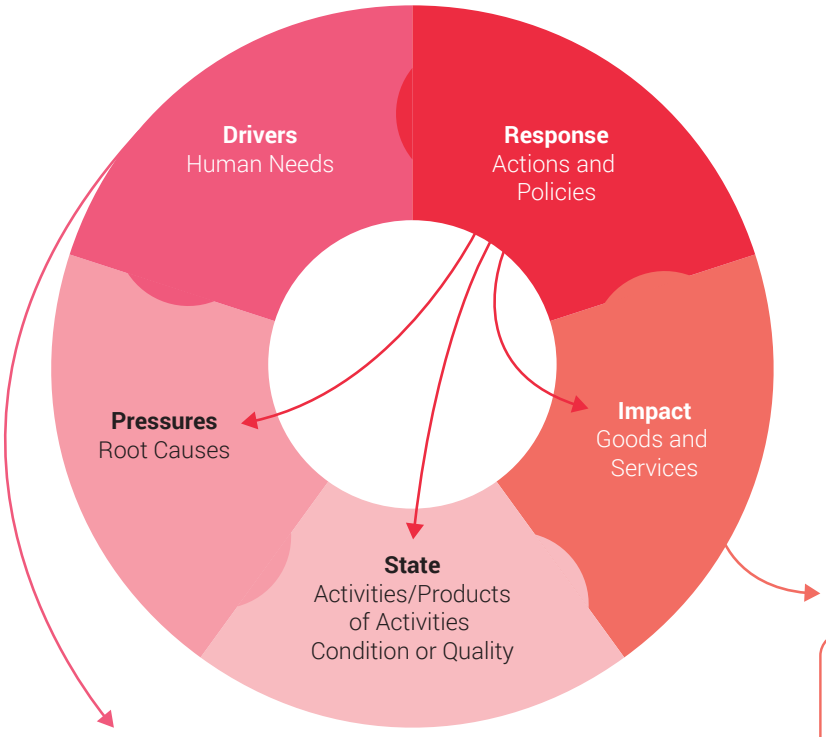
As the environment changes across the globe, some of the conditions under which cities have developed and functioned are being transformed. For example, many urban settlements at higher altitudes in Africa and Latin America were free of the dengue virus as they remained above the temperature threshold for the vectors of this disease. However, rising global temperatures have made some of these cities warm enough for the dengue fever vector Aedes aegypti to thrive (Lozano-Fuentes *et al.* 2012; Equihua *et al.* 2017). This shows how a global change can affect cities locally. The GEO-6 report highlights five drivers of environmental degradation: population growth; urbanization; economic development; technology; innovation and sustainability; and climate change. **Figure 3.2** uses the Driver–Pressure–State–Impact–Response framework to illustrate how these drivers impact cities and highlights how the environmental and city-level impacts can result from the interaction of several driving forces. The remainder of this section examines in more detail how global environmental changes are affecting cities across each of the five dimensions.

3.2.1 Air

The atmosphere has no boundaries and its patterns of circulation make it one of the primary integrators of the Earth system. This means that global environmental changes – both near and far – impact the air quality and climate of cities. Emissions of greenhouse gases and short-lived climate forcers from human and natural sources warm the atmosphere, resulting in significant impacts on cities (IPCC 2018). Emissions of carbon dioxide (CO_2) into the atmosphere, especially from the burning of fossil fuels, industry and land-

2 Examples of specific telecouplings are discussed later in the chapter.

Figure 3.2: The impact of drivers of environmental change on cities and human well-being



Drivers of Environmental Change

Population growth

Examples of impacts on GEO environmental dimension:
Habitat destruction and degration
Competition over resources and ecosystem services
Solid waste and other types of pollution

Urbanization

Examples of impacts on GEO environmental dimension:
Land use change
Air and water pollution
Increased resource and transportation demand
Solid waste and sewage

Economic development

Examples of impacts on GEO environmental dimension:
Habitat destruction and degradation
Competition over resources
Solid waste and other types of pollution
Resource degradation
Loss of ecosystem services

Technology, Innovation and Global Sustainability

Examples of impacts on GEO environmental dimension:
Increased demand for electronics (rare earths)
Disposal of electronic waste
Landscape homogenization
Electromagnetic pollution

Climate change

Examples of impacts on GEO environmental dimension:
More frequent storms, droughts and floods
Salt water intrusion
Warmer waters, algal blooms
Increased land degradation (erosion)

Impacts at the City Level

Potential unrest
Health effects for urban dwellers
Increased waste and pollution
Difficulty to provide services due to rapid growth
Urban growth
Potential overcrowding
Need to provide services to aging population

Potential unrest
Land use competition
Increased waste and pollution
Urban heat island effect
Increased vulnerability
Higher efficient in resource use
Increased competition for ressources
(urban-rural interface)
Surface sealing
Improved delivery for social services

Potential unrest
Health effects for urban dwellers
Increased waste and pollution
Land use competition
Increased inequality
Increased migration
Increased marginalization of vulnerable groups
Impact on water quantity and quality
Changes in living costs

Difficulty to provide services
More efficient and connected services
Increased energy efficiency
Increased inequality in accessing technology
Increased resource efficiency
Potential health impacts (sedentarism)
Urban sprawl

Urban heat island effect
Health and safety effects for urban dwellers
Potential unrest
Land use competition
Damage to housing and infrastructure
Migration to cities
Degraded air and water quality

Note: • Pressures and responses are not presented in this diagram
• Key state and trends are presented in the chapter
• Colored city-level impacts are caused by the interaction of several drivers and pressures

use change, are increasing at 0.6 per cent a year. As of 2018, the resulting atmospheric CO_2 concentration is 407.4 parts per million and the global temperature has risen by of 1.0˚ C (IPCC 2018; Friedlingstein *et al.* 2019; World Meteorological Organization [WMO] 2019a). The second major human-influenced greenhouse gas is methane (CH4). A recent study estimated 575 million tons of CH4 were emitted per year from 2008 to 2017, with 60 per cent of emissions caused by direct human activity such as agriculture, waste management and activities related to fossil fuels (Saunois *et al.* 2020). The warming impacts cities by increasing their mean and extreme temperatures, changing precipitation patterns (resulting in droughts and floods) and increasing the frequency and intensity of cyclonic storms, as well as contributing to rising sea levels (IPCC 2018). These climate pressures impact human health through exposure to extreme temperatures, increased air pollution due to air circulation stagnation events, reduced quality food and water, changes in infectious agents, and population displacement (Balbus *et al.* 2016).

Air quality is currently the largest environmental health risk in cities (UNEP 2019). Globally, poor air quality contributes to 6–7 million premature deaths every year due to outdoor (ambient) and indoor (household) air pollution (Health Effects Institute 2020; World Health Organization [WHO] 2020). Air pollutants know no boundaries: the air quality of cities can be significantly impacted by human and natural activities outside their jurisdiction. The fact that cities cannot control emissions from outside their boundaries presents an urban governance challenge for air quality mitigation strategies. There are only a few examples of transboundary initiatives to improve air quality, including the California Air Resources Board in the United States and the 1979 Convention on Long-range Transboundary Air Pollution, a pioneering instrument that established a regional framework covering Europe, North America, and Russia and former East Bloc countries to reduce transboundary air pollution (United Nations Economic Commission for Europe [UNECE] 2019). More effort is needed to establish air pollution control strategies within cities and across jurisdictions to reduce the human health impacts of these pollutants. It is important to emphasize that air quality and climate change are linked, from their sources, which are primarily from the combustion of fossil fuels, through to their impacts (for example, urban heat islands affect the concentration of air pollutants in cities). As such, they must be addressed in a coordinated manner (Melamed, Schmale and von Schneidemesser 2016).

Dust storms are an example of global environmental changes impacting the climate and air quality in both urban and non-urban spaces (UNEP, WMO and UNCCD 2016) Events such as the Saharan dust storm in June 2020, are expected to become more intense due to increased warming in the North Atlantic and weaker Azores Highs (Clifford *et al.* 2019). The June 2020 dust storm was the largest such storm in decades. Atmospheric circulation patterns transported dust from the Sahara Desert across the Atlantic Ocean, increasing air pollution across the Caribbean, the south-east of the United States, Mexico and Central America (Çapraz and Deniz 2020; Farahani and Arhami 2020; Freedman, Cappucci and Samenow 2020; Soleimani *et al.* 2020). The impacts on human health, weather and climate are currently being studied (United States National Aeronautics and Space Administration 2020).

Other examples include the extreme wildfire seasons in Australia and the United States in 2020, fuelled by record temperatures and severe droughts. Smoke from the wildfires temporarily resulted in the worst air quality in the world in Canberra (Vardoulakis *et al.* 2020) and San Francisco (Cabanatuan 2020). Located at the wildland–urban interface, the fires destroyed many homes, which affected the composition of the smoke. There is still a significant amount to learn about the emissions and chemical processes that occur during wildland–urban interface fires and their impact on human health (National Academies 2020).

3.2.2 Biodiversity

Biodiversity is directly linked to the quality of life of urban citizens, providing a multitude of benefits for humans from ecosystem services and nature's contributions to people.[3] Such services include provisioning (food), regulating (filtering for clean air and water), supporting (underlying and enabling the production of all other ecosystem services) and culture (recreational and aesthetic enjoyment). Biodiversity comprises the biotic natural resources that underpin humanity and urban settlements and allow them to thrive. The world is currently experiencing rapid biodiversity loss (Díaz *et al.* 2019; Intergovernmental Science–Policy Platform on Biodiversity and Ecosystem Services [IPBES] 2019; UNEP 2019). The current rate of global species loss is estimated to be at least tens to hundreds of times greater than the average historical rate of extinction over the past 10 million years, and continues to accelerate, threatening a sixth planetary extinction event within a few centuries (Barnosky *et al.* 2011; Pimm *et al.* 2014; Ceballos *et al.* 2015; Ceballos, Ehrlich and Dirzo 2017; IPBES 2019, section 2.2.5.2.4).

Biodiversity loss impacts cities through the loss of ecosystem functions and the services they provide. Yet biodiversity loss is not inherent to cities: they can also be rich in biodiversity (Elmqvist *et al.* 2013; Aronson *et al.* 2014; Ives *et al.* 2016). Moreover, maintaining biodiversity can provide with significant cost savings. It is key for maintaining functional ecosystems, adapting to other environmental challenges like climate change and providing benefits for humans (Millennium Ecosystem Assessment 2003; Millennium Ecosystem Assessment 2004; Haines-Young and Potschin 2010; Díaz *et al.* 2018; Díaz *et al.* 2019). For example, the loss of insect species that pollinate crops and other vegetation outside the city (a regulating ecosystem service) lowers agricultural productivity, leading to food insecurity (Food and Agriculture Organization of the United

3 Although they are similar, it is possible to distinguish between ecosystem services and Nature's Contributions to People. The former focus on the benefits society receives from ecosystems (see, for example Millennium Ecosystem Assessment 2003; The Economics of Ecosystems and Biodiversity [TEEB] 2011; International Union for the Conservation of Nature 2013; Convention on Biological Diversity 2015; MacKinnon et al. 2019). In contrast, the latter considers both their positive and negative contributions (see, for example, Pascual et al. 2017; Díaz et al. 2018; Intergovernmental Science–Policy Platform on Biodiversity and Ecosystem Services 2019). While this distinction is important, for clarity, we have opted to use the term ecosystem services, since it is more familiar. However, as Kadykalo et al. (2019) note, Nature's Contributions to People is a broader concept.

Nations [FAO] 2015; Mbow *et al.* 2019). Similarly, urban trees substantially reduce pollution (a regulating ecosystem service). This brings major economic benefits, with one estimate based on 10 megacities calculating average annual health savings of $482 million (Endreny *et al.* 2017).

Species diversity also supports ecological and functional redundancy and resilience in the face of environmental shifts (Walker 1992; Rosenfeld 2002; Elmqvist *et al.* 2003; Luck, Daily and Ehrlich 2003; Mori, Furukawa and Sasaki 2013; Oliver *et al.* 2015). For example, the presence of multiple urban coastal wetland plant species can help maintain the ecosystem services of water quality provision and protection from erosion, tidal currents and flooding from storms, even if populations of one particular species are eliminated (Boyer and Polasky 2004).

Urban biodiversity can also help to reduce the impact of infectious diseases, such as when organisms prey upon disease vectors (for example bats, spiders and dragonflies prey upon mosquitoes). It can also include organisms that absorb or "dilute" some of the burden of disease on humans (Epstein 1995; Ostfeld and Keesing 2000; Chivian and Bernstein 2004; Campbell *et al.* 2011; Taylor and Hochuli 2015). A good example of this phenomenon would be the reduction in the transmission of Lyme disease by ticks biting other animals rather than humans. Shifts in biodiversity in cities can have negative effects, or result in ecosystem "disservices" (Lyytimäki and Sipilä 2009) caused by environmental transformations in urban environments (Villa *et al.* 2014). For example, increased proximity between humans and animals in urban settings can also contribute to the spread of zoonotic diseases (Lyytimäki *et al.* 2008; Dobbs, Escobedo and Zipperer 2011; Escobedo, Kroeger and Wagner 2011), of which the current COVID-19 pandemic is a case in point (Leite Júnior *et al.* 2020; Platto *et al.* 2020).

3.2.3 Freshwater

Cities and their environmental dimensions of sustainable development depend on access to sufficient and safe freshwater resources. This explains why cities have historically developed near freshwater bodies. Moreover, prolonged droughts, devastating floods and water mismanagement have led to the fall of multiple civilizations (van den Brandeler and Gupta 2020). Disasters caused by extreme hydrological events have increased significantly in recent decades (partly as a result of climate change) and cities are particularly vulnerable to weather and climate extremes such as droughts, floods and the resulting water quality problems (Pahl-Wostl 2015; see also chapter 4). For instance, 79 large cities have suffered extensively from droughts since 2000 (Xiang *et al.* 2019), including megacities such as São Paulo in Brazil. Similarly, in 2018, Cape Town narrowly escaped "day zero" on which it would effectively have run out of water, albeit at the cost of severe restrictions on water use for residents (Rodina 2019).[4] Many cities face challenges to adapt to more frequent water shortages as a result of rapid and unplanned urban growth and inadequate water management. This trend is exacerbated by the changes in precipitation caused by climate change (IPCC 2018). Rising sea levels can also lead to saltwater intrusion that threatens urban groundwater supplies in coastal cities and their surroundings (Safi *et al.* 2018). Finally, deforestation and other land-use changes in the watersheds of cities are further stressing urban water supplies and increasing the intensity of flooding (McDonald and Shemie 2014).

These pressures have led to tensions between urban and rural water users, especially given that agriculture accounts for an average of 70 per cent of global freshwater withdrawals (FAO 2017). There are also pressures within cities between different peri-urban water users and social groups. Water scarcity and droughts affect the availability of ecosystem services in cities, with negative effects on the health of residents, which can have knock-on effects on social stability (Xiang *et al.* 2019). Chronic water stress and extended droughts contribute to increased migration of people from rural to urban areas (often into informal settlements) and can drive international migration that can fuel or aggravate refugee crises and conflicts (King 2015; Berchin *et al.* 2017).

Moreover, the proportion of urban land subject to frequent flooding is likely to increase from 30 per cent in 2000 to 40 per cent in 2030 (Güneralp, Güneralp and Liu 2015). However, many developing countries lack accurate data on flood risks in cities, a situation that hampers efforts to build resistance (Frick-Trzebitzky, Baghel and Bruns 2017; Osuteye, Johnson and Brown 2017). Finally, while land-use and urban development factors (especially the expansion of impervious areas) are major drivers of increased flood risk, climate change puts additional stress on urban storm and wastewater infrastructure (Güneralp, Güneralp and Liu 2015; Avashia and Garg 2020).

3.2.4 Oceans and coasts

Human settlements have historically grown up around natural harbours. In 2018, a total of 21 of the world's 33 megacities were located in low-lying coastal areas (United Nations 2018). More than 700 million people are estimated to live in urban or quasi-urban areas that are 10 metres or less above sea level (Colenbrander *et al.* 2019). These coastal communities are increasingly vulnerable to the effects of human-induced climate change. Increases in mean sea level and extreme weather events are predicted to continue throughout the century and beyond (IPCC 2018). Models of the vulnerability of coastal populations indicate that, even the rise in sea levels predicted under a low-carbon emissions scenario will threaten almost 200 million people who currently live in areas that will be under water at high tide by the end of the century (Kulp and Strauss 2019). Damaging saltwater intrusion caused by over-extraction of water resources in coastal cities and exacerbated by rising sea levels can infiltrate groundwater (often a source of drinking water), impede drainage and contribute to the contraction and disappearance of shoreline protecting coastal habitats.

4 Section 5.3 examines how Cape Town has built resilience to tackle this situation in future.

Rising sea levels also increase the exposure of coastal cities to storm events. As well as destroying coastal infrastructure, severe storms can have long-term impacts on coastal morphology, eroding beaches and reshaping river mouths, especially when stabilizing vegetation has been removed. Storm surges (caused by strong winds that push seawater onshore) are the main driver of coastal flooding (Resio and Westerink 2008). In 2019, the storm surge from Hurricane Dorian resulted in $4.6 billion of damage in the Bahamas, the United States and Canada. On the island of Grand Bahama, the storm surge reached over seven metres (Le Page 2019). Similar levels of destruction are common across the tropics and modelling suggests that the number of extreme weather events could double in coastal cities by 2050 (Vitousek *et al.* 2017).

In some cases, the impacts of higher tides from rising sea levels and increasing storms are exacerbated by significant land subsidence caused by groundwater extraction and building on compactable coastal sediments. Residents of many coastal cities, such as Jakarta, Venice and Bangkok, as well as urban atoll islands, are already directly or indirectly experiencing these negative impacts (IPCC 2014). Moreover, continued population growth in these high-risk coastal areas is likely to mean more people will suffer adverse physical, social and economic consequences.

Finally, wild-catch fisheries and mariculture are financially and culturally important to many coastal communities. Rising ocean temperatures, nutrient run-off, pollution and acidification are already impacting mariculture and wild fish catches, threatening the livelihoods and food security of communities (Bindoff *et al.* 2019). Major wild-catch fish-producing countries in South-East Asia and South America are likely to be disproportionally affected by the impacts of climate change on fish stocks (Nong 2019). Moreover, in many communities women dominate near-shore fishing and gleaning, meaning they are likely to be most affected by the degradation of coastal marine resources (FAO 2016).

3.2.5 Land and soil

As hubs of human activity, cities require land-based resources such as food, fodder, fibre and forest products that mainly depend on land areas beyond their limits. Land also provides other services such as shelter, property and cultural identity (UNCCD 2017). Land in urban areas and beyond can also be significantly impacted by urban planning decisions, which can have both positive and negative effects on residents. Many of these aspects are affected both directly and indirectly by environmental degradation and urban settlements are no exception. Indirect impacts due to telecouplings are more common than direct impacts and the biggest impacts are arguably on the most important resources of cities. Food and water, for example, mainly come from beyond the city, meaning changes in those areas can significantly affect urban life (chapter 4).

Changing land cover in rural and wild areas indirectly impacts cities. For example, there are causal links between deforestation in the Brazilian Amazon and droughts in southern Brazil, including in cities like São Paulo (Nobre 2014). If deforestation of the Amazon basin continues, it may jeopardize the rainforest's role as the source of rainfall for areas beyond it and could reduce the availability of water in cities and rural areas (Lovejoy and Nobre 2018). The degradation of land resources is associated with changing land cover, fragmentation, desertification and erosion, all of

which severely impact biodiversity (IPBES 2018) and affect well-being at the city level. These impacts affect areas that provide the ecosystem services needed to maintain urban function in cities.

Another illustration of the complex indirect impacts of land resource use and urbanization is the degradation of the land itself. Land degradation is a process that reduces many of the land's characteristics, such as productivity, porosity, vegetation, biomass and biodiversity, in addition to the ecosystem services provided by land resources (UNCCD 2017). Value lost from land degradation and land-use change was estimated to be 10–17 per cent of global gross domestic product (GDP), based on figures for 2010 (ELD Initiative 2015). This has numerous impacts on urban areas. Land degradation reduces agricultural productivity, which can drive up food prices and force farmers in degraded rural areas to seek better opportunities by migrating to cities. It can also lead to expansion of the agricultural frontier as more land is needed for farming to satisfy the resource needs of human populations.

Other direct impacts of global environmental change on land include coastal erosion, which threatens urban infrastructure and increases the vulnerability of coastal dwellers. Climate-induced flooding and land subsidence are expected to cause significant loss to some of the densest coastal cities (Hallegatte *et al.* 2013). Moreover, as mangroves, marshes and other ecosystems are transformed into urban areas, these cities become more susceptible to erosion, storm surge damage and flooding. As urbanization continues, these direct and indirect impacts will likely increase unless urban form and function, equity, transportation, and water and food footprints are transformed to make cities more environmentally sustainable (UNCCD 2017; see also section 4.2).

3.3 How are cities affecting the environment locally and globally?

In parallel to the effects of global environmental change on cities, the current process of urbanization and development of cities is also affecting local, regional and global environments. Sewage pollution in rivers also pollutes coastal areas. Similarly, the effects of urban air and land pollution are not confined to cities: air pollution can degrade ecosystems through acid rain, contributing to biodiversity loss and land cover change beyond the city boundaries. Demand for certain products can also affect and transform land use and ecosystems through telecouplings. This section considers the main impacts of urban areas on the environment and how land-use planning can help minimize the environmental side effects of urbanization.

3.3.1 Air

Greenhouse gas emissions from cities have local, regional and global impacts. While cities cover just 2 per cent of the world's land, their concentration of human consumption and activity means they are responsible for around 70 per cent of total human-induced emissions (UN-Habitat 2016). This means greenhouse gas emissions from cities have a significant impact on the planet as a whole through their impact on climate change.

Emissions of air pollutants from cities impact human health, climate, ecosystems, and food and water security from the local to regional levels (WHO 2016a). Based on the available data, 98 per cent of cities with populations over 100,000 in low-income and middle-income countries exceed WHO guidelines for PM2.5 or PM10, compared with 56 per cent of cities in high-income countries (ibid.). While the density of urban areas increases the efficiency of transport and energy, their high population density and increased consumption and economic activity also lead to higher concentrations of emissions from transport, heating and cooling, waste and construction. These "density trade-offs" also mean more people are potentially exposed to poor air quality and noise (Mueller *et al.* 2020). Air pollution from cities is also transported beyond city boundaries and can be generated downwind through chemical reactions in the atmosphere. In India, for example, ground-level ozone pollution, primarily from air pollution emissions in cities, is responsible for crop yield losses that could feed about 94 million people (Ghude *et al.* 2014).

High levels of greenhouse gas emissions and air pollutant emissions in cities mean local governments and city residents can play a key role in mitigating climate change and improving the air we breathe. While the COVID-19 pandemic initially reduced global greenhouse gas and air pollutant emissions (Forster *et al.* 2020), the reductions did not necessarily translate into improved air quality (Kroll *et al.* 2020; Le *et al.* 2020; Shi and Brasseur 2020). Moreover, the temporary reduction in greenhouse gas emissions is unlikely to have a measurable impact on reducing climate change over the long term (Forster *et al.* 2020; Le Quéré *et al.* 2020). However, the pandemic has provided an opportunity to take stock, allowing researchers to study how reduced emissions in cities will impact local and global air quality and the climate in both the short and long term. This will provide insights into ways to simultaneously improve air quality and mitigate climate change in cities after the pandemic (Forster *et al.* 2020; Rosenbloom and Markard 2020) and research on the impact of reduced emissions during the COVID-19 pandemic may shape air quality and climate change policies for years to come (Schiermeier 2020).

3.3.2 Biodiversity

Cities impact biodiversity both directly, within the urban environment due to urban expansion, and indirectly, through the transformation of ecosystems to produce food and the other resources and provisioning services needed in the city (McDonald, Marcotullio and Güneralp 2013; Seto 2014, McDonald *et al.* 2020). The impacts mainly come from the destruction of natural landscapes and the fragmentation of habitats (for example, palm oil or soy bean production in South-East Asia and South America, respectively), as well as from changes in living conditions, such as temperature increases, changes in the availability and quality of water, soils, nutrients and biomass, and pollution (Pickett *et al.* 2001; Grimm *et al.* 2008). Urban growth is estimated to have caused 190,000 km^2 of habitat loss between 1992 and 2000,

with a further 290,000 km^2 expected to be lost between 2000 and 2030 (The Nature Conservancy 2018; McDonald *et al.* 2020). Species composition in urban areas may also change through the introduction of non-native or invasive species (Müller *et al.* 2013).

The active selection of organisms by humans through activities such as landscaping, gardening and pet breeding alters the composition of species in city landscapes (Williams *et al.* 2009; Kendal, Williams and Williams 2012; Aronson *et al.* 2016; Jenerette *et al.* 2016; Pearse *et al.* 2018). These changes may cause losses and gains in species and result in urban assemblages of species that are both native and non-native to the surrounding area (Ives *et al.* 2016; Lepczyk *et al.* 2017a). Despite the potential for losses, it is nonetheless possible to maintain a significant portion of native biodiversity in the city. For example, in a sample of 110 cities, a majority of native bird and plant species are present in urban areas but their density is significantly lower than non-urban habitats (Aronson *et al.* 2014). In this same sample, another study found that a median value of 52 per cent of plant species were native (La Sorte *et al.* 2014), although not all species have the same adaptability to the urban environment (Lin *et al.* 2012).

Some domesticated areas, such as gardens and parks, may have a greater number and variety of plant species than natural areas in cities (Pearse *et al.* 2018) or the landscape outside the city (Kühn, Brandl and Klotz 2004). Other urban biodiversity trends include biological homogenization, where species composition becomes similar across different urban areas (McKinney 2006; La Sorte, McKinney and Pyšek 2007; McKinney 2008), a phenomenon that may be explained by global plant exchange and the nursery trade, shared aesthetic ideals and trends (Ignatieva and Stewart 2009) and the introduction of potentially invasive alien species. The movement and exchange of organisms can also introduce microorganisms through waste disposal, tourism, food and global transport (Zhu *et al.* 2017), which can favour the spread of some diseases.

There are few studies of urban biodiversity at the global scale (McDonnell, Hahs and Breuste 2009). Most have focused on a single type of organism across multiple locations or patterns of multiple types across a single city (Aronson *et al.* 2014). Most urban biodiversity studies have a regional bias focused on the Global North and temperate areas (Aronson *et al.* 2014; McDonald *et al.* 2020).

Cities are usually a heterogeneous mosaic of habitat patches, offering valuable opportunities for the conservation of certain species and ecosystems (Elmqvist *et al.* 2013; Aronson *et al.* 2014; Ives *et al.* 2016) and to improve their functioning and connections with the surrounding landscapes (section 4.2). The extent of biodiversity within a city depends largely on how much green space is kept intact both inside and outside the city, as well as its connectivity and size (Goddard, Dougill and Benton 2010; Beninde, Veith and Hochkirch 2015). Green spaces include parks, conservation areas, abandoned lots, green roofs, private residential gardens, rivers and reservoirs. Most of these areas also contribute to the well-being of citizens. For example, the Complete Streets approach to transport design promotes street space not only as a transport corridor but also as a social space that enhances the urban environment through leisure, culture and recreation activities, and greenery (Achuthan *et al.* 2019). This improvement contributes to people's health by reducing noise and air pollution and providing opportunities for urban biodiversity. Examples of this initiative can be found globally in cities as diverse as New York, Paris, Bangalore and Buenos Aires.

Urban planning also plays a critical role in improving levels of biodiversity, through ecosystem restoration, the implementation of green and blue infrastructure, biodiversity corridors and nature-based solutions through which species can move (Connop *et al.* 2016; Raymond *et al.* 2017; see also chapter 2). The characteristics of urban green infrastructure determine the environmental quality and ecosystem services provided in the urban landscape (Andersson *et al.* 2020). To be functional, urban ecosystems should be linked to other ecosystems in rural areas through corridors or other restoration efforts (Cohen-Shacham *et al.* 2016; see also chapter 4 and section 5.4.1). Careful consideration of the benefits and trade-offs (for example, social, environmental, and economic) of different ecological configurations is required when deciding the kinds of biodiversity and corresponding functions to be supported in the "novel ecosystems" of cities (Kowarik 2011; Lepczyk *et al.* 2017b; Backstrom *et al.* 2018; see also chapters 4 and 5).

3.3.3 Freshwater

Urbanization increases soil sealing (Ferreira, Walsh and Ferreira 2018), a term used to describe the covering of the ground by impermeable materials that interferes with natural drainage patterns, increasing stormwater run-off and flood risks (Oudin *et al.* 2018; Ren *et al.* 2020). It also prevents groundwater recharge and increases pollution of urban and downstream water bodies. Surface treatments, such as metalled roads, are a major source of ions in groundwater, which can impact the drinking water supply and infrastructure and cause coastal alkalization (Kaushal *et al.* 2017). The effects are worse in sprawling cities (Lee *et al.* 2006; Chen *et al.* 2020). Cities encroach on springs, wetlands and coastal ecosystems, contributing to direct habitat loss, modifying hydrological and sedimentation regimes and altering the dynamics of nutrients and chemical pollutants far beyond urban boundaries (Lee *et al.* 2006). Unplanned urbanization, especially in the cities of the Global South, creates further challenges through the occupation of hillsides and floodplains and the persistence of water infrastructure deficits (Mguni, Herslund and Jensen 2016; Williams *et al.* 2019; see also section 4.2).

Domestic and industrial wastewater and other contaminants are still frequently discharged untreated into water bodies and their instream habitats due to inadequate or absent wastewater infrastructure (McGrane 2016). This has a major impact on the water quality of lakes, wetlands, rivers, aquifers and aquatic life, both within and outside cities (section 4.2). It is also responsible for waterborne

diseases, increased regional water stress and higher costs of water treatment. Emerging priority contaminants, such as pharmaceuticals (for example, antibiotics and antimicrobials) and endocrine-disrupting chemicals, are under-regulated and their long-term consequences on human and ecological health remain unclear. Some persistent organic pollutants (sometimes referred to as "forever chemicals") cannot be removed by current drinking water treatment measures. Diffuse pollution inside cities, from solid waste and lawn fertilizer, and from agricultural fertilizers and pesticides used in rural areas upstream can be regulated to prevent severe degradation of water resources at the local and regional level. In addition to the lack of adequate drainage or flood control infrastructure, solid waste exacerbates hydrological hazards like floods by blocking drainage infrastructure.

Between 1.6 and 2.4 billion people through the world live in river basins that experience water scarcity. This figure has the potential to rise to between 3.1 and 4.3 billion people by 2050, equivalent to 20–30 per cent of the global population (Gosling and Arnell 2016). Demand for water in urban areas is projected to increase by 80 per cent between 2018 and 2050 while total available freshwater will remain more or less constant (Flörke, Schneider and McDonald 2018). In addition to population growth, the economic development that often follows urbanization further increases per capita water use in cities (McDonald *et al.* 2014). The organization of water governance in urban areas (conventional, integrated or adaptive) can further shape approaches to demand and supply management, including the emphasis on measures such as water use efficiency, water loss reduction and greywater reuse (van den Brandeler, Gupta and Hordijk 2019). As sites of concentrated water demand and political and economic power, cities rely on inter-basin transfers for water supplies. However, these can cause water shortages for communities in supply basins and environmental degradation that affects aquatic species (McDonald *et al.* 2014; van den Brandeler 2020). For example, the access of indigenous communities in the rural hinterlands of Mexico City to their local springs was restricted to in order to pipe water and transfer it to the city (Delgado-Ramos 2015; Aragón-Durand 2019).

Measures to increase the urban water supply, such as inter-basin transfers and dams, can thus aggravate tensions between urban and rural areas, as well as regional tensions (Turton *et al.* 2006; Mgquba and Majozi 2020). Unregulated groundwater use in and around urban areas typically depletes aquifers, increasing contamination and causing land subsidence and subsequent damage to underground infrastructure such as pipes, as well as to infrastructure above the ground (Chaussard *et al.* 2014; Minderhoud *et al.* 2017; Hoekstra, Buurman and van Ginkel 2018). Yet there is a general lack of data on groundwater volumes, quality and flows (Flörke, Schneider and McDonald 2018). Cities also affect rainfall patterns as a result of their artificial thermal properties (the urban heat island effect) and increased particulate matter, which can increase downwind precipitation and the generation of convective summer thunderstorms (McGrane 2016).

3.3.4 Oceans and coasts

In many places around the world, from small island states to megacities, urbanization is largely concentrated along the coast (Tibbetts 2002). This concentration of development impacts the marine and coastal environment at the local, regional and global scales. The local impacts include loss and degradation of coastal habitats and

ecosystems and reduction in water quality (section 4.2). Ports and harbours are sources of pollution and are often sites of historical contamination that may pose an ongoing ecological threat. Examples of impacts that extend beyond the local marine environment include those related to the movement of litter, nutrients and other contaminants (both from discharge and run-off and releases to the atmosphere), as well as invasive alien species. As major sources of atmospheric CO_2, cities in general drive global ocean warming and acidification (IPCC 2001; Licker et al. 2019).

Changes to coastal hydrodynamics from shoreline and catchment modifications can have major impacts on sediment deposition and transport. Research shows that coastal fortifications, such as sea walls, that are put in place to protect coastal infrastructure from storms and rising sea levels increase coastal erosion in other areas (Gracia *et al.* 2018). Large-scale engineering works, such as land reclamation, can radically alter the coastal environment. For example, Singapore has reportedly lost more than 65 per cent of local coral reef coverage due to land reclamation (Hilton and Manning 1995; Chou 2016). Despite action in many countries, mangroves, salt marshes, coral reefs and dune systems are still being lost to urban development. Urban population growth also exerts direct pressure on local fisheries around the world (through habitat loss and conversion), as well as indirect pressure, as seafood consumption continues to rise (Bange *et al.* 2017).

Many urban centres are struggling to manage the rise in solid waste. Up to 80 per cent of litter entering the oceans is thought to be from mismanaged urban waste (Li, Tse and Fok 2016). Estimates suggest that the biggest contributors are middle-income countries whose waste management systems have not kept pace with their economic development (Jambeck *et al.* 2015). Litter can accumulate on shorelines, degrade into microparticles that can enter the food chain, sink to the sea floor or remain in circulation, and act as a vector for invasive alien species. Ingestion and entanglement pose a threat to marine organisms and birdlife (UNEP and GRID-Arendal 2016) and can contribute to greenhouse gas emissions (Royer *et al.* 2018).

Cities are also a major source of chemicals in the ocean. Chemicals can be leached from discarded materials, such as plastics, or come directly from land-based and marine sources, such as riverine outflow, coastal run-off, storm water, sewage discharge, airborne particulates, shipping and fishing. High concentrations of persistent organic pollutants, heavy metals like mercury, microplastics and pharmaceuticals are routinely found in fish and shellfish near coastal urban centres (Milenkovic *et al.* 2019; Walkinshaw *et al.* 2020). The discharge or leakage of untreated sewage into the coastal zone is common in many coastal cities, especially in developing countries (UNEP 2016a). Despite continued improvement in wastewater treatment throughout the world, population growth is predicted to outpace any progress made, resulting in increasing nutrient discharge into surface waters, including estuaries and coasts (van Puijenbroek, Beusen and Bouwman 2019).

3.3.5 Land and soil

As a scarce resource, studies show that the physical footprint of urban areas tends to use much less land than other human settlements (UNCCD 2017). Cities house over half of the world's population on less than 2 per cent of its habitable land (Ritchie and Roser 2013; OECD and European Commission 2020). This per capita "efficiency" of people per unit of land increases in line with settlement class (from village to city) and proximity to the city centre (suburban areas are half as efficient as urban centres) (European Commission Joint Research Centre [EC,JRC] 2019). However, "efficiency" needs to be considered more broadly.

Consumption-based ecological footprint studies indicate that an average urban resident's indirect or "telecoupled" land-use (Leisz *et al.* 2016), accounting for urban needs like food, could be around 20 times their direct land-use (Zeng and Ramaswami 2020). These urban consumption patterns directly influence environmental outcomes and need to be transformed (section 4.2). While increased construction densities may promote per capita land-use "efficiency", the inadequate provision of basic services may increase the risk of communicable diseases and reduce quality of life due to overcrowding. This has become particularly evident in some cities during the COVID-19 pandemic (Rocklöv and Sjödin 2020).

Studies indicate that the use of urban land in terms of size, form and the quality of the urban fabric has implications for the local and regional climate (Morote and Hernández 2016; Hanif 2018; Artmann, Inostroza and Fan 2019). While small, dispersed and spread-out cities may alleviate local urban heat islands (Zhou, Rybski and Kropp 2017), they are also associated with higher energy consumption, pollution and carbon footprints, cancelling out any local gains. In contrast, planned cities that are green and dense can mitigate the risk of heat islands at the same time as providing healthy living conditions (Li *et al.* 2020).

Industrial land uses within cities can pollute soil with chemicals containing elements like lead, arsenic and cadmium (Sharley *et al.* 2017; Kubier, Wilkin and Pichler 2019). The expansion of urban areas brings increased industrialization in the urban fringe, which can result in extreme soil pollution (Han *et al.* 2021). Nature-based infrastructure solutions are gaining prominence as part of the effort to address these impacts and promote ecosystem and human health, (Tzoulas *et al.* 2007; Morris *et al.* 2018). As the built environment and materials contribute significantly to increases in greenhouse gas emissions (Meng *et al.* 2017; Kayaçetin and Tanyer 2020), today's urban development and infrastructure investment choices will affect carbon lock-in in the future (Seto *et al.* 2016; see also chapter 4).

One of the major telecouplings of urban areas is food production. About one-third of food grown throughout the world is wasted, either at source, on the way to markets or by consumers (Lipinski *et al.* 2013). With more than 55 per cent

of people living in urban areas, food wastage can increase urban food prices and greenhouse gas emissions as wasted food decomposes in landfills. It also indirectly contributes to habitat loss, since more land is needed for food production, and fertilizers, other inputs and fuel for transportation are wasted. Since food systems are directly or indirectly connected to all 17 SDGs, urban lifestyles and patterns of consumption can affect both sustainable development outcomes and the global climate, especially for the developing world. Many cities are promoting urban agriculture with the potential to significantly reduce the urban ecological footprint and increase food security (Corbould 2013). However, the form this takes (vertical farms, small community farms, etc.) depends on the context of individual cities (Opitz *et al.* 2016; Clinton *et al.* 2018; Azunre *et al.* 2019; Edmondson *et al.* 2020; see also section 5.2.2).

Land-use and land-cover changes and other transformations due to urban expansion (ECJRC 2018) and the resource requirements of cities are occurring at the expense of fertile soils and forest cover, further stressing food security (Güneralp *et al.* 2020) and the loss of ecosystem services (for example, regulation of water and air quality, habitat conservation and carbon storage) (Xie *et al.* 2018). There is an urgent need to understand the trade-offs between the different urban expansion models before committing to largely irreversible changes (Pols and Romijn 2017).

Many countries, especially in the Global South, are also experiencing unplanned urban expansion, through informal settlements, often on environmentally sensitive and vulnerable locations such as slopes, flood plains and wetlands. Human-generated waste in such unplanned developments further pollutes water and soil due to the lack of adequate waste management systems and the increasing the area of unregulated landfills (UNEP 2015; UNEP 2019; Satterthwaite *et al.* 2020). These encroachments destroy and fragment critical habitats. including those of surrounding wildlife, and may cause conflict between humans and wildlife.

3.4 Data and information needs on the state and trends of the environment at the city scale

The previous sections highlighted two critical aspects of urban settlements: firstly, how cities are both affected by and contribute to environmental change; and secondly, how the impacts of environmental change are interconnected and experienced in different ways in different locations (even within the city). **Table 3.1** highlights the relationship between the current environmental state and trends at the city scale and the corresponding data and information needs for decision makers and researchers to be able to better track progress on the important transformations that are needed. The table highlights some of the main data and information gaps related to the urban environment. Filling these gaps is paramount for environmental management, since this will provide valuable information on the interlinkages across the different environmental dimensions (air, biodiversity, freshwater, oceans and coasts, land and soil) and between people and the environment (UNEP 2019, chapter 3).

Table 3.1: Knowns and unknowns at the city scale

Environmental dimension	What we know	Remaining gaps in knowledge
Air	While certain parts of the world are improving air quality, in many cities it is deteriorating and exceeds WHO guidelines for $PM_{2.5}$ and NO_2. Together with greenhouse gases, non-climate air pollutants strongly affect air quality in urban centres. Particulate matter ($PM_{2.5}$ and PM_{10}), alongside some toxic chemicals, are the biggest environmental health risk factor, while ultrafine particles in vehicle exhaust emissions are a source of increasing public health concern in cities. These exposures have a negative impact on the health of urban populations. Poor air quality is caused by anthropogenic and natural emissions of air pollutants from local and regional sources and the formation of secondary pollutants in the atmosphere. This includes global and long-range transport of air pollution. The continued increase in CO_2 and other greenhouse gas emissions and the resulting atmospheric concentration translates into extreme heatwaves, increased droughts and precipitation deficits, flooding and increased precipitation, and rising sea levels in coastal cities (IPCC 2018). COVID-19 is a unique opportunity to study the short- and long-term impacts of reduced emissions on air quality and climate change. This will likely influence mitigation strategies in the future.	Air quality monitoring is limited in many low- and middle-income cities (as well as in some high-income ones), hindering proper air quality assessments. In some cities, there is no monitoring data at all. Satellite monitoring data such as the Copernicus Atmosphere Monitoring Service can help fill gaps. In addition to air quality monitoring, emissions inventories and air quality modelling are needed in lower-income countries to understand the sources and impacts of emissions. Integrated urban hydrometeorological, climate and environmental systems and services are needed and the full spectrum and complexity of urban hydrometeorological and climate hazards need to be considered (WMO 2019a). The methodology for calculating air quality indicators, such as indexes, needs to be standardized globally. Better air pollution epidemiology and the attribution of specific pollutants to disease burden in the urban centres is needed to allow decision makers to target the reduction of specific air pollutants to reduce health impacts. Monitoring and emission inventories are essential for common air pollutants and priority chemicals, such as toxic trace metals and cancerogenic and mutagenic polycyclic aromatic hydrocarbons. Detailed climate change models are needed at the city level to provide better information on potential impacts.

Environmental dimension	What we know	Remaining gaps in knowledge
Biodiversity	Biodiversity is declining globally at all three key levels: genes, species and ecosystems (Pereira *et al*. 2010; Pimm *et al*. 2014; IPBES 2019). Historically, urban growth has been shown to contribute to natural habitat loss, encroach upon protected areas and reduce the habitat ranges of species on the International Union for Conservation of Nature Red List. These trends are projected to continue in the future (The Nature Conservancy 2018; McDonald *et al*. 2020). While biodiversity is decreasing on a global scale, at some local and regional scales in cities, species richness may actually be increasing, with "novel ecosystems" (Hobbs *et al*. 2006) formed from the addition of non-native species (Sax and Gaines 2003; Müller *et al*. 2013), some of which become invasive.	Although biodiversity is decreasing globally, the rate, magnitude and direction of change in biodiversity can vary depending on the scale and whether we are talking about urban or rural environments (Sax and Gaines 2003; The Nature Conservancy 2018). There remain gaps in biodiversity monitoring at the urban scale. Quantification of indirect urban impacts, such as food consumption, energy use and waste production, on biodiversity are less well studied than direct impacts like loss of habitat (McDonald *et al*. 2020). Recent IPBES assessments do not explicitly analyse the urban–rural relationship when it comes to biodiversity (IPBES 2019). Urban biodiversity studies need broader geographic coverage: there is a regional bias focused more on the Global North and temperate areas and less on the Global South, tropical areas and biodiversity hotspots (Aronson *et al*. 2014; McDonald *et al*. 2020).
Freshwater	More and more urban dwellers are exposed to risks related to heavy precipitation and floods. Risks of water supply shortages are also rising in urban areas (Flörke, Schneider and McDonald 2018), aggravating challenges to access sufficient and clean water. Access to drinking water and sanitation has improved in urban areas but residents in informal settlements often remain excluded. SDG 6 progress shows there are still huge gaps in provision, especially in low-income countries. Larger cities increasingly rely on transfers between basins. Water shortages increase tensions and conflicts between urban and rural water users, and between different users in urban and peri-urban areas. Saline intrusion into freshwater supplies is a growing threat to coastal cities. Point source and diffuse pollution of freshwater bodies also remain a concern. Lakes and ponds in urban areas are natural sinks for stormwater drainage, which means they are especially sensitive to urban pollution from solid waste, sanitation and chemicals.	A lack of reliable integrated data hinders assessing the impacts of hydrological disasters in terms of economic and infrastructural damage. Flood impact assessments (pluvial, fluvial, coastal and rising sea levels) and data on coping strategies is challenging due to the lack of detailed topographic and gradient data at the city, neighbourhood and smaller scales. This creates a gap between global data sets and scenarios and targeted local (re)actions. Groundwater data are generally lacking, which hinders estimates of urban groundwater deficits. Irregular groundwater extraction in cities creates additional challenges for estimating groundwater budgets (Flörke, Schneider and McDonald 2018). Data are lacking on the quality and quantity of freshwater, as well as on the quality of urban stormwater run-off. Impacts on human health and ecosystems from emerging contaminants such as microplastics are not yet clear.
Oceans and coasts	Coastal populations are increasing globally and urban centres cover 10 per cent of low-lying coastal land (within 10 metres of the sea level) (Colenbrander *et al.* 2019). Increased coastal development in areas with rising populations threatens coastal ecosystems such as coral reefs, mangroves, salt marshes and sea grasses (Inniss *et al*. 2017; Muñoz Sevilla *et al*. 2019; UNEP 2019). Rising sea levels make urban populations more vulnerable to flooding, saltwater intrusion and coastal erosion (IPCC 2018; Masselink *et al*. 2020). Recent assessment of the impact of rising sea levels (under the high-emissions RCP 8.5 global warming scenario) indicates that by 2050, millions of coastal city dwellers could be displaced by floods (Kulp and Strauss 2019). Ocean warming and acidification are predicted to adversely impact coastal fisheries and aquaculture (IPCC 2018). Cities are point sources of pollution (including plastic, other debris and chemicals) for the marine and coastal environment. Marine litter, much of which originates from poorly managed municipal waste, is increasing in some areas and declining in others (UNEP 2019). Coastal tourism is increasing, both in terms of the number of visitors the area occupied (Jarratt and Davies 2019). This increases pressure on services and the environment. Many large cities are port cities and marine traffic is increasing (Sardain, Sardain and Leung 2019).	Data are required to better predict the timing and extent of coastal change and its impact on urban areas (including human well-being and livelihoods and coastal and ecosystems). Monitoring rising sea levels is inadequate in many coastal centres (especially in the Global South), hampering effective coastal planning and sustainable development. The economic cost from the loss of services provided by coastal ecosystems is poorly understood (including food production and coastal protection) (Todd *et al.* 2019). There is also a lack of data on the impact of climate change on the marine food web and food security (Blasiak *et al*. 2017).

Environmental dimension	What we know	Remaining gaps in knowledge
Land and soil	Overall, while urban areas are overall more "efficient" in terms of land use than other forms of human habitation (ECJRC 2019), they also tend to expand to accommodate growing populations and their telecoupled needs, leading to the conversion of fertile and forest lands (Seto, Güneralp and Hutyra 2012; Seto and Ramankutty 2016). This growth is not the same across all regions: cities in lower-income countries are denser and more compact, whereas middle- and higher-income countries have greater sprawl (ECJRC 2018). Overall, the global per capita area is increasing in urban areas, albeit more so in higher-income countries than in lower- and middle-income ones (Paresi *et al.* 2016). While city centres are becoming greener (Paresi *et al.* 2016), people who are less wealthy are constantly pushed out, reflecting the fact that land is a scarce resource and unequal access is persistent. More and more people are being pushed to live in exposed spaces like high-frequency flood zones (Paresi *et al.* 2016). The morphology and characteristics of urban green spaces and infrastructure have a clear impact on the quality of the urban environment and its functional footprint for people and wildlife (Andersson *et al.* 2020). With poor sanitation and waste disposal systems, land degradation is worsening, especially in low- and middle-income countries. Studies indicate that land degradation and contamination will continue in urban environments (UNEP 2015; Ferreira, Walsh and Ferreira 2018).	Until recently, the existence of multiple definitions of "urban" affected comparative studies and the aggregation of data to study land-use patterns for different size-classes of urban areas. In 2020, the United Nations Statistical Commission endorsed the European Commission's degree of urbanization (ECJRC 2018) as a recommended method for international comparisons. The emphasis on administrative land boundaries in the context of cities fails to capture their telecoupled impacts. Further studies are needed across the administrative and ecological scales of influence to understand urban impact. For instance, it is important to better understand how land conversion to urban areas is affecting food security in terms of soil degradation, water quality, available farmland and the number of farms. We also lack knowledge on the implications of global environmental changes, such as land degradation, desertification and deforestation, on urbanization processes via migration or the reduction in resources required for sustainable habitation. There is a lack of green infrastructure asset registers in most low- and middle-income countries (Schäffler and Swilling 2013), which results in a gap in the valuation of green infrastructure.

3.5 Equity and the environment: impacts on human health and well-being in cities

This section considers how different population groups living in different parts of cities and with varying access to services and quality housing will be affected by changes in air, land and coastal resources, as well as freshwater and biodiversity. Changes in the urban–environment nexus will have implications for the health and well-being of human populations and other species, with the impact varying in line with levels of exposure and underlying vulnerabilities, such as poverty and health conditions.

While urban areas can display great disparities, urban residents may have access to better education, housing and health care, resulting in longer life expectancy (Vardoulakis and Kinney 2019). Wealthier residents typically contribute disproportionately to the urban environmental or ecological footprint through their housing demands, transportation needs, energy usage and consumption patterns but are in a better position to protect themselves from the consequences, due to safety nets like insurance (Satterthwaite 2011; WHO 2016b). Socioeconomically disadvantaged populations are typically exposed to higher levels of air pollution, live in crowded places with substandard urban services and are more vulnerable to infectious disease outbreaks.

In particular, in lower- and middle-income countries, low-income urban populations and people living or operating in the informal sector face the highest levels of exposure to the negative consequences of environmental change. They face bigger challenges due to their limited access to reliable and sufficient incomes, services (ranging from health care and education to financial services) and adequate housing and infrastructure to reduce risk (IPCC 2018; see also chapter 2). This has created a double burden of communicable and non-communicable diseases in these communities (Sverdlik 2011). Yet protecting vulnerable groups has positive health and well-being benefits for everyone in the city. Informal settlements are often located in marginal or poorly-connected areas of cities where land has less value. Residents are more exposed to hazards like river or coastal flooding, landslides or subsidence and the insecurity from insecure land tenure and the inability to access insurance (Dodman and Satterthwaite 2008; Satterthwaite *et al.* 2020). More than half the urban workforce in most countries of the Global South is in informal employment, especially in South Asia (82 per cent in informal employment) and sub-Saharan Africa (over 66 per cent) (Chen, Roever and Skinner 2016). This informality undermines job security and access to social services, increasing vulnerability to market crashes and other shocks, such as COVID-19. Informal, migrant or refugee urban populations may be marginalized by urban governance and legal processes when they are not recognized as residents of the city through house or voter registration. This means their voices may not be heard in planning decisions which will affect their lives and livelihoods (Roy 2009).

These underlying vulnerabilities may intersect with other factors. Populations of migrants (Chu and Michael 2019), refugees or internally-displaced persons, and people

from ethnic or religious minorities (Pearson *et al.* 2017; Illingworth *et al.* 2018) may all face barriers in accessing relevant information about climate change, pollution or other environmental stressors, and may lack the resources to take the necessary coping or adaptation measures. Women may face a disproportionate care burden (Chauhan and Kumar 2016) that threatens their potential to earn income, while home-based workers may face a double impact if their homes and assets are damaged or destroyed by environmental hazards (Alber, Cahoon and Röhr 2017). When extreme events brought on by changes to the climate cause damage to assets and property, people without disaster insurance and tenure security are most vulnerable: they may be unable to recover lost assets, which can in turn affect their livelihoods, and they may be threatened by eviction as governments designate no-build zones in hazardous areas (Satterthwaite *et al.* 2020).

Other environmental challenges in urban contexts, such as water contamination, air pollution and noise, will disproportionately impact poorer population groups who cannot afford improved housing conditions, cleaner household fuels, protective equipment such as air purifiers, water treatment measures or other essential risk-reducing services (Mguni *et al.* 2020). In all cases of ill health brought on by environmental changes, women will face a caring burden, affecting their own livelihood prospects (UNEP 2016b). Where clean water or fuels are unreliable or difficult to source, the burden again often falls on women or young children, impacting their education prospects and health (OECD 2008; Ortiz-Correa, Resende Filho and Dinar 2016; WHO 2016b). Urban residents are disproportionately exposed to heat, due to the urban heat island effect (Heaviside, Macintyre and Vardoulakis 2017), and the effect tends to be worse in lower-income neighbourhoods (Chakraborty *et al.* 2019). Exposure to pollution in air, water and soils is associated with increased cardiovascular and respiratory diseases, neurological damage and cancer. Non-communicable diseases, including diabetes, cancers and cardiovascular diseases, linked to unhealthy diets, sedentary lifestyles and environmental pollution, are also more prevalent (The Lancet 2012). Finally, the transmissibility of infectious diseases is higher in overcrowded, frequently informal urban environments, presenting a challenge for public health services and exacerbating existing socioeconomic and health inequalities.

While rising standards of living and better disaster risk management appear to be reducing loss of life from extreme flood events (United Nations Office for Disaster Risk Reduction 2019), the number of people exposed to extreme weather events has risen (Pahl-Wostl 2015). While the global economic and infrastructure damage to cities from disasters is difficult to assess due to a lack of reliable data, it has been suggested that the magnitude of financial losses is increasing faster than the number of events and the impacts are not equally distributed (Pahl-Wostl 2015). Asian cities typically suffer the most casualties, while North American cities have the highest economic losses, possibly due to the concentration of resource-intensive infrastructure (MunichRe n.d.). The magnitude of reported economic losses does not necessarily reflect the significance of the losses for certain groups within the city, particularly women and children working in the informal and care economies and home-based workers.

Atmospheric pollution has a major impact on cities. For example, increased emissions of greenhouse gases, other pollutants and anthropogenic heat into the atmosphere have implications for urban residents, such as higher temperatures, increased droughts and floods and rising sea levels in coastal cities. The quality of housing and access to cooling systems depends on their affordability and groups like elderly people are particularly vulnerable to exposure to high temperatures at night (Murage, Hajat and Kovats 2017). Exposure to air pollution, both indoors and outdoors, accounts for about one in nine deaths (over 7 million in total) every year worldwide (WHO 2020a), most of which are attributed to air pollution in cities. Long-term exposure to air pollution shortens lifespans (Pope, Ezzati and Dockery 2009; Lelieveld *et al.* 2015), increases the mortality of COVID-19 (Coker *et al.* 2020), affects children's brain development (de Prado Bert *et al.* 2018) and reduces lung growth in children (Gauderman *et al.* 2015). Similarly, short-term exposure has been associated with higher daily mortality in cities (Liu *et al.* 2019) and exacerbated asthma in children (Bouazza *et al.* 2018). Higher temperatures, changing weather patterns (especially stagnation events) and less rainfall due to climate change all worsen air quality, increasing ground-level ozone and particulate matter concentrations (Fiore *et al.* 2012; von Schneidemesser *et al.* 2015). Climate change is also the underlying cause of the prolonged hot and dry conditions that increase the risk of sand and dust storms (WMO 2019b), wild fires and related smoke exposure in urban areas (Vardoulakis, Marks and Abramson 2020).

Almost half the human population directly depends on natural resources and biodiversity for their livelihoods and financial income, including many people classed as vulnerable (Convention on Biological Diversity 2016). Biodiversity loss affects urban residents by reducing many ecosystem services, including provisioning services (for example, food, medicines and fuel), regulating services (for example, clean water and air) and cultural services like recreation and spiritual fulfilment (The Economics of Ecosystems and Biodiversity 2011; Elmqvist *et al.* 2013; IPBES 2019). All urban dwellers remain heavily dependent on green and blue infrastructure and their connected biodiversity on account of their contributions to well-being. However, these are experiencing a reduction in terms of both quantity, quality and diversity, coupled with increased exposure to environmental risks, which will be exacerbated by climate change (IPBES 2019). Access to biological resources is currently uneven across different groups of people and the reduction in ecosystem services may intensify this situation, exacerbating environmental justice, gender and equity differences. The vulnerabilities of people and urban ecosystems are intertwined. For example, riverine ecosystems are vulnerable to changes in water flow, as well as human mismanagement (for example, the release of raw sewage or dredging). This creates vulnerabilities for people who depend on rivers for

food, water or other services (Roy *et al.* 2018). Meanwhile, urban planning processes may ignore the valuable role of natural environments as providers of livelihood resources for poorer urban residents (Roy *et al.* 2018). Poorer populations may therefore be adversely affected both by development, which destroys natural resources such as the infilling of ponds, and conversely by the designation of protected areas, which limit access to people who use them to supplement their income or food supply (see chapter 2).

There are, however, cases in which biodiversity can also be harmful to urban dwellers' health, for example zoonotic diseases like Ebola, Middle East Respiratory Syndrome, West Nile Fever and COVID-19, which jump between animals and humans (UNEP 2020). Urban development, environmental degradation, climate change and increased demand for meat in diets are bringing humans and animals closer together in cities, facilitating the emergence of zoonotic diseases. Paying more attention to the integrated treatment of human, animal and environmental health can help prevent and reduce the risk of the development and spread of zoonotic diseases (UNEP 2020).

Urban biodiversity has been shown to have positive impacts on physical and mental health and well-being (Brown and Grant 2005; Fuller *et al.* 2007; Tzoulas *et al.* 2007; Jorgensen and Gobster 2010; Romanelli *et al.* 2015). Biodiversity loss may affect biocultural diversity (biological resources that are particularly culturally valued) (Maffi 2005; Maffi 2018) and the persistence of traditional ecological knowledge (Maffi 2005; Raymond *et al.* 2010), as well as social-ecological memory (Barthel, Folke and Colding 2010). Further declines in biodiversity could also result in urban dwellers having less contact with nature, a decrease in environmental literacy and an "extinction of experience", with the potential for negative impacts on health and well-being (Louv 2008; Soga and Gaston 2016). This may result in a desire for people to reconnect with nature (Folke *et al.* 2011; Andersson *et al.* 2014). However, it may also allow for new experiences of nature in cities as "novel ecosystems" (Hobbs *et al.* 2006; Kowarik 2011).

Access to sufficient clean freshwater is essential for human well-being (SDG 6). Sustainable water management requires a balance between competing goals and trade-offs to ensure sufficient and safe water for human well-being, food, energy and nature (minimum environmental flows). These challenges are aggravated by infrastructure and institutional structures that were often not designed to cope with multiple stressors (Friend and Thinphanga 2018). Surface and groundwater overuse and contamination is increasing water insecurity, reducing the volume of water available, affecting its quality and driving up costs. In rapidly developing and urbanizing nations that have not yet implemented comprehensive measures to control and treat pollution at source, pollution levels are relatively high (Wen, Schoups and Van De Giesen 2017). Globally, four out of five people in urban areas use piped water supplies (WHO and UNICEF 2017), although this does not guarantee water quality and reliability. Just 39 per cent of the global population (2.9 billion people) use a safely managed sanitation service, and three out of five of them live in urban areas (WHO and UNICEF 2017).

While access in urban areas is higher than in rural ones, residents of informal urban and peri-urban settlements and other vulnerable groups are particularly likely to have precarious access to drinking water and sanitation. Access in urban areas may be overestimated in some cases, since informal settlements are not always counted in the data and also due to differing levels of access (Mitlin *et al.* 2019). Residents of informal settlements often obtain water from communal sources or private vendors at a much higher cost and without quality guarantees, since water is not delivered from a public supply network (United Nations Water 2017; Mguni *et al.* 2020). The lack of a stable water supply can lead communities to store water in open containers, inadvertently providing a vector breeding for dengue, malaria and other waterborne diseases. Poor sanitation leads to the pollution of waterways and coastlines and affects urban dwellers' health (for example, through waterborne diseases) and well-being, especially women and girls who depend on inadequate public sanitation facilities (UNEP 2019). The COVID-19 outbreak has highlighted how the difficulty of good handwashing hygiene in marginalized urban areas disproportionately exposes these groups to infectious diseases (WHO 2020b; Van Belle *et al.* 2020).

In the Global North, shrinking cities means less demand for water, leading to water stagnation and increasing the risk of bacterial growth and microbial contamination in pipes (Naumann and Bernt 2009). Water quality also is also affected by ageing or inadequate infrastructure (for example, lead pipes), a lack of regional planning (Morckel 2017) and a lack of regulatory compliance (Allaire, Wu and Lall 2018).

Many people live in coastal areas, where impacts such as rising sea levels, coastal erosion, storm surges and coastal pollution have direct and indirect effects on the health and well-being. For example, coastal flooding, which is the most common natural hazard and is exacerbated by poor urban planning and inadequate drainage, can cause loss of life and injuries, as well as the contamination of water and food supplies. Because the impacts can be so severe, urban residents affected by floods may experience long-term mental health issues, including stress and anxiety (Fernandez *et al.* 2015; Waite *et al.* 2017). Other impacts include salinity intrusion in groundwater, which can also affect health.

Cities are major sources of pollution for coastal zones. This can impact both residents of cities and people beyond their boundaries. The economic and social costs of marine litter and chemical pollution on cities include indirect costs, such as making them less attractive, disrupting tourism and causing the decline of coastal fisheries and aquaculture. People whose livelihoods rely on coastal and marine ecosystems may be disproportionately impacted. Microplastics and associated contaminants from marine litter can affect the marine food web and potentially, human health through seafood consumption, although the transfer of microplastics from seafood to humans and the implications for human health are still not fully understood (Carbery, O'Connor and Palanisami 2018).

Land provides food, shelter, fodder and fiber to people. It can also contribute to cultural identity and the spiritual needs of urban and rural inhabitants. As a result, it is a critical requirement for human well-being. However, it is still highly scarce and unequally distributed in urban areas, causing access and environmental justice problems. Contested property rights, land grabs and gender gaps in ownership are some of the dynamics that affect marginalized populations, particularly people with low incomes (UNEP 2016b; UNEP 2019; see also sections 4.2 and 2.2).

Governance of common land is highly contested and various actors take advantage of this to pursue construction activities that result in undesired environmental degradation, such as biodiversity loss, loss of access to certain resources by many city dwellers and increased surface run-off (Vencatesan *et al.* 2014; Jain *et al.* 2017; Steel, van Noorloos and Klaufus 2017). Evidence shows that clear recognition of traditional, indigenous and de facto land rights, ownership or tenure incentivizes self-investment, significantly reducing urban land degradation, improving waste management and contributing to the overall health and well-being of people and places (Ding *et al.* 2016; d'Amour *et al.* 2017; UNCCD 2017) by drawing on people's knowledge of resource management and building climate resilience.

Urban consumption patterns remain unsustainable, which means solid waste management remains an integral challenge when it comes to the environment and public health (UNEP 2018b; see also chapter 4). Developing cities in particular are currently struggling with solid waste management crises that disproportionately affect people with low incomes, especially informal recyclers who are exposed to these hazards and residents of informal settlements near waste dumps (Tvedten and Candiracci 2018; Doherty and Brown 2019). Increasing populations, unsustainable consumption patterns and increased demand for natural resources like steel and concrete are also resulting in unsustainable production practices, such as excessive resource extraction through mining (chapters 4 and 5). This may hinder progress towards SDG 12 on sustainable consumption and production.

Since urban growth is expected to vary across regions, it is likely to be a severe issue for sustainability. This is especially true in Africa and Asia, where it has the potential to reduce agricultural and forest lands, further affecting the food systems and livelihoods (d'Amour *et al.* 2017). Much of this growth is likely to be unplanned due to the poor governance systems in these regions, distributing the impacts disproportionately among their populations. Overall, how land is governed will have long-term effects on social and environmental equity outcomes for future generations.

3.6 Interacting impacts and the urgency of action

This chapter has shown the intricate links between cities and their wider environments and how human life and the environment in cities is affected by changes in the environment both beyond their boundaries and within them. These environmental pressures on air, biodiversity, freshwater, land and oceans are also linked in ways that can exacerbate environmental degradation and the deterioration of human well-being. Adapting to environmental change and mitigating these impacts is essential for achieving the SDGs, not only in urban environments.

However, cities do present an opportunity to act and mitigate these impacts on a large scale, by addressing environmental, sustainability (economic and social), physical and community resilience, together with inclusive multi-level governance. These factors need to be addressed together at different administrative, spatial and temporal scales to address the environmental challenges facing and caused by cities. A sectoral approach is not enough: we urgently need planning, actions and integrated approaches that consider the interlinkages between cities and equity and the environment, incorporating nature-based solutions, that explicitly consider people and planetary health in pursuit of a better future for all.

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Chapter 4

Cities that Work for People and Planet

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The previous two chapters have shown that much of our planet's economic, social, cultural and political life plays out in cities, including urban and suburban places, dense urban cores and satellite cities, and expansive metropolitan regions (chapter 2). Cities directly and indirectly account for most of the world's energy and material consumption, greenhouse gas emissions, and waste generation (Seto *et al.* 2014; Baynes and Musango 2018; International Resource Panel [IRP] 2018; Kaza *et al.* 2018). The impacts of this resource consumption and waste and emission generation span the globe and typically have negative effects on the environment. The scale of urban impacts depends on how cities work: how we produce goods and services; how we plan, design and build; how we live, feed, work and travel; and how – and who – governs these urban areas. Reimagined urban futures that address how cities evolve and work and who participates and benefits are needed to avoid the looming environmental and climate crises.

Cities have the potential to radically alter current trends of accelerating climate change, biodiversity loss, pollution and social stress. To see how cities could be part of the solution to these collective challenges, this chapter will offer a multidimensional, flexible and comprehensive vision of an urban future that addresses efficiency and economic organization, the built environment and governance for urban planning. This vision is based on three dimensions of integrated action for urban transformation. These are not blueprints for urban change, because priorities and implementation timescales may vary. But they focus on rethinking current political and economic structures, institutions, policies and behaviours, and moving towards more environmentally sustainable, resilient and socially just futures for both the Global North and the Global South. In short, these dimensions disrupt embedded ideas about cities and urban life.

4.1 Cities as opportunities: using local turning points to avoid global tipping points

As highlighted in the sixth Global Environmental Outlook, the global environment is facing a crisis driven by population growth, demographics, socioeconomic and cultural dynamics and behaviour, technological development, urbanization, and climate change (United Nations Environment Programme [UNEP] 2019). Cities – or more generally urban regions – around the globe (chapter 3) and patterns of urban life have a major influence on this crisis. In a rapidly urbanizing world, we must accept that cities will increasingly play a key role in ensuring an environmentally sustainable and inclusive planetary future. This chapter explores how they can also catalyse global turning points and provide opportunities for sustainable, healthier, low-carbon, resilient, inclusive and just ways of living.

Ensuring cities can take advantage of appropriate levels of responsibility and implement sustainable and equitable transformative actions means addressing a number of challenges:

- the ideologies of unlimited growth that define current economic systems;
- accelerating environmental degradation and climate change;
- ingrained everyday practices, with social inequalities that cut across age, gender, economic status, race and ethnicity, caste, religion, ability and other forms of difference.

Success or failure will be profoundly influenced by how much we consume, where and how often we travel, what we save or add to the waste stream, and widespread expectations of continually expanding consumption. For transformative change, cities must grapple with a series of challenges: decoupling energy and material consumption from the economy and aligning them with planetary boundaries; responding to the complexities of urban systems; working across scales to design comprehensive solutions; reorienting economic structures and incentives; and redirecting policy and cultural practices based on consumerism and accumulation to focus on meeting basic needs and ensuring quality of life and well-being for the planet and people.

The diversity of cities and urban regions – and their institutions – means there is no one-size-fits-all set of solutions (World Climate Research Programme 2019; Bai *et al.* 2018; see also chapter 2). Rather, success depends on the co-production of knowledge and potential solutions across a wide range of cities to support local capacity-building, participatory urban governance, unbiased facilitation, open communication and accountability (World Climate Research Programme 2019; Solecki *et al.* 2021). Social learning has the potential to maximize potential co-benefits, minimize trade-offs and handle undesirable outcomes of approaches implemented at different temporal and spatial scales (Ensor and Harvey 2015; Fisher *et al.* 2016; Lindsay 2018). Finally and crucially, cities need sufficient stable funding from global sources and national and state governments to meet challenges on the ground. The scale of these funding requirements will stretch the fiscal capacities of even the wealthiest countries under favourable economic conditions, let alone middle- and low-income countries during economic downturns or crises, such as the multidimensional crisis created by COVID-19.[1] Windows of opportunity that arise during crises can transform business-as-usual practices that are not considered sustainable. Yet as of May 2020, only 4 per cent of the $7.3 trillion for COVID-19 recovery plans was allocated to "green" productive investments with mid- to long-term returns (defined as investments with the potential to reduce greenhouse emissions) (Hepburn *et al.* 2020, p. S363). A United Nations Environment Programme report that assessed fiscal spending of the fifty largest economies during 2020 confirmed that efforts indeed have fallen short to accelerate a "green recovery" as 18 per cent of recovery spending – of about $14.6 trillion dollars (excluding the European Commission commitments) – or 2.5 per cent

1 Although some crises may present opportunities to accelerate positive transformation, as explored in the Cape Town Resilient Pathway case study in chapter 5.

of total spending is expected to enhance sustainability (UNEP 2021). However, if correctly designed, accelerating green investments in the coming years could promote environmentally sustainable and resilient urban change while reducing inequities within and across generations (Hepburn *et al.* 2020; Organisation for Economic Co-operation and Development 2020; Solecki *et al.* 2021).[2]

Cities are part of a continuum of a globalized but site-specific built space. As such, they need a coordinated and coherent vision of the future to guide transformation pathways, with flexible agendas, plans and coordination agreements. While this vision can be implemented in different ways, the selected pathways must recognize key aspects of cities: social and cultural diversity; social, environmental and spatial interlinkages; complex teleconnections; and capacity constraints on urban governments and civil societies to develop and implement policy. Institutions and urban residents must be willing to adapt to changing circumstances and understand that cities exist within larger organizational and governance systems. Action plans need to be tailored to varying degrees of local autonomy and democracy, and where possible include and empower all types of city residents as key actors. To be successful, transformation pathways for sustainable, resilient and just cities must overcome polarizing views between and within cities in terms of economic, political and social structures, cultures and institutions, patterns of injustice and exclusion, and everyday practices (Biermann *et al.* 2016; Swinburn *et al.* 2019; UNEP 2019; Delgado Ramos 2021).

4.2 Future cities: three dimensions of integrated action for urban transformation

Despite their diversity, cities have underlying similarities that allow them to be collectively reimagined and ultimately transformed. Building on these similarities while recognizing diversity, the task is to design integrated transformational pathways and practices with the power to deliver desirable outcomes on climate, environment, human health, well-being and equity. To be part of the solution, future cities must then address key arenas of urban life and collective action: environmental, economic and social sustainability; physical and community resilience; and just, inclusionary and multispecies governance. This latter entails both human and more-than-human rights to the city (Shingne 2020), as well as what has been termed a nature-positive approach that promotes a "new relationship between people and nature" to protect and restore natural habitats, promote a better built environment, safeguard the diversity of life, and halve the footprint of production and consumption (UNEP 2020a; World Wide Fund for Nature [WWF] 2020; Locke et al 2021).

Cities are both blamed for and burdened by critical environmental challenges, some of which may persist for many decades to come (as is the case with chemical pollution and plastics, discussed in chapter 3). Moreover, while ongoing economic globalization may continue to drive economic and population growth and urban expansion in some cities, other urban regions may be hollowed out as their economic base becomes obsolete or moves elsewhere and populations shrink, leaving a legacy of abandoned neighbourhoods and stranded pollution hotspots (chapter 2).

Yet cities can catalyse transformative change through innovation, education, employment, economic diversity and economies of scale, as well as entertainment and cultural interaction (Bai *et al.* 2018; Intergovernmental Panel on Climate Change 2018; Vardoulakis and Kinney 2019; Solecki *et al.* 2021). Integrated approaches take advantage of the cross-cutting nature of urban dynamics to be forward-looking while addressing a wide variety of legacy challenges (including environmental degradation, economic hardship and wide-ranging social problems). This strength provides a basis to reimagine, redesign, remake and rebuild in ways that contribute both to justice, equity and inclusion and to environmental sustainability, resilience, adaptive capacity and climate change mitigation.

This chapter describes this vision in terms of three primary dimensions of integrated action for urban transformation with the potential to recast cities as solutions rather than problems. Cities are complex dynamic systems and there is no perfect way to partition their activities, problems or related policy prescriptions. The three dimensions focus on flows of energy and materials; urban form (land-use and activity patterns); and behaviours of the individuals and institutions that orchestrate urban life. The dimensions were selected because they lie both at the heart of how cities work and how we can – and should – reshape them to address the pressing needs of the planet.

- **Dimension 1: Net-zero[3] circular cities:** altering energy and material flows to significantly reduce natural resource extraction, and achieve near net-zero greenhouse gas emissions and other forms of pollution and waste.
- **Dimension 2: Resilient & sustainable cities:** changing urban form to protect vulnerable urban places and populations from environmental degradation, the impacts of climate change and extreme events, including associated disasters and everyday hazards.
- **Dimension 3: Inclusive and just cities:** inculcating individual, collective and institutional behaviour and governance frameworks that include all urban residents, urban nature and biodiversity, while considering justice across generations.

2 In the meantime, temporal actions to cope with COVID-19 impacts that are becoming permanent in a diversity of cities, reveal that investments are not only possible but necessary. Small investments in, for example, the expansion of outdoor terraces, bike and pedestrian spaces, and urban green space already have had meaningful effects in cities such as Paris (which added 29.2 km of new bike lanes), London (25 km), Brussels (24.9 km), Berlin (24 km), Toronto (25 km), Bogotá (76 km), Mexico (22 km), and Melbourne (12 km). In Barcelona, in addition to 12 km of new bike lanes, more than 1,300 new outdoor terraces have been created by converting parking spaces around the city (Kraus and Koch 2021; Nikitas *et al.* 2021).

3 The laws of thermodynamics actually limit the possibility of net-zero schemes for material and energy recovery, which in turn constrain the potential of circular economies (due to the entropic nature of the economy itself; Georgescu-Roegen, 1971 and 1975; Giampietro y Funtowicz, 2020). For instance, 'zero-waste' is, strictly speaking not possible. In the area of carbon emissions, the use of the term net-zero emissions does apply from an accounting viewpoint as it allows us to aspire a zero outcome when we subtract carbon captured, for example, by land and water ecosystems, from current carbon emissions. But even if a zero-carbon goal is achieved, it does not necessarily limit environmental degradation and ecological justice. In other cases, the use of net-zero may lead to misleading understandings; for example when buildings are termed net zero energy, this refers to operating energy, and does not account for embedded energy in materials. Thus the net-zero concept must be used with care, despite its positive message.

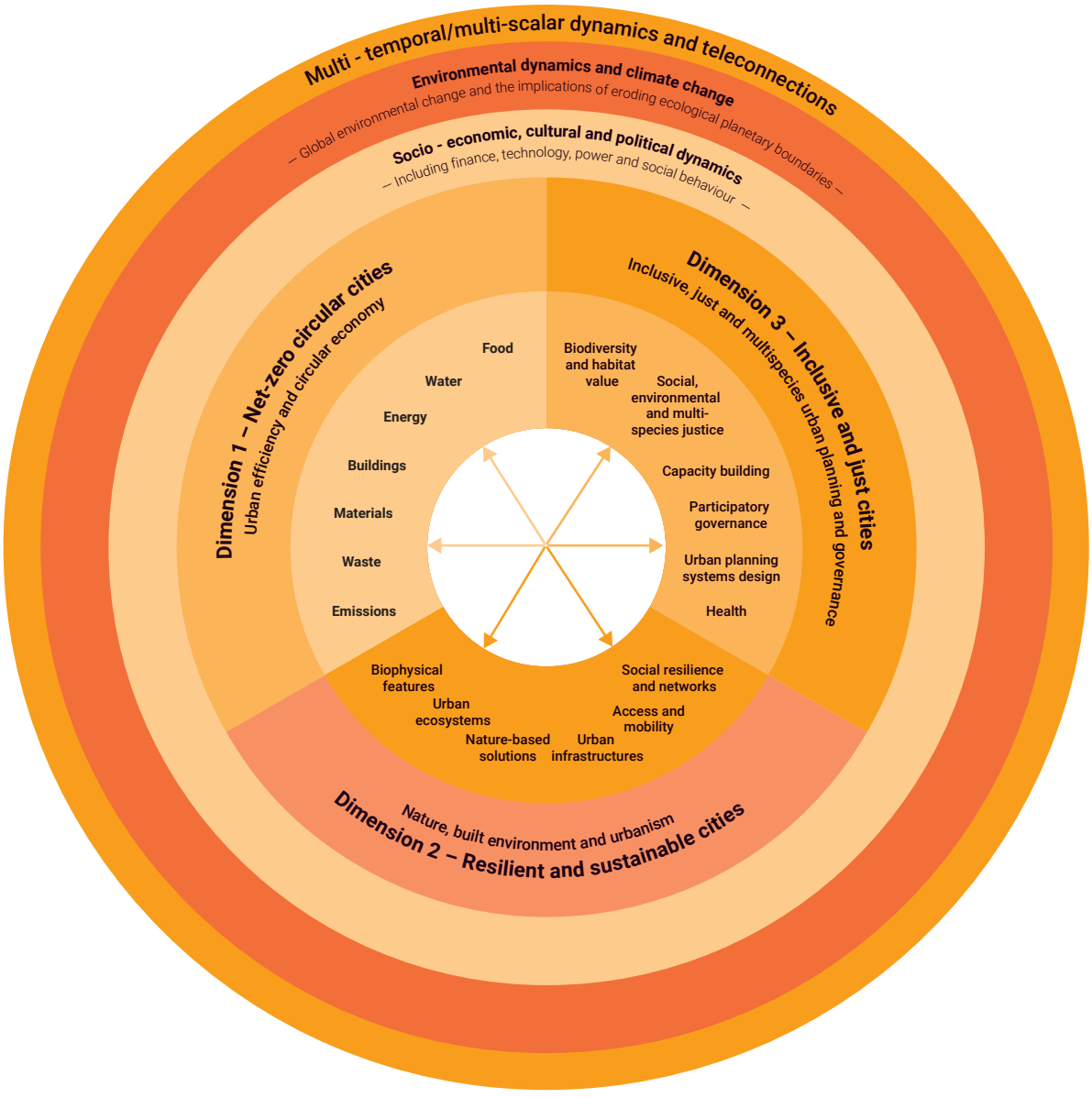
As previously mentioned, these three dimensions are interdependent (**Figure 4.1**). A full urban transformation requires a comprehensive approach to all three and the forces that shape and reshape them. This includes implementation at different economic, financial, political, technological and social scales, while considering cultural dynamics and influences.

Policies, regulations, funding and accountability at the national and subnational levels are fundamental for achieving the goals of these three dimensions of integrated urban action. Governments may have access to critical policy levers and capacities to act, while the private sector, social movements and multiple individual actions can also propel changes that lead to more environmentally sustainable and liveable cities and more inclusive and socially equitable societies. The practical implementation and acceleration of urban transformation is explored in further depth in chapter 5.

4.2.1 Dimension 1: Net-zero circular cities

Despite urban dependencies on inflows and outflows of energy, materials, water, information and people, cities can play a crucial role in advancing environmental sustainability and resilience. Urban transformation can happen if these inflows are used much more efficiently from a systemic – not only sectoral – perspective. This, combined with the substitution of renewable energy for fossil fuels, can be achieved, even in the context of a globalized economy (Uzar 2020; Zeren and Aklus 2020) and behavioural and institutional changes (see third dimension). The sustainable level of the annual per capita consumption of materials in cities has been estimated at between six and eight tons (as indicative target), compared to the current figure of 11.4 tons and the projection of 14 tons under a business-as-usual scenario by 2050 (IRP 2018, p. 41). Urban efficiencies in transport, buildings, heating and cooling can reduce this consumption by between 46 to 67 per cent while further interventions are still possible on a case-by-case basis (IRP 2018).

Figure 4.1: Dimensions of integrated action for urban transformation and their relationships across sub-areas



Buildings constitute much of the physical fabric of cities and urban regions and are responsible for a large share of greenhouse gas emissions. The first dimension acknowledges this by focusing on the resource efficiency of buildings and building operations. This is particularly relevant since buildings in cities are usually directly controlled by local governments. Urban transportation is another major source of energy consumption and pollution. However, as transportation is so closely related to land use, access and mobility, interventions in this area are considered under the second dimension, which deals with resilient and sustainable urban form.

The following description draws on the systems-based framework of urban metabolism, including ideas from industrial ecology and socioecological economics, to envision a circular urban economy, including near-net-zero approaches (Friant, Vermeulen and Salomone 2020) . This dimension of integrated urban action is driven by efficient sociotechnical infrastructure, which involves incorporating new technology into social behaviour, everyday life and the structures and strategies of urban institutions.

Under the first dimension the economies and built environments of cities are designed for cradle-to-cradle material, energy and water flows (for example, Ferrão and Fernández 2013; Esmaeilian *et al.* 2018; García-Guaita *et al.* 2018; Koutamanis, van Reijn and van Bueren 2018; John *et al.* 2019; Maranghi *et al.* 2020; Mohan, Amulya and Modestra 2020). This means:

- reducing waste through second-hand markets or sharing platforms (Ardi and Leisten 2016; Ghisolfi *et al.* 2017; Parajuly and Wenzel 2017);
- sourcing materials from discarded products to make new ones for consumers, business, and industry, and maximizing renewable energy and recycled water to create a continuous virtuous circle of production and consumption (Zeller *et al.* 2019);
- recycling industrial, built environment and household waste into new stocks of materials for manufacturing, using manufacturing by-products across industries (for example, Xavier *et al.* 2019; Arora *et al.* 2020), and collecting, sorting and recycling electronic and electrical equipment waste into new stocks of materials for manufacturing;
- reusing materials, for example by collecting, sorting and sending edible food to people who need it and composting all organic waste for urban and hinterland nutrient cycling (Lin *et al.* 2014) and agriculture (Wielemaker, Weijman and Zeeman *et al.* 2018; Bahers and Giacchè 2019; Edmondson *et al.* 2020).

The fact that not all materials will be locally available means that a regional cycle of production and consumption is desirable, powered by renewable electricity that mobilizes nearby resources in peri-urban areas. Such a system can stimulate the economy and provide jobs for a wide range of people in these exurban communities (Fratini, Georg and Jørgensen 2019). For energy and materials sourced from further away, a transparent and spatially explicit material flow tracking system could be used to monitor nodes along the supply chain and encourage collaboration on design to aid disassembly, the recovery of materials and remanufacture (Stahel 2019), as well as on aspects related to health, equity and worker justice (Davis, Polit and Lamour 2016; Cousins 2017; Delgado Ramos and Guibrunet 2017; Guibrunet, Sanzana and Castán 2017; John *et al.* 2019). Ideally, these monitoring systems would also clearly show critical urban dependencies for resilience and any uneven urban development and dynamics. Making such knowledge openly available can empower the public and decision makers in the long term (Delgado Ramos 2021).

Achieving circular urban production and consumption systems depends on profound changes in the structure of the global and local economies that both drive and react to its dynamics. Most importantly, to overcome structural barriers, the priorities of economic actors need to be reordered so that profit alone does not drive the economy (chapter 2).

Under this first dimension, buildings – old and new; urban and suburban – should be efficient in terms of both energy and materials. They should be able to act as their own power sources and be climate-ready for adaptation and mitigation. Key aspects of this dimension include:

- designing and building highly energy- and resource-efficient buildings and retrofitting existing structures to maximize energy efficiency;
- installing roof-top solar generation (photovoltaics and solar concentrators), wind turbines or geothermal building energy, or renewable energy provided by solar farms and wind turbines in the peri-urban region, which also has the potential to generate resources and jobs in these areas (Bagheri *et al.* 2018; Bracco *et al.* 2018; Arabzadeh *et al.* 2020);
- building distributed public infrastructure and neighbourhood energy generation systems, as well as new building envelopes that generate their own power (Van Den Dobbelsteen, Broersma and Stremke 2011; Sarralde *et al.* 2015; Bagheri *et al.* 2019; Mohajeri *et al.* 2019), which can improve energy efficiency while enhancing resilience and recovery during grid power outages;
- planning buildings and districts so that they rely on renewable energy to relieve pressure on the grid or whose design reduces energy consumption through passive heating and cooling, daylighting, energy recovery ventilation, battery systems to store excess renewable energy for when it is needed, reflective roofs, and insulating green rooftops (Dabaieh and Johansson 2018; Sudhakar, Winderl and Priya 2019; Global Alliance for Buildings and Construction, International Energy Agency [IEA] and UNEP 2020a);
- using local, recycled and innovative materials (such as advanced concrete or steel produced with hydrogen; Hajek 2017; European Parliament 2020).

If enough new buildings produce excess renewable energy, they can offset consumption by buildings that may not

be suitable for energy-efficiency retrofits (for example, historic structures) and buildings waiting for energy-efficiency renovations and other adaptations to enhance environmental sustainability and climate readiness (Dávi *et al.* 2016; Mokhtara *et al.* 2019; Kim *et al.* 2020; Moran, O'Connell and Goggins 2020). Distributed generation, energy storage technologies and climate-ready grids can also contribute to efficient energy supplies, especially in the developing world, where vast numbers of buildings currently lack access to energy infrastructure. Local projects like these can benefit from collaborative governance schemes at the local, regional and national levels (de Reuver, van de Lei and Lukszo 2016; Winfield and Weiler 2018). If the energy and materials footprints of residential and commercial buildings and offices need to be reduced and their lifecycles extended to serve additional generations of users, this can be done through modifications, redesign and retrofitting. Any reductions in energy use and environmental impact would also offset the environmental footprints of substandard housing, especially in informal settlements. Such improvements may increase as rising household incomes and government subsidy programmes incentivize investment in housing quality, infrastructure, utility service provision and opportunities for land and homeownership to improve the quality of life and resilience of all dwellers.

Under this dimension, buildings would collect and use rainwater on-site. Greywater and rainwater could be reused by buildings themselves through living walls and green roofs, with multiple benefits, such as passive cooling, air filtering and improved aesthetics (Pradhan, Al-Ghamdi and Mackey 2019). They could also be used around the city, collecting, treating and reusing them as locally as possible to limit the need for water imports from elsewhere (Yoonus and Al-Ghamdi 2020). Nature-based solutions such as bioswales could retain water on-site to support local landscapes and habitats, while rainwater harvested on rooftops or through other small-scale systems could become a resource, rather than a nuisance to be rapidly disposed of downstream (Khirfan, Peck and Mohtat 2020). These types of water resources can improve access to drinking water from public supply systems, particularly for residents in informal urban settlements or refugee camps, and create storage during heavy rainfall. Moreover, using small-scale systems decreases stress on stormwater infrastructure and reduces the risk of overflows and floods, as shown by strategies being implemented in Mexico City (Tellman 2019), Wuhan (Dai *et al.* 2018) and Singapore (Brears 2020).

The idea of circular cities does not imply that the introduction of new technologies will be free from impacts or that levels of consumption will need to decline equally across all regions and cities. This would be fundamentally unjust, since millions of poor people need to increase their consumption of goods and services and will need to do so for some time to come in order to thrive. While we need absolute advances in aggregate efficiency of urban resource use, these would likely be distributed differently across different populations. Some people and cities would need to reduce their consumption patterns and become much more circular to decouple products or services from their environmental impact, while others would continue to consume in a linear fashion and avoid waste through both innovative and traditional methods and technologies for waste reduction, recycling and avoidance. There are two key areas in which measures to make cities more circular are imperative: urban metabolism (arising from production and consumption patterns) and buildings.

Urban metabolism

The term urban metabolism refers to how cities import resources, circulate them through production and consumption subsystems, and generate waste as residuals. The resources imported by cities include energy, water, nutrients and other organic materials, as well as a wide range of products with embodied resources and processed materials. The production and consumption systems range from manufacturing and technology, public and consumer

services, and finance and business services through to food and building materials. Supporting circular urban metabolisms requires a comprehensive approach that increases efficiencies for urban systems through changes in individual, sociocultural, and managerial and operational business practices. It also requires structural changes, such as closed-loop systems across industrial and consumer markets, alongside the corresponding infrastructure (especially in countries and economies where these loops do not currently exist). Moreover, the resources and materials that may form part of these closed circular loops must also be available (see example from Kerala, India, in chapter 5). These changes in practices may accelerate with the introduction of new technologies to improve absolute efficiencies within urban sociotechnical infrastructure and those that influence social processes, market structures, regulatory regimes and governance arrangements (IRP 2018). By coupling urban integrated planning and resource management, a metabolic shift can achieve results that would not be possible through isolated interventions or business-as-usual approaches. These changes are necessary because if we stay on our current path, by 2050 total urban resource consumption across the world would reach about 90 billion tons, 50 to 60 per cent more than the estimated global urban and rural energy and material consumption for 2000 (IRP 2018).

Given current urban land use, density and form, a combination of resource-efficient technologies and a range of actions, from building designs and codes, renewable energy generation and transportation through to waste management would be required. Notwithstanding the uncertainties inherent to estimating the potential scale of these combined interventions, a clear positive outcome is likely: under a resource-efficient scenario, cities may reduce land use by 5 to 20 per cent, metal consumption by 5 to 30 per cent, water consumption by 35 to 50 per cent and greenhouse gas emissions by 30 to 50 per cent (IRP 2018). A scenario based on more strategic densification,[4] with transportation playing a bigger role, could improve these results, reducing land use by 20 to 40 per cent, metal consumption by 30 to 50 per cent, water use by 36 to 60 per cent and greenhouse gases by 40 to 60 per cent (IRP 2018).

Implementing an urban metabolism approach requires many coordinated measures (**Figure 4.1**), from managing urban inflows through to progressively reducing and closing urban outflows (measures also comprise improvements to urban form, urban densities and land-use planning, as discussed in the second dimension), including:

- end-of-life regulations for consumer and industrial products, starting with the ones with the largest impacts on urban metabolism (particularly energy flows);
- consumer products that can be returned to producers for material recovery, with recovered materials used to feed closed-loop production systems using innovative industrial ecologies tailored to social and cultural context, and physical, financial and institutional infrastructures to support markets for recovered materials;
- formalizing the collection of waste and recyclables, partnering with or incorporating workers from the informal economy into recycling operations by offering training, safe and healthy working conditions, and living wages (for European examples, see the Urban Waste project; for a Latin American experience, in Medellin, Colombia, see the reports on life quality published by Medellin Cómo Vamos);
- improved and standardized models of material flow analysis and life cycle assessment that can assess, monitor and identify the changes needed in the urban circular economy footprint, which, when linked together, can capture the non-linear and complexity of these material flows. To build trust in these results, the data for these models and the modelling itself should be overseen by independent entities, such as universities, and follow a common methodology.[5]

Measures to support the transition to this circular urban metabolism include establishing material exchanges, funding recycling centres based on the best available technology and offering jobs and training. Lisbon provides an example of transitional steps to create matrix models of energy and water (Agencia de Energía e Ambiente de Lisboa [AEAL] 2015; AEAL 2016) as does the Plan Économie Circulaire for Paris based on an urban metabolism approach (Agence dÈcologie Urbaine not dated; Mairie de Paris 2017).

Developing circular urban metabolism models and data-collection protocols can also contribute to the shift (Petit-Boix and Leipold 2018; Dijst et al. 2018; Lavers Westin et al. 2019; Lucertini and Musco 2020). Examples include the models and simulation tools developed by the Global Initiative for Resource Efficient Cities, particularly the Spatial Microsimulation Urban Metabolism tools and the UNEP Urban Circularity platform, as well as the participatory urban metabolism mapping and analysis toolkit developed by Ecocity Builders and its partner organizations. The durability of construction materials and building design also needs to be improved, while allowing for reuse and recycling and avoiding construction material waste. Many cities are already on this pathway and have made major commitments under the C40 Zero Waste Declaration.

Efficient and reusable buildings

A wide mix of strategies is essential to maximize building efficiency in terms of energy, water and waste. These include standards for reusing and rehabilitating vacant housing and dilapidated infrastructure, as well as retrofitting existing architecture. These approaches may require policy interventions from the state. Buildings also constitute "mines" of raw materials for further use, with the potential to harvest, recycle and reuse their components at the end of their useful life. Performance standards and commitments for retrofitting are particularly relevant in this area.

4 Strategic densification can be described as a process of intensifying the number of jobs, people and amenities, and thus of mixed land uses, located within a network of primary and secondary relatively high-density nodes that are well-connected by efficient, sustainable and affordable mass transit systems and infrastructure for active transport.

5 These entities and their corresponding knowledge platforms can support the principle of additionality in urban transformational agendas over multiple political cycles (World Climate Research Programme 2019; Delgado 2021; Solecki *et al.* 2021). On the ground, local governments and NGOs can use participatory approaches to implement data collection and analysis initiatives.

Firstly, national and local assessment standards and performance-based building codes, standards and certifications should ensure that all new construction and major retrofit projects and building operations minimize energy, water use and waste production, and that buildings are treated as future "mines" for construction materials to recycle their embodied carbon. For energy, for example, standards could require projects to put energy back into the grid or use energy offsets from renewable energy when location, climate or building type make self-sufficiency unfeasible (Thomas, Menassa and Kamat 2018). Standards can also set ambitious criteria to minimize water use, municipal waste and building debris, especially in low-income peripheral neighbourhoods and countries that are recipients of debris (dumped or shipped) (Tauhid and Azwani 2018; Duan *et al.* 2019; Bao and Lu 2020; Lederer *et al.* 2020; Ram, Kishore and Kalidindi 2020). Designing new buildings so that they are easily disassembled and reusable and using buildings that will be demolished as storehouses of value and utility in future construction can move the building sector towards a closed-loop model (Arora *et al.* 2020).

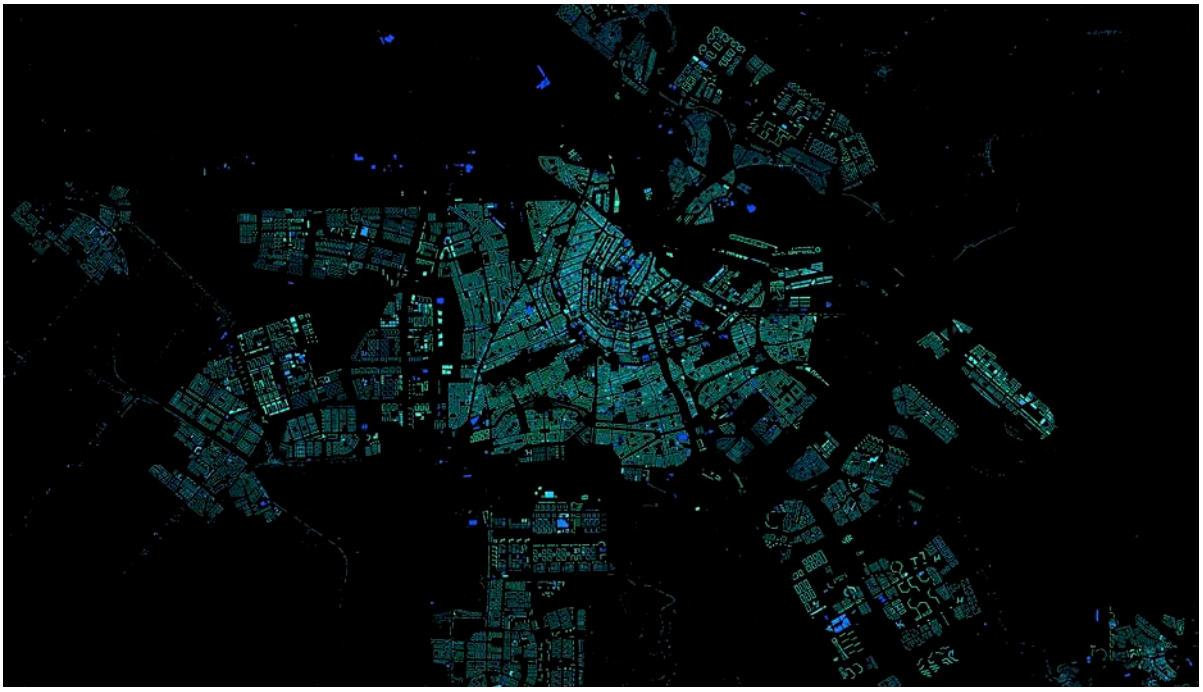
Secondly, national and local commitments to retrofit cities to upgrade existing building stock (Global Alliance for Buildings and Construction, UNEP and IEA 2020a and 2020b; UNEP 2020b) play an important role in improving energy and water efficiency and reducing waste. Most of the built environment is durable, and older building stock will be in use for decades, if not centuries. Programmes to avoid the construction of less durable buildings through durability standards also play an important role. Similarly, it is vital to ensure that the embodied energy and materials of buildings are used for as long as possible to maximize resource efficiency. While there may be a tension between historic preservation and retrofits to improve sustainability, historic retrofits are a good way of enhancing environmental sustainability and historic preservation itself is a broader sustainability strategy, since it can avoid much of the carbon intensity of new construction (Delgado Ramos 2019; Foster 2020).

These commitments could ensure that all dwellings – including those in informal settlements or refugee camps – are structurally safe and provide efficient heating, cooling, water and sanitation, and good indoor air quality (ideally free from chemical and microbial contamination). Standards also empower residents to guide the evolution of neighbourhoods towards efficiency goals, while respecting cultural values, practices and patrimony, ensuring that construction and debris do not unfairly burden vulnerable communities.

Transitional, context-sensitive measures are also needed, both to reduce aggregate global energy demand and to correct inequities in energy access and consumption within cities and between cities in the Global North and South. These measures include:

- best-practice life cycle analysis requirements for new construction or retrofitting of individual buildings and multi-building projects;
- use of buildings (and other materials from decommissioned infrastructure) as material banks or "mines", providing inputs to the circular economy thanks to component parts that are designed to be reused, repurposed or recycled for new projects and fed back into the local economy (Baccini and Brunner 2012; Stegman, Londo and Junginger 2020) (**Figure 4.2**);
- renewable energy for buildings, including solar, wind, geothermal and microgrids;

Figure 4.2: Maps of retrievable copper (blue-green) in Amsterdam. Such maps can be used to identify sites with urban mining potential.



Source: Waag 2016 Bert Spaan, Marc Kunst

- construction debris and municipal waste reduction, reuse, repurposing and recycling programmes, some of which may be located in regional hinterlands;
- water quality monitoring, supply, conservation and recycling and reuse programmes, as well as indoor air quality monitoring, integrated into new building codes and procurement requirements (Bilal *et al.* 2020);
- water, nutrients and energy recovery from buildings and larger municipal wastewater streams to offset nutrient demand in agriculture, minimize eutrophication of urban waterways and recover energy embedded in wastewater (Kakwani and Kalbar 2020; Qadir *et al.* 2020).

These transitional measures can reduce urban energy consumption and water use, improve access to clean water and sanitation, and improve water quality for people and nature, immediately jumpstarting reductions in building energy and water use.

Net-zero circular cities support public health by improving environmental quality. They provide livelihoods, opportunities for active, non-motorized travel, enhanced public transport infrastructure, local-regional access to healthy food, and reduce adverse health risks and exposures. Creating these cities will require sustained action, supported by grass-roots organizations and urban communities, national and subnational governments, organized labour, business, the academic sector and industry. Administrative boundaries in many urban regions may also need to be reconsidered, alongside the establishment of state and regional governance structures with the capacity to act (chapter 2). Doing so is not without limitations and challenges. Examples can be found in Portland in the United States, the Megalopolitan Area in central Mexico and Randstad in the Netherlands. Jurisdictional fragmentation in metropolitan regions can affect industrial investment decisions, while uniformity in building performance standards encourages widespread compliance. City and hinterland area economies based on circular economy principles could thus maximize environmental sustainability and also improve relations between the city and hinterlands in a mutually beneficial, non-extractive way.

The path towards near net-zero circular cities will certainly face challenges and require intelligent evolutionary transformational pathways (chapter 5). But this transformation is also an opportunity to make important additional changes, including remaking the urban physical fabric with new opportunities for adaptive reuse and building urban resilience and environmental sustainability (discussed further under the second dimension). This could be achieved through the design and redesign of the built environment, the establishment of circular economy facilities and activities in areas in need of economic development and investment, and by strengthening local networks with shorter communications and feedback loops that enhance resilience.

Training and education programmes for circular cities can enhance the lives of marginalized groups, including women, people of colour, people with disabilities, children and youth, religious minorities, indigenous people and immigrants (hence supporting the third dimension). As such, this first dimension can help to ensure a just and equitable shift from a fossil fuel economy to one based on renewable energy, improved shelter, transport, food security and sovereignty, health, safety and sanitation in urban communities (especially poor communities, informal settlements and racialized or otherwise marginalized communities). This dimension of integrated urban action has the potential to empower cities as hubs for environmental sustainability and justice, but also to empower residents by encouraging proactive behaviour and critical thinking (Ghisellini, Cialani and Ulgiati 2016).

4.2.2 Dimension 2: Resilient and sustainable cities

The need to move people and goods around cities means even efficient cities will still use large energy flows. The second dimension considers cities whose physical form promotes energy-efficient transportation, such as cycling and walking, since urban design influences non-motorized mobility (Sarkar *et al.* 2015; Zhao *et al.* 2018; Zhao and Wan 2020). Under this dimension, public transportation options are fast, ubiquitous and public transit, shared mobility and private vehicles are all battery powered or fully electric, running on renewable energy (supporting the first dimension) (Majumder *et al.* 2019; Helgeson and Peter 2020). This is complemented by circular economy strategies that support the reduction of primary raw materials extraction through battery reuse and recycling (Baars, Domenech and Bleischwitz 2021). Urban design and land use prioritize access to everyday needs, avoiding long-distance travel. Making homes, work, school, shopping and recreation accessible helps cities to be denser, more efficient and more equitable. Urban neighbourhood and district designs can feature integrated energy, water and waste systems, as well as food security features, to create more sustainable urban forms. In addition, the ground level of cities (or urban ground plane) itself can also be reclaimed to overcome the current dominance of motor vehicles and free up land for walking, bicycling, and other uses including green space (see the UNEP Integrated Guidelines for Sustainable Neighbourhood Design for examples).

Sustainable and inclusive urban form involves creating clean, safe and attractive places that support vibrant street life, walking, cycling and public transit, affordable housing, small businesses and green infrastructure for flood protection, as well as heat, noise and air pollution mitigation, parks and urban habitat, and city farms. This dimension of integrated urban action counters current wasteful, unhealthy and inequitable patterns of development based on a building-by-building approach and where land is covered by roads that are primarily designed for cars and the associated infrastructure such as parking and gas stations. Instead, it promotes an urban development model based on systems and districts that help make housing healthier by improving indoor air quality and sanitation infrastructure. With the right measures in place (mostly to protect housing affordability and security of tenure), it can also improve affordability, reducing expenditure on heating, cooling and private cars. All this can free up resources – including time – for the creation of small green businesses, activities in green

and public spaces, and family and community life, especially for poorer people and neighbourhoods (supporting the third dimension) (Dávalos, Maldonado and Polit 2016).

Under the second dimension, urban form implies strategically adding density and different uses of land in cities, while also considering potential trade-offs for risk prevention and urban resilience. Candidate areas for these strategic interventions include neighbourhoods without enough spaces to support mixed-use developments that increase access to everyday needs, walking and cycling opportunities, and urban environments that are rich in public transit (UNEP 2020b). The COVID-19 pandemic, and more generally the prospect of future widespread contagions, raise the question of whether this mixed use, walkable urban form and associated density is desirable. Early results of empirical analyses (Blanco 2020) suggest that neither city size nor dwelling unit density (per acre or hectare) are in themselves factors in the spread of COVID-19, although more work remains to be done (United Nations 2020; United Nations Human Settlements Programme [UN-Habitat] 2021). Instead, urban space-modelling and production that has led to residential crowding in low-income communities appears to be the main factor (Carozzi, Provenzano and Roth 2020; Hamidi, Sabouri and Ewing 2020; Sethi and Creutzig 2021). In New York City, communities mainly populated by people who are unable to work from home (including "essential workers", who are disproportionately people of colour) may have had faster increases in caseloads, hospitalizations and mortality (NYU Furman Center 2020). This phenomenon has also been observed in cities in Nigeria and Mexico, where COVID-19 infections and deaths have been clearly linked to informality, poverty and lack of access to public services (Ugwu *et al.* 2020; CONEVAL 2021). Other cases have also revealed similar instances of "hidden poverty" in urban areas and the implications for the spread of COVID-19 in cities in the Global South, including Bogota, Santiago de Chile, Rio de Janeiro, Sao Paulo, Delhi, Mumbai and Hong Kong (Hamidi, Sabouri and Ewing 2020; Lustig *et al.* 2020; Patino 2020; United Nations 2020).

With respect to urban density, when public health measures are in place and followed, density actually supports urban populations during a pandemic. However, the design is crucial. High-rise towers that are accessible only via elevators are often undesirable, as are closely spaced single-family housing neighbourhoods that lack parks and open space (Mayen and Cafagna 2021). High-density, low- and mid-rise urban forms, such as multi-family floor walk-up housing with between three and five floors and accessible via both stairways and elevators is desirable in terms of health and liveability (Chow 2002). Mixed-used, mid-rise residential buildings with internal courtyards and an urban fabric featuring wider sidewalks and more cycle lanes allow easy access to daily essential services, promote neighbourhood cohesion and reduce isolation among people working from home. This dense urban design offers accessible open-air green spaces where residents can walk, exercise, play with children and companion animals and socialize with friends and family while respecting social distancing requirements (Honey-Rosés *et al.* 2020). Lastly, the types of urban form proposed here are also crucial to avoid the planetary risks posed by climate change and environmental degradation.

This model of urban living based on greater sharing of space, infrastructure and amenities challenges urban residents, particularly in the Global North, to rethink the ideal of low-density privatized lifestyles. Urban life atomized by distance, social difference and individual ownership compromises urban resilience and inhibits the collective action needed to adapt the built environment in the face of climate change. Achieving this vision of the future requires planning that delivers both social and built environment resilience and denser and more interdependent cities.

This dimension promotes cities with cleaner air, soil and water, with less GHG and other pollutant emissions and more blue, green and grey infrastructure that helps people and places adapt to the effects of climate change and provides immediate protection from climate events (Matthews, Lo and Byrne 2015; Li, Uyttenhove and Van Eetvelde 2020). Sea walls, river barrages and other traditional grey infrastructure may be required in some cities and can even enhance urban life through multifunctional design. However, this must be achieved without transferring risk to peri-urban or rural hinterland residents. In contrast, in other cities, nature-based infrastructure solutions may replace grey infrastructure (Depietri and McPhearson 2017; Delgado Ramos *et al.* 2020). Alongside a variety of critical strategies for improving mechanical cooling (UNEP and IEA 2020), blue and green infrastructure such as floodable and floating buildings, parks and open space, green roofs and walls, and carefully designed and tended urban and peri-urban forests can reduce ambient temperatures, the severity of heatwaves and wildfire risk (Livesley, McPherson and Calfapietra 2016). Tree-lined streets, bioswales, and windbreaks offer shelter and shade, provide habitat and movement corridors for wildlife while making walking, biking and other types of physical activity more enjoyable and reducing vulnerability to heat stress (Schuster *et al.* 2017). Bringing urban creeks and streams back to the surface makes cities more permeable and reduces flood risk. Similarly, the restoration of estuaries and wetlands using nature-based vector controls improves flood protection, access to nature, leisure space, multispecies benefits and ecosystem health (Walton 2019). Finally, planning that takes into account people with low incomes, allows parks, open and public spaces, habitats and green infrastructure to be more fairly distributed across the city, while limiting eco-gentrification driven by real estate strategies for place-branding and increased property values (this is discussed further in the third dimension) (Wolch, Byrne and Newell 2014; Ruth and Gulsrud 2016; Wu *et al.* 2019; Nesbitt *et al.* 2019; Mulligan *et al.* 2020; Tubridy 2020; Baró *et al.* 2021). Nature-based solutions in practice need to be aesthetically appealing to citizens while generating new green urban commons based on participatory co-creation, social innovation and collaborative governance (Frantzeskaki 2019).

This dimension also prioritizes social as well as physical resilience. Social resilience in the face of environmental change depends on the capacity of residents and

neighbourhoods to act and mobilize public, private and non-profit resources (Satterthwaite *et al.* 2020). Cities can rigorously assess risks to both social and physical resilience related to buildings, infrastructure and urban services, given the proximity of residents to industry and natural hazards. By explicitly recognizing the uneven social distribution of vulnerability and risk (across many dimensions of social difference and geographic scales; Mac Gregor *et al.* 2021), cities can take active measures to protect people who are most vulnerable through transformative or comprehensive community-led initiatives (Martin 2015; Satterthwaite *et al.* 2020). Urban places with thickly woven and well-resourced social fabrics and participatory approaches can ensure that all neighbourhoods – regardless of private wealth – have local organizations and facilities that foster social resilience, while preserving cultural heritage. This can support localized disaster relief and risk management planning, with better representation of all areas of the city in metro-wide sustainability and climate-response planning. It can also underpin caring for residents (human and non-humans) during extreme events (Steele, Mata and Fünfgeld 2015; McEwen *et al.* 2018). This dimension of integrated urban action will require overcoming barriers (chapter 2) to comprehensive resilience planning, where governance systems develop resistance to change, hindering flexibility and adaptability (Shatkin 2019).

There are four main areas of work to achieve resilient and sustainable cities: a) environmentally sustainable urban form, b) urban access and mobility, c) resilient built environments, and d) resilient urban societies and communities.

a) Environmentally sustainable urban form

Building according to sustainable urban land-use patterns and densities, including mixed and socially inclusive districts and ecosystem services delivery, involves the following key strategies:

- Urban/metro growth boundary policies and expansion criteria to protect agricultural land, forests and wildlife habitats, ensuring the health of urban watersheds and guiding urban transportation infrastructure expansion to shape future urban form, land uses and connectivity (UNEP 2020b);
- Innovative regional transport systems (see section 4.2.2.b below) featuring protected rights-of-way for pedestrians and cyclists, all-electric vehicle fleets, mass transit systems and flexible, small-scale autonomous personal vehicles;
- Smart allocation of space freed up through reducing the role played by cars to urban parks and open spaces, paths, trails and natural habitats, including wildlife corridors;
- Proactive urban and regional planning through governance systems that can link different actors operating on this scale and empowered with resources and robust regulatory and legislative mechanisms;
- Participatory urban governance systems that provide a sound framework for developing pathways to change urban form (Hölscher *et al.* 2019) but that are open enough to foster movements for social change and technological innovation that address informality, particularly in the Global South (UNEP 2020c).

Transitional measures in this dimension include adopting urban plans for urban trees and forests, parks and open space, biodiversity, food security and the health of watersheds. Not only do these measures enhance resilience, they also protect public health (De Carvalho and Szlafsztein 2019; Gómez-Moreno *et al.* 2019; Guo *et al.* 2019; van Ryswyk *et al.* 2019). Experiments in cities from around the world – for example the participatory urban resilience programme of Chokwe in Mozambique (UN-Habitat 2017; Rockefeller Foundation 2019) – show how community governance and community development models can

reshape urban form. These include local capacity-building programmes, grass-roots organizational development initiatives, local and regional visioning exercises, participatory land-use planning, community-based visioning and budgeting, and microfinance programmes designed to provide sustainable livelihoods and access to capital for informal businesses. Examples of initiatives that could be adapted in pursuit of a just transition to more sustainable urban form include the Climate Budget of Oslo (Municipality of Oslo 2019), REDE 9 URB-AL (n.d.), the network for local finance and participatory budgeting in Latin American cities sponsored by the European Commission and local participatory budgeting schemes, such as those in New York and Buenos Aires (New York City Council n.d.; Buenos Aires Ciudad n.d.). These examples confront a number of challenges, such as the ability of participatory institutions to engage and retain volunteers, and the ability of constituents to substantively shape priorities and propose concrete solutions (Su 2018).

b) Urban access and mobility

The second area is urban access and mobility. This involves sustainable, low-carbon transportation infrastructure, efficient public transit and freight handling, non-motorized mobility and an appropriate mix of land-use patterns and densities. Policies to achieve this include:

- Investment in clean public transit and freight handling, powered by electrification and battery systems that do not export pollution from power generation. This would help to eliminate pollution hotspots associated with heavy traffic congestion, freight train terminals and seaports and airports, improving air quality and public health (Khreis *et al.* 2018; Sclar *et al.* 2020). Transit should link job centres with housing, civic spaces, health facilities, schools and retail districts, joining up urban and suburban communities. Service quality, comfort and speed are key to ensuring preference for transit;
- Developing urban transport infrastructure and land-use planning that encourages non-motorized forms of mobility (walking and cycling). These strategies include walkable streets, dedicated bike lanes, safe routes to school programmes and secured and attractive pedestrian trails and pathways to promote physical activity and health (Poswayo *et al.* 2019; Koszowski *et al.* 2019);
- Urban design plans that promote mixed land-use patterns and transit-oriented development to increase access and connectivity between origins and destinations (Ibraeva *et al.* 2020; Knowles, Ferbrache and Nikitas 2020; Liang *et al.* 2020). This contributes to the goal of "15-minute cities" as articulated by Paris, reducing travel times for daily activities to a quarter of an hour. These types of urban design strategies can preserve historical buildings and cultural heritage (Renne and Listokin 2019) and, if guided by universal design principles, allow cities to become more accessible to people with disabilities, as well as to other groups (Inturri *et al.* 2017; Kębłowski *et al.* 2019; Lah 2019; Raman and Roy 2019);
- Measures that address affordable transportation access, such as subsidies for low-income commuters or fare-free transit access (Shin 2020).

Transitional measures are critical, particularly in cities that require extensive redesign, retrofitting and new transit infrastructure on a large scale to increase use of mass transit or non-motorized modes of travel. Mandates for the production of electric cars and motorcycles powered by renewable energy, such as in the Netherlands and Norway, may also be needed, although this measure will primarily be confined to countries that can afford and technically support it. Regulatory incentives and disincentives such as congestion pricing, access restrictions for polluting vehicles, fuel taxes and fuel portfolio standards to reduce car use can also play a role in the transition. Cities can also encourage the use of alternative transportation and car and truck drive fleet efficiencies in energy use and pollution reduction (Jephcote, Chen and Ropkins 2016; Gu *et al.* 2018; Steinsland *et al.* 2018; Tscharaktschiew and Evangelinos 2019; Yu *et al.* 2019).

c) Resilient built environments

The strategies of this third area of work primarily relate to infrastructure:

- Development of redundant renewable energy systems that can handle shocks and stresses, and can be adapted as populations migrate to different habitable areas and smaller cities expand;
- Infrastructure reinvestment programmes to repair, maintain and extend existing water, renewable energy, municipal waste, air quality management and flood control infrastructure for all residents and communities, regardless of socioeconomic status, degree of informality or status of tenancy or land occupation;
- Infrastructure monitoring and assessment technologies to alert risk managers, as well as disaster prediction and warning systems to alert vulnerable populations (Grimmond, Xu and Baklanov 2014; World Meteorological Organization [WMO] 2019; International Telecommunications Network [ITU] 2020);
- Green and blue infrastructure investment in the construction and maintenance of green roofs, bioswales, parks, rehabilitated streams, mangroves, wetlands and floodplains to build in redundancy with stormwater and flood controls and mitigate urban heat island effects and associated energy use. Investment in education and skills development for technicians and engineers to build and maintain these systems (Sanchez and Reames 2019; Delgado Ramos *et al.* 2020);
- Biodiversity infrastructure to allow multiple species access to land and water while simultaneously encouraging physical activity, socializing, community activities and connecting with nature. This also supports multiple organisms and biocommunities in the urban landscape (Connop *et al.* 2016; Frantzeskaki 2019; Hunter, Cleary and Braubach 2019);
- Equity in infrastructure distribution and maintenance, ensuring that benefits are shared equitably by all urban residents (Nesbitt *et al.* 2019; Mulligan *et al.* 2020);
- Urban design innovation that is adapted to either hotter or colder regions and increased extreme weather events, along with equitable long-term strategies and finance for urban retreat or resettlement as necessary.

Transitional measures include identifying the highest-risk urban zones (for example, waterfronts, low-lying communities and vulnerable buildings) and developing interim multiscale infrastructure solutions – based on existing technologies and nature-based solutions that can be incrementally funded – to deal with flooding, monitor and reduce air pollution (Air Quality Expert Group 2018) and mitigate the urban heat island effect (Tan, Lau and Ng 2016). These solutions can range from regional levee systems and city seawalls through to neighbourhood bioswales. They will need to be adjusted and redirected as new patterns of climate change risks emerge, as exemplified by the Cloudburst Management Plan in Copenhagen (Lerer *et al.* 2017).

d) Resilient urban societies and communities

The fourth and final area of work involves resilient urban societies and communities, reflecting the fact that social resilience is just as important as the resilience of urban physical infrastructure. Approaches include:

- Social infrastructure investment programmes to build neighbourhood social capital and entrepreneurial and institutional capacity, expand participation in citywide infrastructure investment programmes and strengthen local organizations and networks;
- Local climate adaptation, disaster and recovery plans, and local capacities to implement them, helping create networks for mutual support in the face of extreme events (Grimmond, Xu and Baklanov 2014; Davidson *et al.* 2019; Fu 2019; Saja *et al.* 2019; WMO 2019; ITU 2020);
- Targeted assistance programmes to support marginalized social groups and communities, including women, ethnic and religious minorities, people with disabilities, children and youth, the elderly, and migrants and refugees by building genuinely inclusive social resilience mechanisms to deal with ongoing stressors and the ability to deal with unexpected extreme events (Wijsman and Feagan 2019).

Transitional measures include explicitly identifying the communities most vulnerable to risk and creating neighbourhood relief and recovery centres that can mobilize quickly, listen to the broad range of needs voiced by residents and meet immediate needs through participatory decision-making processes (Oluoko-Odingo and Mutisya 2018). Early warning systems for floods, hurricanes and other extreme events that provide advanced warning are also critical. Collaboration between different levels of government, academia and local populations can be an important factor, as shown by the AlertaBlu system in Blumenau, Brazil (Delgado Ramos *et al.* 2020).

Dimension two actively contributes to the first dimension through its focus on low-emission transportation systems linked to more efficient urban forms. It also supports the third dimension by creating living-wage employment opportunities, improving living conditions, ensuring the health of socioecological systems and prioritizing social resilience through inclusive planning and governance. Moreover, interactions across these dimensions argue for transformative models for economies, markets and investments, highlighting the need for enterprise as service, work as participation, investment as commitment and money as a social good. This aspect relates to the third dimension, since it requires this renewed economic perspective to deliver lasting prosperity, community well-being, robust social life and the rights of nature (Royal Government of Bhutan 2012: Jackson 2016; International Panel on Social Progress [IPSP] 2018). These economic models will require a paradigm shift (Sandberg, Klockars and Wilén 2019; Hanaček *et al.* 2020; Khmara and Kronenberg 2020; Jackson 2021). While they will not be free from constraints and contradictions, we must recall that "prosperity today means little if it undermines prosperity tomorrow" (Jackson 2016, p. 150).

4.2.3 Dimension 3: Inclusive and just cities

If cities can envision and achieve a circular economy, build sustainable and resilient urban forms and develop their social fabric in the ways best-suited to their specific context, this should translate into reduced inequality, additional livelihood opportunities and new pathways for upward mobility. However, without an explicit vision for social inclusion and justice, these strategies may still fall short. This means it is vital to ask just what characterizes an inclusive and just city on a finite planet.

The first dimension shows that achieving net-zero circular urban systems depends on a set of profound changes in the structure of the global and local economies that both drive the change and react to its dynamics. More importantly, the priorities of people, businesses and governments need to be reshaped so that value can still be obtained from these circular systems, helping overcome the lock-ins discussed in chapter 2. This means moving away from the current emphasis on the "financial economy" (stock markets, financial speculation and wealth generation), which primarily benefits its actors and institutions, and instead enabling economies aligned with the planetary boundaries, while focusing on the "real" economy. This involves the sustainable production of goods and services, alongside the value they create for workers and households, communities, society and life in general (Mazzucato 2018; Fonteneau and Pollet 2019; Serrano *et al.* 2019). It also means targeting consumption to meet collective needs – as well as individual ones – and to better protect the planet. Collaborative mapping of alternative economies can inform this process (Labaeye 2017; Labaeye 2019). Specifically, circular urban production and consumption that emphasize qualitative rather than quantitative growth (discussed further below), requires not only the ideas and knowledge that can be put into practice but also a rethinking of governance (Kovacic *et al.* 2021).

Building circular economies should focus on what we expect them to deliver, which in turn should connect to our understanding of development and the importance we place on supporting human capacities for all on a finite planet (Jackson 2016). The material basis of human life is critical for eradicating poverty and advancing social equity. Yet, if resilience and sustainability are to be equally addressed,

this must be founded on a careful and collectively organized management of the global commons, including climate and biodiversity. Priorities for circular cities, some of which are aligned with the model for the green economy, would also include responsible private sector production, jobs and wages; public sector employment and collective consumption of goods and services (such as social safety nets, education and training and retraining); and the health and well-being of communities and households (IPSP 2018).

The transition to a circular urban economy will entail fundamental changes in business, industry and labor markets. If well designed, new start-ups, factories, workshops, cooperatives, training centres, social and health care centres, and public programmes have the potential to address social and economic inequalities and disparities in health and well-being (chapter 2). They can provide training, meaningful livelihoods, better health and prosperity to those people who are economically marginalized. In turn, this can close gaps across income groups and transform cities from places with deep inequalities (for example, informal settlements next to glittering skyscrapers) into places that provide economic opportunity for people regardless of social difference. Every neighbourhood, however modest or informal, has the potential to be a healthy place of hope and opportunity, supported by a circular economy that is guided by principles of human prosperity, equity and justice (Schröder, Lemille and Desmond 2020).

As noted in chapter 2 of this report, encouraging deliberative and participatory schemes can also help avoid over-reliance on technological fixes that work against vibrant and more sustainable and resilient local economies. The involvement of communities, through public assemblies that are formally included in decision-making processes, as well as independent resident-based coalitions and networks, can actively contribute to increasing urban social equity, inclusion and health. Preliminary efforts that move in this direction include Sustainable Seattle, Climate Assembly UK and the Citizen Convention on Climate in France. Other formal initiatives are expected as an outcome of the Escazú Agreement (2018, ratified in 2021) and the Aarhus Convention and its Protocol (1998).

Understanding the third dimension requires considering for whom are we planning an inclusive and just city, which urban visions are in play, who creates them, who benefits and who suffers, and who contests them and why (Heynen, Kaika and Swyngedouw 2006; Albrechts 2015; He 2015; Meerow, Newell and Stults 2016; IPSP 2018; de Sá *et al.* 2019).

In addition to the technocratic planning, decision-making and power relations that typically define the (uneven) distribution of risks and resources in cities, it is necessary to consider all residents, both present and future. For example, refugee numbers in cities are likely to increase due to the dynamics of the global political economy and geopolitical conflicts, as is the case with large-scale migration from Central America to Mexico and the United States (Economic Commission for Latin America and the Caribbean 2018; Congressional Research Service 2021). However, climate change and environmental degradation will also be driving forces. Within each group of city residents, there are also finer grained social differences and patterns of exclusion related to gender, age, economic status, race and ethnicity, caste, religion, sexual orientation and many other intersectionalities. Sociological and community aspects of resilience are also important and include values, behaviour patterns, knowledge, the ability to adapt, transform and innovate, and differing degrees of vulnerability and access to power, social networks and capital (Wilkinson 2011; Folke *et al.* 2016; Patel *et al.* 2017).

All residents should have "rights to the city" (Lefebvre 1968), including (a) rights to public data and information, participation in decision-making, and justice in the distribution of public services (for example, principle 10 of the Rio Declaration); (b) the right to participate in shaping urban resilience plans, strategies and projects (Friend and Moench 2015); and, more broadly, (c) the additional right to help shape urban space and community life. These rights can also be creatively extended beyond human residents to encompass the countless other species that live in cities, either because they have always lived among people or because they are increasingly pushed into urbanized areas as climate and environmental change impact their habitats and homes ranges (Urbanik and Johnston eds. 2017).

This dimension seeks to shake up conventional ways of thinking and catalyse new ideas, taking into account the fact that humanity's future is so closely bound up with that of animals and wildlands that support biodiversity. It proposes a more inclusive vision based on the concept of the multispecies city (Wolch 1998; Houston *et al.* 2017; Parris *et al.* 2018; Kirbis 2020; Shingne 2020; Oke *et al.* 2021). Such an approach encompasses the idea of a city that respects nature and protects and restores the diversity of both animals and plants. However, it goes further by recognizing the importance of sentient animals, requiring moral consideration in discussions of inclusion. It also involves choices on urban form, land use and property, since these may lead to habitat fragmentation and can impact urban greening strategies and other multispecies urbanism interventions (Cooke Landau-Ward and Rickards 2019). Plants and animals are harmed by human-focused urban systems and lifestyles. Yet they are critical to a healthy trophic structure, nutrient cycling, soil health and other essential ecosystem services for people, including the happiness and joy of seeing wild nature in the city.

For some, this will constitute a challenging thought experiment, since some non-human species can be disease vectors that threaten human health (for example, mosquitos infected with malaria or the zika virus).[6] This has led to scientific recommendations to close wet markets, reduce the illegal hunting and trapping of wildlife and focus on their conservation rather than their persecution (Turcios-Casco and Gatti 2020). Humans can also pose health threats to animals (for example, roadkill). Yet multispecies cities are unavoidable, and the proposals of this dimension are essential for planning a nature-positive, multispecies city.

Start by considering a city whose human residents enjoy equitable access to basic needs and livelihoods that can support individuals and families, regardless of social or spatial differences. Such cities ensure enough nutrition, housing, education, health care and life chances for all residents and their children, protecting them (as well as flora, fauna and other forms of life) from disproportionate exposure to environmental hazards and harm. Such cities also seek to ensure fair access to the natural resources needed to support human and non-human everyday life. These resources include clean air, water, soils, ecosystem services provided by native plants, local and regional habitats, urban parks and forests, and the freedom to safely experience and explore the natural world. Many of these resources are not distributed equitably (Baró *et al.* 2021).

This dimension also presents a city with inclusive urban governance, taxation and spending programmes where all residents use their freedom and rights to engage and organize for institutional change to improve their lives and change policies or practices they perceive as unjust. Inclusive governance and public finance may mean redrawing administrative and jurisdictional boundaries, creating multijurisdictional cooperative agreements and empowering regional governance bodies to set and enforce targets. Such an approach could help to overcome fragmented metropolitan regions, characterized by stark divisions between rich and poor municipalities, which lack effective regional oversight or coordination to counterbalance local control. This fragmentation also limits possibilities for regional resource sharing and redistribution. Changes at higher levels of government may be required to minimize counterproductive inter-metropolitan competition, legitimize and empower local authorities, and ensure that these entities have financial and regulatory capacities. Regional institutions themselves should be inclusive and transparent, helping build social learning networks, explicit empowerment strategies and multilevel collaboration (Gómez-Álvarez *et al.* 2017).

Imagine inclusive cities that recognize that people living in poverty are typically at higher risk than people with higher levels of income and wealth because factors such as where they live in the city and their housing status (lack of affordability, precarity, informality) and less affluent or powerful social networks and institutional access. Low-income populations are less able to recover, improve their conditions and reduce their vulnerability to climate change (Satterthwaite *et al.* 2020). This recognition paves the way for intersectional climate mitigation and adaptation plans that explicitly prioritize the protection of the most vulnerable groups of residents (including people who live in slums, women, the elderly, children and people with disabilities). Policies should also include social provisions at the national level, ensuring aspects such as affordable housing, income transfers and urban infrastructure remediation, all designed to address the causes of vulnerability.

Lastly, picture a city that recognizes and values its multispecies character, the non-human world of the wild, companion and farmed, including many species that provide crucial ecosystem services for people and non-human nature; a city where "those who control and plan cities [...] consider the more-than-human" (Parris *et al.* 2018), acknowledging the intrinsic value of nature and the respect it demands. A multispecies perspective allows cities to play a major role in protecting planetary biodiversity (especially

6 In the case of COVID-19, one of the plausible hypotheses for the origin of the virus is that bats infected with coronavirus infected pangolins that are hunted by humans and sold in wet markets for human consumption. Yet, there are four main hypotheses for how COVID-19 emerged: (1) zoonotic direct transmission; (2) introduction through intermediate hosts followed by zoonotic transmission; (3) emergence through the cold/food chain; and (4) a leak from a laboratory (WHO 2021).

in endangered species "hotspot" regions that are also home to fast-growing urban areas) and by serving as refuge for wildlife (Goddard, Dougill and Benton 2010; Derby Lewis *et al.* 2019). Multispecies inclusion demands more "caring capacity" from city residents, businesses and institutions, and ways to "hear" and recognize multispecies voices. It also prompts cities to develop multispecies plans as part of their regular urban planning and policymaking process, as well as ways of explicitly considering the needs of plants, animals and biodiversity, alongside people (Apfelbeck *et al.* 2020; Xie and Bulkeley 2020).

Multispecies cities accept responsibility for restoring ecosystems (both near and far) damaged by their extraction and use of energy, materials and natural resources. They plan for added risks of potential zoonoses from urbanization and biodiversity loss and consider the implications of environmental degradation and climate change for biodiversity and the different species that are currently resident or expected to arrive as climate migrants (Steele, Mata and Fünfgeld 2015). Examples of pioneers of such a multispecies approach include Ecuador and Bolivia, whose constitutions enshrine the rights of nature, as well as Mexico City, whose constitution respects the rights of companion animals. While these provisions have yet to be fully implemented in practice, they are laudable first steps in a desirable direction. Smaller-scale but even more noteworthy examples are Curridabat, Costa Rica and Baseline, a new planned community in Colorado (United States). Curridabat's innovative "Sweet City" urban plan highlights the critical role of pollinators, which are recognized as official citizens of the city alongside their plants and trees (Greenfield 2020; Kitchen 2020); Baseline's private sector developer, working with entomologists and horticulturalists, has established a 'pollinator district' that links land use regulations to pollinator needs. Other cases that recognize pollinators' value are Oslo, London, and Mexico City, which have placed "insect hotels" in different locations associated with landscape and green area design and management.

This dimension of the vision has three major areas for action:

a. Inclusive urban planning

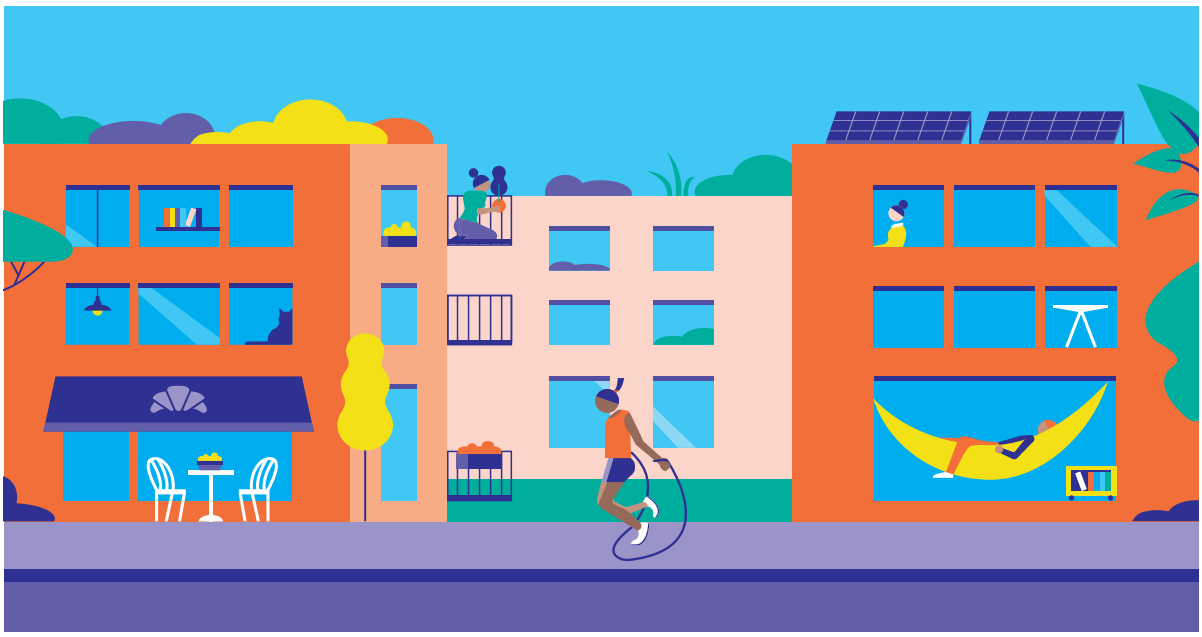
The first is inclusive urban planning, which entails infrastructure improvements to protect everyone and planned relocations of specific neighbourhoods, implemented via inclusive processes that empower and provide adequate resources to the most vulnerable people (Deakin 2012; Bush and Doyon 2019), in contrast to recent relocation examples that have harmed the poorest people (Ajibade and McBean 2014).

As a transitional measure, cities should create or update existing urban plans, since planning itself is often not undertaken or out of date. This leaves many decisions to be framed by the private sector and shaped by market and financialization dynamics (Shatkin 2008). Plans should include pre-planning analyses of climate vulnerability and urban biodiversity (including domestic, companion and feral animals and plants, particularly those with conservation and cultural value). They should comprise as well inclusive planning and urban design processes, informed by data and resident science programmes that gather situated knowledge, guided by equity planning principles and environmental justice goals that draw on users (including women and children, and the elderly). An inclusive planning process design recognizes that social learning is two-way and becomes embedded in permanent "double loop" learning processes (Grönholm 2020). For example, people living in poverty in informal settlements or refugee camps may need to learn about planning to be effective participants and may need legal support to hold government authorities and developers to account. However, both planning practitioners and more affluent residents can learn from residents of informal settlements and other marginalized groups when it comes to reuse, repair, recycling, the efficient use of material resources and developing flexibility to adapt or serve precarious residential populations.

b Equitable distribution of climate investments

The second area is equitable climate investment plans that follow climate finance guidelines (Carty, Kowalzig and Zagema 2020; Patel *et al.* 2020) and prioritize physical and social infrastructure to protect low-income neighbourhoods, including informal settlements. Retrofitting infrastructure – the majority of infrastructure spending in the United States (Kane and Tomer 2019) – to emphasize climate resilience could also ensure equitable distribution through revising the distribution of infrastructure benefits and using investment to correct long-standing injustices. For example, infrastructure plans to address the lack of access to adequate drinking water and sanitation services can reduce water pollution and waterborne diseases while respecting the diverse neighbourhood social fabric and enforcing human rights to water, sanitation and a healthy environment.

Equitable social infrastructure distribution efforts may include risk alert programmes, outreach, service delivery, and emergency rescue and support programmes for the elderly and people with disabilities, health or mobility challenges. At the same time, anti-displacement programmes restrict unfettered land markets that can catalyse gentrification and the displacement of poor people (especially residents of informal settlements). This phenomenon may occur as insurance pricing begins to account for risk more accurately, making riskier neighbourhoods like low-lying areas, which are typically occupied by poor people, unaffordable, or as physical infrastructure improvements are made reduce the risk of neighbourhoods. This is particularly important with the addition of green infrastructure that is meant to protect against extreme events such as flooding. Studies of cities in the Global South indicate that the distribution of urban green cover may favour peripheral lower-income communities in some geographic locations (Spescha 2020). Other research reveals higher-income neighbourhoods have a propensity to be closer to green space (Fernández-Álvarez 2017), while some cities display a more mixed pattern (Ruiz-Luna 2019). In the Global North, green cover is often correlated with socioeconomic status (Schwarz *et al.* 2015), except in depopulating cities where low-income neighbourhoods are associated



with an abundance of vacant green lots. In either case, new and attractive green infrastructure can make urban neighbourhoods and waterfronts more liveable and hence may drive up property values, to the detriment of residents on lower incomes. The equitable distribution of a variety of high-quality parks and open spaces can counter pressures for this "green gentrification".

Transitional measures such as climate action investment planning workshops and social network development with neighbourhood groups, urban practitioners and public and private sector actors can prepare all stakeholders to make informed infrastructure proposals, participate in selecting alternatives and negotiate the geographic allocation of climate infrastructure investments. As an example, Decidim digital platform is used by some cities for strategic planning, participatory budgeting initiatives, public consultations and other participatory and communication processes (Solecki *et al.* 2021). Another key transitional strategy is the provision of redistributive hazard insurance. In Houston, for example, low-income minority neighbourhoods are prioritized for flood protection funding, rather than allocating these resources based on the value of at-risk properties, which would favour wealthier neighbourhoods (Flavelle 2020). Similarly, in Manizales, Colombia, earthquake insurance requires more affluent households to pay insurance premiums that cover protection for low-income ones (Marulanda *et al.* 2014).

c. Multispecies and nature-positive strategies

Thirdly, based on sound science and local knowledge, multispecies and nature-positive strategies should advance along two simultaneous tracks:

1. Urban biodiversity plans and habitat designs that protect areas of high biodiversity from disruption and development, create single and multispecies habitat and landscape corridors and restore habitat where possible while addressing the novel ecosystems that will inevitably appear as ecozones shift in response to changing temperature and precipitation regimes that alter habitat character. Biodiversity plans also support water, nutrient and energy cycles to sustain ecosystem services and evolutionary processes through biodiversity (Parris *et al.* 2018). Planning and design should preserve and expand urban forests, bioreserves and stepping-stone habitats, maintain natural drainage lines, retain and use storm water, and develop grey, green and blue infrastructure projects, such as the restoration of urban rivers and streams and the creation of green roofs and walls. This infrastructure can enhance biodiversity, integrate plant conservation strategies and use vacant, neglected and newly available spaces to increase habitats (Parris *et al.* 2018).

2. Multispecies disaster preparedness plans that recognize the vital role played by companion animals, domestic animals, urban wildlife and plants in the quality of urban life. Efficient metropolitan land use should be prioritized to minimize the loss of wildlands. Moving towards a circular economy can limit use of virgin materials such as forest products upon which animals depend and prevent pollution and waste from entering the environment (for example, plastics and novel chemical pollutants). Promoting low-carbon, high-nutrition, plant-based diets avoid or at least reduce greenhouse gas emissions from animal agriculture, save water, feed more people and respect non-human lives.

Transitional measures include explicitly identifying the most vulnerable communities and creating facilities and approaches to meet immediate needs. These are likely to include emergency alert systems and neighbourhood relief and recovery centres that can be quickly set up in the advent of extreme events like floods and fires. These centres must consider gender and safety issues to be able to meet needs for shelter, health care and food security (the latter supported by robust local and regional food systems). Transitional measures also include recognizing sociocultural

differences in attitudes towards animals and coexistence (Nyhus 2016; Rupprecht 2017) and public education and discussion programmes through schools and community service organizations to expand the understanding of non-human urban residents (their ways of life and urban geographies). This may require exploring ways to give a voice in governance to non-humans (Beatley and Bekoff 2013) and developing regulatory strategies to protect plants and animals from harm.

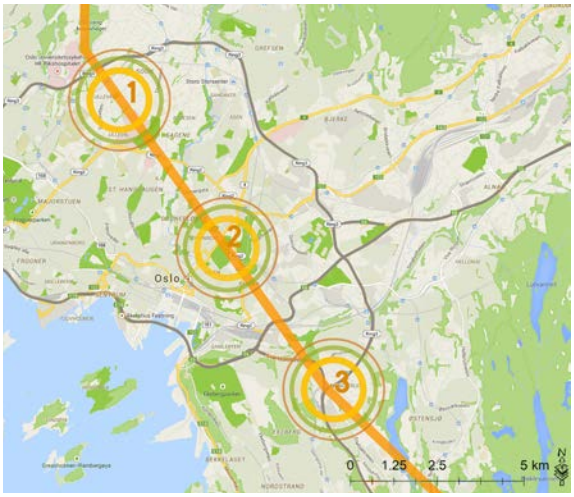
Finally, transitional measures include preparing people for new animals that may appear in their cities as a result of climate change or biodiversity loss, including new animal disease vectors, and the emigration of other species. Such changes will result in the emergence of novel urban ecosystems, beyond those such as ornamental gardens that already characterize most cities (Ahern 2016). The emergence of new species compositions is particularly common to habitat patches affected or abandoned by humans and that remain part of the urban fabric (Kowarik 2018). This complex dynamic cannot be controlled, but it does call for active support of existing and native biodiversity to prevent the localized extinction of species by protecting existing habitat quality and creating landscape connections. Oslo's bee highway (**Figure 4.3**) is a good example of a purpose-built connection. The initiative is the first of its kind and is designed to provide pollinator pathways through the city for both wild and domesticated bee populations via urban landscape design and maintenance, habitat protection, dedicated private gardens and beekeeping facilities. This experiment appears to be working as intended, although "precautionary zones" have been identified in the city, where wild bees may need additional protection in the future through the addition of flowering plants (Stange *et al.* 2017). A more futuristic proposal, which builds on earlier landscape models such as the Emerald Necklace in Boston in the United States is the Rutas Naturbanas habitat corridor that runs through the entire city of San Jose Costa Rica and whose first kilometre was funded by a private company. These large-scale landscape interventions may provide opportunities to design city wildland buffers both to protect animals from human intrusion and to protect people from the dangers of the presence of wildlife, such as attacks and disease transmission.

The third dimension of integrated urban action has clear linkages to the first two. It highlights the fact that inclusivity, fairness and justice are prerequisites for building a circular economy and that a circular economy benefits non-human species (dimension one). In terms of the second dimension, this connects with urban design and resilience plans and investment, as well as early warning systems and disaster recovery.

The third dimension is also perhaps the most challenging to achieve. Cities throughout the world have struggled to create just and inclusive places, plans and policies for their different residents. Cities need to recognize patterns of social and environmental injustice and address the fact that plans and policies that work for one group may not work for another due to factors such as gender, race or ethnicity, migration status, age, economic status, caste, religion and ability. There can be significant gaps between state policy goals and practice on the ground. While empowerment is challenging in all types of cities, this is especially true in places with weak rule of law and protections for individual rights or where there are high levels of insecurity or traditions of equity planning are lacking. Challenges to social participation and co-production increase during wars, natural disasters, pandemics and other calamities. Yet mobilizing residents around inclusion, institutional support for social learning and explicit equity planning and participation policies are crucial for further inclusion and justice (chapter 2).

The value of multispecies cities, characterized by a consideration for the well-being of biodiversity and the requirements to allow animals and plants to persist and thrive, may be new for some people. However, as the idea of planning for urban nature becomes more widespread, it is being embraced by an increasing number of scholars and planning practitioners (Russo and Cirello 2017; Arof *et al.*

Figure 4.3: Oslo's bee highway



Source: Adapted from Food Tank 2016

2020; Beatley 2020). Multispecies urban planning is largely uncharted territory and while it may seem daunting, it is nonetheless compelling (Houston *et al.* 2017). Humans do not live outside nature and our welfare is tied intimately to the fate of the other species with whom we share the planet. This is why biodiversity loss is considered one of the core planetary boundaries, along with climate change (Steffen *et al.* 2015; Hoornweg *et al.* 2016). It can lead us to a point of no return, further from the conditions of the Holocene, which have supported life as we know it and which we arguably have a duty to protect. Cities, national governments and global governance bodies have crucial roles to play in terms of vision and of enabling the protection of urban biodiversity and nature by creating the multispecies cities of the future.

Each of these ambitious and integrated dimensions for urban transformation and its related goals must be started and then constantly evolved over time in the face of changes in context. The vision and goals for the cities of the future and the strategies to achieve them will face many challenges. Moreover, progress towards achieving goals will not be uniform over time. On occasions, our limited capacity to imagine and implement these transformative pathways and to innovate, collaborate, act and persevere may slow their achievement but they also hold the key to realizing our ambitions for planetary survival and wellbeing.

4.3 Working across dimensions for maximum local to global impact

This chapter has considered three dimensions of integrated urban action as ways of transforming cities for the future. However, it has also noted that these dimensions are neither separate nor separable. Actions across dimensions increase the potential for cities to address systemic, cross-cutting issues and to contribute to global urban agendas:

- circular cities can promote social inclusion by improving the quality of air, soil and water, reducing waste, creating new economic opportunities, and achieving near net-zero built environments that make buildings (including housing) healthier, less expensive to operate, and more comfortable;
- sustainable cities can support circular economies by redesigning urban land, transportation systems and urban infrastructure in general to reduce GHG emissions and other pollution, while resilient cities can support biodiversity conservation and social inclusion by providing green infrastructure and climate adaptation programs based on equity and participatory planning principles;
- multispecies cities in which residents respect non-human lives and the diverse soils and plants that support them can build urban resilience by protecting urban green space, conserving habitat and biodiversity, improving ecosystem services (including urban thermal comfort), and promoting plant-based diets.

The approaches for these dimensions of integrated urban action contribute to achieving critical global urban agendas and reversing the damaging environmental trends outlined in chapter 3.

4.3.1 Links across dimensions

Firstly, circular cities are a pathway to sustainability, justice, equity and health. An economy redesigned on principles of circularity can address the need of all urban residents for access to livelihoods, clean air and fairly distributed clean water. It can create new jobs, occupations and markets, and allow waste to be used as inputs for manufacturing and agriculture. Reductions in pollution and GHG emissions are also important benefits from circular production processes (Haines *et al.* 2007). Compact, walkable cities and affordable and low-emissions public transportation improve air quality (Vardoulakis *et al.* 2018). Energy-efficient buildings and local renewable energy microgrids can reduce indoor emissions and toxic chemicals and increase thermal comfort (World Health Organization [WHO] 2016). Finally, water-efficiency measures can have ecosystem benefits and provide clean water for all (Delgado Ramos and Blanco 2017).

Secondly, there are human and environmental health benefits from restoring biodiversity, by planning inclusive and multispecies cities for the future. Biodiverse cities can promote physical and mental health, equitable access to nature, smaller environmental footprints and resilience. Nature-based and multispecies plans and policies recognize both the inherent and instrumental value of all organisms and support local and endemic species (Maller 2021). Granting spaces for people and non-human nature to thrive can also help to ensure a resilient, biodiverse urban ecosystem.

Finally, food security and resilience can be supported by local and regional diets and food systems that also avoid food waste (Coulson and Sonnino 2019; Reina-Usuga *et al.* 2020). Changes in urban diets, which are currently energy and water intensive can make a big difference to energy and water footprints. Promoting healthier diets that take into account sustainability could reduce water footprints by 18 per cent, while vegetarian diets could reduce this footprint by up to 37 per cent (Food and Agriculture Organization of the United Nations 2020, p. 105). Similarly, in the United States, the consumption of fossil fuels associated with the food system could be reduced by 3 per cent by shifting towards healthy diets and up to 74 per cent for energy-efficient ones.

Regional food systems are also relevant for large cities where local and regional production, distribution and processing can work together using environmentally sustainable production practices (such as agroecological practices; Egerer and Cohen eds. 2020). In the Global South, local provision has a particularly important role to play in creating a stronger social economy while moving towards a healthier and more affordable food system that respects and preserves diverse foodways and biocultural heritage (Vierikko *et al.* 2015; Buizer, Elands and Vierikko 2016;). Regional food systems can also increase urban resilience, reduce organic waste, support soil health, nourish urban plants and forests and reinvigorate green spaces, including urban farms, vegetable gardens and urban orchards.

Figure 4.1 highlights how these synergies work together across the three dimensions. The figure shows how different components of each dimension can generate synergies (positive and negative) within and across dimensions. Examples include:

- infrastructure (green, blue and grey) and food systems strategies are vital to the first two dimensions as they have significant benefits in terms of circularity and climate, especially since resource efficiency can reduce latent stressors and enhance resilience (as noted in the UN-Habitat New Urban Agenda);
- urban form and nature-based solutions are key to the first two dimensions, since they can enhance resilience and reduce vulnerability linked to inequalities;
- drives for efficiency in the use of resources and in energy may generate trade-offs if the redundancies of the sociotechnical systems critical to urban resilience are not considered;
- urban revegetation can have negative impacts, such as propagating allergies that affect public health;
- progress in the first two dimensions may be limited without effective changes in governance, as outlined in the third dimension, to build local capacity to act in bold ways that are equitable, inclusive and transparent, recognizing the ties that bind cities and nature.

To accelerate urban transformation towards more liveable cities where urban dwellers fully participate in local governance, live in healthier and more resilient communities and enjoy more equitable access to efficient public services and economic opportunities, every city will need to work through all three dimensions, including their components and interactions. However, they will need to do so at the intensities and temporal and spatial scales that respond to their own priorities, needs, capacities and governance. Advancing all dimensions of integrated urban action as a whole multiplies their potential benefits, working across linkages to explore unique opportunities and enhancing positive synergies or potential multi-benefits or avoiding negative outcomes. Chapter 5 discusses specific pathways for achieving each dimension in greater depth.

4.3.2 Localizing global urban agendas

A key challenge facing cities and urban regions around the world is to effectively contribute to key global and regional agreements and agendas that support the future urban vision proposed here or adapt them to their local context (**Figure 4.4**). The three integrated dimensions described in this chapter are consistent with the normative principles of sustainability, equity, resilience and others included in the aforementioned global agreements. Most of these agreements explicitly or implicitly mention the role of action at the city level, meaning they can help guide cities in their efforts to contribute to avoiding global tipping points.

The 2030 Agenda for Sustainable Development is a comprehensive international agenda that includes specific Sustainable Development Goals (SDGs). Many of them relate to cities and SDG 11 explicitly covers urban environments. The 2030 Agenda also supports other global agreements, such as the Paris Agreement, the Sendai Framework, the New Urban Agenda and the forthcoming New Deal for Nature, which supports the post-2020 global biodiversity framework of the Convention on Biological Diversity (McDonald *et al.* 2018; ICLEI – Local Governments for Sustainability [ICLEI] and Cities Biodiversity Centre 2020). The task is to localize these agreements with aggregate policies and strategies and coordinate forward-looking measures by governments, city networks, coalitions of mayors, international and regional development banks, academia, the private sector and civil society (for guidelines and tools, see UNEP 2020c). This bottom-up process, which starts with cities, is a critical pathway to meet multilateral environmental agreements simultaneously promoted at multiple levels, from international agencies, through national, state and provincial levels of governance, all the way down to the urban and metropolitan levels.

These efforts show the interlinkages and potential synergies between different global agendas and the role of cities in achieving goals. Examples include the Sustainable Cities Impact Programme, funded through the Global Environment Facility-7 by UNEP in collaboration with C40, ICLEI and the World Resources Institute (Global Environment Facility 2020). Current reporting of climate action by cities in the context of global agreements and agendas (for example, C40, the Voluntary Local Review process for the SDGs and the Carbonn Center) are also valuable, as they reveal the many different realities of cities around the world. Finally, cities such as Copenhagen, Johannesburg, Montreal, New York, Paris, Rio de Janeiro, Seoul and Sydney , among others, are already taking their own steps to counter the impacts of climate change, mitigating GHG emissions and promoting adaptation (Seto *et al.* 2014; ICLEI 2018; C40 Cities and Arup 2020; Delgado Ramos *et al.* 2020). **Figure 4.4** shows how the three dimensions are linked to regional and global agreements.

4.4 From city visions to realities: transformative pathways to change

Achieving the cities of the future based on the dimensions outlined in the chapter will not be without its challenges. While these examples of future cities set out a general direction – and even constitute a paradigm shift – they must be grounded in practical and wide-ranging realities. Making the dimensions a reality requires not only identifying potential challenges, but also adopting a creative approach to devise solutions on different timescales while working together across cities, developing durable capacities and robust local governance systems, and encouraging urban residents to adopt novel everyday practices that support the future cities envisioned in this chapter.

The extent of the challenge will depend on how the transformation goals for cities will be set and their level of ambition. Another key issue is the capacities – in terms of resources and expertise – currently possessed by cities and nations and that can be used to achieve and implement

Figure 4.4: Interactions between international agreements and the three dimensions of urban transformation

DIMENSION 1
Net-zero circular cities

Materials
SDG: 11, 12 & 13

Buildings
SDG: 7, 9, 11 ,12 & 13
CBD: 4

Energy
SDG: 7, 9, 11 & 12
CBD: 4

Water
SDG: 6
CBD: 6, 7, 8, 13 & 14

Food
SDG: 9, 11 & 12

Waste
SDG: 11, 12 & 13

Emissions
SDG: 9, 11 & 13

DIMENSION 2
Inclusive and just cities

SENDAI: 1
CBD: 15
SDG: 11, 17 & 19

Social resilience and networks
SENDAI: 1 & 3
SDG: 11 & 13

Access and mobility
SENDAI: 1, 2 & 3
SDG: 10, 11 & 13

Urban infrastructures
SENDAI: 1, 3 & 4
SDG: 9, 11 & 13

Nature-based solutions
SENDAI: 1 & 3
SDG: 3, 6, 11, 13 & 15

Urban ecosystems
CBD: 15

Biophysical features
SDG: 2, 12, 13, 14 & 15

DIMENSION 3
Resilient and sustainable cities

SENDAI: 4
SDG: 1, 2, 3, 5, 6, 10, 11 & 17

Health
SENDAI: 2 & 4
CBD: 2, 14, 15, 17 & 18
SDG: 3, 5, 6, 7, 8, 11 & 13

Urban planning systems design
SENDAI: 1, 2, 3 & 4
CBD: 4, 17, 18 & 20
SDG: 4, 5, 11, 13, 16 & 17

Participatory governance
SENDAI: 1, 2 & 4
CBD: 17, 18 & 19
SDG: 4, 5, 16 & 17

Capacity building
SENDAI: 2 & 4
CBD: 4 & 19
SDG: 4, 11, 13, 14, 15 & 17

Social environmental and multi-species justice
CBD: 1, 5, 6, 8, 9, 11, 12, 13, 14, 15, 18 & 19
SDG: 1, 5, 10, 11, 14, 15 & 16

Biodiversity and habitat value
CBD: 13 & 15
SDG: 15

these dimensions. As mentioned by the Global Research and Action Agenda on Cities and Climate Change Science (World Climate Research Programme 2019), access to sufficient, high-quality, and accessible data will also be helpful, not only to enable tools for smart cities (these tools must be appropriate, equitable and transparent) but also to promote open access to data, evidence-based decision-making and citizen and resident science. Achieving sustainable, resilient and inclusive urban futures means less individualistic action and an emphasis on the co-creation and co-production of solutions. Cities will need to draw on a wide range of contributors: national governments, regional and international organizations, businesses responsible for building infrastructure, international cooperation agencies, non-governmental organizations, coalitions of mayors, the scientific community, practitioners, city networks, communities and individuals. Crucial also are businesses to support urban transformation actions and policymakers to develop enabling legislation that considers the intersectoral nature of the challenge. The variety of behaviour changes that individual residents will need to embrace could be daunting, requiring not only public messaging and education campaigns, but also powerful and consistent incentives and user-friendly innovations that can influence consumption, travel, diets and other factors (Coskun *et al.* 2015; Shahzalal and Hassan 2019; Baum and Gross 2017).

Cities work in many different ways. There is no one route or pathway for a city to achieve this vision and these dimensions. The pathways presented in chapter 5 will depend heavily on the characteristics of each individual city and historical, geographic and biophysical differences, as well as those related to culture, patterns of consumption, population size and diversity, and political and economic structures and dynamics (Schröder *et al.* 2018). The degree of acceptance or resistance when it comes to change in cities (chapter 2) could be highly significant. As such, cities will follow different pathways to realize the dimensions set out in this chapter. These pathways will be shaped by the potential for ground-breaking change and the ability to actively accelerate a major urban transformation over time. Pathways should be adapted depending on the potential for radical change and the time frame.

Table 4.1 illustrates how the three urban dimensions might play out along transformational pathways. For each dimension and its subareas (as shown in Figure 4.2), we provide two types of action or strategies key to the realization of that subarea's goals. For example, under Dimension #1's subarea of food we consider "food waste reduction" and "urban and peri-urban agriculture" as two basic types of action (among many that are possible) designed to meet the goal of creating an efficient, low-carbon urban food system. Reading across the table provides an estimate of the urgency of implementing such strategies, and which areas of the world are apt to (or have the capacity to) rapidly absorb – or be able to make quick progress – along this pathway compared to areas that will need more time for goals achievement. Certainly, these estimations can change if decisive action are put in place.

The future cities envisioned in this chapter all have corresponding transformation pathways, transitions and measures designed to achieve them, all of which will provide multiple benefits over the short and long term. Trade-offs will be required for bold transformations, particularly in the face of the global pandemic. Some of these may be politically and socially challenging. We must also remember that when moving forward on one dimension, it is important to avoid undermining progress in the other two. Yet if harnessed together, these dimensions and the transformative vision behind them can make cities agents of the changes that the world urgently needs.

Table 4.1: Urban dimensions, sub areas, and types of action: Urgency and global region absorption capacities

Dimension component	Type of actions	Urgency	Areas of potential absorption under a transformation pathway scenario		
			Fast	Intermediate	Slow
Dimension 1– Circular cities					
Food	Food waste reduction	I	– Latin America and the Caribbean – Africa – West Asia – Asia and the Pacific	– Pan-European Region	– North America
	Urban& peri-urban agriculture	ST	– Latin America and the Caribbean – Africa – Asia and the Pacific	– North America – Pan-European Region – West Asia	
Water	Leakages reduction and recycling	I ST	– Latin America and the Caribbean – Pan-European Region – Asia and the Pacific	– Latin America and the Caribbean – West Asia	– Africa
	Water harvesting	ST	– Latin America and the Caribbean – Africa – West Asia – Asia and the Pacific	– North America – Pan-European Region	

Dimension component	Type of actions	Urgency	Areas of potential absorption under a transformation pathway scenario		
			Fast	Intermediate	Slow
Dimension 1 - Circular cities					
Energy	Renewable generation	I ST	– North America – Pan-European Region – Asia and the Pacific	– Latin America and the Caribbean – West Asia	– Africa
	Carbon/fuel taxes and congestion pricing	ST	– North America – Latin America and the Caribbean – Pan-European Region – West Asia – Asia and the Pacific	– Africa	
Buildings	Sustainable design	ST		– North America – Pan-European Region – Asia and the Pacific	– Latin America and the Caribbean – Africa – West Asia
	Retrofitting	ST MT	– Pan-European Region	– North America – Asia and the Pacific	– Latin America and the Caribbean – Africa – West Asia
Materials	Reduction of consumption	I	– North America – Pan-European Region	– Latin America and the Caribbean – West Asia	– Africa – Asia and the Pacific
	Reuse of manufactured products	ST MT	– North America – Pan-European Region	– Latin America and the Caribbean	– Africa – West Asia – Asia and the Pacific
Waste	Composting	I	– All		
	Second-hand markets/sharing platforms	ST	– All		
Emissions	Mitigation technologies, including electrification	ST MT	– North America – Pan-European Region	– West Asia – Asia and the Pacific	– Latin America and the Caribbean – Africa
	Sustainable and low carbon diets	I	– All		
Dimension 2 – Resilient and sustainable cities					
Biophysical features	Monitoring and alerting systems	I ST	– North America – Pan-European Region – Asia and the pacific	– Latin America and the Caribbean – Africa – West Asia	
Urban ecosystems	Biodiversity conservation and multispecies strategies	I	– All		
	Urban river restauration	I	– All		
Nature-Based solutions	Revegetation	I ST	– All		
Urban infrastructures	Grey infrastructure for risk reduction	ST MT	– North America – Pan-European Region – Asia and the Pacific	– West Asia	– Latin America and the Caribbean – Africa
	Green and blue infrastructure	ST	– North America – Pan-European Region – Asia and the Pacific	– Latin America and the Caribbean – Africa – West Asia	
Access and mobility	Resilient/low-carbon transport infrastructure	I ST		– North America – Pan-European Region – Asia and the Pacific	– Latin America and the Caribbean – West Asia – Africa

Dimension component	Type of actions	Urgency	Areas of potential absorption under a transformation pathway scenario		
			Fast	Intermediate	Slow
Dimension 2 – Resilient and sustainable cities					
	Walkable urban form	ST MT	– Asia and the Pacific	–North America – Latin America and the Caribbean – Pan-European Region	– West Asia – Africa
Social resilience and networks	Strengthening socioeconomic links with rural hinterlands	ST	– All		
	Protection of vulnerable urban places & populations	I	– North America – Pan-European Region	– West Asia – Asia and the Pacific	– Latin America and the Caribbean – Africa
Dimension 3 – Inclusive and just cities					
Health	Social and health centers for improving equity	I	– North America – Pan-European Region	– West Asia – Asia and the Pacific	– Latin America and the Caribbean – Africa
	Universal health insurance	I		– North America – Pan-European Region – West Asia – Asia and the Pacific	– Latin America and the Caribbean – Africa
Urban planning systems design	Integrated socio-ecological urban planning	ST		– North America – Pan-European Region – Asia and the Pacific	– Latin America and the Caribbean – Africa – West Asia
	Incentive alignment across city governments subunits	ST MT	– North America – Pan-European Region	– West Asia – Asia and the Pacific	– Latin America and the Caribbean – Africa
Participatory governance	Community-informed budgeting	I	– All		
	Inclusion of multispecies representaction	I	– All		
Capacity building	Use of situated knowledge	I	– North America – Latin America and the Caribbean – Pan-European Region	– Africa – West Asia – Asia and the Pacific	
	Institutional capacity building	I	– North America – Pan-European Region – Asia and the Pacific	– Latin America and the Caribbean – West Asia	– Africa
Social, environmental and multi-species justice	Just climate-environmental action investment plans	I	– All		
	Just distribution of infrastructures and public services	I	– North America – Pan-European Region	– West Asia – Asia and the Pacific	– Latin America and the Caribbean – Africa
Biodiversity and habitat value	Connected urban park and open space networks	I	– North America – Pan-European Region	– West Asia – Asia and the Pacific	– Latin America and the Caribbean – Africa
	Urban/wildland interface protection	I	– All		

I Imminent (2021-2025) ST Short Term (2026-2030) MT Mid Term (2031-2040)

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Chapter 5

Achieving Urban Transformation: From Visions to Pathways

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5.1 From lock-ins to transformative pathways

The fundamental changes needed to achieve the vision and dimensions presented in chapter 4 require a shared understanding, commitment and desire for profound, strategic and substantial change to tackle interconnected environmental and development challenges through the notion of "transformation". In recent years, urban practitioners, policymakers, local authorities and communities, social movements and activists, think tanks and academics alike have shared thinking in this direction.

However, planning for such transformation is a massive challenge for cities, where policy and investment changes often occur incrementally and where systemic changes often require decades of consistent leadership, investment, and aligned effort. Change might typically begin with an inspiring project, a new policy, a new knowledge partnership, or an active coalition. Over time, these important first steps may become catalytic efforts towards the development of a transformation pathway, involving multi-faceted, articulated, sustained and scaled up efforts, leading over time to transformative changes at the city scale and beyond.

This chapter showcases some of the impressive efforts that cities have made in starting transformative processes to turn visions into actions that make a difference. The pathways and cases presented here are not intended to illustrate the best or only way to create transformative change, as no city has yet reached this ambitious goal. Rather, they offer key principles and practices of policymaking, planning, multilevel governance, citizen participation, technological development and other crucial elements that together pave the way for transformative change. It is important to recognize that in most cases, the outcomes achieved at the city level represent only a fraction of the potential transformation a city needs to produce to achieve social and environmental justice and the environmental sustainability objectives called for in GEO-6 (United Nations Environment Programme [UNEP] 2019). The real-world examples reviewed throughout this chapter point towards the successful restructuring of fundamental processes of governance that can sustain and eventually achieve these transformational outcomes in the longer term.

As shown in **Figure 5.1** and discussed in chapter 2, designing and activating pathways towards sustainable and just outcomes requires simultaneous efforts and commitment to tackle deep-seated lock-in processes relating, in particular, to the political economy of cities, outdated urban planning approaches and exclusionary governance models. This shift requires addressing difficult trade-offs, working in an integrated fashion across visioning, planning, budgeting, procurement and operations, and confronting existing power structures and balances. It also requires improvements to be made in terms of technology and infrastructure, with specific emphasis on valorizing existing knowledge and low-tech approaches and on equitable access to new technology and related materials and product designs. Additionally, just transitions to urban sustainability require changes in the education and training of urban professionals and managers, and changes in consumer preferences and behaviours.

This is no small task, which explains the tendency towards inertia in many cities, even as they adopt ambitious Sustainable Development Goals (SDG) and other sustainability targets.

The importance of tackling these lock-ins should not be underestimated, as they mark the difference between current and desired outcomes and are key to counteracting natural resource extraction, carbon-intensive development, and environmentally damaging practices – the impacts of which are described in chapter 3 – all of which worsen social inequalities. In other words, once lock-ins have been overcome, transformative pathways are much more likely to succeed.

The term "pathways" describes the different ways in which institutions and city-makers create the enabling conditions, deliberative forums, policies, planning routes, markets, technologies, products and consumption choices that can achieve transformative results.

The establishment of a transformative pathway often begins from a single entry point:

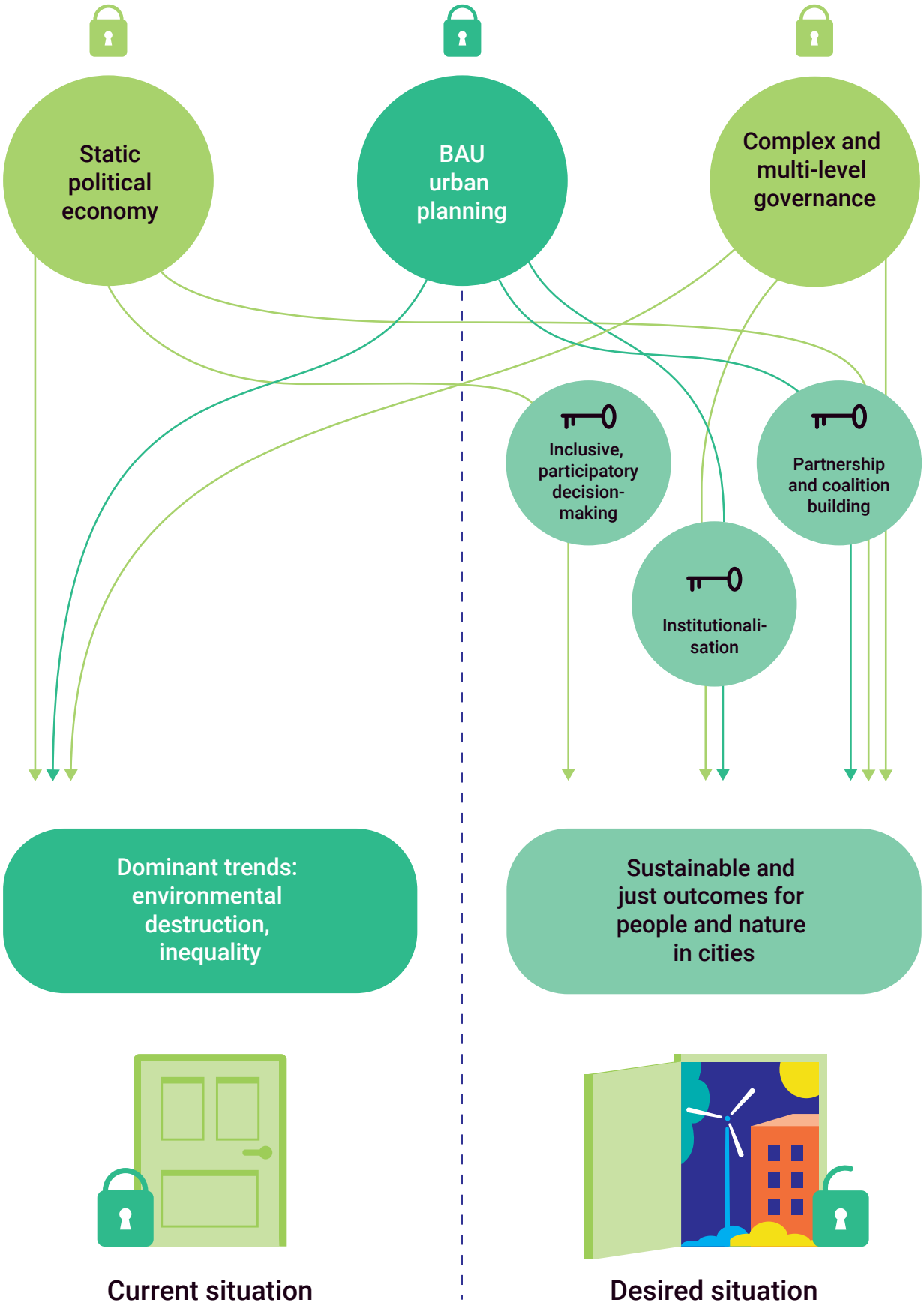
- Sometimes the process starts with the implementation of innovative policies;
- In other cases, transformative pathways occur through changes in the organizational and governance structure of urban institutions.

In some cases, pathways are led by the collective action of citizens and civil society organizations. A number of bold city actions that, over time, bring about the major environmental, resilience, equity and social justice changes described in chapter 4 are examined below. Moving towards this vision and these dimensions involves changes in socioeconomic, political and technological systems, as well as fundamental changes to culture, collective decision-making and individual behaviour.

Pathways might initially be triggered by forward-looking city strategies, reactions to local or global shocks, adaptations to chronic stresses or a combination of these factors (Levy *et al.* 2017). However, without paying careful attention to the multiple dimensions that enable pathways to become systemic and transformational, opportunities to advance the vision and dimensions described in chapter 4 can be missed. Focusing on each of these three dimensions, this chapter examines the entry points, opportunities and precedents that these pathways can build upon. Each pathway contains case studies used to demonstrate how it might be shaped, based on a large amount of empirical evidence of success and trade-offs.

While real-world examples of significant urban transformations are not always easy to identify, the examples in this chapter aim to show how transformative pathways are being crafted in practice and why they

Figure 5.1: Ways to overcome lock-ins



matter. This is not intended to provide prescriptive measures of what should be done, nor to glorify the initiatives undertaken in specific contexts. Doing either would be naïve and even counterproductive. Instead, the pathways and cases are presented here to inspire learning from current and ongoing approaches and initiatives, while casting a critical eye on both their potential and shortcomings. The aim is to acknowledge the diverse factors that might trigger such transformative pathways, as well as the actual conditions that might enable cities to overcome lock-ins and become transformative in different contexts, in order to reverse the negative environmental trends examined in chapter 3.

The pathways deal respectively with strategic approaches to building urban circularity (section 5.2), achieving deep decarbonization (section 5.3) building resilience in a city (section 5.4) and building an inclusive and just city (section 5.5). This last pathway examines how and why introducing a justice perspective into all pathways is crucial to ensure that the whole is greater than the sum of its parts. The final section explores the key lessons emerging from interactions across all pathways and what makes them truly transformational.

5.2 Net-zero circular cities pathway

As discussed in chapter 4, the goal of transforming cities to work in a circular fashion involves (re)designing and (re) integrating urban resource use in cities such that as a city grows and improves quality of life, its demands for new resources as well as its generation of waste are driven to near-zero. The notion of a circular city is inspired by the functioning of natural ecosystems, in which resources are conserved and wastes from one organism provide nutrients for others, resulting in net-zero pollution.

Transformation towards circular cities requires that local governments become more familiar with the interlinked concepts of resource flows, urban metabolism and circular economy:

- **Resource flows** represent the movement of resources (for example materials, energy, people and information) into the city, how they circulate between sectors and uses, how they accumulate within the city and how the remainder exit the city;
- **Urban metabolism**, depicted in detail in chapter 4, describes how these flows interact to shape the city, service the needs of its people, and impact the surrounding hinterland (Musango, Currie and Robinson 2017). In this pathway, the aim is to shift the urban metabolism from linear to circular, so that the amount of resources entering and waste exiting the city are minimized;
- **Circular economy** is one in which a continuous flow of technical and biological materials creates opportunities for social and economic value to be created in the process of shifting towards circularity. Much more than simply recycling,[1] it benefits from an integrated approach at multiple levels – from government-run infrastructure systems to private sector facilities and community initiatives.

Transformative pathways for circular cities need to be adapted to each city's circumstances, characteristics and political realities. There is no standardized solution, as some efforts in cities such as Rotterdam and London and a wide range of Chinese cities already demonstrate (London Waste and Recycling Board [LWARB] 2017; Gladek *et al.* 2018; Prendeville *et al.* 2018; Wang *et al.* 2018). Yet, many cities are moving aggressively towards what are often termed net-zero energy, water and waste buildings, defined as those that:

- minimize their operating energy demand through design and meet their ongoing energy needs through renewable energy and district heating/cooling strategies;
- minimize total water consumption and wastewater discharges while maximizing alternative water sources such as rainwater or greywater;
- and reduce, reuse, recycle, compost or recover solid waste streams (other than hazardous or medical waste), with no waste disposal to landfills or incinerators (Fowler *et al.* 2017; Lützkendorf and Balouktsi 2019).

A variety of studies show the possibility of making buildings far more cost-effective by reorganizing utilities to further incentivize energy and water conservation, supported by very efficient production infrastructure (Pero *et al.* 2019; Laine, Heinonen and Junnila 2020; Terés-Zubiaga *et al.* 2020).

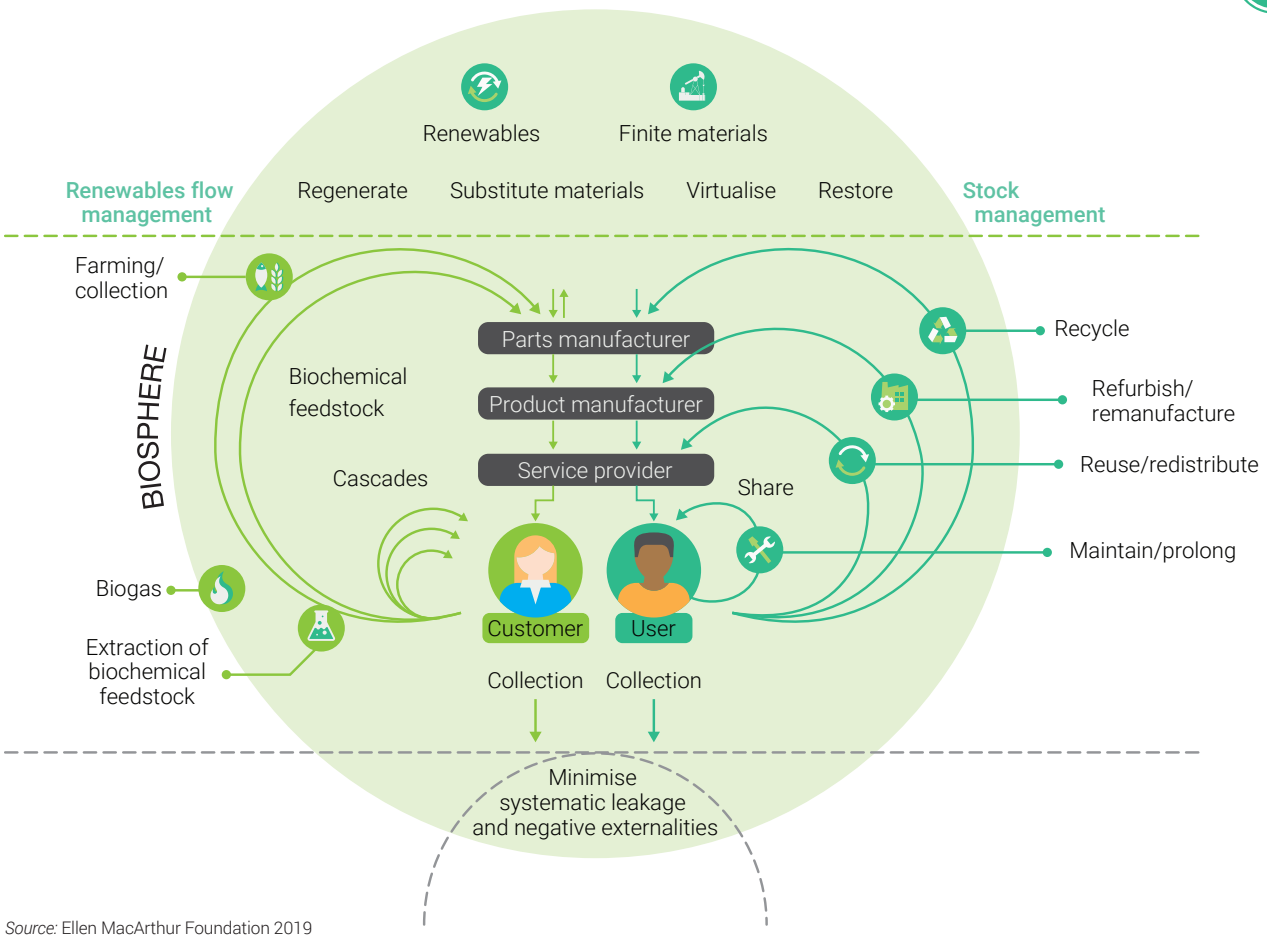
Figure 5.2 illustrates the multiple options available for circular economic value to be created by governments, businesses and citizens. It can serve as a useful framework for cities to understand the full range of possibilities for circular cities.

While saving resources and minimizing waste often come with financial incentives, shifting beyond isolated private sector initiatives and pilot projects towards circular cities requires a systemic approach informed by a detailed understanding of a city's urban metabolism and the integration of circularity principles throughout the entire city system. As awareness of resource use plays a significant role in directing resource efficiency and equity efforts, urban metabolism needs to be understood and monitored to assist strategic planning by local governments (International Resource Panel [IRP] 2018; Musango, Currie and Robinson 2017). Measuring resource use and the production of waste across the urban system at each stage of processing and use is a good starting point for identifying areas for systemic redesign and intervention. Doing so can both reduce resource consumption and process and direct "waste" resources for use in other city processes.

Circular cities can also become part of larger circularity initiatives, as local governments around the world are coming together to pledge their commitment to the shift towards circular economies. In Europe, over 20 cities have committed to this transition by signing the European Circular

1 It involves concepts such as eliminating single-use products, extending the life of products and promoting new behaviours such as reusing products.

Figure 5.2: Outline of a circular economy



Source: Ellen MacArthur Foundation 2019

Cities Declaration (European Circular Economy Stakeholder Platform 2020)[2] since its launch in 2020. This followed the launch of the Green Circular Cities Coalition in East Asia in 2019, which aims to connect cities, experts, businesses and relevant stakeholders to shift the mindset from "waste management" towards "resource management", reduce waste, and increase circularity via exchange of experiences and mutual learning (ICLEI – Local Governments for Sustainability East Asia 2021).

Despite these efforts, global resource flows are becoming less circular each year, declining from 9.1 per cent to 8.6 per cent circular between 2018 and 2020 (Circle Economy 2020a). It is estimated that doubling current levels of circularity would reduce global emissions by 39 per cent by 2032 and ensure that global average temperature rise remained below 2 degrees (Circle Economy 2021). Moreover, estimates show that the emissions created by consumption in cities are at least as high as the emissions directly linked to local activities (C40 Cities 2018). In this context, circular economy practices are increasingly being recognized as a means of achieving city-level net-zero carbon targets.

Non-state actors such as ICLEI, C40, the Ellen MacArthur Foundation and the International Union for Conservation of Nature (IUCN) are convening local governments from all regions to assess which policies and local government actions can best support the net-zero carbon circular economy transition (United Nations Framework Convention on Climate Change [UNFCCC] 2019). Front-running cities such as Turku in Finland are developing circular economy plans to support their carbon neutrality ambitions (ICLEI – Local Governments for Sustainability 2019).

While a narrow understanding of the circular economy might solely focus on environmental and economic issues, there is increasing recognition of the need to address societal issues too, as highlighted in the description of the first dimension – net-zero circular cities – included in chapter 4. One example of a current related initiative is the collaboration between ICLEI, Circle Economy and the United Nations Environment Programme (UNEP) in Bogor, Indonesia, which aims to estimate local circular economy jobs and develop a circular economy action plan for recovery in selected sectors after COVID-19.

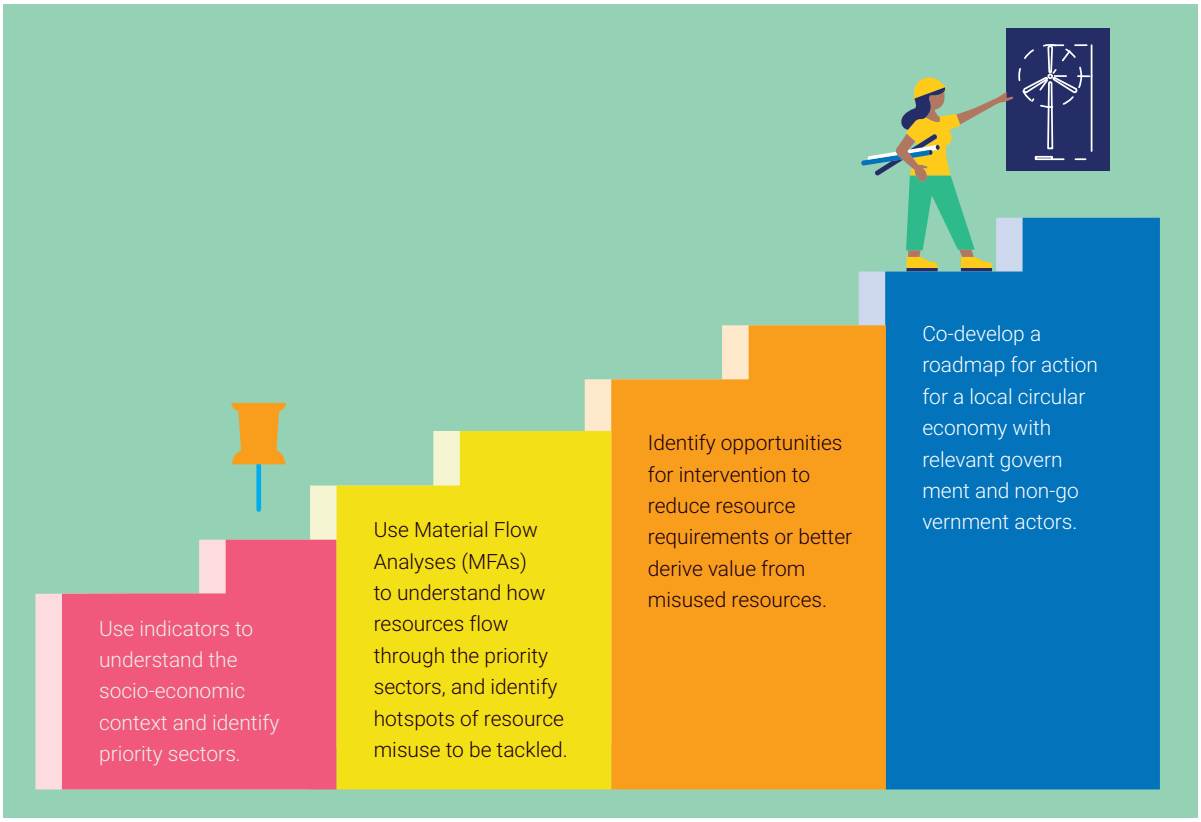
The capacity and expertise to gather, analyse and interpret material flow data rarely lies within local governments and typically requires external assistance. In recent years, several specialist organizations have emerged to serve the increased

2 The declaration has been developed by a broad group of European organizations committed to enabling the transition to a circular economy at the local level, including ICLEI – Local Governments for Sustainability, Circular Flanders, the Collaborating Centre for Sustainable Consumption and Production (CSCP), the European Circular Economy Research Alliance (ECERA), the European Investment Bank (EIB), the Ellen MacArthur Foundation, Eurocities, London Waste and Recycling Board (LWARB), UN Environment Programme and the WCYCLE Institute.

demand from cities for data-driven circular strategies. For example, Circle Economy has worked with over 20 cities to develop city-level strategies informed by material flow analysis. Their "Circle City Scan" process involves the steps illustrated in **Figure 5.3** (Circle Economy 2020b).

To ensure that decision-making is inclusive and participatory, these processes should be designed to include groups of diverse local stakeholders from various government departments, the private sector, non-profits and civil society, who can then share experiences and learnings through a series of workshops. To align these actors on common circularity priorities, the city's material flow data should be represented in simple, easy-to-understand diagrams (for example, Sankey diagrams) that help them form a shared understanding of how their city uses and/or misuses resources. The result of a City Circle Scan process is outlined below in the Amsterdam case study. Other non-profit organizations have also undertaken similar participatory action approaches to urban environmental accounting, such as Ecocity Builders through their work in Cuzco, Peru and Medellín, Colombia (Eberlein 2018).

Figure 5.3: Approach to performing a Circle City Scan

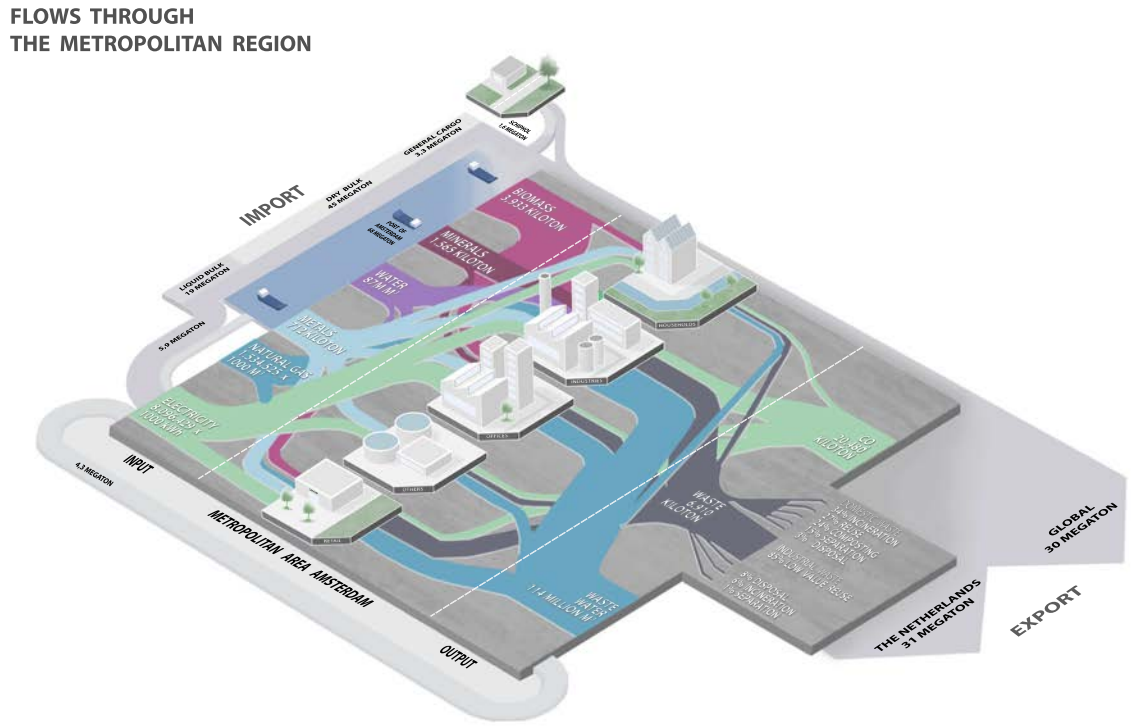


Box 5.1: Case study – Using a circular strategy to transition towards full circularity in Amsterdam, The Netherlands

Amsterdam started its transition towards full circularity with a Circle City Scan, which focused on the built environment, food and organic waste, and consumer goods value chains to make the circular economy concept tangible to local stakeholders (Circle Economy 2015). Implementation of the Learning by Doing and Circular Innovation programmes helped boost the market, with the city's completion of over 100 projects in recent years helping to further contribute towards a circular economy. Evaluating the impact of these projects on jobs, emissions, economic value and raw material use indicates that a circular economy not only leads to environmental gains, but can also have positive socioeconomic impacts. This has helped build local support for the concept and align various actors towards achieving shared goals (Circle Economy 2015).

With the approval of the Amsterdam Circular 2020–2025 Strategy in April 2020, Amsterdam is now focused on scaling up and accelerating its existing circular projects, employing all of its available municipal tools and including businesses and residents in the process. In addition, the municipality lobbies at the national and European levels for certain financial, fiscal and legal frameworks, making the city a champion of the circular economy (Circle Economy 2015).

Figure 5.4: Example of a material flow diagram used to explain the urban metabolism of the Amsterdam Metropolitan Area



Source: Circle Economy 2015

5.2.1 Materials circulation

To achieve a circular city and understand a city's urban metabolism, it is crucial to know and understand the flows of physical materials (for example, water, fossil fuels, metals, biomass) that cities use. Although recycling has received significant attention in recent decades, circular cities present opportunities to avoid waste and create and maintain value throughout the value chains of the materials that a city uses. These opportunities can have a greater impact than "end-of-pipe" approaches and may also be more financially viable.

The Indian city of Alappuzha offers lessons in fostering social justice through circular initiatives, while improving working conditions for urban waste workers.

The case study of Alappuzha demonstrates how multilevel governance, engagement processes and sufficient resources can create conditions for long-lasting change. Although the immediate outcomes in this case are limited to organic waste recycling (a small component of circular economies), the adoption of a decentralized model, local innovation and citizen engagement all signal a more fundamental transition towards a system that is capable of handling bigger environmental shifts in the future. It is helpful to contrast this with efforts in other cities in India that focus solely on technological solutions, such as waste-to-energy plants, to reduce the size of landfills, and that do not invest in more process-focused change.

Box 5.2: Case study – Encouraging the reduction, reuse and recycling of waste through decentralized waste management in Alappuzha, India

Alappuzha, a city of approximately 174,000 people in Kerala, India, was one of five cities recently recognized by the United Nations Environment Programme (UNEP) for building an effective solid waste management system (UNEP 2017). Instead of relying on expensive formal solid waste management systems that would have been beyond the reach of most citizens, the city adopted a highly successful decentralized waste management system under the "Clean City, Clean Home" campaign. Although this case study focuses on material reuse, the city's transformative change extends beyond the state of current outcomes and represents more fundamental shifts towards transformative processes of decentralization, citizen engagement and local and appropriate technological development.

A centralized waste management model was tried first in the city, but the decentralized model proved more viable and was therefore subsidized and supported by government agencies. Individual households were encouraged to set up an aerobic pipe composting units or portable biogas plants. Innovations such as kitchen bins (developed by the Kerala Agricultural University) (Simon 2015) – which are able to treat up to 2,000 kg of organic waste and produce high-quality compost in three months – complemented individual household efforts and local community workers stepped in to monitor dumping and encourage good practices.

Overall, the project has led to the installation of about 5,000 kitchen bins, 3,000 biogas plants and 2,800 composting units, which together handle about 80 per cent of the city's organic waste. The sale of biogas and manure fetches approximately $80,500 and $40,200, respectively. Waste management-related transport costs have also decreased by almost $69,000, as the decentralized system does not rely on door-to-door waste collection. The Alappuzha case offers the following key lessons on the process of urban systems transformation:

- **Individual incentives attract participation and build long-term commitment:** The programme focused heavily on raising awareness of the benefits of and building responsibility and participation in waste management. Empowering individuals to take responsibility for their own waste kept government costs low and promoted innovative and customizable solutions. In schools, students were incentivized to participate in cleanliness and waste segregation programmes. Ownership and control over biogas plants and composting units provided a strong incentive for household participation and promoted long-term engagement and commitment to the project.
- **Strong political commitment and support aids the waste management sector's transition:** The Kerala state government's desire to transform the waste management sector and encourage long-term, sustainable solutions was a key success factor. The government worked to identify problems, secured collaborations with different agencies, subsidized the campaign and actively promoted decentralization. The knowledge that household waste management would reduce social disparities by opening up other opportunities to waste workers and encouraging a positive attitude towards waste collection was a motivating factor in the government's implementation of the programme.

Gaps in the circular waste management chain can be filled through multiple strategic partnerships. For example, for this project, technical and research institutions developed localized and creative solutions; the Agency for New and Renewable Energy Research and Technology (ANERT), which is the nodal agency for the Ministry of New and Renewable Energy Sources in Kerala, and the Integrated Rural Technology Centre (IRTC) were instrumental in setting up household biogas plants and composting units; the Kerala Agricultural University developed innovative measures that addressed important gaps in consumer needs; and the government partnered with local contractors to collect plastic waste from households.

5.2.2 Nutrient circulation

One of the key dimensions of building circular cities is the development of resilient, inclusive, equitable and environmentally sustainable urban food systems. Food is a strategic entry point to eradicating poverty, strengthening gender equality and reducing vulnerability in a multidimensional manner (van Veenhuizen and Danso 2007) and relates to all three dimensions in chapter 4. In order to address the social and environmental consequences of the predominantly private sector-driven food system, many cities across the Global North and Global South have implemented local or regional food strategies, food charters and other food system-related policies and initiatives to regionalize and close nutrient cycles (Tartiu and Morone 2017).

It is estimated that at least one third of global food is wasted before consumption (O'Donnell *et al.* 2015). A key and growing challenge in creating more sustainable urban food systems is therefore to cut food waste by diverting surplus edible food from disposal to those in need in a safe and timely manner. This is particularly important in cities with high levels of poverty, where inadequate nutrition has devastating impacts on the development potential of low-income communities. Developing countries account for 44 per cent of global food loss and waste (Lipinski *et al.* 2013), though food loss differs significantly among countries (Food and Agriculture Organization of the United Nations [FAO] 2011).

Given the amount of water, energy, nutrients and other inputs that are used for food production, reducing food waste has a significant role to play in reducing a city's ecological footprint.

Food products and the nutrients (including fresh water) they contain have many different uses according to their nature and condition. As the Food Recovery Hierarchy in **Figure 5.5** shows, systems and institutions are required to optimize the societal value derived from surplus food on multiple levels, starting with reducing surplus food in the value chain as early as possible. Composting and incineration should only be considered once all other avenues have been pursued.

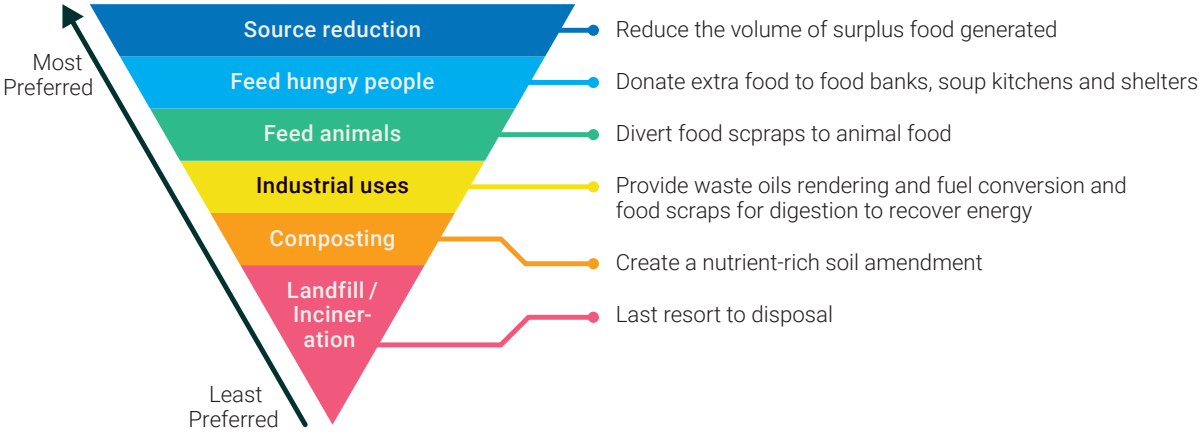
Although most existing approaches focus on tackling food waste through large suppliers (such as supermarkets), a study carried out in Chicago shows that residents can generate nearly twice as much food waste as businesses on an annual basis (Pai, Ai and Zheng 2019). The study also reveals that there is a spatial mismatch between food waste generators and potential users, and highlights the need to consider both large and small food generators (for example, convenience stores and restaurants) in relation to local users to enhance food reuse and recovery.

Progress towards more inclusive, resilient and environmentally sustainable urban food systems cannot be achieved overnight and requires the long-term commitment of local governments as well as integrated, multilevel, contextually-appropriate approaches. The Participatory Urban Agriculture Project (AGRUPAR) illustrates the multiple gains that can be achieved over time when citizens participate in the planning of a City Region Food System (**Box 5.3**).

Seeking transformative change through urban food systems requires moving beyond total food production and total consumption at the national level to the individual, household, community and city levels, since it is at these levels where many living in food deserts go hungry amid stacked supermarket shelves and bustling markets, and where multiple entry points can be pursued to build resilient, equitable and environmentally sustainable systems. Participatory processes that include those disadvantaged by the current food system play an essential role in identifying where support is required.

The case studies demonstrate how initial actions and resultant circular economy pathways related to urban metabolism and resource flows can significantly impact how resources flow into cities and how waste flows out of them. These pathways link to the first dimension discussed in chapter 4 (net-zero circular city) and should be combined with the decarbonization pathway (section 5.3) to ensure the dimension's full achievement and impact.

Figure 5.5: The food recovery hierarchy



Source: United States Environmental Protection Agency 2021

Box 5.3: Case study – Improving access to healthy and nutritious food in Quito, Ecuador

The Participatory Urban Agriculture Project (AGRUPAR) was launched in 2002 by the Municipality of the Metropolitan District of Quito as a strategy to improve access to healthy and nutritious food and to provide livelihood opportunities, especially for female heads of household. Over the years, training programmes supporting more than 21,000 people have operated in more than 3,600 urban gardens in and around the city. AGRUPAR participants produce more than 870,000 kg of food per year (Paredes 2019). In 2015, Quito became one of eight cities throughout the world to test and implement the City Region Food System project, building an agrifood policy for the city region in a participatory manner. Quito's main objective is to become a city where food is a right for all through a horizontal approach that seeks to improve health, sustainability, resilience, equity, education and economic development (Dueñas 2019).

In promoting and supporting urban food production, AGRUPAR has also helped close nutrient cycles. It is estimated that each participating family composts 12.5 kg of kitchen scraps on average per week, resulting in approximately 1,820 tons of organic waste being recycled each year (FAO 2015). The increased availability of fresh produce in the city also reduces the need for food to be imported from rural areas and other countries, leading to reductions in food costs, fossil fuel usage, air pollution and emissions.

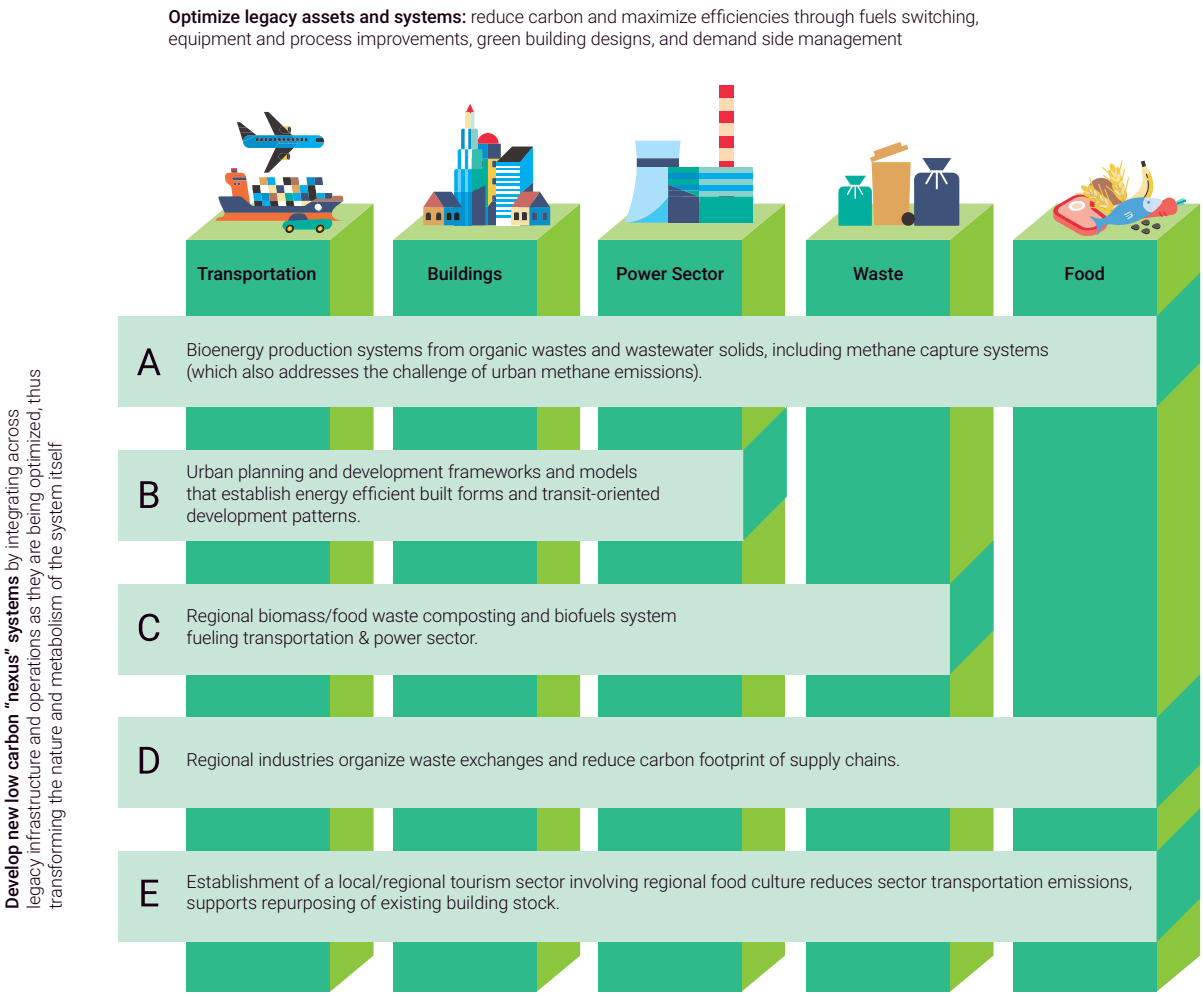
5.3 Decarbonization pathway

Since the late 1980s, city governments worldwide have been preparing and implementing plans and making investments to reduce their greenhouse gas emissions. Some measures to achieve this have included energy retrofits and fuel switching (from coal to natural gas to renewable electricity), in addition to other energy-efficiency measures in buildings and the utility, transportation and waste management sectors. Such measures have often led to net local reductions in energy costs along with net increases in local employment (European Parliament 2010; International Energy Agency [IEA] 2020). Hundreds of cities have now committed to achieving net-zero carbon emission targets for their buildings, for whole districts, and increasingly for the whole city. Bristol (the United Kingdom), for instance, has set a target of becoming a net-zero city by 2030 (Dudd 2019), while in 2019, Toronto (Canada), pledged to become net zero (including offsets) by 2050.[3] Moreover, the European Strategic Energy Technology Plan (SET Plan), launched in 2007 by the European Commission, supports the 100 Positive Energy Districts programme, which will advance the design, technology and finance practices needed to transform city districts across Europe into net-positive generators of their own low- or no-carbon energy supplies (Bossi, Gollner and Theierling 2020). However, fully meeting the net-zero carbon targets currently being adopted by cities will require further systemic change.

Figure 5.6 illustrates the dual aspects of a general decarbonization pathway for cities. The vertical columns represent existing sectors and their "legacy" (i.e. outdated) infrastructures, which have been organized and regulated as separate, unintegrated systems. The start po of urban decarbonization efforts has typically involved the implementation of eco-efficiency measures and retrofits within each of these vertical operational areas and their systems and facilities, along with related adjustments to user behaviours. The last decades of urban greenhouse gas reduction efforts have mostly taken such a sector-focused approach, with sector- and facility-specific retrofits having included fuel switching, more efficient equipment and eco-building designs, demand-side management and related regulatory reforms and economic incentives, among others.

The horizontal columns in the figure represent integrated new systemsthat need to be developed to transform not

Figure 5.6: Decarbonization pathway for cities



3 It is important to note that many of the net-zero targets being set by cities do not include their "scope 3" emissions or the emissions that the city influences upstream or downstream of its boundaries. For this reason, these net-zero targets need to be combined with a circular city approach so that the environmental impact of the full value change of the materials entering and existing in a city can be included.

only the efficiencies but also resource cycles and carbon intensity of these urban systems and processes. Systemic transformation involves further innovation and integration of the above verticals and ultimately the establishment of new resourcing and servicing systems for urban regions that are optimized for decarbonization purposes. Transitions from legacy systems or sectors (i.e. the vertical columns) to integrated new systems (i.e. the horizontal columns) as part of an overall transformation of urban metabolism has been the central focus of the "urban nexus" agenda (Deutesche Gsellschaft für Internationale Zusammenarbeit [GiZ] and ICLEI-Local Governments for Sustainability 2014), in which a city's energy, water, food and waste systems are integrated for optimal efficiency and resilience.[4]

As cities push to further decarbonize systems and infrastructures, and to transform these into low-carbon and renewable energy sources, new and different types of urban systems are required in five areas, as shown in **Figure 5.7**.

Figure 5.7: Key elements of urban decarbonization pathways

4 Examples of such nexus systems include: (1) Linköping (Sweden), which is harvesting biogas from multiple organic waste sources for transportation and other uses; (2) Växjö (Sweden), which has developed a regional forestry and biomass management system that supports the city's 2020 target of 50 per cent of the city's new buildings to be built from renewable wood resources, replacing carbon-intensive and non-renewable resources; (3) Toronto (Canada), where in 2014, the Toronto Regional Conservation Authority established a business partnership (which includes Canada's largest international airport) to operate a regional materials exchange, which by 2019 had recycled 18,500 tons of waste materials among its members, thereby reducing further greenhouse gas emissions.

Each effort to integrate a city's historically separated land-use, building, power, transportation, waste and food, and forestry systems typically requires a wide range of specialized innovations. For example, the introduction and scaling up of rooftop solar power systems on residential and commercial buildings has required technological and business service innovations, such as solar and storage product offerings. However, it also typically and crucially involves the deregulation of central power grids to permit feed-in from small generators, in addition to the establishment of special feed-in tariffs and economic incentives, the design and establishment of mini- and microgrids, retrofits in buildings' power conversion systems and training of households on the management and maintenance of their systems. Similarly, the system-wide reduction of carbon intensity in urban transportation systems eventually requires the full integration of transportation planning and development with land-use planning, development and building design, as well as transportation behaviours, to fundamentally reduce the demand for fossil fuel-powered mobility.

Ultimately, systemic change in a city's energy metabolism needs to involve a series of systemic change initiatives if dramatic reductions are to be achieved in the demand for additional energy inputs to meet future human and economic needs. For example, a systemic transformation of urban transportation involves more than the electrification of vehicles, the increased use of transit services or cycling. It also requires a shift in the need for mobility to provide access to parts of the city, in addition to changes in the energy sources needed to power the different modes of transportation.

Creating new systems and enabling policy and regulatory environments that can eventually replace legacy systems often requires coordinated innovations and interventions at all levels of government and across the public and private sectors (C40 Cities and Arup 2017), as the Beijing (China) case study shows (**Box 5.4**).

Urban decarbonization needs to address a wide range of carbon emission drivers, which extend far beyond the

Box 5.4: Case study – Integrating decarbonization into the growth agenda of a fast-growing city (Beijing, China)

The Beijing case study illustrates how the decarbonization of urban regions generally requires a scaled, system-wide transformation of power systems that includes the region's development, the decarbonization of national and regional power grids, a reduction in the energy intensity of key metropolitan industry sectors and significant innovation in the regional building industry. In this case, top-down decision-making aligned city-level climate and environmental targets with national targets (such as carbon neutrality) and the performance evaluation system for government officials to achieve the targets set in the city's five-year plans.

Beijing's achievements are also notable for the way in which decarbonization has been integrated into its regional growth strategy. For example, in terms of gross domestic product, the city's carbon intensity declined by 23 per cent from 2015 to 2020, exceeding the mitigation target of an 18 per cent reduction included in its 13th Five-Year Plan (2016–2020). In its upcoming 14th Five-Year Plan (2021–2025), Beijing aims to peak its carbon emissions before 2025, with a continuous reduction in emissions thereafter (The Central People's Government of the People's Republic of China 2021).

Beijing's achievements – and further efforts within the context of the city's 13th and 14th Five-Year Plans – have mainly focused on five lines of work:

1. Decarbonization of the energy fuel mix and end-use by: a) managing the city's growth in energy end-use within an overall limit of 10 per cent between 2015 and 2020; b) shutting down all coal-fired power plants and continuing to implement the coal to clean energy policy (The Municipal Government of Beijing 2017) through an initial conversion to natural gas; and c) subsidizing the development of renewable energy sources for all sectors, importing green power from other provinces and promoting the establishment of a cross-province green power trading market.
2. A phase-out of traditional industry within the industrial sector, which are being replaced with lower carbon industry, and carbon-intensity reductions within the traditional manufacturing sector. Specific industrial development areas include clean energy vehicles, cloud computing, big data, 5G, next-generation health care, and aviation and satellite applications. In 2013, Beijing launched one of the first carbon emission trading markets in China, which includes eight energy-intensive industries such as power generation, heating and aviation. In 2020, 4.7 million tons of emissions were traded.
3. A reduction of the region's traffic congestion (The Municipal Government of Beijing 2016) through further development and promotion of public transportation and the construction of a large network of electric vehicle charging infrastructure to reduce the average service radius to 5 km (The Municipal Government of Beijing 2019).
4. The entry into force of new mandatory waste sorting regulations in 2020, which aim to reduce methane and carbon emissions in the waste management sector through increasing the reuse and recycling of solid waste (Standing Committee of Beijing Municipal People's Congress 2019).
5. Partnerships with its neighbouring city, Tianjin (China's fourth largest city), to accelerate coordinated greenhouse gas emissions reductions and quality improvements in the previous action areas, and with Hebei Province to coordinate decarbonization efforts across the larger urbanized region.

jurisdiction and direct powers of local government. The Beijing case study illustrates that coordinated efforts across all levels of government and the private sector are crucial in decarbonizing the power grid, containing urban sprawl and related private vehicle use, creating markets for private sector renewable energy generation, cogeneration and microgrid development, and driving innovation in the regional building industry. As cities and their local governments and authorities increase the ambition of their decarbonization targets, the focus of their efforts evolves from sector-specific efficiency retrofits and demand-side management to the design and establishment of new decarbonized systems. **Figure 5.8** summarizes the general requirements for systemic transformation.

Figure 5.8: Requirements for systemic transformation

5.4 Resilient and sustainable cities pathway

The field of urban resilience emerged in the 1980s as urbanization in hazard-prone locations became recognized as a key driver underlying the increase of the human and economic costs of catastrophic events (Abramovitz 2001; United Nations General Assembly 1989). Urban resilience experts initially focused on hazard and catastrophic risk management, disaster reduction measures and disaster response capabilities in government and business. In the early 2000s, that focus changed to include climate resilience, addressing the growing risks associated with a particular subset of hazards arising from global climate change.

As an emerging field, urban resilience practices were first informed by the experiences of disaster risk reduction experts in confronting both episodic small-scale disasters and the social and economic dimensions of climate-related urban crises and catastrophes (Burayidi *et al.* 2020). Events such as Hurricane Katrina in New Orleans in 2005 (Santos 2019) highlighted the extent to which, even in the wealthiest nations, chronic stresses of poverty and inequality, poorly designed transportation and telecommunications systems, weak institutions and poor intergovernmental coordination undermine a city's capacity to effectively respond to and recover from a disaster and advance its development goals. Similarly, the COVID-19 crisis has demonstrated in many cities how hazards in the public health arena can interact with climate-related hazards to multiply harm and sustain losses, in addition to how the impacts of such interacting shock events can cascade through particular vulnerable business sectors, livelihoods, households and communities.

These events have highlighted the social and institutional dimensions of a city's resilience capacity and advanced a new developmental approach to urban resilience (Davoudi *et al.* 2012), as discussed in the resilient and sustainable cities dimension in chapter 4. This approach was pioneered by La Red throughout Latin America in the 1980s, before being promoted by the Asian Cities Climate Change Resilience Network in 2008, and the 100 Resilient Cities initiative in 2013 (100 Resilient Cities 2019; Martín *et al.* 2018).

The developmental approach to urban resilience considers how chronic stress and vulnerability in a city's population, communities and institutions contribute to its risks, in particular those that arise from stresses borne by the urban poor and other vulnerable groups (such as disenfranchised racialized,and ethnic groups, migrants, those with disabilities, elderly persons, youth and women) or by particular economic sectors. The result is an urban resilience model focused on the city's underlying capacity to absorb shocks, adapt and "bounce forward" to achieve and sustain its development ambitions. This approach differs from the earlier disaster risk reduction focus on "bouncing back" from a shock event to a city's original state without addressing its chronic stresses and vulnerabilities. To apply the developmental approach, urban planning, investments and technical solutions that are needed prior to, during, and following crises to reduce catastrophic exposures, survive acute shocks and adapt should be designed to reduce the chronic stresses that the city's poor and vulnerable face, and to strengthen local government institutions, their functions, processes and operations, and relationships with communities and social organizations (Collier *et al.* 2014). Measures to reduce and mitigate the risks of future shocks should therefore ultimately be designed to provide co-benefits and should strive to meet current development ambitions and needs (Tanner *et al.* 2015).

Building on this model, the pathway for building urban resilience will focus on the following two foundational capacities of city governments and urban communities:

- **resilience planning capacities** of local governments, and their city-building partners and community stakeholders, and related **processes** for policy, planning and institutional reforms, which are needed to prepare and implement a cross-sector, holistic, developmental strategy and agenda for society-wide resilience, and
- **resilience design** in the context of specific urban investment projects, programmes and operations, which should be regularly prioritized through the resilience planning process mentioned previously.

5.4.1 Developing resilience planning capacities and processes

Local governments that pursue a developmental resilience approach have typically developed two key planning processes and capacities. Both of these approaches need more collaboration between local government and service utilities, the private sector and community stakeholders across all sectors, and other levels of government. These approaches involve:

i) **Resilience assessments.** Some cities have institutionalized a range of comprehensive hazard and stress assessment processes to determine the cumulative risks arising from the interaction between potential shock events and existing local populations, as well as institutional stress conditions under different scenarios. A resilience assessment typically considers near-term quantifiable risks and longer-term (for example, 30 year) hazard, exposure and vulnerability trends and scenarios that could undermine the city's strategic or longer-term development goals. The assessments cut across different thematic and operational areas, addressing their interdependencies, and identify priority areas of exposure and risk that require system-wide resilience-building efforts. Such efforts include actions to strengthen the capacity of households, communities, businesses and organizations to respond, adapt and recover from shock events. Performance indicators can be developed to help monitor and guide the contributions of different sectors and programmes to the development of such system-wide resilience.

   Establishing such a comprehensive view of conditions and interdependencies between government, private, civic and community situations generally requires

the broad engagement of these stakeholders in a participatory assessment and planning process. Providing educational support, data and assessment information, especially for the most vulnerable communities and population groups, is crucial to enabling their effective contribution in the process, and may require the development of a distinct local political mandate along with more participatory and open governance. For example, the urban resilience strategy of Accra, Ghana, includes an entire section focused on embracing the informal sector's contribution to resilience-building (Accra Metropolitan Assembly 2019) and was developed in partnership with the local affiliates of Slum Dwellers International (SDI).

ii) **Coordination, leadership and institutionalization.** Due to the cross-sectoral, system-wide nature of resilience-building, the preparation and implementation of urban resilience plans have typically needed the establishment of a distinct leadership approach and management capacity to coordinate resilience-building efforts across different jurisdictions, sectors and urban systems and their respective stakeholders. Urban regions can be divided into small and often uncoordinated, if not competing, local government jurisdictions. Within these jurisdictions, city administrations and management are often organized into separate sectors that do not regularly coordinate their work and may even work at cross-purposes. City plans and investments within the urban region may be executed by distinct entities, which also manage unintegrated infrastructure and services. Addressing major resilience challenges, such as chronic flooding or drought, requires action across various city processes, such as spatial planning and development regulation, technical assessments, budgeting and procurement, building codes and permitting, and local government asset management and service functions. It also generally requires changing private sector practices and the behaviours of city residents. New senior management functions and roles are being established in many cities to coordinate resilience planning and project efforts across jurisdictions, operations and sectors, providing such cross-cutting leadership capacity. In Los Angeles, for example, the mayor not only established a Chief Resilience Officer within his office, but also mandated the establishment of standing Chief Resilience Officers in all city departments (Los Angeles Mayor's Office 2018)

Cities of the Global South face significant challenges when trying to build resilience strategies. The Cape Town case study (**Box 5.5**) helps illustrate how the city overcame such challenges.

Active involvement of social change organizations, urban communities, connected rural hinterlands, businesses and industry is also crucial (Grabowski, Klos and Monfreda 2019), and in turn requires an understanding of the role that perceptions, traditional and local knowledge, and cultural and everyday practices play in community participation (Bodoque *et al.* 2016; Kagan *et al.* 2018). Extensive retrofits and urban planning may be necessary interventions in resilience-building, but may threaten sites of heritage, archaeological resources and significant cultural value, and therefore need to be tailored to diverse contexts, collaboratively planned and equitably implemented.

Box 5.5: Case study – Creating a transformative pathway for resilience in Cape Town, South Africa

In 2018, when Cape Town first established its resilience planning efforts, the city was confronted by a severe drought crisis, which was then followed by the COVID-19 public health and economic crisis just 17 months later.

Cape Town's resilience practices built upon post-apartheid local government planning and institutional reforms that were established to address the apartheid-era legacy of chronic inequality. In 1996, the South African Government established integrated development planning requirements for local governments (Beall, Crankshaw and Parnell 2000). This resulted in the development of local capacities within Cape Town and obliged the city to consider interrelationships between its spatial structure, infrastructure and urban services systems, and social and economic justice and environmental conditions. This integration-oriented approach, which is central to the creation of urban resilience, also led to the development of organizations and partnerships that became central to Cape Town's resilience planning efforts in 2016–2019.[5]

In 2017, the city appointed a Chief Resilience Officer and created a new resilience team, with support from 100 Resilient Cities. The team completed a comprehensive resilience assessment, which included interviews with over 11,000 civilians and 200 thematic experts from community-based organizations, non-governmental organizations, businesses, academia and the government (City of Cape Town 2019a). The assessment considered the separate exposures and risks facing each of the distinct areas of city services, city operations and the economy, along with various aspects of social vulnerability to those exposures (for example, health, security). It also focused on how risks in each area interacted with those of other areas, which helped refine cross-cutting priorities for action. The result of this process was an official city government commitment, in partnership with stakeholders, to implement 75 initiatives for policy reform, programmatic action and project implementation. These initiatives are organized under five key resilience-building workstreams, each with distinct goals, which together reflect the city's defined transformative pathway for resilience:

- a compassionate, holistically-healthy city
- a connected, climate-adapted city
- a capable, job-creating city
- a collectively, shock-ready city
- a collaborative, forward-thinking city.

During Cape Town's resilience planning process, an acute water supply crisis emerged, which demanded the immediate and intensive deployment of its new resilience planning and partnership capacities. By early 2018, the city was preparing for "Day Zero", i.e. the exhaustion of its potable water sources.[6] Efforts to forestall Day Zero were mainly coordinated by the city's new resilience team and the related network of external support organizations. The Day Zero communication campaign reduced city-wide water use by 40 per cent from 2015 levels through the successful use of regulatory, technical and voluntary measures and related economic incentives. To support society-wide mobilization, the campaign built upon constructive relationships between the city, civil society organizations and the business community, while also encouraging citizen responsibility through a wide range of voluntary measures, including the collection of grey water for toilet flushing, installation of rainwater tanks and water-saving devices, and relandscaping of lawns. Some businesses removed themselves from the municipal water system, and new businesses emerged to meet the soaring demand for water-saving devices.

The design and execution of Day Zero campaign measures required constant consideration of their equity impacts, extensive public education and consideration of new "choice architectures" (Thaler and Sunstein 2008) to steer behaviour change. Water pressure levels were balanced across different areas to ensure that sufficient volume was available to maintain equitable access for households of all income levels.

During the crisis management period, the city also began preparing a new long-term water strategy and applied the "bounce forward" developmental resilience approach while drafting its broader resilience strategy, reflecting both the near- and long-term aspects of resilience planning (City of Cape Town 2019b). The Cape Town Water Strategy was developed using future scenarios of rainfall uncertainty, demand uncertainty and institutional inertia. The sum of measures addressing each scenario was further evaluated using three climate change stress tests. The resulting strategy was based on a comprehensive systems approach, which considered all aspects of water supply, management, consumption and equity across the entire regional watershed, including the restoration and further development of natural systems.

The city launched its final comprehensive Cape Town Resilience Strategy in August 2019, and its final Cape Town Water Strategy in February 2020. In March 2020, the city identified its first cases of Covid-19, marking the start of an equally severe shock. Cape Town's Chief Resilience Officer and resilience team immediately assumed city-wide coordination and response planning on behalf of the city, applying approaches and coordination mechanisms developed in the previous resilience strategy planning efforts.

5 These organizations are cited in the Cape Town Resilience Strategy as the African Centre for Cities of the University of Cape Town, GreenCape, the Cape Investor Centre, the Western Cape Economic Development Partnership and SDI. (City of Cape Town 2019a, p. 2).

6 The city and its strained water utility had to address the crisis within the context of unique policy, jurisdictional and socioeconomic constraints. In 2001, the South Africa Government instituted a hard-won gain for the country's historically disenfranchised majority: the guarantee of 6,000 litres per month of free water supply to all households. The central government also transferred water service responsibilities from central and provincial governments to municipalities, while retaining decision-making authority and investment responsibility for new water supply infrastructure. The legacy of low water service tariffs, the free water policy, growing service demand and the inability to expand water supply infrastructure strained the local water utility, which was then further impacted by the drought.

5.4.2 Resilience-based design

The implementation of an urban resilience pathway involves the design and management of resilience within the fundamental components of a city, i.e. its infrastructure, streets, districts and neighbourhoods, facilities and buildings, utilities and services, businesses, livelihoods and households. To achieve such comprehensive implementation, new design capacity, expertise and guidelines may need to be developed within each area, in collaboration with the relevant stakeholders (Laberenne 2019).

Figure 5.9 shows four key aspects of resilience design for any project, asset, service or activity that contributes to city-wide resilience. In Cali, Colombia, for example, this design framework was used to develop a detailed set of design and operational recommendations for school infrastructure resilience, based on the city's plan to replace 69 per cent of its existing school buildings (Alcaldía de Santiago de Cali and 100 Resilient Cities 2018). The city has used the four areas of the framework to inform its application of retrofit funds, which have been used not only to reduce schools' risks from earthquakes, but also to improve their use for various community functions, such as health clinics and community centres, and to better address socioeconomic challenges through school curricula.

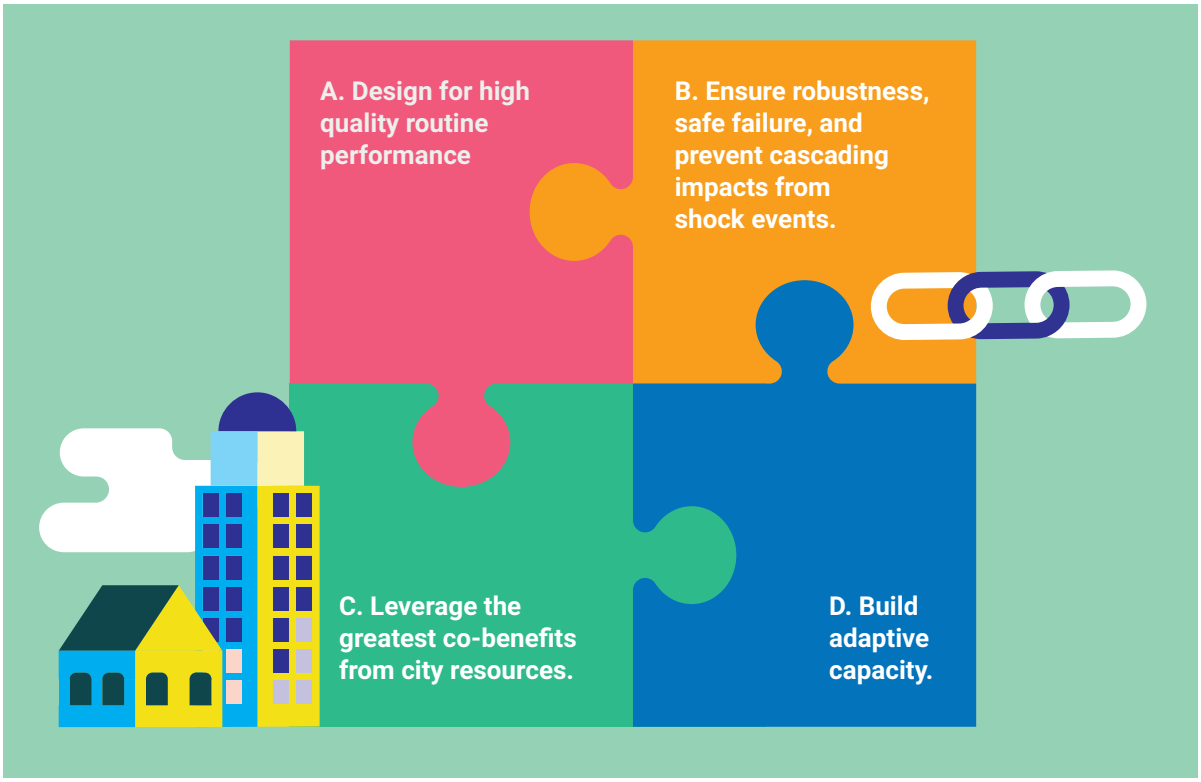
Each of the four steps requires the following important actions:

A. **Design for high-quality routine performance.** Design and manage the asset, service or activity so that it can reliably achieve high-quality performance, specifically contributing to the city's targeted development objectives under routine conditions. Although such basic performance may seem the least common denominator of responsible design, many cities and stakeholders require greater support to achieve established general performance standards. Poorly designed and maintained assets and infrastructure contribute to increased risk and can exacerbate chronic stress conditions.

B. **Ensure robustness and safe failure, and prevent cascading impacts from shock events.** Design and manage the asset, service or activity so that it can maintain function and performance under extraordinary or "shock" conditions to which the city is exposed, and so that if there is a failure, potential cascading impacts are minimized. This requires the comprehensive assessment of risks and interconnectedness between assets services and activities. For example, it is not enough to design buildings to mitigate harm and losses from earthquakes, as access to transportation systems is also needed to ensure effective evacuation in crisis responses. Solutions for robustness and safe failure often require the development of specific capacities through training for operators and workers and for household and community-level civic responses, along with the incorporation of special features, such as redundant power or water supplies.

C. **Leverage the greatest co-benefits from city resources.** Resilience design emphasizes securing the maximum possible societal benefit from any particular investment or service, with a particular view towards helping

Figure 5.9: The four aspects of resilience design



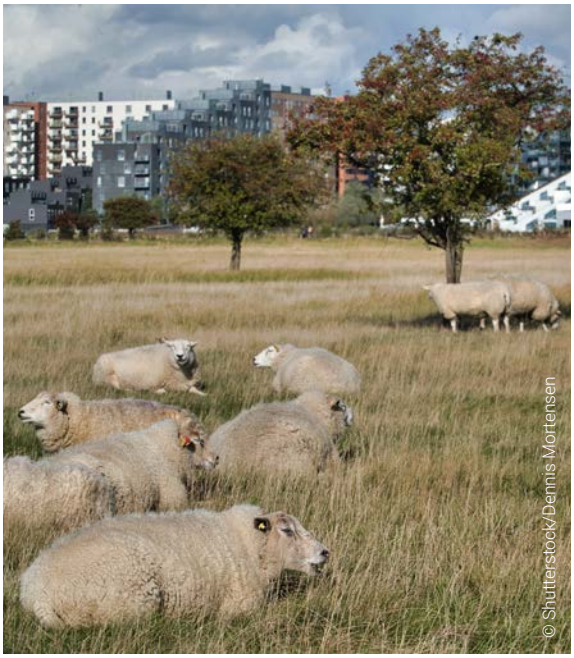
vulnerable groups and locations. Specifically, resilience design seeks to generate co-benefits that contribute to the reduction and mitigation of a city's main chronic stress conditions that reduce the capacity of people, businesses and institutions to withstand shock events. To identify and develop co-benefits, the approach generally requires collaboration between stakeholders and across departments, functions and disciplines, and to co-design with vulnerable communities.

D. **Build adaptive capacity.** A resilience design process advances the design of assets and infrastructure through enabling their adaptability to new needs and operating conditions. It also seeks to raise the awareness and develop the capacity of institutions, businesses, communities and households to anticipate changing circumstances. The design process builds know-how and facilitates access to relevant information in the instance of an extraordinary shock event.

The concept of urban resilience has evolved over time to advance a wide range of development aims and to address new catastrophic threats, such as climate change. Urban resilience work continues to help develop governance systems and processes that are more integrated and inclusive. The Cape Town case study demonstrates how the process of building transformative urban resilience can be used to address situations of acute shocks and multi-dimensional chronic stress, which many other cities are also currently facing as they continue to deal with the COVID-19 crisis and fallout.

5.5 Inclusive and just city pathways

The final dimension of an inclusive and just city (discussed in chapter 4) can be defined as one in which all – both humans and non-human species– have the equal opportunity to thrive, and where health outcomes and environmental benefits are shared equitably, regardless of people's economic status, gender, age, ethnicity, religion and ability. However, although the need to articulate justice in the pursuit of urban environmental sustainability and resilience has been long acknowledged (Agyeman 2005; Heynen 2013; UN-Habitat 2015), equity considerations for all occupants of cities, both human and non-human, are often absent from sustainable urban development efforts (Bulkeley, Edwards and Fuller 2014; Horne 2017).[7] Working towards this aim requires confronting the historical contexts that have produced and continue to produce injustice. The persistence of a historical disregard for nature, the increasing commodification of urban life, the inadequacy of planning systems and the invisibility of the "informal" city are just some of the underlying processes discussed in chapter 2 that impede the transition towards inclusive and just cities.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Although fair access to resources is a key component of transformative change, efforts to build justice into the vision discussed in chapter 4 show that focusing solely on such access and distribution is not enough. For example, addressing equitable and environmentally sustainable access to food throughout American cities requires tackling the differentiated impacts of policy measures on marginalized black communities, the exclusion of agroecological practices and the loss of biodiversity (Raja, Morgan and Hall 2017). While many American urban policies have focused their attention on the "poor diets" and individual behaviour of African-Americans, very little attention has been given to the steady decline of their control over healthier and more sustainable food production. Pursuing environmentally sustainable and socially just urban development therefore demands tackling processes of maldistribution and misrecognition in cities, while also seeking equality in decision-making participation and striving towards nature-positive actions. In short, such urban development requires bridging actions towards justice, environmental sustainability and resilience through everyday planning and political practices, and critically examining historical urban contexts and policies and the factors that make them unjust.

Valuing cities as complex, self-organizing "adaptive systems" that are structured through multiple human and non-human interactions across different scales and levels of organization is therefore important (Olazabal 2017). To avoid locking urban development into socially and environmentally negative pathways, cities need to be more self-sufficient in terms of food, power and water, create multiple options for recycling, reusing and remanufacturing materials, and enhance car-free mobility, which links back to the circular cities pathway (section 5.2). These substantial changes are not easy, particularly in the time frame in which urgent action is needed. It is clear that transformative action towards inclusive and just urban development requires difficult ethical questions to be tackled in relation to human and non-human species, and the collective capacity of city residents to be strengthened through the state's capacity to lay the foundations for equitable processes and outcomes.

7 For example, when confronted with competing priorities and interests, local authorities often struggle to align low-carbon aspirations and equitable housing to ensure that all households have equal access to low-carbon services through accountable production and distribution mechanisms.

Building upon these ideas, this section explores four distinctive approaches through which pathways towards nature-positive, just and equitable urban development are built in practice (**Figure 5.10**).

The case studies in this section show how initiatives and processes that are allowed to mature over time provide room for reflexive learning, which in turn expands the scope for transformative change.

5.5.1 Renaturing the city with equity

The notion that cities should be designed with and not against nature is not new, but has re-emerged in recent years (McHarg 1969; Steiner *et al.* 2019).[8] Under the wide umbrella of "urban greening", "biophilic cities" and the "renaturing" of cities, there is a growing call for collective action to protect biodiversity in and around cities in order to ultimately prevent irreversible loss and damage to the natural systems on which humankind depends. This is known as a "nature-positive" approach to urban development.

In this pathway, nature-based solutions should be adopted across different urban systems and ecosystems, for example, in coastal cities where urban landscapes and seascapes meet and where human behaviour and urban development have profound impacts on both terrestrial and marine ecosystems (United Nations Economic and Social Commission for Asia and the Pacific 2019). This field is now evolving from its original focus on economic and instrumental values to encompass a more critical and holistic perspective on justice and equity issues (Randrup *et al.* 2020).[9] Responses to calls for renaturing cities include Barcelona's Green Infrastructure and Biodiversity Plan 2020, Melbourne's vision to enhance the city's biodiversity and human well-being by restoring native vegetation through nature-based solutions, and Shanghai's ambition to become a "sponge city" for flood prevention through the replacement of concrete sidewalks with permeable pavements, street rain gardens and rooftop gardens.

Meanwhile, other cities are engaging in participatory processes that guide environmentally sustainable regeneration in targeted derelict areas, a trend observed across many American cities, which have transformed previous rail corridors into public greenways under the Rails-to-Trails initiative, while also providing havens and habitat for wildlife (Scherrer *et al.* 2021). A similar approach has been adopted in Berlin, where citizen action has led the transformation of the disused Tempelhof airport into one of the city's most popular parks. Formerly, a symbol of Nazi megalomania, in 2014 the park was at risk of privatization due to pressure from investors to capitalize on its real estate development potential (Bijak and Racoń-Leja 2018). However, the site was reclaimed as part of the city's commons, thanks to the action of 100% Tempelhofer Feld [100% Tempelhofer Field], a group of civil society organizations that act as environmental stewards to conserve the park's biodiversity and prevent its development (Schalk 2014).

Figure 5.10: Pathways for nature-positive, just and equitable urban development

8 Since 2008, the Convention on Biological Diversity (CBD) has included a focus on cities and subnational governments. The Plan of Action on Subnational Governments, Cities and Other Local Authorities for Biodiversity (2011–2020), adopted in 2010, has helped cities coordinate local and national biodiversity strategies and action plans. The Post-2020 Global Biodiversity Framework will guide implementation for the coming decade in pursuit of the 2050 vision of "living in harmony with nature". In addition, CitiesWithNature – a joint initiative by ICLEI, The Nature Conservancy and the International Union for Conservation of Nature (IUCN), with support from the CBD – provides an international platform for cities to enhance their urban nature and work towards greater sustainability.

9 Race and gender equality considerations have played a key role in expanding the scope of current debates and practices. For example, the work of GenderCC – Women for Climate Justice is an example of the emerging global networks that are seeking to overcome gender-blindness throughout the world. GenderCC is a broad coalition that works throughout the Global North and Global South to ensure that gender-responsive approaches are implemented in urban climate adaptation, mitigation and low-carbon development. For more information about GenderCC's work, see https://www.gendercc.net/home.html.

However, greening initiatives can lead to increases in land prices, thereby reducing access to affordable land and pushing poor populations away from working areas, which undermines their well-being and the potential scope of nature-positive solutions. This vicious circle points to the need to complement greening strategies with other measures, such as further land taxation to reduce land speculation, the displacement of people with lower incomes and the commodification of nature (Raja, Morgan and Hall 2017). Retaining and increasing social housing is key to preventing green achievements from being made at the expense of lower-income groups (Rigolon and Németh 2019).

A critical factor in the success of most city-greening initiatives is to plan for gentrification effects before displacement happens. A "just green enough" approach can uncouple environmental regeneration and clean-up from high-end residential and commercial development (Curran and Hamilton eds. 2017). The experience of the Sunset Park neighbourhood in Brooklyn, New York, illustrates how this looks in practice (Simpson 2019). In this case, Latino community-based organizations are driving greening strategies built on the experience and expertise of the neighbourhood's working-class foreign-born residents. Combining racial justice activism with climate resilience planning, the group advocates for investments and training for existing small businesses (often Latino-owned) to develop an environmentally sustainable and circular local economy. Similar initiatives in the North Brooklyn Industrial Business Zone are working to ensure that a Superfund[10] clean-up and other remediation measures do not end up displacing workers and residents in manufacturing areas.

Other examples of balancing environmental sustainability and equity concerns include:

- Buenos Aires, where local authorities have undertaken an extensive programme to improve the city's river basins in order to better handle flood events and protect low-income communities that are most at risk, while also extending access to drinking water (C40 Cities 2019);
- Cape Town, where efforts are being carried out to retrofit poorly insulated homes in low-income communities in order to reduce energy demand and improve the health of many residents susceptible to tuberculosis and other illnesses;
- Barcelona, whose 2018 Climate Plan adopted a strategic focus on citizen involvement in the design of socially-inclusive climate actions that simultaneously address climate challenges and socioeconomic inequality to the benefit of all residents (C40 Cities 2019).

What these experiences have in common is a focus on ensuring that environmental improvements are not pursued at the expense of equity considerations. This calls for an in-depth consideration of nature and social diversity, along with the prevention of green gentrification processes (Anguelovski *et al.* 2018).

5.5.2 Building equity into environmental sustainability and resilience

Significant and long-standing efforts also exist in instances where city decision makers have included equity considerations into programmes to improve environmental sustainability and resilience. Such efforts often originate following social mobilization and the demand to bring together calls for social and environmental justice. This requires a commitment to opening and sustaining participatory processes that give voice to those who are typically marginalized. Developing an inclusive agenda does not therefore mean placing emphasis on issues to be tackled, but on the groups of people whose experiences matter and on those best-placed to lead the process. Citizen-led change often begins with an identification of historical cases of environmental injustice, including an in-depth analysis of their spatial manifestation and driving forces. As shown in the case of Seattle, Washington (**Box 5.6**), a sustained and iterative process of collective diagnosis and concerted action can mature over time to tackle interdependent social and environmental challenges.

Box 5.6: Case study – Seattle and the Duwamish Valley Program, United States of America

The city of Seattle has long been at the forefront of advancing environmental sustainability, with its municipal electric utility having become the first large utility in the United States to achieve carbon neutrality. The city is also making good progress to ensure that 30 per cent of all new vehicles are electric by 2030 and its recycling rates are among the highest in the country.[11] Nevertheless, the city's administration acknowledges that Seattle's environmental performance will not be enough if structural inequalities are not tackled (Coven 2018).

In 2015, Seattle launched the Equity & Environment Initiative (EEI) and subsequently created an Environmental Justice Committee, which included African-American community leaders, low-income residents, foreign-born residents, refugees and those with limited English proficiency. Recognizing that there are gender and age biases in local leadership, emphasis was placed on engaging women and youth from these communities. Constructing new spaces and opportunities for participatory democracy was essential to enable discriminated communities to shape the actions and resources required to support an urban environmental agenda centred on racial equity. This led to the launch of the Duwamish Valley Program (DVP) in 2016, a multidepartmental effort to advance environmental sustainability and equitable development in an area where local dwellers had experienced well-documented injustices for years.

10 The term "Superfund" designates polluted locations in the United States of America which require a long-term response to clean up hazardous material contaminations. In the United States and other countries, such as the United Kingdom, institutionalized mandates are in place to remediate industrial lands for repurposing.

11 Despite these achievements, Seattle, along with other cities on the west coast of the United States and Canada known for their enhanced environmental performance, are still largely dependent on imported wealth, which highlights the importance of addressing their dependency on tourism and its associated high energy-intensive impacts.

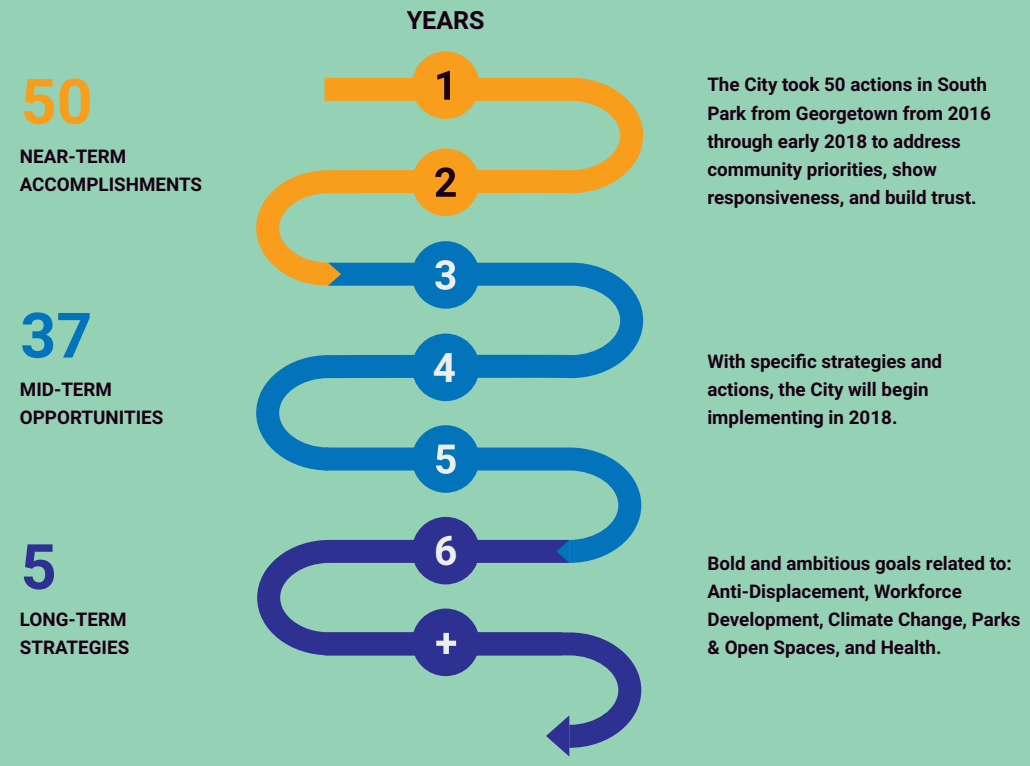
Home to approximately 5,600 people and numerous businesses and industries, Duwamish Valley is not only a Superfund site in need of a long-term response to clean up hazardous material, but also an area where local communities face many other stresses, and which has received significantly less investment than other parts of Seattle over the years. In Duwamish Valley, local residents are disproportionately exposed to air and noise pollution and have limited access to open space and healthy food. Hospitalization rates for asthma are the highest in the country and the area frequently experiences flooding. The DVP started with an 18-month process that engaged residents, workers and businesses to identify their priorities, values and aspirations, which resulted in a co-designed action plan to expand livelihood and housing opportunities, improve environmental and health outcomes and increase investments in Duwamish Valley.

To tackle these objectives comprehensively, the DVP relied on the community-led Healthy Living Assessment tool to understand how racial inequality and health disparities correlated, where such disparities were found, what impacts these had and for whom. This georeferenced system enabled key interconnections between social and built-environment health determinants to be identified, and specific measures and investments in health-promoting infrastructure and opportunities to be targeted to where they were most needed. For example, the Healthy Living Assessment revealed that life expectancy in predominantly African-American low-income areas was 13 years lower than in white upper-income neighbourhoods. Similarly, about 24 per cent of women and men living in disadvantaged areas lacked any form of health insurance – almost twice the city-wide average. A lack of mobility options, high incidence of diabetes and food insecurity are also very prevalent in these areas. The DVP included equity indicators to track impacts and housing displacement according to race, ethnicity and income, as well as demographic information to understand who was benefiting from local authority investments (Coven 2018).

The DVP also enhanced political participation in local decision-making beyond male-dominated leadership through improving its diversity. For example, a coalition of Latino women led local efforts to pursue affordable housing and anti-displacement strategies, making the reality of low-income renters in the Duwamish Valley a more prominent issue. Actions to prevent city-wide displacement were supported by the adoption of the Displacement Risk Index, a living map that shows where marginalized population displacements are more likely to occur. The establishment and use of accessible georeferenced information tools showed how key factors change over time and made it possible to project essential trends for forward planning.

Figure 5.11 shows how the programme evolved from short-term accomplishments into long-term strategies. The Environmental Justice Committee works as a bridge between the city administration and local communities to ensure that environmental actions are meaningful at the local level and to anticipate and tackle real estate trends that could lead to green gentrification and displacement.

Figure 5.11: Duwamish Valley action



Source: Coven 2018

5.5.3 Developing a rights-based approach to equitable and environmentally sustainable development

A rights-based approach to social and environmental challenges has dominated much of the urban discussion during the first two decades of the twenty-first century, both in relation to the right to the city and rights in the city (United Nations 2017). The call to action by the United Nations 2030 Agenda for Sustainable Development (United Nations 2015) and the United Nations Conference on Housing and Sustainable Urban Development (Habitat III) reflected this desire for inclusivity. In recent years, social movements, thinkers and progressive local authorities alike have included a rights-based ethics approach into planning and governance as a means to co-create transformative change through renewed social contracts that hold socioenvironmental justice at their core.

Several cities across the world have adopted a rights-based approach to articulate environmental sustainability and social equity questions through their resource allocation, policies, programmes and projects. Participatory approaches and citizen engagement are needed to support such an approach. The case study of Rosario, Argentina (**Box 5.7**), exemplifies how a city rights-based approach can mature over time to give voice to those typically marginalized and to protect common values across different spheres of urban life. Fostered over 20 years of continuous commitment to decentralization, transparency, accountability and participation, Rosario developed a broad vision towards achieving equity and sustainability, along with a democratically-grounded process that drives the city's strategic planning for the whole metropolitan area.

One of the most significant achievements of Rosario – and other cities committed to incorporating social justice into their planning processes – lies in their capacity to reverse previously established municipal priorities and long-term trends of underinvestment in the urban poor and nature-positive solutions. As argued by Cabannes (2014) such "reversion" implies shifting political and territorial priorities by enabling those previously excluded to co-participate in decision-making and by ensuring historical investments that previously did not reach poor neighborhoods and adjacent rural areas now do.

5.5.4 Seeking environmental sustainability and equity beyond the city

One of the most difficult challenges faced by cities worldwide is to decouple their prosperity from the appropriation of natural assets and the displacement of unwanted impacts to distant "elsewheres" through their large ecological footprints (Allen 2014). If this trend remains unaddressed, the impact of cities on interregional and intergenerational justice will continue to go unchallenged.

Seeking environmental sustainability and equity beyond the city requires taking into account how material flows work in the face of wider social, ecological and technical systems (McPhearson *et al.* 2016). As shown in previous sections, this aim can be greatly advanced through decarbonization and circularity. Due to the often-insurmountable difficulties for a city to work on its own to close material loops, shift to renewable energy sources, increase reuse and recycling of materials or lower the CO_2 footprint of its economic activities, it is not surprising that most initiatives in this area rely on networks that work to increase such innovative changes around the world. Examples include the C40 network, a worldwide coalition of 94 cities committed to reducing their greenhouse gas emissions (Poon 2019).[12] Although it is too early to assess the impact of such initiatives in fostering change into wider groups of cities, when socially anchored, these networks can open

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12 By 2019, about 30 cities within C40 reported to have curbed emissions by 22 per cent on average. Berlin, London and Madrid lowered their emissions by 30 per cent, with Copenhagen reaching a dramatic 61 per cent, though in relative terms, its peak emission levels were historically significantly lower than those of other cities in the coalition (Poon 2019).

Box 5.7: Case study – Building a rights-based approach into local planning in Rosario, Argentina

Since 1989, successive mayors in Rosario have built upon the core principles of progressive municipalism. Over the years, the democratization of municipal governance has involved the decentralization of resources and decision-making capacities to the district level. With over one million inhabitants living in the city's six districts, each district undertakes a robust and grounded participatory process to develop urban projects and allocate municipal resources, and also to develop the strategic plan for the whole of Rosario and its update every 10 years (Steinberg 2005). Outcomes of this approach include a comprehensive climate change plan that seeks to integrate urban agriculture, food security and greening, temperature mitigation and stormwater management strategies, while promoting cost-effective solutions to building insulation and drainage infrastructure improvements.

An essential component of Rosario's long-term approach to equitable and sustainable urban development has been the Rosario Habitat programme. Created in 2001, the programme focuses on improving living conditions and tenure security, while promoting physical and social integration in the estimated 91 informal settlements that house approximately 155,000 people in the city. Despite facing difficulties in relation to land-use rights, the programme set an important precedent through showing that the upgrade of settlements (rather than the relocation of communities) is a viable strategy for cities. By 2008, the Rosario Habitat programme had been implemented in 11 informal settlements, rehousing over 1,000 families in safe relocation sites and allowing twice as many families to stay in their original settlements through a wide range of upgrading measures. The programme ended in 2012, having invested almost $72 million during its first phase. Since then, the rehabilitation of informal settlements has continued under the national Neighbourhood Improvement Programme (PROMEBA), which works across other municipalities (Almansi 2009).

A second key component in Rosario's strategy has been its Urban Agriculture Programme (PAU). Launched in 2002, to supplement the city's food donations to people living in poverty, PAU gradually became aligned with the national programme Pro Huerta, with its scope expanding to integrate urban agriculture into land-use planning. This included the systematic identification of vacant land and the official recognition of farming carried out on peacefully usurped vacant plots, a practice that emerged in Rosario during periods of economic crisis, but which is also frequent in other cities in the Global South, even during normal times. Granting use rights for urban agriculture gave urban farmers the certainty to invest, while PAU became responsible for monitoring and controlling the use of vacant land for farming throughout the city. Farmers were also encouraged to work on plots of land alongside roads, railroads and streams, where they were permitted to farm indefinitely as part of greening within the city. Enhanced access to land and tenure security also led to the creation of communal gardens with access to water made available through new wells and water pumps installed by the municipality (Rosenstein 2008). The programme has a strong gender focus and benefits disadvantaged women through the creation of new livelihoods along the full food chain (Guénette 2010). By 2020, PAU had secured 75 hectares within Rosario for agroecological production and urban gardens and preserved over 700 hectares for food production in peri-urban areas. Over 2,500 tons of fruit and vegetables produced annually benefit more than 2,400 families.

The third component of Rosario's strategy is its participatory budgeting. First introduced in 2003, participatory budgeting has become a key redistributive mechanism, a rights-based governance instrument, a communication tool and a vehicle for citizenship capacity-building (Lerner and Schugurensky 2007). Between 2003 and 2011, the annual participatory budget amounted to roughly $9 million, representing around 22 per cent of the municipal budget for investment (Cabannes and Lipietz 2015). Rosario's participatory budgeting promotes gender equality through women's parity in political participation, along with the prevention of domestic violence against women and children, and has earmarked part of the budget available to initiatives to support youth. In 2013, Rosario introduced a voting system in Braille and translated the participatory budgeting manual into an indigenous language, becoming the first city in Argentina to adopt a multicultural approach to planning spearheaded by participatory budgeting (Corbetta and Rosas 2017).

Through adopting a rights-based approach, Rosario has explored a full reinvention through various planning mechanisms, such as a clear set of rules and processes to guide public and private urban development through land reserved for public and community spaces, the preservation of historical and natural heritage, density controls and a land-value capture policy. Of course, this and similar redistribution mechanisms are not without challenges, so the fact that they have remained operational throughout the city for many years is remarkable.

opportunities for equity considerations to be more closely aligned with substantial environmental improvements.

As seen in the pathways and cases examined, producing environmentally sustainable and equitable outcomes not only requires initiating change in the city, but simultaneous processes of interlinked changes, as well as the establishment of accountable governance systems to ensure that social and environmental benefits flow across diverse social groups, over space and time (Andersson *et al.* 2019). This means tackling the lock-ins discussed in chapter 2, which will otherwise prevent transformative change from taking root due to the political economy, urban planning and governance barriers that currently exist at the city level.

5.6 Achieving urban transformations: key lessons

The pathways examined throughout this chapter are complex, yet they must be so if they are to help solve the interlinked problems of social equity and environmental sustainability. However, as this chapter has shown, cities, city networks, local actors and national governments have been successful in achieving at least some of the objectives of the transformative change needed to reach these goals. One overarching lesson learned is that it is unrealistic to expect any one actor to play a transformative role alone. As highlighted in chapter 2, many cities do not have the funds, capacity or agency to act, and national governments often fail to fully understand and respond to city-level environmental challenges and inequities. Single national-level policies, incentives for a limited set of actors (such as behavioural change measures or the inducing of competition among cities) and better technology are unlikely to achieve transformative change in isolation. Furthermore, many existing programmes and policies are geared towards simple transitions that do not recognize the crucial role that citizens need to play in driving forward urban transformation. **Figure 5.12** shows a number of key steps that can be taken to set cities on a transformative pathway.

For any transformative pathway to be successful, each of these steps requires several important actions, which include the following:

- **Use stresses and shocks as opportunities for long-term visioning:** While many actions may begin as responses to chronic stresses or specific shocks, their scope can be converted to long-term and strategic responses. Time should therefore be allowed for discrete actions to evolve into a system that produces wider impacts. This requires the development of long-term strategies and space for reflexive learning.
- **Incorporate insights from data and science into decision-making processes:** Many of the insights needed to guide transformative pathways require specialist expertise that does not often sit within local governments. Expert guidance is sometimes needed to gather, process and interpret the data required for material flow analyses, greenhouse gas baselines and resilience assessments, among others. Street science and participatory processes of engagement are also valuable to develop meaningful local strategies, ensuring that key trends are understood by multiple audiences who can take complimentary actions and hold each other accountable. City networks can play a valuable role in providing guidance and in some cases can help connect cities with funding to conduct these studies.
- **Take a critical approach to establish meaningful agendas:** The sharing of planning ideas and practices often means that cities are expected or encouraged to embark on pathways that might not be relevant to them. For instance, not all cities are high carbon emitters and may instead need to prioritize climate change adaptation. Most cities face a combination of challenges that need to be identified and tackled in line with their own development pathways, instead of using pathways that may be prescribed externally.
- **Expand the political space for decision-making to those who are typically excluded:** During the process to relieve vulnerable communities and social groups of environmental burdens, ensure that they are fully involved in decision-making processes in meaningful ways that increase their visibility and voice. For this to happen, vulnerable communities should not just be approached as "intended beneficiaries", but as rightful agents of change.
- **Take advantage of existing technology developers, knowledge-based institutions and networks, and form early partnerships with political parity in decision-making:** These partnerships are crucial for guiding priorities, developing locally-appropriate technologies (including digital enablers of governance), testing and piloting new ideas, conducting monitoring and evaluation, developing long-term local knowledge and strengthening capacity. Crucially, grass-roots organizations and educational institutions can also be well placed to source and analyse data on urban inequality, informality and environmental degradation, filling in important knowledge gaps in key governance and policy formulation processes.
- **Seek equity and social justice across all local environmental action and programming:** Achieving equity and social justice requires strategies to shift the multiple structural drivers of inequity that are commonly found in cities, and should in no way be addressed as an afterthought. In the case of informality, for example, the everyday activities, livelihoods and contributions of women and men need to be recognized and supported, rather than viewed as a burden.
- **Drive gender empowerment and equality:** Gender inequality in cities can arise from a combination of low-income, inadequate and expensive living spaces, limited access to basic infrastructure and services, exposure to environmental hazards, high rates of crime and violence and a range of impacts linked to patriarchal systems of exclusion. These deprivations amplify the burden of reproductive, productive and community work among women. Moreover, as the impacts of climate change worsen or health crises such as COVID-19 unfold, these are likely to increase the difficulty and time needed to deal with multiple demands, which include a wide range of caring roles typically performed by women and young girls. To tackle gender inequality, urban practitioners and decision makers need to consider the important role of basic infrastructure and service provision in reducing gender disadvantages, and embrace the roles that women and girls can play in finding solutions that meet their specific, changing needs and aspirations in and around cities.
- **Invest in instruments for cross-sectoral collaboration, governance and implementation:** Transformative action requires cross-sectoral integration, yet current governance arrangements tend to operate in departmental or sectoral silos. It will not be possible to successfully pursue broad cross-sectoral goals unless investments are made to increase coordination across

Figure 5.12: Steps to start a city on a transformative pathway

sectors or departments (Candel and Biesbroek 2016). This could include explicit collaboration across existing government programmes, interdepartmental working groups (for example, Cape Town's resilience team) and legislative orders, among others. Beyond coordination, long-term institutional capacity is also key to pave the way for transformative change, even through changing political priorities.

- **Foster inter-city exchanges and co-learning:** While it is important that urban agendas consider their own context, geography and history, there is enormous value in sharing experiences with other cities. Networked learning can enable cities to think more critically about future challenges that are not a current priority, or encourage others to identify historical processes and barriers that are impeding their efforts to achieve a more environmentally sustainable and equitable future. In recent years, city networks and national and international associations of local governments have played an important catalytic and intermediary role in creating opportunities for idea-sharing among cities, building partnerships with other spheres of government, advocating for policy change, providing neutral platforms for local stakeholders to engage and building local government capacity. A wide variety of national and international local government networks have been established to support cities in transforming their urban systems and metabolisms.
- **Pursue coordinated collaborations for transformative impact:** Multilevel governance structures that coordinate a wide range of actors are powerful mechanisms for transformation if used effectively to mitigate the risks associated with pilot projects and to enable upscaling. Mechanisms such as grants and subsidies, incentives to trigger performance improvements, favourable legislation and effective decentralization at the levels of local government can create the conditions for multiple complimentary actions that are aligned towards achieving transformative goals. It is well-known that local governments in developing countries are often unable to address all their needs with their own resources. As such, there is a need for national (and sometimes international) support, particularly to address global issues such as decarbonization. Beyond government institutions, the private sector and civil society are important partners for development. Innovative financing options for urban infrastructure are also important methods for overcoming limited public sector capacity and for attracting funding to cities (UNFCCC 2019). Moreover, collaborations with civil society can help fill communication and implementation gaps, and can support collective visions and governance frameworks that are crucial for effective transformation. Finally, strengthened opportunities for citizen co-production can open up new avenues for improving governance capacity.
- **Design urban infrastructure for more environmentally sustainable production and consumption:** Due to its long-lasting nature, urban infrastructure can become "locked in" and shape resource needs for decades to come. It can therefore also play a key role in shifting environmentally unsustainable production and consumption patterns in cities by providing alternative systems (for example, public transport instead of highways). However, decisions about infrastructure investments and the protection of environmental resources and ecosystems may sometimes clash and often exclude issues of equity or social justice. Cities need to balance the protection of vital ecosystem services and ensure the rights of people living in poverty and those living on rural-urban borders to prevent infrastructure from promoting unsustainable patterns of urban growth and expansion.
- **Build reciprocal rural-urban linkages:** A range of flows and interactions between urban and rural areas can serve as entry points for the development of interventions with reciprocal benefits. These include the two-way movement of people, capital, information, nutrients and ecosystem services, among others. Ecosystem services between urban and rural areas can be strengthened by maintaining or rebuilding ecological infrastructure as a strategy for improving water and food security, sustaining livelihoods, reducing poverty and building resilience to disasters and climate change impacts. It is therefore important to adopt planning approaches that consider this rural-urban divide and engage with the governance systems that can ultimately determine how, where and what type of projects work and for whom.
- **Use foresight and planning to prevent negative impacts and unintended consequences:** Many of the experiences reviewed throughout this chapter more often than not show that efforts to enable transformative change in one area could trigger negative impacts and unintended consequences in another. This can be seen in the experiences of many cities embarking on environmental sustainability initiatives, which in turn have led to eco-gentrification and displacement. Such consequences must not be addressed as an afterthought. Rather, planning must incorporate the adoption of proactive and preventive mechanisms, for example, through the adoption of land-value capture instruments and the protection of social housing and mixed-use buildings.
- **Gather knowledge from real-world actions to encourage learning and replication:** This requires refining the way that transformative change is thought about and how it contributes to or undermines substantial change. Thought should be given to the following four key considerations:
  a) Assess the reach of concrete actions, plans and programmes: Do they have city-wide impacts? Do their impacts extend beyond the city?
  b) Scrutinize their impact sensitivity: Do these actions and interventions respond to the diverse sociocultural needs, experiences and aspirations of women, men, girls and boys? Do they protect and enhance biodiversity and nature's rights within and beyond cities?
  c) Consider their empowering capacity to help build equal political participation in the governance of transformative change: Do they open political

spaces and discussions beyond the realm of mainstream institutions and powerful actors? If so, are these approaches properly resourced to play a substantial role? Is the knowledge and capacity of the participants fully recognized and strengthened?

d) Examine their catalytic capacity to ignite change beyond the usual types of interventions and goals: Do these interventions and practices trigger further transformative actions in other spheres? Do they have the capacity to nurture and grow innovations and to be replicated enough to gradually bring about substantial change to environmentally unsustainable and inequitable governance systems?[13]

As Maassen and Galvin (2019) argue "real world examples of deep urban transformations are hard to come by."

Fortunately, there is a rich history of progress towards the changes needed, as demonstrated throughout this chapter. Collectively, we must identify what does and does not work and create ethical principles for transformative action from existing experiences and projected trends. Doing so will allow for the development of collective knowledge and experience based on how cities, citizens, local authorities and their networks are co-producing pathways towards progressive and forward-looking urban agendas, inspiring others to do so too. The responsibility and opportunity to take on this challenge lies with each and every one of us.

13 Emergent discussions offer precise frameworks for capacity-related questions by delineating analytical, managerial and political capacity across multiple levels of governance. See, for example, (Wu, Ramesh and Howlett 2015).

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Co-Chairs´ Concluding Remarks

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Co-chairs: Julie Greenwalt (Go Green for Climate), Diego Martino (Universidad ORT Uruguay; Asesoramiento Ambiental Estratégico (AAE)

The global urbanization trend is continuous, rapid and unstoppable (United Nations Environment Programme [UNEP] 2019). The speed of the urbanization process leaves us with no alternative and little time: Cities must be a central part of the global paths towards sustainability. Cities have the potential to be the most significant opportunity for global sustainable development. If the efficiency of cities is improved, wealth can be created and poverty reduced while reducing the current pressure on ecosystems (International Resource Panel 2018; UNEP 2019). However, the window of opportunity is small and narrowing. Decisions made today, particularly in those rapidly urbanizing centers, will dictate the direction of those cities for decades to come. Once a river is covered, a highway is built, a low rise suburb is constructed, a path is set for many years to come.

Processes occurring in urban areas are currently affecting the local and global environment. At the same time the urban environment is being affected by global environmental changes, which, coupled with environmental pressures from the cities themselves, make the urban environment unhealthy in many places. Air quality, biodiversity loss, decrease in water quality and quantity, and ocean pollution are regular consequences of environmentally unsustainable urban processes. These impact the health of urban dwellers; one in nine deaths every year is attributed to exposure to air pollution, decrease in biodiversity and natural areas can affect physical and mental health, poor water quality increases the risk of vector-borne diseases and ocean pollution (e.g. microplastics) can affect human health (see chapter 3).

These impacts are not equally distributed across urban dwellers. Air quality disproportionally affects children (asthma, brain development, lung growth) and heat waves affect the elderly. Informal and economically disadvantaged groups are also more exposed and have less capacity to adapt to floods, landslides and other effects of climate change, they also have less access to services from public supply networks (e.g. water), making them more vulnerable to waterborne diseases. These negative health outcomes affect women directly and more so when they face a caring burden, which affects their own livelihood prospects (see chapters 2 and 3).

Complex, interlinked structural barriers deeply rooted in the political economy and governance of cities represent enormous challenges for making change. This report uses the term lock-ins to explain how they commit cities to current environmentally unsustainable patterns and prevent sustainable and just urban transformations. They need to be tackled, because

> *"environmental policy is necessary but inadequate by itself to address systemic ecological problems, solutions to which require a more holistic approach"* (UNEP Environment 2019).

A comprehensive and inclusive approach is necessary in urban planning and governance, both within city management and at different scales (regional, national, subnational, urban, local) to catalyze a just and environmentally sustainable future.

The world is full of inspiring and innovative urban initiatives, however a persistent theme throughout the many meetings, workshops, and discussions we held during the production of the GEO Cities Report that there is not a perfect example or clearly tested roadmap for sustainable transformation that every city could blindly follow and lead to the outcomes that are necessary. In those same discussions, what did emerge was a myriad of small-scale inspiring examples, large sectoral success stories and early sustainable development headways that give reason for hope when looking towards the future. The diversity of examples and experiences should help move city makers to break away from inertia and city planning defaults (IRP 2018), which keeps the 'lock-ins' in place, and should encourage them to envision cities as the ones pictured in chapter 4, as well as following experiences emerging from other cities and experimenting themselves (IRP 2018).

The vision of urban settlements presented in the Quito declaration captures chapter 4 of this report:

> *"We envisage cities and human settlements that are participatory, promote civic engagement, engender a sense of belonging and ownership among all their inhabitants, prioritize safe, inclusive, accessible, green and quality public spaces that are friendly for families, enhance social and intergenerational interactions, cultural expressions and political participation, as appropriate, and foster social cohesion, inclusion and safety in peaceful and pluralistic societies, where the needs of all inhabitants are met, recognizing the specific needs of those in vulnerable situations."* (United Nations 2017)

We must consider this ambition a possibility, since it is of essence to make civilization sustainable.

Moving towards circularity in cities, decarbonization of urban economies, increasing resilience and decreasing inequity are essential elements presented in this report to exemplify pathways towards sustainability. Any potential pathways to these sustainable urban futures are inherently complex because they need to consider context as well as the multiple interlinked dimensions, including the lock-ins. This complexity means multiple actors need to be involved in finding the solutions, generally at different scales, in the implementation of any transformational policy.

After more than two years of reflection several things are clear – there is an urgent and dire need for reconfiguring how cities function in order to address critical environmental problems with just outcomes for people and nature. It is also clear that this is not easy and there is no simple guidebook to be had but we must take inspiration and action from what information is available. We need to take risks and confront massive underlying issues because a better future is possible for our cities and our planet and we cannot be afraid to take action to make these visions a reality in cities, from Baltimore to Montevideo.

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Appendix

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Acronyms and Abbreviations

AGRUPAR	Participatory Urban Agriculture Project
ANERT	Agency for Non-conventional Energy & Rural Technology
BRT	Bus-Rapid Transit
C40	C40 Cities Climate Leadership Group
CCA	Climate change adaptation
CH4	Methane
CO2	Carbon dioxide
CODI	Ministry of Social Development and Human Security's Community Organizations Development Institute
CRFS	City Region Food System
CRO	Chief Resilience Officer
DPSIR	Driver-Pressure-State-Impact-Response
DRR	Disaster risk reduction
DVP	Duwamish Valley Program
EEI	Equity & Environment Initiative
FAO	Food and Agriculture Organization
FSSM	Food System-Sensitive Methodology
FYPs	Five-year plans
GCOM	Global Covenant of Mayors
GDP	Gross domestic product
GEO	Global Environment Outlook
GHGs	Greenhouse gases
H2O	Water
HFCs	Hydrofluorocarbons
ICCEP	International Conference on Clean Electrical Power
ICT	Information and communication technologies
IDP	Integrated development planning
IIED	International Institute for Development
IUS	Integrated Urban Hydrometeorological, Climate and Environmental Systems and Services
IZA	Institute of Labor Economics
LCA	Life cycle assessment
LULC	Land use and land cover
MFA	Material flow analysis
N2O	Nitrous oxide
NDCs	Nationally determined contributions
NEMMP	National Electric Mobility Mission Plan
NF3	Nitrogen trifluoride
NGOs	Non-governmental organizations
O3	Ozone
PAHs	Polycyclic aromatic hydrocarbons
PAU	Urban Agriculture Programme
PB	Participatory budgeting
PER	Strategic Plan of Rosario
PFCs	Perfluorocarbons
SARS	Severe Acute Respiratory Syndrome
SARSAI	School Area Road Safety Assessment and Improvements
SDGs	Sustainable Development Goals
SDI	Slumdwellers International
SF6	Sulfur hexafluoride
SLCFs	Short-lived climate forcers
SSEG	Small-Scale Energy Generation Programme
SUMS	Social Urban Metabolism Strategies
TEEB	The Economics of Ecosystems and Biodiversity
UCLG	United Cities and Local Government
UHI	Urban heat islands
UNFCCC	United Nations Framework Convention on Climate Change
VLR	Voluntary reviews
VNR	Voluntary National Reviews
WHO	World Health Organization
WUI	Wildland-urban interface

Glossary

This glossary is compiled by the Global Assessments Unit of UNEP. Sources for all terms and definitions can be found here.

Abundance
The number of individuals or related measure of quantity (such as biomass) in a population, community or spatial unit.

Acidification
Change in natural chemical balance caused by an increase in the concentration of acidic elements.

Adaptation
Adjustment in natural or human systems to a new or changing environment, including anticipatory and reactive adaptation, private and public adaptation, and autonomous and planned adaptation.; In human systems, the process of adjustment to actual or expected climate and its effects in order to moderate harm or exploit beneficial opportunities. In natural systems, the process of adjustment to actual climate and its effects; human intervention may facilitate adjustment to expected climate.

Adaptive capacity
The ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences.

Aerosol
A collection of airborne solid or liquid particles, with a typical size between 0.01 and 10 micrometres (μm), that resides in the atmosphere for at least several hours. Aerosols may be of either natural or anthropogenic origin.

Alien species
Species accidentally or deliberately introduced outside its normal distribution.

Anthropocene
A term used by scientists to name a new geologic epoch (following the most recent Holocene) characterized by significant changes in the Earth's atmosphere, biosphere and hydrosphere due primarily to human activities.

Anthropogenic
As a result of human activity.

Aquifer
An aquifer is an underground layer of water-bearing rock. Water-bearing rocks are permeable, meaning they have openings that liquids and gases can pass through. Sedimentary rock such as sandstone, as well as sand and gravel, are examples of water-bearing rock. The top of the water level in an aquifer is called the water table.

Billion
10^9 (1,000,000,000).

Biocultural heritage
Living organisms or habitats whose present features are due to cultural action in time and place.

Biodiversity
The variety of life on Earth, including diversity at the genetic level, among species and among ecosystems and habitats. It includes diversity in abundance, distribution and behavior, as well as interaction with socio-ecological systems. Biodiversity also incorporates human cultural diversity, which can both be affected by the same drivers as biodiversity, and itself has impacts on the diversity of genes, other species and ecosystems.; The variability among living organisms from all sources, including terrestrial, marine and other aquatic ecosystems, as well as the ecological complexes of which they are part. Biodiversity includes diversity within species, between species and of ecosystems.

Biogas
Gas, rich in methane, which is produced by the fermentation of animal dung, human sewage or crop residues in an airtight container.

Biomass
Organic material, above and below ground and in water, both living and dead, such as trees, crops, grasses, tree litter and roots.

Biosphere
The part of the Earth and its atmosphere in which living organisms exist or that is capable of supporting life.

Biotic
Live and living organism. (Terminology for integrated resource planning and management, 1999 - X2079E).

Bottom-up
From the lowest level of a hierarchy or process to the top.

Breakwater
A hard engineering structure built in the sea which, by breaking waves, protects a harbour, anchorage, beach or shore area.

Burden of disease
The burden of disease can be thought of as the measurement of the gap between current health status and an ideal health situation where the entire population lives to an advanced age, free of disease and disability.

Capital
Resource that can be mobilized in the pursuit of an individual's goals. Thus, natural capital (natural resources such as land and water), physical capital (technology and artefacts), social capital (social relationships, networks and ties), financial capital (money in a bank, loans and credit), human capital (education and skills).

Carbon intensity
The amount of emissions of CO_2 released per unit of another variable such as gross domestic product, output energy use, transport or agricultural/forestry products.

Circular economy
A circular economy is a systems approach to industrial processes and economic activity that enables resources used to maintain their highest value for as long as possible. Key considerations in implementing a circular economy are reducing and rethinking research use, and the pursuit of longevity, renewability, reusability, reparability, replaceability, upgradability for resources and products that are used.

Circular City
A city that eliminates waste, keeps goods and their ingredients in use and regenerates natural systems. This can involve more distributed ways of managing resources, including exchanging or renting goods instead of buying them.

City region
An urban development on a massive scale: a major city that expands beyond administrative boundaries to engulf small cities, towns and semi-urban and rural hinterlands, sometimes expanding sufficiently to merge with other cities, forming large conurbations that eventually become City region.

Civil society
The aggregate of non-governmental organizations and institutions representing the interests and will of citizens.

Climate Change
The UN Framework Convention on Climate Change defines climate change as "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods."

Climate variability
Variations in the mean state and other statistics (such as standard deviations and the occurrence of extremes) of the climate on all temporal and spatial scales beyond that of individual weather events. Variability may be due to natural internal processes in the climate system (internal variability), or to variations in natural or anthropogenic external forcing (external variability).

Coastal area
In general, a geographical area of land and water along the coast, affected by the biological and physical processes of both the terrestrial and marine environments.

Coastal environment
An environment in which the coast is a significant element or part. The extent of the coastal environment will vary from place to place depending on how much it affects, or is affected by, coastal processes and the management issues concerned. It includes at least three distinct, but inter-related, parts: the coastal marine area, the active coastal zone, and the land back-drop.

Coastal planning
Coastal and Marine Spatial Planning (CMSP) is about proper use and management of ocean and coastal spaces based on publicly agreed upon goals and objectives. It is about ensuring that marine uses are compatible and occur in areas where environmental effects are avoided or minimized. The need for CMSP is the result of increasing competition for ocean space by existing and emerging users.

Coastal zone
The geomorphologic area either side of the seashore, in which the interaction between the marine and land parts occurs in the form of complex ecological and resource systems, made up of biotic and abiotic components, coexisting and interacting with human communities and relevant socio-economic activities.

Co-benefits
The positive effects that a policy or measure aimed at one objective might have on other objectives, without yet evaluating the net effect on overall social welfare. Co-benefits are often subject to uncertainty and depend on, among others, local circumstances and implementation practices. Co-benefits are often referred to as ancillary benefits.

Conservation
The protection, care, management and maintenance of ecosystems, habitats, wildlife species and populations, within or outside of their natural environments, in order to safeguard the natural conditions for their long-term permanence.

Coronavirus disease 2019 (COVID-19)
Illness caused by a novel coronavirus, 'severe acute respiratory syndrome coronavirus 2' (SARS-CoV-2), which was first identified amid an outbreak of respiratory illness cases in East Asia. The outbreak was first reported to WHO on 31 December 2019. On 30 January 2020, WHO declared the COVID-19 outbreak a global health emergency and the following March a global pandemic, WHO's first such designation since declaring H1N1 influenza a pandemic in 2009.

Critical habitat
Geographic area containing physical or biological features essential to the conservation of a listed species or an area that may require special management considerations or protection.

Crop
(The total amount collected of) a plant such as a grain, fruit, or vegetable grown in large amounts.

Cross-cutting issue
An issue that cannot be adequately understood or explained without reference to the interactions of several of its dimensions that are usually defined separately.

Crowding in
The mobilization of private sector finance for innovative investment projects through public sector (co) financing of these investments.

Cultural heritage
It includes the physical (tangible) and/or non-physical (intangible) manifestation of an indigenous peoples and local communities' cultural heritage, in accordance with the traditional inheritance and transmission.

Decarbonization
Remove carbon or carbonaceous deposits from (an engine or other metal object).

Deforestation
Conversion of forested land to non-forest areas.

Dengue
An infectious diseases caused by any one of four related viruses transmitted by mosquitoes. The dengue virus is a leading cause of illness and death in the tropic and subtropics. As many as 400 million people are infected yearly.

Desertification
Land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors, including climatic variations and human activities. It involves crossing thresholds beyond which the underpinning ecosystem cannot restore itself, but requires ever-greater external resources for recovery.; When individual land degradation processes, acting locally, combine to affect large areas of drylands.

Disaster risk management
The application of disaster risk reduction policies and strategies, to prevent new disaster risks, reduce existing disaster risks, and manage residual risks, contributing to the strengthening of resilience and reduction of losses. Disaster risk management actions can be categorized into; prospective disaster risk management, corrective disaster risk management and compensatory disaster risk management (also referred to as residual risk management).

Disaster risk reduction
The conceptual framework of elements intended to minimize vulnerability to disasters throughout a society, to avoid (prevention) or limit (mitigation and preparedness) the adverse impacts of hazards, within the broad context of sustainable development.

Downstream
Away from the source or with the current.; In the direction of a stream's current.

Driver
The overarching socio-economic forces that exert pressures on the state of the environment.

Dust storm
The result of terminal winds raising large quantities of dust into the air and reducing visibility at eye level (1.8 metres) to less than 1000 metres.

Early warning systems
Complex tools and processes aiming to reduce the impact of natural hazards by providing timely and relevant information in a systematic way.

Earth system
The Earth System is a complex social-environmental system of interacting physical, chemical, biological and social components and processes that determine the state and evolution of the planet and life on it; The Earth´s interacting physical, chemical, and biological processes. The system consists of the land, oceans, atmosphere and poles. it includes the planet's natural cycles — the carbon, water, nitrogen, phosphorus, sulphur and other cycles — and deep Earth processes.

Eco-efficiency
Minimizing environmental pressure while maximizing economic benefit, is a key sustainability principle. A country's economy can be thought of as a huge resource-processing plant. Raw materials, including energy and water, go into the economy as inputs to various production or consumption processes. At the other end, the result is goods, services and waste. The transformation process is intended to result in some human benefit. Maximizing the efficiency of resource use and minimizing pollution during the entire transformation process across economic sectors is critical to achieving sustainable development or economic benefit.

EcoHealth
An emerging field that examines the complex relationships among humans, animals and the environment, and how these relationships affect the health of each of these domains. One Health deals with biomedical questions, with an emphasis on zoonoses, and is historically more health science-driven. In contrast, the EcoHealth concept is defined as an ecosystem approach to health, tending to focus on environmental and socio-economic issues and initially designed by disease ecologists working in the field of biodiversity conservation.

Ecological footprint
A measure of the area of biologically productive land and water an individual, population or activity uses to produce all the resources it consumes and to absorb the corresponding waste (such as carbon dioxide emissions from fossil fuel use), using prevailing technology and resource management practices. The ecological footprint is usually measured in global hectares.

Ecological infrastructure
A concept referring to both the services provided by the natural ecosystems, and to nature within the man-made ecosystems.

Ecosystem
A dynamic complex of plant, animal and micro-organism communities and their non-living environment, interacting as a functional unit.; Ecosystem: A dynamic complex of vegetable, animal and microorganism communities and their nonliving environment that interact as a functional unit. Ecosystems may be small and simple, like an isolated pond, or large and complex, like a specific tropical rainforest or a coral reef in tropical seas.

Ecosystem function
An intrinsic ecosystem characteristic related to the set of conditions and processes whereby an ecosystem maintains its integrity (such as primary productivity, food chain and biogeochemical cycles). Ecosystem functions include such processes as decomposition, production, nutrient cycling, and movements of nutrients and energy.

Ecosystem health
The degree to which ecological factors and their interactions are reasonably complete and function for continued resilience, productivity and renewal of the ecosystem.

Ecosystem restoration
The "process of assisting the recovery of an ecosystem that has been degraded, damaged or destroyed".

Electrification
The action or process of charging something with electricity.

Emerging contaminant
Broadly defined as any synthetic or naturally occurring chemical or any microorganism that is not commonly monitored in the environment but has the potential to enter the environment and cause known or suspected adverse ecological and(or) human health effects.

Emission pathway
The trajectory of annual greenhouse gas emissions over time.

Empowerment of women
According to the UN, it has five components: 1) women's sense of self-worth; 2) their right to have and to determine choices; 3) their right to have access to opportunities and resources; 4) their right to have the power to control their own lives, both within and outside the home; 5) their ability to influence the direction of social change to create a more just social and economic order, nationally and internationally.

Endangered species
A species is endangered when the best available evidence indicates that it meets any of the criteria A to E specified for the endangered category of the IUCN Red List and is therefore considered to be facing a very high risk of extinction in the wild.

Environment
Surroundings including water, air, soil and their interrelationship as well as all relationships between them and any living organisms.

Environmental conservation
Action aimed at preventing environmental degradation; implies rational use and management of resources.

Environmental degradation
Environmental degradation is the deterioration in environmental quality from ambient concentrations of pollutants and other activities and processes such as improper land use and natural disasters.

Environmental education
The process of recognizing values and clarifying concepts in order to develop skills and attitudes necessary to understand and appreciate the interrelatedness of humans, their culture and biophysical surroundings. Environmental education also entails practice in decision-making and self-formulation of a code of behaviour about issues concerning environmental quality.

Environmental flows
Quantity, timing and quality of water flows required to sustain freshwater and estuarine ecosystems and the human livelihoods and well-being that depend on these ecosystems. Through implementation of environmental flows, water managers strive to achieve a flow regime, or pattern, that provides for human uses and maintains the essential processes required to support healthy river ecosystems.

Environmental footprint
The effect that a person, company, activity, etc. has on the environment, for example the amount of natural resources that they use and the amount of harmful gases that they produce.

Environmental health
Those aspects of human health and disease that are determined by factors in the environment. It also refers to the theory and practice of assessing and controlling factors in the environment that can potentially affect health. Environmental health includes both the direct pathological effects of chemicals, radiation and some biological agents, and the effects, often indirect, on health and well-being of the broad physical, psychological, social and aesthetic environment. This includes housing, urban development, land use and transport.

Environmental impact
The change in well-being of ecosystems, resulting from a process set in motion or accelerated by human actions.; Any change to the environment, whether adverse or beneficial, wholly or partially resulting from an organization's activities, products or services.

Environmental justice
A mechanism of accountability for the protection of rights and the prevention and punishment of wrongs related to the disproportionate impacts of growth on the poor and vulnerable in society from rising pollution and degradation of ecosystem services, and from inequitable access to and benefits from the use of natural assets and extractive resources.

Environmental monitoring
Regular, comparable measurements or time series of data on the environment.

Environmental performance
Environmental performance relates to action by governments and other actors, including implementation of processes that support environmentally sustainable economic growth. Essentially, environmental performance is a measure of the gap between the actual state of what is being measured and targeted policy goals.

Environmental pressure
Pressure resulting from human activities which bring about changes in the state of the environment.

Environmental quality
A state of environmental conditions in environmental media, expressed in terms of indicators or indices related to environmental quality standards.

Environmental sustainability
Refers to the capacity of economic growth processes and social change to ensure that natural resources are not depleted faster than they can be regenerated and that ecological systems remain viable. Economic growth must stay within existing carrying capacities. Mounting environmental pressures cannot be handled successfully, through a sole focus on improving environmental performance. A closer look needs to be taken at the environmental sustainability of an economic system. As applied to economic growth refers to the capacity of economic growth processes and social change to ensure that natural resources are not depleted faster than they can be regenerated and that ecological systems remain viable.

Epidemiology
The branch of medicine which deals with the incidence, distribution, and possible control of diseases and other factors relating to health.

Equity
Fairness of rights, distribution and access. Depending on context, this can refer to access to resources, services or power.

Erosion
The wearing away of the land by running water, rainfall, wind, ice or other geological agents, including such processes as detachment, entrainment, suspension, transportation and mass movement.

Eutrophication
The degradation of water or land quality due to enrichment by nutrients, primarily nitrogen and phosphorous, which results in excessive plant (principally algae) growth and decay. Eutrophication of a lake normally contributes to its slow evolution into a bog or marsh and ultimately to dry land. Eutrophication may be accelerated by human activities that speed up the ageing process.

Exposure
The presence of people, livelihoods, species or ecosystems, environmental functions, services, and resources, infrastructure, or economic, social, or cultural assets in places and settings that could be adversely affected.

Feedback
Where non-linear change is driven by reactions that either dampen change (negative feedbacks) or reinforce change (positive feedbacks).

Feed-in tariff
A feed-in tariff is an energy policy focused on supporting the development and dissemination of renewable power generation. In a feed-in tariff scheme, providers of energy from renewable sources, such as solar, wind or water, receive a price for what they produce based on the generation costs. This purchase guarantee is offered generally on a long-term basis, ranging from 5 to 20 years, but most commonly spanning 15–20 years.1 The cost of the tariff payments are typically shared with the electricity consumers.

Flood
Usually classified into three types: river flood, flash flood and storm surge. River floods result from intense and/or persistent rain over large areas. Flash floods are mostly local events resulting from intense rainfall over a small area in a short period of time. Storm surge floods occur when flood water from the ocean or large lakes is pushed on to land by winds or storms.

Food security
Physical and economic access to food that meets people's dietary needs as well as their food preferences.

Food system
Food systems are usually conceived as a set of activities ranging from production to consumption. It is a broad concept encompassing food security and its components – availability, access and utilization – and including the social and environmental outcomes of these activities. Food systems in developing countries have been largely transformed by globalization. This change offers tremendous opportunities for food workers to access new and better employments. Yet, small scale food producers and other food workers are still too often excluded from the benefits generated by food businesses.

Forest
Land spanning more than 0.5 hectares with trees higher than 5 metres and a canopy cover of more than 10 per cent, or trees able to reach these thresholds in situ. It does not include land that is predominantly under agricultural or urban use.

Fossil fuel
Coal, natural gas and petroleum products (such as oil) formed from the decayed bodies of animals and plants that died millions of years ago.

Gender
Gender refers to the roles, behaviors, activities, and attributes that a given society at a given time considers

appropriate for men and women. In addition to the social attributes and opportunities associated with being male and female and the relationships between women and men and girls and boys, gender also refers to the relations between women and those between men. These attributes, opportunities and relationships are socially constructed and are learned through socialization processes. They are context/ time-specific and changeable. Gender determines what is expected, allowed and valued in a woman or a man in a given context. Gender is part of the broader socio-cultural context, as are other important criteria for socio-cultural analysis including class, race, poverty level, ethnic group, sexual orientation, age, etc.

Gender empowerment
In its broadest sense, it is the expansion of freedom of choice and action. It means increasing one's authority and control over the resources and decisions that affect one's life. As people exercise real choice, they gain increased control over their lives. Poor people's choices are extremely limited, both by their lack of assets and by their powerlessness to negotiate better terms for themselves with a range of institutions, both formal and informal.

Global commons
Natural un-owned assets such as the atmosphere, oceans, outer space and the Antarctic.

Global warming
Increase in surface air temperature, referred to as the global temperature, induced by emissions of greenhouse gases into the air.

Globalization
The increasing integration of economies and societies around the world, particularly through trade and financial flows, and the transfer of culture and technology.

Governance
The act, process, or power of governing for the organization of society/ies. For example, there is governance through the state, the market, or through civil society groups and local organizations. Governance is exercised through institutions: laws, property-rights systems and forms of social organization.

Green economy
There is no internationally agreed definition of green economy and at least eight separate definitions were identified in recent publications. For example, UNEP has defined the green economy as "one that results in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities. It is low carbon, resource efficient, and socially inclusive" (UNEP, 2011). This definition has been cited in a number of more recent reports, including by the UNEMG and the OECD. Another definition for green economy offered by the Green Economy Coalition (a group of NGOs, trade union groups and others doing grassroots work on a green economy) succinctly defines green economy as "a resilient economy that provides a better quality of life for all within the ecological limits of the planet."

Green infrastructure
A strategically planned network of high quality natural and semi-natural areas with other environmental features, which is designed and managed to deliver a wide range of ecosystem services and protect biodiversity in both rural and urban settings.; A network of multi-functional green space, urban and rural, which is capable of delivering a wide range of environmental and quality of life benefits for local communities.

Green job
A green job is work in agricultural, manufacturing, research and development (R&D), administrative, and service activities that contribute(s) substantially to preserving or restoring environmental quality. Specifically, but not exclusively, this includes jobs that help to protect ecosystems and biodiversity; reduce energy, materials, and water consumption through high efficiency strategies; de-carbonize the economy; and minimize or altogether avoid generation of all forms of waste and pollution.".

Green roof
They are an extension of the existing roof which involves a high quality water proofing and root repellent system, a drainage system, filter cloth, and a lightweight growing medium and plants. Green roofs reduce storm water runoff, energy consumption, and greenhouse gas emissions. They also represent opportunities for significant social, economic and environmental benefits, particularly in urban settings.

Greenhouse gases (GHGs)
Gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and emit thermal radiation. This property causes the greenhouse effect. Water vapour (H_2O), carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4) and ozone (O_3) are the primary greenhouse gases in the Earth's atmosphere. There are human-made greenhouse gases in the atmosphere, such as halocarbons and other chlorine- and bromine-containing substances. Beside CO_2, N_2O and CH_4, the Kyoto Protocol deals with sulphur hexafluoride (SF_6), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and nitrogen trifluoride (NF_3).; The atmospheric gases responsible for causing global warming and climatic change. The major greenhouse gases are carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). Less prevalent, but very powerful, GHGs are hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6).

Grey water
Water the quality of which has been adversely affected by human use, in industrial, agriculture or domestically. The grey water footprint of a product is an indicator of freshwater pollution that can be associated with the production of a product over its full supply chain. It is defined as the volume of freshwater that is required to assimilate the load of pollutants based on natural background concentrations and existing ambient water quality standards. It is calculated as the volume of water that is required to dilute pollutants to such an extent that the quality of the water remains above agreed water quality standards.

Gross domestic product (GDP)
The value of all final goods and services produced in a country in one year. GDP can be measured by adding up all of an economy's incomes – wages, interest, profits, and rents – or expenditures – consumption, investment, government purchases, and net exports (exports minus imports).

Groundwater
Water that flows or seeps downward and saturates soil or rock, supplying springs and wells. The upper surface of the saturated zone is called the water table.

Habitat
(1) The place or type of site where an organism or population occurs naturally. (2) Terrestrial or aquatic areas distinguished by geographic, living and non-living features, whether entirely natural or semi-natural.; The natural home or environment of an animal, plant or other organism.

Habitat fragmentation
Alteration of habitat resulting in spatial separation of habitat units from a previous state of greater continuity.; A general term describing the set of processes by which habitat loss results in the division of continuous habitats into a greater number of smaller patches of lesser total and isolated from each other by a matrix of dissimilar habitats. Habitat fragmentation may occur through natural processes (e.g., forest and grassland fires, flooding) and through human activities (forestry, agriculture, urbanization). Habitat loss and fragmentation have long been considered the primary cause for biodiversity loss and ecosystem degradation worldwide. Habitat fragmentation often refers to the reduction of continuous tracts of habitat to smaller, spatially distinct remnant patches. Although some habitats are naturally patchy in terms of abiotic and biotic conditions, human actions have profoundly fragmented landscapes across the word, altering the quality and connectivity of habitats.

Habitat loss
Habitat destruction: a process of land use change in which one habitat-type is removed and replaced with another habitat-type. In the process of land-use change, plants and animals which previously used the site are displaced or destroyed, reducing biodiversity.

Hazard
A potentially damaging physical event, phenomenon or human activity that may cause the loss of life or injury, property damage, social and economic disruption or environmental degradation.; The potential occurrence of a natural or human-induced physical event or trend or physical impact that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems and environmental resources. In this report, the term hazard usually refers to climate-related physical events or trends or their physical impacts.

Heavy metals
A subset of elements that exhibit metallic properties, including transitional metals and semi-metals (metalloids), such as arsenic, cadmium, chromium, copper, lead, mercury, nickel and zinc, that have been associated with contamination and potential toxicity.

Human health
Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity.

Human well-being
The extent to which individuals have the ability to live the kinds of lives they have reason to value; the opportunities people have to pursue their aspirations. Basic components of human well-being include: security, meeting material needs, health and social relations.

Institutions
Regularized patterns of interaction by which society organizes itself: the rules, practices and conventions that structure human interaction. The term is wide and encompassing, and could be taken to include law, social relationships, property rights and tenurial systems, norms, beliefs, customs and codes of conduct as much as multilateral environmental agreements, international conventions and financing mechanisms. Institutions could be formal (explicit, written, often having the sanction of the state) or informal (unwritten, implied, tacit, mutually agreed and accepted).

Invasive species
Introduced species that have spread beyond their area of introduction (and, rarely, native species that have recently expanded their populations), and which are frequently associated with negative impacts on the environment, human economy or human health.

Land cover
The physical coverage of land, usually expressed in terms of vegetation cover or lack of it. Influenced by but not synonymous with land use.

Land degradation
a long-term loss of ecosystem function and services, caused by disturbances from which the system cannot recover unaided.

Land reclamation
The restoration of productivity or use to lands that have been degraded by past human activities or have been impaired by natural phenomena.; The operation or process of changing the condition or characteristics of land so that improved utilization can be achieved. This may be accomplished by various means such as irrigation of arid land, drainage of swamp or waterlogged land, protection from flood menace of land constantly subject to overflow.

Land use
The functional dimension of land for different human purposes or economic activities. Examples of land use categories include agriculture, industrial use, transport and protected areas.

Land use planning
Land-use planning involves the systematic assessment of environmental, economic and social impacts of the range

of potential uses of land in order to decide on the optimal pattern of land use. Land-use planning and systematic conservation planning has seldom been explored explicitly as a tool in global scenarios.

Landslide
A slope mass earth movement where a soil or substrata mass slides over a contact surface called sliding surface.

Life-cycle analysis
A technique to assess the environmental impacts associated with all the stages of the life of a product – from raw material extraction through materials processing, manufacture, distribution, use, repair and maintenance, and disposal or recycling (cradle-to-grave).

Literacy
The ability to read and write.

Livelihood
(The way someone earns) the money people need to pay for food, a place to live, clothing, etc.

Lock-in
Lock-in occurs when a market is stuck with a standard even though participants would be better off with an alternative.

Mainstreaming
Taking into consideration as an integral part of the issue in question.

Mangrove
A tree or shrub that grows in chiefly tropical coastal swamps that are flooded at high tide. Mangroves typically have numerous tangled roots above ground and form dense thickets.

Mariculture
The cultivation of marine organisms in their natural environment.

Marine
By marine is meant coastal and offshore waters in which the salinity is maximal and not subject to significant daily and seasonal variation.

Megacities
Urban areas with more than 10 million inhabitants.

Microplastics
Small plastic pieces, less than five millimeters long which can be harmful to our ocean and aquatic life.

Mitigation
In the context of climate change, a human intervention to reduce the sources, or enhance the sinks of greenhouse gases. Examples include using fossil fuels more efficiently for industrial processes or electricity generation, switching to solar energy or wind power, improving the insulation of buildings, and expanding forests and other 'sinks' to remove greater amounts of CO_2 from the atmosphere.

Morphology
(1) The physical characteristics of living organisms.
(2) The branch of biology that deals with the form of living organisms, and with relationships between their structures.

Municipal solid waste
A mixture of domestic, small-scale industrial and demolition solid wastes generated within a community.

Natural capital
Natural assets in their role of providing natural resource inputs and environmental services for economic production. Natural capital includes land, minerals and fossil fuels, solar energy, water, living organisms, and the services provided by the interactions of all these elements in ecological systems.

Natural environment
All living and non-living things that occur naturally on a particular region where human impact is kept under a certain limited level.

Natural hazard
Natural process or phenomenon that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage.

Natural heritage
Natural features consisting of physical and biological formations or groups of such formations, which are of outstanding universal value from the aesthetic or scientific point of view; geological and physiographical formations and precisely delineated areas which constitute the habitat of threatened species of animals and plants of outstanding universal value from the point of view of science or conservation; natural sites or precisely delineated natural areas of outstanding universal value from the point of view of science, conservation or natural beauty.

Natural resources
Materials or substances such as minerals, forests, water, and fertile land that occur in nature and can be used for economic gain.

Nature's contributions to people
All the contributions, both positive and negative, of living nature (diversity of organisms, ecosystems, and their associated ecological and evolutionary processes) to people's quality of life.

Nature-based solution
Actions to protect, sustainably manage, and restore natural or modified ecosystems, that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits.

Nature positive
Enhancing the resilience of our planet and societies to halt and reverse nature loss.

Non-state actors
Non-state actors are categorized as entities that (i) participate or act in the sphere of international relations; organizations with sufficient power to influence and cause change in politics which (ii) do not belong to or exist as a state-structure or established institution of a state; do not have the characteristics of this, these being legal sovereignty and some measure of control over a country's people and territories.

Nutrient cycling
Biogeochemical cycle, in which inorganic nutrients move through soil, living organisms, air and water. In agriculture, it refers to the return of nutrients absorbed by plants from the soil, back to the soil. Nutrient cycling can take place through leaf fall, root exudation (secretion), residue recycling, and incorporation of green manure.

Nutrients
The approximately 20 chemical elements known to be essential for the growth of living organisms, including nitrogen, sulphur, phosphorus and carbon.

Organizations
Bodies of individuals with a specified common objective. Organizations could be political organizations, political parties, governments and ministries; economic organizations, federations of industry; social organizations (non-governmental organizations (NGOs) and self-help groups) or religious organizations (church and religious trusts). The term organizations should be distinguished from institutions.

Pandemic
The worldwide spread of a new disease. An influenza pandemic occurs when a new influenza virus emerges and spreads around the world and most people do not have immunity.

Participatory approach
Securing an adequate and equal opportunity for people to place questions on an agenda and to express their preferences about a final outcome during decision making to all group members. Participation can occur directly or through legitimate representatives. Participation may range from consultation to the obligation of achieving a consensus.

Peri-urban
Denoting or located in an area immediately adjacent to a city or urban area.

Planetary boundaries
A framework designed to define a safe operating space for humanity for the international community, including governments at all levels, international organizations, civil society, the scientific community and the private sector, as a precondition for sustainable development.

Persistent organic pollutants
Chemical substances that persist in the environment, bioaccumulate through the food web, and pose a risk of causing adverse effects to human health and the environment.

Photovoltaic
Capable of generating voltage as a result of exposure to visible or other radiation.

Planetary boundaries
A framework designed to define a safe operating space for humanity for the international community, including governments at all levels, international organizations, civil society, the scientific community and the private sector, as a precondition for sustainable development.

Planetary health
Defined as "the achievement of the highest attainable standard of health, wellbeing, and equity worldwide through judicious attention to the human systems—political, economic, and social—that shape the future of humanity and the Earth's natural systems that define the safe environmental limits within which humanity can flourish. Put simply, planetary health is the health of human civilization and the state of the natural systems on which it depends". In 2014 the Rockefeller Foundation and The Lancet jointly formed the Commission on Planetary Health to review the scientific basis for linking human health to the underlying integrity of Earth's natural system.

Policy
Any form of intervention or societal response. This includes not only statements of intent, but also other forms of intervention, such as the use of economic instruments, market creation, subsidies, institutional reform, legal reform, decentralization and institutional development. Policy can be seen as a tool for the exercise of governance. When such an intervention is enforced by the state, it is called public policy.

Policymaker
a member of a government department, legislature, or other organization who is responsible for making new rules, laws, etc.

Pollutant
Any substance that causes harm to the environment when it mixes with soil, water or air.

Pollution
The presence of minerals, chemicals or physical properties at levels that exceed the values deemed to define a boundary between good or acceptable and poor or unacceptable quality, which is a function of the specific pollutant.

Poverty
The state of one who lacks a defined amount of material possessions or money. Absolute poverty refers to a state of lacking basic human needs, which commonly include clean and fresh water, nutrition, health care, education, clothing and shelter.

Premature deaths
Deaths occurring earlier due to a risk factor than would occur in the absence of that risk factor.

Private sector
The private sector is part of a country's economy which consists of industries and commercial companies that are not owned or controlled by the government.

Projection
The act of attempting to produce a description of the future subject to assumptions about certain preconditions, or the description itself, such as "assuming it is 30°C tomorrow, we will go to the beach."

Protected area
A clearly defined geographical space, recognized, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values.

Provisioning services
The products obtained from ecosystems, including, for example, genetic resources, food and fibre, and freshwater.

Public sector
The portion of society that comprises the general government sector plus all public corporations including the central bank.

Recycled water
Water that is used more than one time before it passes back into the natural hydrologic system.; Water, other than first-use or reclaimed water, which has been obtained from a food processing operation, or water that is reused in the same operation after reconditioning.

Renewable energy source
An energy source that does not rely on finite stocks of fuels. The most widely known renewable source is hydropower; other renewable sources are biomass, solar, tidal, wave and wind.

Reservoir
The habitat in which the agent normally lives, grows, and multiplies. Reservoirs include humans, animals, and the environment. The reservoir may or may not be the source from which an agent is transferred to a host.

Resistance
The capacity of a system to withstand the impacts of drivers without displacement from its present state.

Resource flows
Represent the movement of resources (e.g. materials, energy, people and information) into the city, how they circulate between sectors and uses, how they accumulate within the city and how the remainder exit the city.

Risk prevention
Strategies that are implemented before a risk event occurs. Reducing the probability of an adverse risk increases people's expected income and reduces income variance, and both of these effects increase welfare. There are many possible strategies for preventing or reducing the occurrence of risks, many of which fall outside of social protection, such as sound macroeconomic policies, environmental policies, and investments in education. Preventive social protection interventions typically form part of measures designed to reduce risks in the labor market, notably the risk of unemployment, under-employment, or low wages due to inappropriate skills or malfunctioning labor markets.

Riverine
Relating to or situated on a river or riverbank; riparian.

Sand and dust storms
Sand and dust storms are common meteorological hazards in arid and semi-arid regions. They are usually caused by thunderstorms – or strong pressure gradients associated with cyclones – which increase wind speed over a wide area. These strong winds lift large amounts of sand and dust from bare, dry soils into the atmosphere, transporting them hundreds to thousands of kilometres away. Some 40% of aerosols in the troposphere (the lowest layer of Earth's atmosphere) are dust particles from wind erosion. The main sources of these mineral dusts are the arid regions of Northern Africa, the Arabian Peninsula, Central Asia and China. Comparatively, Australia, America and South Africa make minor, but still important, contributions. Global estimates of dust emissions, mainly derived from simulation models, vary between one and three Gigatons per year.

Scale
The spatial, temporal (quantitative or analytical) dimension used to measure and study any phenomena. Specific points on a scale can thus be considered levels (such as local, regional, national and international).

Scenario
A description of how the future may unfold based on if-then propositions, typically consisting of a representation of an initial situation, a description of the key drivers and changes that lead to a particular future state. For example, "given that we are on holiday at the coast, if it is 30°C tomorrow, we will go to the beach".

Security
Relates to personal and environmental security. It includes access to natural and other resources, and freedom from violence, crime and war, as well as security from natural and human-caused disasters.

Sediment
Solid material that originates mostly from disintegrated rocks and is transported by, suspended in or deposited from water, wind, ice and other organic agents.

Sedimentation
Strictly, the act or process of depositing sediment from suspension in water or ice. Broadly, all the processes whereby particles of rock material are accumulated to form sedimentary deposits. Sedimentation, as commonly used, involves transport by water, wind, ice and organic agents.

Sensitivity
Measures the magnitude and rate of response in proportion to the magnitude and rate of climate change.; The degree to which an agroecological or socio-economic system responds, both positively and negatively, to a given change.

Sewage
Liquid waste matter, usually containing human excrement.

Sink
Any process, activity or mechanism which removes a greenhouse gas, an aerosol, or a precursor of a greenhouse gas from the atmosphere.

Smart Cities
A smart city is a designation given to a city that incorporates information and communication technologies (ICT) to enhance the quality and performance of urban services such as energy, transportation and utilities in order to reduce resource consumption, wastage and overall costs. The overarching aim of a smart city is to enhance the quality of living for its citizens through smart technology.

Social distancing
Also called 'physical distancing', means keeping six feet (two meters) of space between yourself and other people outside of your home, not gathering in groups, staying out of crowded places and avoiding mass gatherings.

Social network
A social structure made up of a set of actors, such as individuals or organizations, and the ties between these actors, such as relationships, connections or interactions.

Socioeconomic
Of, relating to, or involving a combination of social and economic factors.

Soil
The upper layer of the Earth's crust transformed by weathering and physical/chemical and biological processes. It is composed of mineral particles, organic matter, water, air and living organisms organized in genetic soil horizons.

Soil health
The capacity of soil to function as a living system.; The continued capacity of soil to function as a vital living system, within ecosystem and land-use boundaries, to sustain biological productivity, promote the quality of air and water environments, and maintain plant, animal, and human health.

Soil pollution
It refers to the presence of a chemical or substance out of place and/or present at higher than normal concentration that has adverse effects on non-target organisms.

Soil sealing
It refers to the permanent covering of the soil surface with impermeable artificial materials such as asphalt and concrete.

Source
Any process, activity or mechanism that releases a greenhouse gas, an aerosol or a precursor of a greenhouse gas or aerosol into the atmosphere.

Spatial planning
Spatial planning is a process that should consider the social, economic, environmental and governance objectives of sustainable development, in order to aim at an integrated management of land, water and living resources for the development of aquaculture and expansion of the sector in a sustainable and equitable way, including mitigation measures for changing climatic conditions.

Species diversity
Biodiversity at the species level, often combining aspects of species richness, their relative abundance and their dissimilarity.

Species richness
The number of species within a given sample, community or area.

Surface water
All water naturally open to the atmosphere, including rivers, lakes, reservoirs, streams, impoundments, seas and estuaries. The term also covers springs, wells or other collectors of water that are directly influenced by surface waters.

Sustainability
A characteristic or state whereby the needs of the present population can be met without compromising the ability of future generations or populations in other locations to meet their needs.

Sustainable development
Development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs.

Synergies
These arise when two or more processes, organizations, substances or other agents interact in such a way that the outcome is greater than the sum of their separate effects.

Technology
Physical artefacts or the bodies of knowledge of which they are an expression. Examples are water extraction structures, such as tube wells, renewable energy technologies and traditional knowledge. Technology and institutions are related. Any technology has a set of practices, rules and regulations surrounding its use, access, distribution and management.

Telecoupling
Socioeconomic and environmental interactions between distant coupled human and natural systems and has become more extensive and intensive in the globalized era.

Threshold
The level of magnitude of a system process at which sudden or rapid change occurs. A point or level at which new properties emerge in an ecological, economic or other

system, invalidating predictions based on mathematical relationships that apply at lower levels.

Tipping Point
The critical point in an evolving situation that leads to a new and sometimes irreversible development.

Top-down
Used to refer to a situation in which decisions are made by a few people in authority rather than by the people who are affected by the decisions.

Transformation
State of being transformed. In the context of GEO-5, transformation refers to a series of actions that explores opportunities to stop doing the things that pull the Earth System in the wrong direction and at the same time provide resources, capacity and an enabling environment for all that is consistent with the sustainable-world vision.

Transformational change
The process whereby positive development results are achieved and sustained over time by institutionalizing policies, programmes and projects within national strategies. It should be noted that this embodies the concept of institutionally sustained results – consistency of achievement over time. This is in order to exclude short-term, transitory impact.

Transitions
Non-linear, systematic and fundamental changes of the composition and functioning of a societal system with changes in structures, cultures and practices.

Trillion
10^{12} (1,000,000,000,000).

Uncertainty
A cognitive state of incomplete knowledge that can result from a lack of information or from disagreement about what is known or even knowable. It may have many types of sources, from imprecision in the data to ambiguously defined concepts or terminology, or uncertain projections of human behaviour. Uncertainty can therefore be represented by quantitative measures (for example a probability density function) or by qualitative statements (for example reflecting the judgement of a team of experts).

Urban agriculture
It consists of small areas within cities, such as vacant lots, verges, shipping containers and balconies, that are used for growing crops and raising small livestock or milk cows for own consumption or sale in neighbourhood markets.

Urban forest
A description of towns and cities which are the source of wastepaper as one of the raw materials used for paper making.

Urban heat island
An area within an urban area characterized by ambient temperatures higher than those of the surrounding area because of the absorption of solar energy by materials like asphalt.

Urban metabolism
A model to facilitate the description and analysis of the flows of the materials and energy within cities, such as undertaken in a material flow analysis of a city. It provides researchers with a metaphorical framework to study the interactions of natural and human systems in specific regions.

Urban sprawl
The decentralization of the urban core through the unlimited outward extension of dispersed development beyond the urban fringe, where low density residential and commercial development exacerbates fragmentation of powers over land use.

Urbanism
An integration of urban and rural development in terms of sustainable resource use and the convergence of human well-being.

Urbanization
An increase in the proportion of the population living in urban areas.

Vector
An organism or vehicle that transmits the causative agent or disease-causing organism from the reservoir to the host. Often thought of as a biting insect or tick but can be an animal or inanimate object. Many living vectors are bloodsucking insects and ticks, which ingest disease producing microorganisms during a blood meal from an infected host (human or animal).

Virus
An infectious agent of small size and simple composition that can multiply only in living cells of animals, plants or bacteria. The name is from a Latin word meaning "slimy liquid" or "poison."

Vulnerability
An intrinsic feature of people at risk. It is a function of exposure, sensitivity to impacts of the specific unit exposed (such as a watershed, island, household, village, city or country), and the ability or inability to cope or adapt. It is multi-dimensional, multi-disciplinary, multi-sectoral and dynamic. The exposure is to hazards such as drought, conflict or extreme price fluctuations, and also to underlying socio-economic, institutional and environmental conditions.

Wastewater treatment
Any of the mechanical, biological or chemical processes used to modify the quality of wastewater in order to reduce pollution levels.

Water footprint
The water footprint of a person, company or nation is defined as the total volume of freshwater that is used to produce the commodities, goods and services consumed by the person, company or nation.; The total volume of

freshwater used in the operations of an FVC, from the delivery of inputs at the production stage to consumption in end markets.

Water quality
The chemical, physical and biological characteristics of water, usually in respect to its suitability for a particular purpose.

Water scarcity
Occurs when annual water supplies drop below 1 000 m3 per person, or when more than 40 percent of available water is used.

Water security
A term that broadly refers to the sustainable use and protection of water systems, the protection against water related hazards (floods and droughts), the sustainable development of water resources and the safeguarding of (access to) water functions and services for humans and the environment.

Water stress
Occurs when low water supplies limit food production and economic development and affect human health. An area is experiencing water stress when annual water supplies drop below 1 700 m^3 per person.

Water supply
The amount of water which is available or made available for use.

Wetland
Area of marsh, fen, peatland, bog or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water to a depth, at low tide, that does not exceed 6 metres.

Wildlife
Wild animals collectively; the native fauna (and sometimes flora) of a region.

Zika virus
A mosquito-borne flavivirus first identified in Uganda in 1947 in monkeys. Zika virus disease is caused by a virus transmitted primarily by Aedes mosquitoes, which bite during the day. Most people infected with the Zika virus do not develop symptoms, and those that do suffer mild symptoms (fever, rash, conjunctivitis, muscle and joint pain, malaise or headache) for 2–7 days. Zika virus infection during pregnancy can cause infants to be born with microcephaly and other congenital malformations, known as congenital Zika syndrome, and is associated with other complications of pregnancy, including preterm birth and miscarriage. Outbreaks of Zika virus disease have been reported in Africa, Asia and the Americas.

Zoonoses
Diseases that can spread between animals and people, moving from wild and domesticated animals to humans and from humans to animals. Every year, nearly 60,000 people die from rabies, and other zoonotic diseases such as avian influenza, Ebola and Rift Valley fever constitute additional threats. These diseases affect not only human health but also animal health and welfare by causing lowered productivity (e.g. in terms of milk or egg quality and safety) or death, with significant harm to farmer livelihoods and national economies. The current COVID-19 pandemic is a zoonotic disease.

"As the voices for human settlements and the environment within the UN system, we are extremely pleased to present a detailed roadmap for decision makers. It is based on the best science we have today and compiled by world-renowned cities experts. We hope this report will give practical guidance adding to the extensive work by other groups to propel cities towards a new environmentally sustainable and just future."

Inger Anderson, Executive Director of United Nations Environment Programme
Maimunah Mohd Sharif, Executive Director of Human Settlements Programme

GEO for Cities aims to inform, engage and support dialogue among city decision makers and other actors involved in urban issues. The GEO-6 report, published in 2019, identified urbanization as one of five main drivers of environmental change and also looked at the impact on cities and city residents of related challenges such as climate change, biodiversity loss and pollution. The GEO for Cities looks at these issues, but also presents the types of solutions that can lead to environmentally sustainable and just cities.

The GEO for Cities process is led by two co-chairs, guided by an Advisory Committee of organizations focused on urban and environment solutions (ICLEI, C40, Cities Alliance, IIED, ODI, IIHS, GCSE), has been drafted by around 20 expert authors and supported by the GEO Secretariat.

The environmental and urban challenges outlined in this report require urgent and sustained attention from everyone involved in building or managing cities. To achieve Sustainable Development Goal (SDG) 11, we must make cities and human settlements inclusive, safe, resilient and environmentally sustainable. UNEP, UN-Habitat, the GEO for Cities Advisory Committee, its co-chairs and the expert authors hope that this report will lead to the urgent action needed for cities to become the beacons of environmental excellence that help their citizens lead productive, prosperous and equitable lives. Enjoy and take action!

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