GEO FOR CITIES

Healthy Cities, Healthy People

(Working Title)

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UN HABITAT FOR A BETTER URBAN FUTURE

GEO 6 GLOBAL ENVIRONMENT OUTLOOK

HEALTHY PLANET HEALTHY PEOPLE

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1 Why GEO for Cities, Why Now?

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Welcome to the second edition of the Global Environment Outlook (GEO) for Cities! We are very pleased to share this analysis of urban and environmental trends with innovative visions and pathways for an environmentally sustainable future led by cities large and small from around the globe. With the world still suffering from the COVID-19 pandemic and many of the world's biggest and most vibrant cities affected by this terrible virus, the need for transformational action for a healthy planet, healthy people and healthy cities has never been more critical. COVID-19 sends us an important message, that a healthy planet is essential for us to maintain our own health. It's time to take stock of our relationship with nature now and how we can build back better and greener so that nature is central to 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 this publication and how it relates to our own experiences in Africa and North America. We envision this document as one that mayors, from both large and small cities, can refer to in order to redesign their cities to be positive for nature and healthy spaces for humans. We also want this publication to guide public and private sector urban experts so that cities can contribute positively to a world with increased biodiversity, a stable climate and the near-zero waste economies of the future.

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

Maria-Helena Jose Correia Langa: Thank you David. The Municipality of Mandlakazi Village is a vibrant and green city located in Gaza Province, occupying an area of about 93.4 km2 and with a population of about 51,000 people living in a mixture of urban and peri-urban areas. With only about 20 km out of a total of 240km of open roads being paved, road access in peri-urban neighborhoods is difficult, leading to a reduction in the quality of services provided for residents of the municipality.

The issues in Mandlakazi are reflective of the entire country of Mozambique as it is undergoing a process of urbanization. By 2025, it is projected that Mozambique will be the fourth most urbanized country in the Sub-Saharan Africa region, having a higher concentration of population

in urban areas. In addition, roughly 75% of the population (INE 2017) is employed in the informal sector, where they lack job security and labour rights. Currently there is a significant lack of infrastructure, equipment and services throughout Mozambique, with 42% of urban households devoid of a water source inside their compounds, 13% without a latrine or toilet, 39% using shared improved sanitary facilities and 28% lacking mains electric supply or connection to the home.

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

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

However, in spite of its larger population and size, Toronto faces high urban density, concentrated property, and ageing infrastructure, increasing the city's vulnerability to climate hazards that have impacted the city over the last decade. Moreover, Toronto is situated on the banks of one of the Great Lakes, Lake Ontario, which makes the city particularly susceptible to episodes of flooding and extreme weather. For instance, the city witnessed major city-wide flooding in July 2013, an extreme ice storm in December 2013, the flooding of the Toronto islands in Spring 2017, and a significant heatwave in late Summer 2017. The risk for Toronto is that these climate hazards are becoming more variable, frequent, and intense, and leading to Toronto experiencing "hotter, wetter, and wilder" weather.

This phenomenon is also typical of other North American cities more generally. As a result of global warming, North American cities are also likely to experience more coastal flooding, droughts, intense heat waves, increased rainfall intensity, and higher storm surge levels and hurricane wind speeds.

And as in every city in North America, certain groups in Toronto, referred to as climate vulnerable populations,[1] run the risk of being disproportionately affected by climate hazards due in part to increasing income inequality. Although Toronto is prosperous and growing, the city is also economically divided, as higher-income neighbourhoods are better served with more access to essential housing, transit, and public services, leading to less poverty and higher health outcomes for residents. In addition to undergoing a process of urbanization, both within Mandlakazi and

[1] https://www.toronto.ca/wp-content/uploads/2019/05/8ecc-CRF_Final_v3_AODA.pdf p.52

across Mozambique, what are some of the particular challenges Maria-Helena, especially related to the environment and the climate emergency, confronting Mandlakazi?

Particular challenges, especially related to climate emergency and environment

Maria-Helena: The biggest challenges holding the city of Mandlakazi back are budgetary capacity, poverty, infrastructure conditions, poor housing, and weak solid waste management. The city, just like many small and intermediate Mozambican cities, has a weak coherent governance system, including issues with transparency and accountability.

Due to its geographic location, Mozambique is highly exposed to natural hazards and climate change impacts such as floods, cyclones, sea level rise, etc. Changing rainfall patterns are projected to result in a reduction of Mozambique's river flows, which will lead to a decrease in the availability of surface water and soil water recharge, impacting ground water resources and the water table in wells.

With the anticipated growth of the city population, Mandlakazi will continue to face a myriad of climate related challenges in the coming decades, some of which will undermine its ability to address the impacts related to climate change and the rapid urbanization. The challenge for Mandlakazi will be to work with different stakeholders to establish public and public–private partnerships that will secure long-run investments with strong returns and public benefits, such as land tenure security, resilient social and critical infrastructures, improved access to basic services and housing.

Pandemic, COVID-19 and inequality

David: The pandemic has exposed the stark inequality in our cities, and COVID-19 has made visible the deep vulnerabilities and inequities that pervade so many of our cities and our urban ways of life. Across North America, the pervasion of systemic racism, sexism, inequality, and unequal access to basic healthcare are all driven by the same institutional and economic failures. What's more, these drivers of social injustice are the same as those behind pandemics and environmental breakdown. They have underscored the extent to which we are all connected, dependent on each other, and dependent on a safe and healthy planet.

In the post-pandemic era, we must rethink urban design, planning and management and our relationships to urban systems. Stimulus responses to COVID-19 at all levels of governments must be green and just, promote sustainable and resilient urban planning, slum upgrading programs, clean energy, building energy efficiency, as well healthier mobility, including mass transit,

walking and cycling, among others. This of course, can only be attained if we stop investing public money in fossil fuels, and redirect it to green plans and projects.

To achieve the necessary levels of emissions reduction, stimulus funding and investments not only have to be green, but they have to be made available immediately. If we prioritize a green and just recovery that is consistent with limiting global heating to below 1.5°C, we could create 50 million good green jobs by 2025, prevent 270,000 premature deaths due to poor air quality, and save $1.4 billion USD in health costs from reduced hospital admissions for cardiovascular and respiratory diseases in North America. 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.

Maria-Helena: The pandemic has also exposed and exacerbated many disparities and problems in Mandlakazi as well. Informal settlements and poverty in Mozambique are a clear indication of these vulnerabilities and inequities stemming from poor housing, water, sanitation and hygienic conditions and limited access to health services. Consequently, washing hands regularly and observing self-isolation, quarantine, lockdown and social distancing policies in these areas, as per WHO recommendations, is objectively difficult in the current conditions. As the virus continues spreading in Mozambique, we will increasingly see more people suffering from severe health consequences, not just because of limited access to healthcare and basic services (water, sanitation, etc,), but also as a result of them being forced to prioritise their economic needs and concerns over their health. Preparedness and early action by local governments and communities is essential. Once an outbreak occurs, escalation can be rapid, leaving little room for further planning.

With no exception for Mandlakazi, city leaders, particularly in Sub-Saharan Africa, face the challenge of how best to deal with recovery planning and management from COVID-19 alongside the existing pressures of climate change, resource depletion and continued socio-economic inequalities. But we have a lot of positive progress to build from….

Positive examples & progress

Maria-Helena: The City has been promoting participatory governance from a gender perspective, and has created several participation tools to this end, including the Municipal Children's Forum, Municipal Youth Forum, Municipal Women's Forum, and the Municipal Citizen Forum. The city's successful experience in engaging with communities through participatory approaches and gender empowerment is also critical to increased resilience. A systematic linkage of disaster risk reduction (DRR) and climate change adaptation (CCA) has been enhanced by community

engagement in the planning process. This focus on DRR and CCA, as well as empowering women, is one of the biggest goals for the future and achieving sustainable development. What have been some of the efforts in Toronto and other cities on climate change and sustainable development?

David: As Canada's largest city, multicultural and cosmopolitan Toronto has long been at the forefront of environmental protection. During my time as mayor, we set out a comprehensive framework to cut its urban GHG emissions by 30% by 2020 compared to 1990 baseline levels. As a result of a plan introduced in 2007 and the closing of a coal-fired plant by the Ontario government, we've exceeded this target by reducing Toronto's GHG emissions by 33% below 1990 levels. Toronto's City Council, under current Mayor John Tory, declared a climate emergency in 2017 and unanimously endorsed TransformTO. Building on the 2007 foundational plan Change is in the AIR, TransformTO is a blueprint for longer term low-carbon goals, including a 65% reduction of GHG emissions by 2030 and carbon neutrality by 2050 or sooner. The plan is simultaneously designed to grow the city's economy and address the causal links between environmental degradation and growing urban inequality. Mayors are all well aware of their responsibility to protect all residents, especially those living in vulnerable communities and climate risk zones, against climate risks. Working collaboratively through global and regional city networks, such as C40 , the, GCOM, UCLG, ICLEI and Metropolis, among others, and alongside private sector partners, mayors have made great progress in fostering equitable, resilient, and sustainable urban trajectories. Regrettably, one cannot paint the richest and biggest emitters of the G20 and other national governments in such a positive light –as it is often said, while nations merely talk, cities act. Yet, despite their willingness to act and the strong actions they lead, mayors and city governments could do more to achieve their climate ambitions with the active support of national governments and international institutions. This is precisely why cities are calling for greater collaboration with regional and national governments to deliver ambitious and transformative climate action plans.

Looking Forward: The transformative potential, what excites us and this report

The resounding message emanating from climate activists and young people around the world is that now is the time to follow the recommendations of climate experts/scientists and take immediate and decisive action to protect the planet before it is too late. Voters are showing that they agree, as is evidenced by the recent wins of political parties that have placed the climate agenda at the heart of their political platforms.

Capacity issues, diverse cultural contexts, and longstanding injustices that stem from race, gender, and other forms of discrimination cannot be dismissed if environmental initiatives are to

be sustainable and effective. Now is the time for the urban community to come together and collectively assume leadership to facilitate radical and equitable changes in the ways we live, travel, and consume in cities. Given the chance, mayors, residents, and businesses can enact lasting positive change that will benefit everyone and the planet.

Initiatives, such as local Green New Deals in several US cities or the launch of the C40 Mayors' Agenda for a green and just recovery, demonstrate that climate change and inequality are increasingly approached as intertwined challenges, and that a green and just recovery program to address climate change is the new social contract for the 21st century that entrenches a firm commitment to the preservation of the planet and its people.

- What you will find here

GEO for Cities strives to be an extension of the main GEO-6 report, presenting and explaining the findings of UNEP's flagship environmental assessment in a way that helps city decision makers take clear action. This report starts out in Chapter 2 with an examination of how cities function and the challenges and barriers to action that cities face, as well as some opportunities for catalyzing change. Chapter 3 of the report then examines how today's environmental challenges are affecting cities and how cities are contributing to these environmental issues. Chapters 4 examines the types of future cities that will help address the environment, economic and social challenges we currently face. City decision makers may see themselves in these 'realms' and may also see areas where their cities could improve. Finally, chapter 5 explores the pathways that would need to be followed to reach the 'ideal' cities explored in chapter 4.

This report will try to answer the following questions for city decision makers:

What is the scale of the environmental challenge that cities face heading towards 2030 and 2050?

What will the world look like if we remain on the path in which we currently find ourselves?

What should cities aim to change if they are to lead the way in addressing these environmental challenges and how will this make life better for the people that live in cities?

How can cities make these changes real? What tools are at their disposal? Where will they need to seek help in making these changes real and which examples are already out there that they could follow?

The environmental challenges outlined in this report urgently require political attention from the global community. UNEP, UN-Habitat, the Advisory Committee, the co-chairs and the expert authors hope that this report will be a catalyst for action that is needed to move cities to become

the shining beacons of environmental excellence that contribute to productive, prosperous and equitable lives of their citizens. Please enjoy and then take action!

2 Urban Dynamics for Environmental Action

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Key Points (Key Messages to be developed)

2.1 Introduction

Over the last 6,000 years, urban growth and urbanization processes have taken place at an ever-accelerating pace (UN Population Fund 2007; United Nations [UN] 2019). This urbanization has brought about increased quality of life for many . Urban life provides some of its residents with access to better education, housing, services and health care, resulting in longer life expectancy (Vardoulakis and Kinney, 2019). But for others, and arguably an urban majority, urban life is synonymous with the challenges of poverty, congestion, ill health and feelings of isolation or dislocation. The basic services required for dignified human life remain elusive for large swathes of urban populations (Satterthwaite et al 2020). Whereas cities have produced wealth, knowledge and efficiencies, they have also been the harbingers of poverty, inequality, pollution, environmental degradation, resource depletion, as well as biodiversity loss. Urbanization, along with habitat loss, are central drivers of environmental change (UN 2019 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 acts as a precautionary measure - or a sobering pause - in this tale of transformation and transformative pathways towards more equitable and sustainable futures. It sketches out the deep-rooted challenges of inequality, pollution, environmental degradation, resource depletion and biodiversity loss; and notes that these have persisted - indeed, have increased - *despite* global, national and local efforts towards sustainable urban transitions. Rising to the challenge of necessary urban transformations therefore requires as a prior step naming and understanding these persistent challenges. We refer to these as lock-ins; that is complex, structural barriers that are deeply rooted in the political economy and the governance web particular to each city and that, combined, contribute to slowing down the pace of urban transformation.

This reading of the systemic failures to transform (so far) - or at least of the limited nature of change in *most* cities - is nested within a prior investigation of key urbanization trends globally. This investigation forefronts the diversity of cities and urban areas in terms of population, size, urbanization dynamics and relationship to the environment and ecosystems, and the highly contrasted capacity of cities and urban areas to respond to the growing and interconnected challenges of 21st century urbanization. In particular, many of the rapidly urbanizing cities of the global South are poorly equipped to deal with these challenges, whereas they are most affected by deepening inequality and the impacts of climate change and general environmental degradation. Most cities are currently on unsustainable trajectories, contributing to and entrenching multiple dimensions of ecological, social and economic unsustainability - albeit in different ways, with differentiated impact, and in ways that are yet to be fully grasped.

The chapter closes with an exploration of some of the key building blocks of transformative action that have, nonetheless, helped position a growing number of cities as drivers of sustainable, low-carbon, resilient, healthy, and inclusive futures. As this chapter highlights, prefiguring chapter 5, disruption to 'business as usual' occurs at multiple scales, comes from multiple sources/agents, and is often pioneered by singular, even small catalytic actions. However, for the kind of large-scale systemic change that is now also urgently called for and described in chapter 4, local authorities and urban communities will require support and shared risks beyond their boundaries. Setting and maintaining cities on transformative pathways, this chapter argues, will require the reinforcement of networks of learning and support, including from national governments.

2.2 The State of Cities

Describing the current state of cities with regards to environmental action requires highlighting the diversity within and between cities and some of the key linkages between cities and the environment that affect the shared trajectory of urban environmental and socio-economic (un)sustainability. This brief overview rests on an understanding of the relationship between cities and the environment as bi-directional: cities, their people, and their infrastructures are affecting natural environments within, around and across their boundaries; at the same time, cities are vulnerable to environmental change. As chapter 3 will detail this across several dimensions - air, biodiversity, freshwater, oceans and coasts, and land – this chapter focuses on the people, built environment and governance of urban areas and the potential for a more positive relationship among these. Increasing inter and intra urban inequality, within a growing and uncurtailed consumer- and commodity-based global economy, is currently shaping cities and the environment .

2.2.1 Rapid But Varied Urban Growth

Between 1975 and 2015, the global rural population increased by 488 million people, while the global urban population grew by almost 2.9 billion people, increasing the share of the global urban population from 47% to 52% (Pesaresi et al. 2016, p. 49). By 2050, the share of the global urban population is forecasted to reach nearly 70% (United Nations [UN] 2019a). The staggering pace of global urban population growth over the last decades is well rehearsed by now; however, there are marked variations within these broad trends. Going forward, 90% of urban growth is expected to take place in low-income and middle-income countries, (UN Environment [UNEP] 2019a). with, more than half of the growth, approximately two billion people is expected to take place in Africa, Asia is expected to grow by 650 million people and Latin America by 180 million; Europe's population, on the other hand, is expected to decrease during this time time period of 2019-2050 (UN 2019b).

The geographic shift in this "second wave of urbanisation" (UNFPA, 2007) arguably puts cities of Asia and Africa at the heart of the sustainability agenda in the coming decades (Simone and Pieterse, 2017). Given the infrastructure deficits and limited fiscal base of local authorities in many of these settings, rapid urbanisation is likely to exacerbate conditions of 'slum urbanism' as city governments and housing markets are unable to keep pace with rapid growth trajectories (ibid; Pieterse 2014). In cities where urban growth far outpaces economic growth, governments and other urban stakeholders have difficulty responding to socio-economic stress, let alone multiple environmental crises.

Urbanisation trends also point to the growing significance of medium-sized cities and peri-urban areas. Whilst much of urban imagination is connected to megacities, small and medium cities are in fact growing at the highest rates (see Figure 2.1); albeit with differences per region (see Figure 2.2). By 2025, small and medium cities will outpace growth rates in the developed world and emerging market mega-cities combined (McKinsey Global Institute 2011, p. 4). These cities bridge the gap between rural populations and urban centres, and importantly act as a stepping stone in rural-to-urban migration in rapidly urbanising contexts (UN Human Settlements Programme [UN Habitat] 2015a, p. 3). Yet small and medium cities tend also to be more vulnerable to natural hazards and climate change than big cities and megacities (Birkmann et al. 2016). They also tend to have greater recovery capacity deficits (UNEP 2019a).

City size however does not begin to capture the diversity of urban forms, nor the processes by which they grow - or shrink. For instance, the growth of sprawling suburban and peri-urban regions - a significant trend for several decades in both higher- and lower-income countries (UN Habitat

Figure 2.1 City growth rates (UNEP 2019a, p. 32)

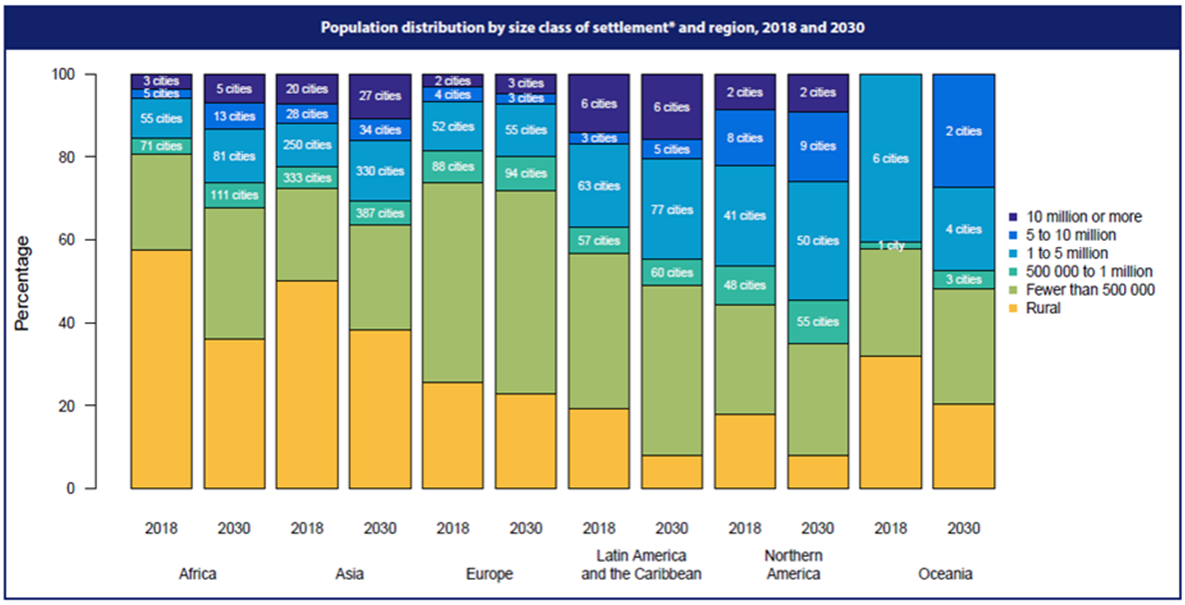


Figure 2.2 Population distribution by size and class of settlement and region, 2018 and 2030. Source: The World´s cities in 2018

2016, p. 37) - can be linked to multiple processes, including evolving rural-urban linkages, land markets, an absence of a regulatory environment for development, or lifestyle preferences. Such factors are locally specific and connected both to long-term urban growth trajectories and more contingent dynamics.

Such trends further entrench a rift between the variety of urban forms globally and ongoing visions or plans tied to dense, built-up urban settlements. In 75% of countries, both the urban population and the urban built environment have grown, but in other countries population growth and built environment growth are decoupled (Pesaresi et al. 2016). In regions such as Europe, built-up area doubled whilst the population remained stable (Ibid., p. 6). In 2015, 65% of global built-up areas were concentrated in high income countries, around 30% were in middle income countries, and just 6% were in low income countries (Ibid., p 35), contrasting with urban population spread. Meanwhile, with the rise of high-rises in the peripheries of cities in China, India, Turkey and Brazil, suburbanization can no longer be characterized by low density, and the spatial configurations and lifestyles of suburbs are developing without corresponding city centers (Keil 2018).

The COVID-19 pandemic is likely to influence these processes – although in ways yet to be understood. While it may lead to slower rates of urbanization, COVID-19 may accelerate the expansion of suburban and peri-urban patterns of urbanization, as remote working makes residential settlements more independent from workplaces in urban cores.

2.2.2 Growing Inequality and Implications for the Environment

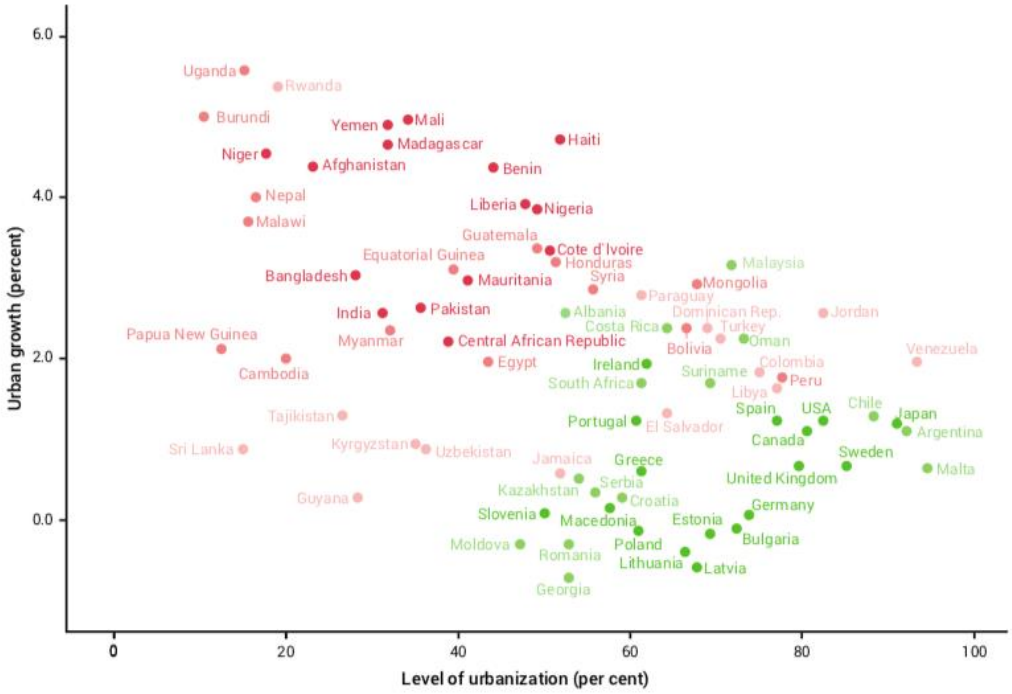
While it is impossible to capture a single urban growth trajectory nor a dominant urbanisation pattern, there is an emerging pattern of growing inequality, both within and between cities. The Covid-19 pandemic has exposed vividly these inequalities in many places.. Two thirds of urban dwellers live in cities where income inequalities increased between 1980 and 2010 (UN Habitat 2014a, p. 9). This inequality is a key concern of the global SDGs (UN 2020) and the New Urban Agenda (UN 2017). Unprecedented wealth accumulation, has resulted in divided cities (Graham and Marvin 2001; International Resource Panel [IRP] 2018, p 178), and if current inequality trends continue, the top 0.1 percent of the population will own more wealth than the global middle class by 2050 (Alvaredo et al. 2017, p. 198). The urban divide is even starker, as cities have greater economic inequalities than countries overall (UN Habitat 2015b, p. 1). However, urban inequality operates through multiple and intersecting dimensions such as race, class, gender, ethnicity, caste; and is reflected in highly unequal access to opportunities such as education and jobs, as well as material goods including housing, services and infrastructure. These inequalities result in bifurcated spatial configurations in many cities and urban areas, which have been deepening (Graham and Marvin, 2001).

This growing inequality contributes to environmental unsustainability within cities and beyond, and also shapes the potential for environmentally sustainable responses to urbanization (See also Chapter 3). Cities, for instance, account for 70% of GHG emissions globally and this is expected to grow in the midst of continued urbanization and mass migration (Intergovernmental Panel on Climate Change [IPCC] 2014). Meanwhile, 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 fueled by heightened inequality" (UNEP 2019a, p. 27). Inequality within and between cities remains one of the highest barriers to achieving environmental sustainability (Chancel and Piketty 2015; Oxfam 2015 in UNEP 2019a).

The impact of inter and intra-urban inequality is exacerbated in regions that are at high risk of climate change impacts, such as rising sea levels, flooding and droughts. Such risks, and cities' ability to mitigate them are not equally shared. Many growing cities, home to the fastest growing population, are located at or below sea level, such as Lagos and Dhaka where half a million people live below sea level (Pesaresi et al. 2016, p. 65). Here, changes in urban population interact with climate change to the detriment of urban inhabitants. In contrast, coastal New York City is able to finance a seawall protecting affluent Manhattan. The contrasting picture speaks to a broader trend whereby Global North cities bear most responsibility in exacerbating climate change and

biodiversity loss (through historical and ongoing energy use and consumption patterns) and yet are best able to buffer themselves from some of the consequences. Meanwhile, Global South cities, in their diversity, are bearing the brunt of climate change impact with disproportionately lesser resources to adapt and transform (African Development Bank [ADB] 2019; IPCC, 2018; UNEP, 2019) (see Figure 2.3).

Equally, the burden of adapting to rising sea levels is unequally shared 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 for financing adaptation to a changing climate. Poorer communities, on the other hand, are disproportionately vulnerable to and affected by sea level rises - just like other climate-related risks such as flooding and drought (Satterthwaite et al, 2020). In some places, such as rural-coastal Bangladesh, climate impacts are being used as an excuse to remove farmers from their land for resettlement into unequal urban regions in the name of adaptation instead of exploring options that preserve agrarian livelihoods and cultures, and consequently (Paprocki 2019).



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: Garschagen et al. (2014)

Figure 2.3 Where rapid growth faces vulnerability (UNEP 2019a, p. 34)

In addition to affecting cities' and households' ability to adapt to a changing climate, urban inequality is becoming further entrenched by climate change mitigation activities both in urban cores and peri-urban areas in some countries. Resource efficient urbanism, for example, has come at the expense of social inclusion. Emerging 'green enclaves' such as Masdar in Abu Dhabi and upmarket green suburban estates promote low-carbon urban living for an exclusive and affluent few urban dwellers (IRP 2018, p. 31). Equally, terms such as "green gentrification" describe the growing phenomenon by which energy efficient developments are contributing to the displacement of low-income - and often racialized - communities (Checker 2011): when local air quality battles are won and energy efficient housing is installed, real estate prices go up and the urban wealth divisions become exacerbated. Sprawling, and fast growing peri-urban areas are often used as a blank slate to experiment with sustainable interventions, such as ecosystem service schemes, and reinforce existing socio-environmental inequalities (Allen 2004).

Ironically, individualized pro-environmental behaviors and building design give the illusion that affluent lifestyles have low environmental impacts. And yet, as environment and climate justice movements have highlighted, affluent countries and urban dwellers contribute the most to the climate crisis (Kartha et al. 2020). For example, Manhattan is often heralded for being sustainable because of its high density (Owen 2004), but when emissions from Manhattanites' travel and consumption patterns are taken into account, the per capita climate impact of New York's densest borough far outpaces its sprawling suburbs and less affluent areas of the city (Cohen 2016). In Germany, household income is a better predictor of carbon footprints than are environmental awareness and behaviors (Moser and Kleinhückelkotten 2018). In light of such findings, organized groups, activists and academics alike are calling for the integration of housing justice and global rights agenda into urban climate action plans (Rice et al. 2019)[include references to Global Platform for the Right to the City, Habitat International Coalition and the UN Special Rapporteur on Housing].

When inequality and climate change are inextricably linked, their solutions must be as well. These patterns also highlight the importance of coordinated local, state, and national policies that can address structural drivers of GHG emissions.

There are two detrimental effects against sustainability that are produced directly by heightened inequality:

1. because of the highly uneven distribution of resources, the level of growth required to lift people out of poverty is far larger than it would be in a more egalitarian distribution (Ravallion 2001; Bourguignon 2002; World Bank Group 2004). Put another way, the world would not have to grow at very high rates to improve the lives of those worse off if the distribution of those gains was more equally distributed.

2. high inequality is associated with a preference for overconsumption of private and positional goods, weakening public and merit goods (López and Palacios 2014; Samaniego et al. 2014).

Addressing urban inequalities will allow cities and urban growth to be a key source of environmental solutions. While business as usual urbanization disconnects ecosystems functions and structure, (IRP 2018) equitable cities have the potential to provide access to education, income, information, healthcare, and culture, all of which can be supportive of sustainability (Ibid.). Equitable, sustainable cities can generate resource efficiencies and biodiversity protection due to the concentration of population, economic potential. Yet, we continue to build and govern cities in ways that perpetuate inequalities and without due consideration for the impact they have on finite planetary resources and the healthy ecosystems upon which they depend (IRP 2018). In the following section we examine the forces that lock cities into unsustainable and unequal urbanization trajectories.

2.3 Unpacking city 'lock-ins'

Despite increasing scientific evidence on the costs of inaction (IPCC 2014; UNEP 2018; ADB Group et al 2019), the majority of cities and urban areas appear stuck on unsustainable 'business as usual' trajectories characterized by interconnected and deepening environmental and social crises. Cognizant of the difficulties involved in steering cities on net-zero, resilient, inclusive and just trajectories outlined in Chapter 4, this section analyses some of the key processes that are contributing to the slow pace of change or to worsening scenarios. Specifically, it focuses on three overlapping layers: the structural drivers or political economy of cities; urban planning; and the multiple governance webs within which cities operate .

2.3.1 The political economy of cities

Underpinning 'business as usual' trajectories are a series of structural drivers that act to lock cities and urban areas into unsustainable urban trajectories. These 'lock-in' processes can be broadly characterised into economic structural drivers on the one hand and, on the other,

entrenched systems of power. These cut across gender, race, ethnicity, age, sexuality, migrant status and, in each city and in different ways, intersect with class and caste interests to reproduce inequalities (Levy et al. 2017). As is described below, both dimensions work together to perpetuate urban systems that, within and across cities, entrench unjust distributions of the benefits and burdens of environmental impacts, while deepening extractive urban development trajectories (Agyeman et al, 2003).

Whilst it is difficult to generalize processes at play, the majority of cities and urban areas remain locked into development pathways based on productivist development models, with little consideration given to natural resource constraints or environmental and biodiversity protection (UNEP 2019). Whether dominated by the service sector, by manufacturing, or enmeshed in the management of raw material extraction, these models are reliant on boosting local and international production and consumption of individual and collective goods - a far cry from the restorative and carbon-zero aspirations described in chapter 4. Importantly, this trend speaks as much to informal economic processes as it does to the 'recorded' or formal economy, thereby speaking to the broad economic base that underpins most cities. This is, in part, due to the workings of international value chains that tie much of urban and peri-urban based informal economic processes to global productivist/extractive models (Chen & Carré 2020). Examples here include 'just in time' economic processes linking home-based textile workers in Rio de Janeiro's informal neighborhood of Rocinha (Brazil) with luxury clothing brands, or informal mining practices in Kolwezi's peri-urban periphery (Democratic Republic of Congo), integral to the functioning of tech giants such as Apple, Dell, Microsoft or Tesla (Kelly 2019).

Of course, and as is described below, city actors are not solely responsible for entrenching unsustainable economic models. Indeed, the transformation aspirations of actors at the city scale are more often than not thwarted by the enduring power, at national and international levels, of Gross Domestic Product (GDP) as marker of 'success' (Shehabi 2020) and by the extractive logics of global trade, anchored in conceptions of limitless growth and shareholder profits imperatives (Kavanah and Veldman 2020). However, many cities and city-based actors are active participants in such processes, proactively playing the global economy competition game, and adopting or maintaining resource-intensive entrepreneurial and (real estate) developer approaches (Shatkin 2017; Shin et al. 2016). All of this, despite long-standing evidence on the environmental costs of these approaches (Revi et al. 2014, UNEP 2014) and their impact on deepening socio, infrastructural and spatial divides within urban fabrics (Sassen 1991; Graham and Marvin 2001).

Structural drivers that drive unsustainable urbanization also affect those numerous cities that are delinked from prominent global economic circuits. Cities bypassed by the evolving needs of the

520 global economy, such as rust-belt cities of Europe and North America, or small and intermediary
521 cities in many parts of Latin America, Africa, the Middle East and Asia, or cities purposefully
522 excluded for geopolitical rationales (e.g. Havana). For those cities and urban areas figuring on the
523 margins of (in)formal global economic networks, major barriers to activating just transformation
524 often lie in their weak economic (and tax) base, as well as limited capacity required for addressing
525 deep inequalities, chronic poverty and inadequate infrastructure. In such contexts, broadening
526 the base of the economy, whilst simultaneously rebuilding vulnerable ecosystem services and
527 natural resources and habitats is a major challenge (Swilling and Annecke 2012; Pieterse 2011).

528 Adding to, and deeply entangled with unsustainable economic structural drivers, are entrenched
529 power relations related to intersecting social identities (e.g. gender, race, caste, migrant status,
530 and other markers of socio-economic difference) that vary by local context but tend to reinforce
531 inequalities in cities. These power structures are often the product of long-standing historical
532 processes and yet continue to shape urban dwellers' access to, and control over, resources -
533 material (such as land, housing) as well as intangible (such as opportunities or education).
534 Importantly, such power structures also play a key role in determining urban dwellers' ability to
535 participate in and influence key decision-making processes pertaining to the (re)distribution of
536 goods, services and opportunities (Agyeman et al. 2003; Swilling and Annecke 2012; Levy et al.
537 2018). It is this latter aspect, specifically, that shapes the contours and possibilities for change -
538 and acts as a major lock-in to status quo scenarios.

539 Just as other infectious diseases before it, COVID-19 has shone a vivid light on these deep-seated
540 markers of urban inequality. Ethnic minority groups, indigeneous populations, women, informal
541 workers and dwellers have been hit disproportionately hard by the pandemic and by the set of
542 policy responses adopted at national and city levels (Aldridge et al. 2020; UNDESA 2020; UN
543 Women 2020; WIEGO 2020). Already, commentators are attributing these disproportionate
544 effects to a combination of pre-existing factors. These include services and infrastructure
545 considerations such as poor / haphazard access to basic water and sanitation services, limited
546 access to healthcare services and overcrowding; but also factors related to the type of work that
547 people are engaged with, such as 'essential services', care work and informal work where it is not
548 possible (or has not been made possible) to 'work from home' or in a physically distanced
549 environment with protective gear. Poor diets, health status and exposure to pollution have also
550 been identified as aggravating factors. Such factors are all material manifestations of unequal
551 social relations at the city scale with informal dwellers and workers, etchnic minorities, women,
552 disproportionately affected. Strikingly, these factors are the very same markers of vulnerability
553 to 'every day' and disaster risks, whose extent and ramifications are being amplified by the effects

554 of climate change and biodiversity loss (Bull-Kamanga et al. 2003; Satterthwaite and Bartlett
555 2017; Bahn et al. 2020), as described in chapter 3.

556 The impact of COVID-19 in shaking such entrenched power structures has yet to be seen. In
557 particular, we have yet to witness whether calls to 'build-back-better' will resonate with
558 organised community groups' insistence on 'build[ing]-back-*fairer*' (Wong and Mannan 2020) - a
559 call, which in many parts of the world, has taken on a racial justice connotation. Entrenched power
560 structures, however, have proven particularly resilient in the past, buttressed by a number of key
561 social reproduction institutions, including education systems. (Social) media and substantial
562 chunks of cultural infrastructures (e.g. much of pop culture, Bolly/Holly/Nolly-wood and
563 Telenovelas) have often proven complicit in sustaining unequal and unsustainable urban systems
564 through the promotion of highly consumerist aspirations and general adherence to the status quo.
565 Meanwhile, most recent populist political movements, globally, appear to be reinforcing long
566 established extractive political imaginaries and everywhere, indigenous populations and
567 ecological protectors are seeing their very existence challenged (Greenfield and Watts 2020). The
568 parallel rise of small but vocal 'radical' movements in favour of climate action – in some cases
569 articulating a link to necessary socio-economic transformation agendas – appear to indicate
570 growing polarization around shared urban futures. It is too early, however, to surmise their long-
571 term impact on shifting the political economy of cities. In the interim, the deep-seated structural
572 forces sketched above manifest in urban practices that tend to perpetuate 'business as usual'
573 scenarios that operate, consciously or unconsciously, in the interests of urban and/or global elites
574 and at the expense of sustainable urban trajectories.

575 ### 2.3.2 Urban planning and its drivers - perpetuating 'business as usual' scenarios

576 When urban planning visions and practices take into account the interconnectedness of cities'
577 built environment, culture, ecosystems and natural habitats, they are critical instruments in
578 managing deep-seated social and environmental challenges of urbanization (Chimhowu et al.
579 2019, UN Economic and Social Commission for Asia and the Pacific [UNESCAP] and UN Habitat
580 2019). Urban planning has a role to play in addressing the complex challenges of meeting the
581 basic needs of vulnerable urban communities, meeting aspirational demands in a competitive
582 market, and responding to multiple and intersecting environmental crises. In practice, planning
583 priorities are ridden with complex and conflicting trade-offs, which act as barriers to their
584 transformative potential. This section unpacks what has restricted the transformative potential
585 of urban planning, and instead appropriated planning visions and practices to further
586 unsustainable and unjust outcomes.

2.3.2.1 Urban planning visions

Urban planning is at once a discursive and a practice field. Moving cities towards resilient, socially just, zero carbon and nature positive trajectories relies, in part, on visions of urban futures that put environmental and socio-economic sustainability at their core. Yet, the process that enables the shift from a majority of urban planning visions to those outlined in Chapter 4, remains elusive. As is described below, 'business as usual' visions can be amended to include sustainable principles, but this partial adoption is insufficient as deep-seated political economy lock-ins and the power structures that underpin them, tend to restrict any long-term and significant transformative action in cities.

Most cities of the 21st century are being produced and reproduced through urban visions that center competitiveness, growth, and order, as key aspirations with only shallow reference to sustainability and equity considerations. G*lobal city* and '*world-class*' imaginaries continue to be attractive drivers for many cities worldwide, buoyed by international rankings and the skylines of Dubai and Singapore as aesthetic emulation (Roy and Ong 2011, Watson 2014). Such visions often follow outdated urban planning traditions and principles of orderliness, rationality and control (Diez Medina and Monclus 2018), which remain powerful drivers for many cities worldwide - from Naya Raipur in India to Enugu in Nigeria (Ghertner 2015; Walker et al 2017). Visions of modernity are bolstered by urban planning curricula that have largely failed to incorporate current realities and citizen priorities, and instead continue to uphold tools and ideals that center the experiences of certain 'successful' cities in the global North (Porter 2010, Huxley 2016, Sudaresan 2019). Embedded in political projects (Schatz 2010), such urban planning visions are regularly invoked to favor dominant racial, cultural, or religious identities in the public realm - especially in ethnically divided or post-war cities as 'ethnocratic regimes' (Yiftachel 2004) - under the guise of 'public interest' planning.

In many cases, environmental concerns have been folded into such dominant planning visions, but with notions of '*green urbanism'* continuing to promote world-class aesthetics and consumption cultures, by using low-carbon and 'smart' technologies and building solutions. Where successful, these result in promoting walkable, mixed-use neighborhoods, compact and high-density, transit-oriented developments and close-knit communities, for example with big - data assisted planning and development of large public transportation networks like the Metro line in Singapore or the modernization of bus systems in Asia and Latin America (Hidalgo et.al. 2010) that have led to a shift towards low-carbon mobility trends. But green urbanism visions can also be deeply embedded within parochial, cultural and class structures. So when sustainability visions are drawn-up without particular attention to socio-spatial justice

considerations, there is a risk of further deepening the politics of inequality, restricting access to urban commons and urban services for vulnerable communities. Baviskar (2002) writes about urban greening initiatives in upper class neighborhoods of South Delhi, as projects perpetuating a culture of 'bourgeois environmentalism', that restrict the poor from accessing neighborhood parks. Checker (2011) argues, in the context of Harlem in New York City, that the 'seemingly a-political language of sustainability planning' often results in material and technological successes in sustainable development. These tend to underplay equity considerations and result in 'environmental gentrification', pushing low-income communities out of middle to high-income neighborhoods.

Dominant city visions, whether modern, world-class, green or smart, fall short of the kind of transformational visions described in chapter 4. This is largely because while they may pay tribute to resilience and sustainability, their nesting within ongoing growth-oriented and ordering logics tend to perpetuate unsustainable, technocratic and business as usual practices instead of addressing the combined objective of social and environmental justice in cities .

2.3.2.2 Unpacking planning practices

The tools and processes that urban planners use to design, demarcate and develop cities have the potential to shift cities onto just and sustainable trajectories. However, oriented by the political-economic pressures laid out above, they tend to act as barriers to transformation and further deepen city lock-ins. Three areas of practice are particularly worth unpacking as critical for unlocking city potential and catalyse transformative action. These are: the management and expansion of urban land through land use zoning; broadening the scope of infrastructural decisions; and addressing economic development as part of planning practices. In all three areas, planners sometimes entrench unsustainable trajectories because they are upholding current political-economic structures. In other cases private developers capitalize on the absence of planning in rapidly urbanizing peri urban areas that have outpaced their local government capacities, with unfavorable results for the environment (Winarso et al. 2015). The perpetuation of unsustainable planning practices and development driven by non-city actors has led to unequal and splintered urban environments (Graham and Marvin, 2001) that bear a huge cost on the environment.

Urban land management: Land use zoning is the oldest spatial planning tool used by cities to manage the distribution of land and resources, protect natural ecosystems and ensure an improved quality of life for urban residents. Yet zoning regulations, in many contexts, continue to reflect persistent power relations in cities, embedded in deep histories of colonial, racial, ethnic or communally segregated pasts (Porter 2010, Agyeman 2020, Zenou and Boccard 2000). In the

United States, for instance, the systemic underinvestment in particular racialised neighbourhoods is directly related to red-lining instruments put in place since the 1930s (Rothstein 2017). In turn this historical underinvestment correlates today with higher heat exposure in red-lined neighbourhoods (Wilson 2020). Elsewhere, government tactics of 'gray spacing' (Yiftachel 2009) - or the development of spaces of 'in between' legality - illustrate the use of zoning instruments to entrench or expand access to land for dominant groups, often at the expense of marginalised urban dwellers.

Peri-urban areas of growing cities present unique planning challenges globally. Yet as planners attempt to balance growth and environmental protection, land use regulations can rapidly entrench inequalities and lead to 'differential sustainability' (Allen 2014). In these urban 'frontiers', land use regulations are often adjusted to trigger real estate activities that, more often than not, compromise the natural ecosystems that are a source of sustenance for the peri-urban poor. Similarly, urban greening initiatives focused on natural resource conservation tend to rely on land use zoning that confines informal settlements in peri urban areas. Yet, without accompanying land markets (re)regulation or (re)zoning, this equates to further restrictions on city access for the poor, the excluded or new entrants, for whom peri-urban settings often act as steppingstones for accessing urban opportunities (ibid). Exclusionary zoning mechanisms perpetuate poverty cycles, and restrict vulnerable communities from being active agents of 'nature positive' city imaginaries.

Infrastructure decisions that decide which services and resources will be accessed by whom are critical for positioning cities on just transformation pathways (see chapters 4 and 5). Yet, infrastructure planning is influenced by many pressures and inputs, some of which are contradictory. Affordability and risk, distributional considerations, and sustainability imperatives all need to be factored into decisions and many times these end up reproducing top-down and technocratic solutions or solutions that reflect only the aspirations and world views of dominant urban actors. The result is a perpetuation of asymmetrical or splintered urbanism (Graham and Marvin 2001) which, in extreme cases is reflected in enclaves of infinite access and extreme deprivation sharing space in close proximity. This broad statement holds true from basic infrastructure such as water, waste and sanitation (Allen 2006, Bjorkman 2015) to mass-transit networks [refer to figures in section 2.2 for intra -city differences]. Addressing equity with sustainability considerations through infrastructure investment is admittedly an arduous task. Research on the equity and inclusion indicators for Bus-Rapid Transit Systems in cities such as Bogotá, Lima, Mexico City, Ahmedabad, Johannesburg and Istanbul (Venter et al. 2017), concludes that these sustainable mobility alternatives have a huge impact on environmental and economic

(affordability) indicators, but largely fail to improve access in the poorest neighborhoods of these cities. This is despite project proposals including clear pro-poor and inclusionary aspirations. Most failed either on spatial coverage (initial implementation phases did not include poor neighborhoods), or because changes in pricing systems resulted in increased fare for poor customers travelling from far distances to city centers for work (Ibid.).

In addition to the environment justice and inequality concerns embedded in the provision of basic infrastructure, climate-related infrastructure in particular can act as a barrier to just transformation. In most global South cities, poor communities often live in flood and hazard prone areas of cities (Mitlin and Satterthwaite 2013, p. 141): along water canals and rivers, or marshlands and coasts. In the context of disaster risk reduction, when increasing climate uncertainty and frequency of extreme weather events is gaining political attention, cities like Manila, Philippines, are using disaster risk mitigation measures as a means to propagate slum evictions (Alvarez & Cardenas 2019). Increased political attention on climate change resilience, especially in flood-prone cities, has led cities to adopt mega-infrastructure solutions: like sea walls, dykes and levees; instead of nature-based solutions (Jongman 2018). These mega-infrastructure projects are cost intensive, and often negatively impact the relationship vulnerable communities have with their city and its ecology, like fishing communities of Southern India. A surge in the number of breakwaters and seawalls built along almost 60% of the coast of Kerala, in South India, have increased the risk of sea erosion in villages along the northern coast and reshaped their relationship with the sea as long beach stretches are replaced by seawalls or boulders and tetrapods (Abraham 2018). There is a need to broaden the scope and visions associated with infrastructure decisions - currently dominated by grey infrastructure projects - by including blue-green systems as 'hybrid solutions' for risk mitigation and adaptation (Alves et al. 2020), based on ecologically and socially restorative approaches (further discussed in Chapters 4 & 5). Some cities in Latin America and the Carribean are deploying nature-based solutions as part of their road design and development process to counter dependencies and impacts on associated ecosystems (Mandle et al. 2016). International coalitions and platforms like UNEP's Cool Coalition, or the Think Nature and Cities4Forests platforms enable cross-city learnings and support cities to move away from traditionally drawn grey infrastructure plans and promote hybrid solutions to reduce ambient daytime temperatures (UNEP 2019b) (further discussed in section 2.3.3).

Finally, building and restoring robust social infrastructure systems in cities are necessary to overhaul the infrastructure planning and decision making required to undo city lock-ins. As the world battles the COVID-19 pandemic, infrastructure decisions have become ever more critical,

where millions living in informal settlements and other forms of vulnerable housing with poor access to basic services, are left most exposed (Du et al. 2020). The lack of social infrastructure, particularly in cities of the global South, have presented insurmountable challenges for the urban poor who largely depend on informal social networks for livelihoods and basic services like water, electricity and healthcare (Roy 2020). Conversely, social welfare networks in several parts of the developing world like Nigeria (Ajibo 2020) and India (Menon et al. 2020) have formally or informally organised to fill critical gaps in their cities' social and health infrastructure systems, to meet the needs of vulnerable groups.

Economic development has the potential to radically shift cities from deeply unsustainable trajectories towards environmentally transformative and socially just pathways. But, much of economic priorities and budget allocations are driven by national and state agendas that fail to engage with the particulars of given cities (discussed further in Section 2.3.3). However, there is a larger scope for cities to think about the connections between planning and economic development; paying greater attention to labor absorption, skill development, and worker productivity. As the world's population becomes more urban (UN 2019a), the share of informal labor in developing cities will increase. Cities need to actively identify fair, economic development opportunities for marginal workers; and develop ways to engage with the informal sector through fair policies, social security, and better access to services and infrastructure. Cities can leverage this moment of sustainable transitions, to allocate resources for training and skill development, to absorb new migrant labor in green jobs.

Beyond the fact that it's difficult to do local economic development and the fact that the levers are not all in the hands of cities, there is often an invisibility at best/ or reticence to recognise the 'real' economy as constitutive of city economies that betrays modernist/bifurcation of economies - linked to the political economy of many cities.

Cities and city administrators can benefit from tools that help evaluate the myriad social and environmental co-benefits of reorienting planning priorities towards more sustainable urban trajectories. However, this is not easy. It requires challenging the political economy of cities; and yet, cities are restricted by several other factors that are beyond their capacity to influence - including jurisdictions, national and international interests, capacity deficits and mainly a lack of flexible finance. These barriers further stabilise the political economy of city lock-ins. To catalyse transformative change in cities, these factors must be closely investigated.

2.3.3 Cities as Complex Systems: The governance web of cities

Cities are complex systems of interdependencies across geographic, institutional and governance scales, where numerous actors and processes interact (Bai et al. 2016). Cities are governed by a very broad spectrum of governance and policy instruments defined at national and federal levels, including national policies shaped by international commitments for sustainable development and a better environment such as the Sustainable Development Goals (SDGs) and Nationally Determined Contributions (NDCs) amongst others.

But cities' functions and responses are also shaped by actions and decisions taken by actors and institutions within and beyond the urban boundaries that may have contradictory or unsustainable aims. When a city is nested within an unsustainable regional or national trajectory, reorganizing processes within the city has a limited impact. For example using carbon dioxide accounting tools to track local emissions does little to reduce global carbon emissions because it does not disrupt how carbon enters and exits a city (Rice 2014). Cities can, in practice, act as frontlines of sustainable and inclusive development (Guterres 2019); and indeed, local interventions have the potential to advance sustainable development not only at the city-level, but also at the national level and beyond. However, this opportunity has not been optimally utilized. Most international targets (SDGs, NDCs) depend on city-level implementation for success, yet in most cases, cities have not been party to international and national agenda setting or implementation strategy development (UN HAbitat 2020). This is a missed opportunity for ensuring ownership, capacity and finance to enable cities to drive for this success.

Propelling cities into a sustainable and equitable urban transition will require substantial investments. For instance, even the largest and most able city governments can deliver only a fraction of their emission reduction targets as part of NDCs due to the lack of adequate financial resources (UN Habitat 2020). Most urban local governments grapple with insufficient funds, particularly for infrastructure, service provision, and socially and environmentally responsible public interventions. This puts most city governments in a position of dependence vis a vis central funds, allocated under national level policies, programs and missions earmarked for urban development (Guha 2019). With this fiscal dependence, comes a number of strings that relate in part to the priority accorded to cities and urban regions within broader national development and sustainability strategies. In some contexts, cities continue to play an ambiguous role in national imaginations, or are considered threats to national identity and power structures (UN Habitat 2014b). This is often reflected in ambivalent policies and attempts to curtail the autonomy of cities and this leads to the centrality of power and resources resting with the national governments.

Most of the national policies on infrastructure development, transport planning, and energy management even though not urban specific, have implications on the functioning of cities. National level policies can play a crucial role in promoting low-carbon development of cities. For instance, in India, to promote energy-efficient low-carbon development, the national government launched the National Electric Mobility Mission Plan (NEMMP). Under this plan, the government introduced EVs in multimodal public transport in several cities which aligned with promoting low-carbon and sustainable development in cities (Rahiman et al. 2019). However, in many places, even if cities want to take positive action, prevailing unfavourable national policies can 'lock-in' the unsustainable 'business as usual' trajectory at the local level. For instance, most cities rely on fossil fuel based centralized energy systems which account for high emissions from urban areas. As cities operate in a broader governance and institutional framework, even if cities had the will to change this, they may be limited in their ability to take action without support from the national government. Major decisions around infrastructure investments and development that cut across different sectors such as energy, transport, water, buildings etc. are taken by national governments and in some cases state governments too.

While many cities continue to function within the tents of centralized governance and institutional framework, there are some cities that have tried to transcend this. For example, in the case of energy systems, all operations of the City of Sydney are run on a decentralised 100% renewable energy system, even though on the national front, the 'Technology Investment Roadmap' developed to foster low-carbon development in Australia is not necessarily in alignment with the emission reduction targets as per the NDCs (O'Malley 2020; Wray 2020). In the case of Sydney, the adoption of a sustainable city level alternative to meet its energy needs and thereby reducing its dependency on a fossil-fuel based centralized energy system, demonstrates an agent of change that can drive sustainable and just transitions.

Even though national governments are increasingly trying to adopt a decentralized approach to devolve power to city governments, such processes are mostly unfinished and marked by inconsistencies in the legal and regulatory frameworks and responsibilities assigned. This often gives rise to conflicting mandates and limited resource capacity in the local bodies. Even in cases where cities function as autonomous entities, they grapple with limited financial resources and capacities. Most cities tend to be under-resourced, with no governing mandate to make a substantive change on this front. This is especially true of those low- to medium-income cities in Africa and Asia, which represent the major locus of urban growth globally. Most city governments are unable to cope with the rapid urbanization and burgeoning urban population and they struggle to deliver basic urban services such as water, sanitation, health care etc. due to deficit

resources. The increasing rate of urbanization and population density can lead to creation of risks, especially when urbanization is rapid, poorly planned and occurring in a context of prevailing poverty. The lack of basic services, housing, and health care services can compound the impacts of natural hazards and extreme events resulting in widespread disaster. For example, in case of an extreme rainfall event, waterlogging and flooding can be caused due to poor solid waste management practices clogging storm water drainage systems and increasing loss of property, assets and even life.

There is a crucial need for building capacities in the urban institutional framework to manage complex urban challenges and issues. Many cities in developing countries grapple with ensuring the provision of basic services as most local governments function inefficiently with just a fraction of the required staff in place and out of which more than two-thirds lack formal academic qualification and training (Cities Alliance/UK AID, 2018). Some countries have only very few educational institutions that can produce professionals such as urban planners, data analysts, climate, and environmental scientists that can be deployed at the local level to design, plan, and build cities in accordance with cutting edge, socially just and environmentally transformational paradigms.

Further, cities fail to function as an integrated setup. The prevailing system comprises several departments, agencies, organizations and networks steering urban development. Due to siloed bureaucracy and culture, cities may even grapple with addressing a mundane issue due to the existence of sector-specific departments which complicates the process. City governments have separate and specialized bureaucratic departments, with each of these departments dealing with a specific urban sector, such as housing, transport, or green and public spaces. Existing institutional silos, lack of inter-departmental communication and coordination pose challenges in mainstreaming just transition objectives, which require close collaboration across multiple departments. The existing formalized city governance structure hinders adoption of integrated responses to address environmental problems and inequalities in cities.

Another prevailing challenge impeding sustainable and just urban development is the lack of proper data and data systems for planning. In most cities, there is little or no data providing relevant information on the provision of basic services for the urban poor living in informal settlements. In some cities, even though 30-60% of the urban population live in these informal settlements, basic information, such as street names and addresses, are unavailable or missing (Satterthwaite 2020a). This provides very limited opportunities for bridging basic service gaps and reducing inherent vulnerabilities of the residents of these informal settlements. Even though

there are census authorities that produce data in most countries, the data produced primarily serves the national governments. Disaggregated data which can be utilized by urban local bodies for planning is not produced and sometimes the census data itself is not made accessible to urban local bodies. Even for realizing international targets and goals such as the SDGs and NDCs, it is crucial for urban local bodies to have disaggregated data for successful implementation. The challenges of maintaining data are further aggravated due to low institutional capacity, funding and accountability. There are several city governments who have responded to the deficiencies in official data by developing their very own common database (Satterthwaite 2020c). This means, collecting and compiling all relevant data housed in different departments. This then poses the added challenge of dealing with compartmentalization of government agencies and departments working in silos.

As cities grapple with the 'lock-ins' that transcend the urban boundaries, a systems approach promoting sustainable urban development can stimulate transformative action (Bai et al. 2016). A systems approach calls for attention to the interdependent processes linking cities with their regional hinterlands, other cities, nation states, and beyond. It is crucial to identify and understand the external factors and interlinkages that act as barriers to transformative change and acknowledge their power to drive urbanization in a different direction.

2.4 Catalyzing Just Transformations

The previous section has outlined the powerful forces that serve to maintain many cities and urban areas on unsustainable trajectories. These 'lock-in' forces reveal the lack of basic services taken for granted by so many more developed communities, alongside the entrenched and deeply interconnected systems of injustice and oppression that are produced by, and help to create, unsustainable trajectories for so many of the world's cities.

'Shifting' such path-dependent trajectories or disrupting 'business as usual' requires not only reducing environmental impacts and restoring ecological (re)connection; it also requires deep and whole-of-society engagement with issues of equity and justice, challenging current systems of distribution, recognition, and participation. It requires addressing difficult trade-offs, working across silos and, most arduously still, shifting entrenched power structures and balances. This is no small task and goes some way in explaining the tendency towards inertia. Certainly, the short-termism inherent in most current political systems (democratic or other) tends to favour the maintenance of power structures and short-term appeasement (e.g. jobs in carbon intensive industries), at the expense of uncertain long-term transformation processes. However, there are examples of cities that are disrupting 'business as usual' and where actors are enabling just

transformations. More often than not, such responses are the result of collaborative processes at multiple scales (C40 2015).

Pathways toward just and inclusive urban transformations are explored in detail in Chapter 5, with particular attention provided to pathways towards building net zero circular cities, urban resilience, social inclusion and just cities. Below, we highlight three underpinning building blocks that have been shown to enable transformative change. These building blocks or practices both enable and reflect shifts in the political economies of cities and help address some of the capacity constraints and governance blockages that keep cities locked on unsustainable trajectories. Although there is great variation in how these practices are implemented, there is much to learn about how they have emerged, the actors involved in catalysing transformative change and some of the processes that have been developed to scale up or sustain such change.

2.4.1 Inclusive, Publicly Engaged Decision-Making

A key source of lock-in to environmentally unsustainable and unjust urban trajectories is the exclusion of some (at times, majority) local voices and urban publics from policy and planning. Recognising and opening up the decision-making process, and giving voice to those who, historically have not informed urban policies and planning strategies can help address both equity and environmental unsustainability. At stake here is ensuring that those most affected by unsustainable 'business as usual' scenarios are heard, that their needs are taken into consideration, but also that their knowledge of urban dynamics, and their capacity to partner in solution-finding are taken seriously. Inclusive strategies and practices prioritize local concerns, local environments and environmental values - but do so in ways that forefront working with informality and marginalized groups.

Important solutions: addressing redistributive issues, but also addressing the underlying decision-making structures that perpetuate unequal access to and distribution of resources, services and opportunities at the city scale. This means deepening institutions inclusive of race, gender, ethnicity, and status. Key examples are participatory budgeting, community-led planning, true public engagement in policy development, and localized and locally-led national and global initiatives. Engaging the public for inclusive decision-making processes that can break out of the entrenched power structures requires that urban residents are informed about benefits and risks and the processes are conducted with transparency and accountability. Residents need to be informed about the full slate of environmental issues affecting them - as outlined in the following chapter - and the possibility for change and solutions described in chapters 4 and 5. Similarly information and experience from residents needs to be adequately captured and respected in

processes, combined with the information and perspectives from the scientific and business community as well as the wider regional or national scale as appropriate.

In addition to the information and data from a variety of urban residents, the needs, concerns and priorities of different communities and people need to be adequately heard and engaged in discussions. Women and girls may have different perspectives on greenspaces, parks and public transportation due to safety concerns. The elderly and people with disabilities may assess mobility and access needs in their city differently from youth and business owners. Processes that better capture these differences will not only better suit a wider variety of residents but can also help come up with innovative solutions.

These processes must address the need to change behaviors in the context of current attitudes and individual desires for wealth accumulation, lifestyle choices and aspirations for the future. The rising middle class in cities in emerging economies, informal residents fighting for quality of life upgrades in cities across the world, and the elderly in high-income countries with shrinking populations all have expectations about what their lives should look like that unfortunately have too often been coupled with a high-consumption, carbon intensive outcomes. Conversely many young people in cities across the planet are recognizing the need for a change and are choosing more sustainable lifestyles for themselves and advocating for politicians and businesses to follow suit.

Inclusive decision-making processes are critical to working from within the city to disrupt the structural societal factors that have resulted in fragmented and unsustainable urban places.

2.4.2 Partnerships and Coalition-Based Governance

Coalitions, partnerships and organised city networks have been shown to be key for moving urban sustainability and equity agendas forward, allowing cities to navigate the gaps in capacity, information, authority, and resources presented above. These can range from ad hoc arrangements to formal authority sharing and reflect cities' efforts to respond to the challenges presented by business as usual planning and governance. Such partnerships and coalitions are often difficult to establish, resource and maintain and sometimes have presented their own entrenched political challenges. Their creation and maintenance are iterative and require reinforcing. Building the capacity of city governments to engage in such partnerships and lead coalition building can be an effective strategy for transition and allow cities to demonstrate leadership in complex issue areas.

City networks at the global and regional level have worked for the past couple of decades on a wide range of topics related to governance and sustainability with an increased focus on nature

and climate change in the past decade These platforms foster learning and capacity building, allow cities to advocate for what they need and to have a seat in international fora and influence the outcomes. 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 cities, large and small,from across the globe, that were committing to collective actions towards sustainability in the wake of the first Earth Summit (Rio Earth Summit). ICLEI has been joined by a large variety of organisations and movements that work to provide a collective and widely diverse range of services and tools to cities that benefit from these connectivity instruments, formally and informally. City networks are combining efforts and providing simple and easily accessible entry points for cities to connect and work together to catalyze a more sustainable trajectory through innovative partnerships.The Global Task Force, the Global Covenant of Mayors for Climate and Energy (GCOM) and the nature-focused CitiesWithNature initiatives are some of the best examples of networks and initiatives coming together to provide integrated and enabling platforms to inspire cities to take bold and often groundbreaking efforts towards a more sustainable shared urban future.

Finance is consistently a barrier to effective and transformative action at the city level. City governments, especially in small and medium-sized cities, are limited in their own fiscal sources and face many barriers to unlocking international funds and private sector investment. Recognizing this deficit, an emphasis on multi-level collaboration between cities and national levels of government is especially key for sustainable urban infrastructure. In Dar-es-Salaam, funding for the Bus Rapid Transit (BRT) system was facilitated by the National Government with a mix of national budget allocation and international loans from the World Bank and African Development Bank (Tozer, forthcoming).

Coalition building with non-state actors, including the business sector, civil society, NGOs and scientists/researchers is also crucial both because it reinforces the inclusive process highlighted previously as well as helps to expand capacity and insight. In many situations, the private sector can help close the capacity gap and innovation gap. GCOM’s Innovate4Cities program has started exploring how the private sector can engage with city governments in support of this. Energy has been a typical entry point for innovation and businesses in many city contexts but communities and governments are continually exploring how to better engage small and medium-sized enterprises on resilience and nature-based solutions. Civil society and community organizations - such as Slumdwellers International (SDI), the Asian Coalition for Housing Rights - have long been active in the urban development space especially around informal settlement upgrading,

community organizing and data collection, and service delivery. These organizations have more recently engaged with climate and environment. For example in Malawi, the local SDI affiliate started a savings program to help residents recover from extreme events like flooding which they have seen increase as the result of climate change. On building coalitions between the research community and urban practitioners and policymakers, the Cities and Climate Change Science conference was held in Edmonton, Canada in March 2018. It brought together these communities with the IPCC to create the Global Research and Action Agenda on Cities and Climate Change - setting out key priorities for action, collaboration and research and data gaps.

2.4.3 Institutionalization for Longevity and Scaling Up

A key challenge for just urban transformations is ensuring that successes and innovations (whether top down or bottom up) are embedded, scaled up and out and institutionalised in some way or another, in order to ensure longevity. Long term, cross sectoral, cross scale planning with a diverse range of expertise is key for transformation. It requires ongoing feedback and learning. This means that innovations must extend beyond a mayor or particular civil servant's tenure, incorporated into budgets and able to attract further resources and support. An example of this strategy can be found in New York City's city council passing legislation to require climate action planning by future mayors; this measure helped to ensure the persistence of climate action planning during the transition from Mayor Michael Bloomberg to Mayor Bill DeBlasio in 2014 (Hughes 2019).

Institutionalization also helps to mainstream innovations and facilitate their scaling up, for example from a pilot project to a city-wide initiative. If pilot projects are to contribute to just urban transformations "they must, at some point, move beyond the initial test site or boundaries within which they were created" (Hughes et al. 2018). Embedding climate change considerations in annual reviews or requiring robust public engagement in policy making serves to broaden the reach of potentially transformative measures.

By holding local governments accountable for action, local communities and residents also have a role to play in ensuring longevity of changes as well as uptake of initiatives piloted in at the community level. Institutionalizing finance for community-led action and capacity is also critical for the community to have a continual, long-term engagement. This has worked effectively for informal settlement upgrading in Thailand with the Baan Mankong Province.

National governments can also enable transformational changes with national policies that solidify the critical contribution of cities to national development and environmental goals. They

also can support scaling-up to other cities, especially secondary cities in the country and ensuring learning is exchanged.

2.5 Concluding Statement

Many of the challenges and barriers described above are not particularly new, but they take on new dimensions and urgency because of increased urbanization combined with vulnerabilities and inequalities that are being confronted with the global environmental crises of biodiversity loss and climate change. Some of the lock-ins, especially related to political economy, have grown over time and exacerbated the inequality described in section 2.2 instead of addressing it. Other barriers related to extractive global industries and urban planning practices are in contrast to just and sustainable goals for the future and need to be re-examined especially in light of trends described in chapter 3.

Despite the structural challenges they face, breaking up this lock-in and these barriers is possible. Urban decision makers remain at the forefront of our world's most complex and interconnected challenges. Many are taking steps and making ambitious pledges to address the intertwined challenges of equity, sustainability and unmet basic needs of urban communities. Frontrunner cities are setting the pace and inspiring many more to follow in their footsteps. Their commitments and actions preview the formidable potential of urban transformations and reveal key practices that are starting to have the potential to - indeed do - disrupt business as usual scenarios and catalyze new trajectories.

This chapter has examined three key enablers to shifting the trajectory: (1) expand the breadth of stakeholders from within city involved in decision-making in a meaningful way (2) build stronger coalitions and partnerships within and beyond the city (3) solidify those changes with institutions for long-term, widespread and lasting change.

Chapter 4 picks up on several of these themes to help us imagine a new future where we are not constrained by these lock-ins and barriers but instead overcome them reaping benefits for people, multiple species, the shape of cities and ultimately the planet. Then chapter 5 picks up on the enablers and visions to delve into what has worked and what can work with inspiring examples of cities that have built broad coalitions across sectors to advance the circular economy, institutional change for urban resilience, and pivoting towards rights-based and equitable approaches to sustainability.

Disruption at the scale needed and for positive gains requires leadership. And this leadership needs to be fostered and supported within cities, by city leaders such as mayors as well as through

the support of international and national frameworks. National governments have a critical role to play in supporting diverse processes and just transformations, especially addressing finance and governance gaps.

Sometimes the entry point is starting small, with effective but very localized action for one community or one aspect of mobility that show short-term benefits with the potential for longer-term synergies. In other instances looking at the city more holistically and better understanding the connections beyond the city catalyzes change and solutions for food or water or energy. Transformation is iterative involving a change in processes and systems as well as outcomes. Enablers, solutions and the right action is also very context specific and will need to account for the diversity and uniqueness of cities based on size, demographics, main economic drivers, design of the built and state of the environment to determine priorities.

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3 The State of the Environment in Cities

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Key messages

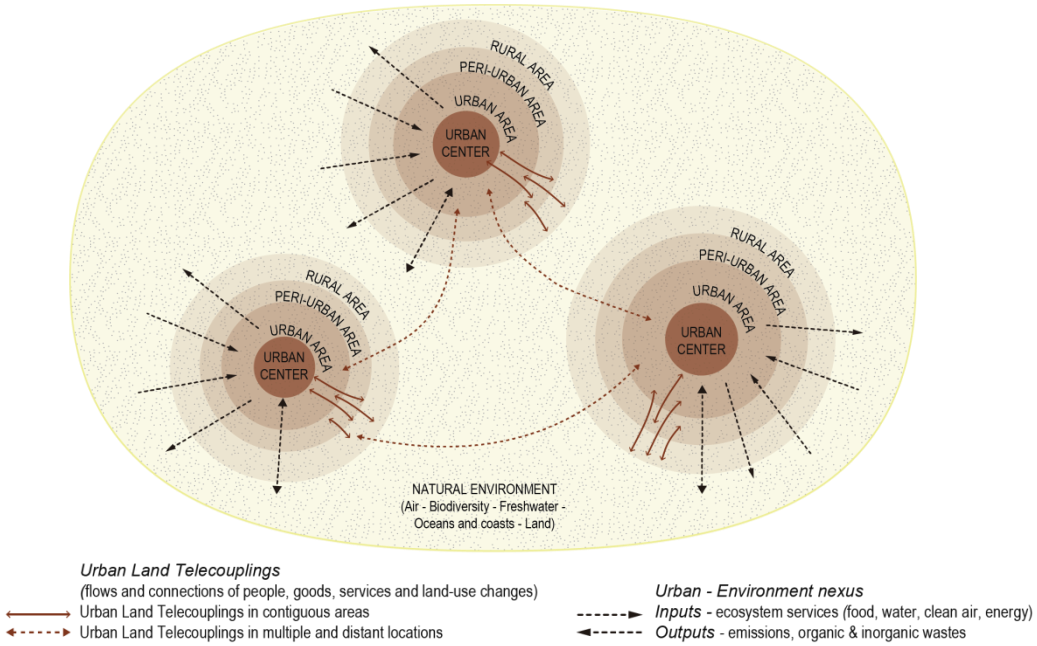
- **Cities are continuously interacting with other places**. It is through these interactions that urban dynamics are possible. In this process, cities transform places beyond the urban environment.
- **Urban planning and city management need to take into account these connections in order to achieve multiple SDGs simultaneously**. These interactions can generate synergies and tradeoffs that intertwine the (un)sustainability of different locations.
- **Global environmental change affects cities**. The conditions in which cities developed and function are transforming. Even global changes (i.e. climate change) have direct impacts at the city level. There is a need to consider the implications of these transformations at the urban level.
- **Global environmental changes affect the quality of life or urban residents**. Environmental changes in air, freshwater, biodiversity, oceans and coasts and land, even in faraway but connected places, affect human aspects such as health, equity and food security at the city level.
- **Cities also contribute to global environmental change**. Urban activities contribute to current environmental change trends, but also provide an opportunity to reduce their impact.
- **There are major gaps in terms of data quantity and quality for effective management at the city level**.
- **Urban environment planning and management need to consider ecological processes and nature-based solutions for all city inhabitants, both human and non-human**.

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

An important characteristics of urban areas is that they continuously exchange people, resources and information with other places (Seto *et al.* 2012; United Nations Convention to Combat Desertification [UNCCD] 2017). It is through these interactions that urban settlements change in both space and time, and these 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, and other distant cities and rural locations, create complementary and synergistic relations (United Nations Human Settlements Programme [UN-Habitat] 2015). Although cities are embedded within their immediate environment, the footprint of cities goes beyond jurisdictional boundaries, as food, water, sanitation, clean air and energy needs are rarely satisfied within the city limits and people move, either temporarily or

permanently, between urban and rural areas (Haase 2019). These connections can be both locally with nearby, contiguous spaces, and at the regional and global levels with places that do not share a boundary with the city (also known as 'telecouplings') (Liu, J. *et al.* 2013; Seto and Reenberg 2014; Fragkias, Islam and Sprague 2017(Figure 3.1).

Figure 3.1 Cities are interconnected and depend on those connections. Cities influence the environment and the environment influences cities.



Source: Agustina Apud Marquez, based on Seto *et al.* 2012; Ravetz, Fertner and Nielsen 2013.

Therefore, defining an urban settlement solely on its administrative boundary ignores the multitude of connections and flows that make the city possible and achieving urban sustainability (SDG 11) 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 old ones (Güneralp, Seto and Ramachandran 2013). In other instances, global investment and supply chains and consumption patterns in one area changes those in others (United Nations Environment Programme [UNEP] 2019)(See GEO-6 Healthy Planet, Healthy people: chapters 3 and 8). Therefore, cities can be conceptualized as nodes of a network where the intensity of connections with the immediate vicinity and faraway places changes with time and across space[2] (Glaeser, Ponzetto and Zou 2016; Cities Alliance 2019).

As urban growth takes place, many synergistic relationships with other areas may be overlooked and the environmental impact of cities might increase at the expense of the functional needs of

[2] The reader will find examples of specific telecouplings later in the chapter

the city and the well-being of its dwellers. The pressures exerted by urban growth also affect inhabitants of other areas and nature's contributions to human well-being. City planners and practitioners need to be on the alert for signals of these tradeoffs and to keep in mind that urban sustainability is tied to the sustainability of the areas connected to the city (See section 5.4.4). Without considering these urban telecouplings it will be extremely difficult to achieve SDG 11 targets and many other SDGs, as pressures and impacts are also connected through these urban/rural, urban/natural resources and urban/urban linkages.

Urban settlements vary tremendously in their social, economic, environmental, political, and technological contexts. For example, all cities are already facing the impacts of climate change and its associated changes to human well-being. However, impacts, both present and future, will depend on the cities´ context and characteristics. For example, coastal cities may need to plan for sea level rise, 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).

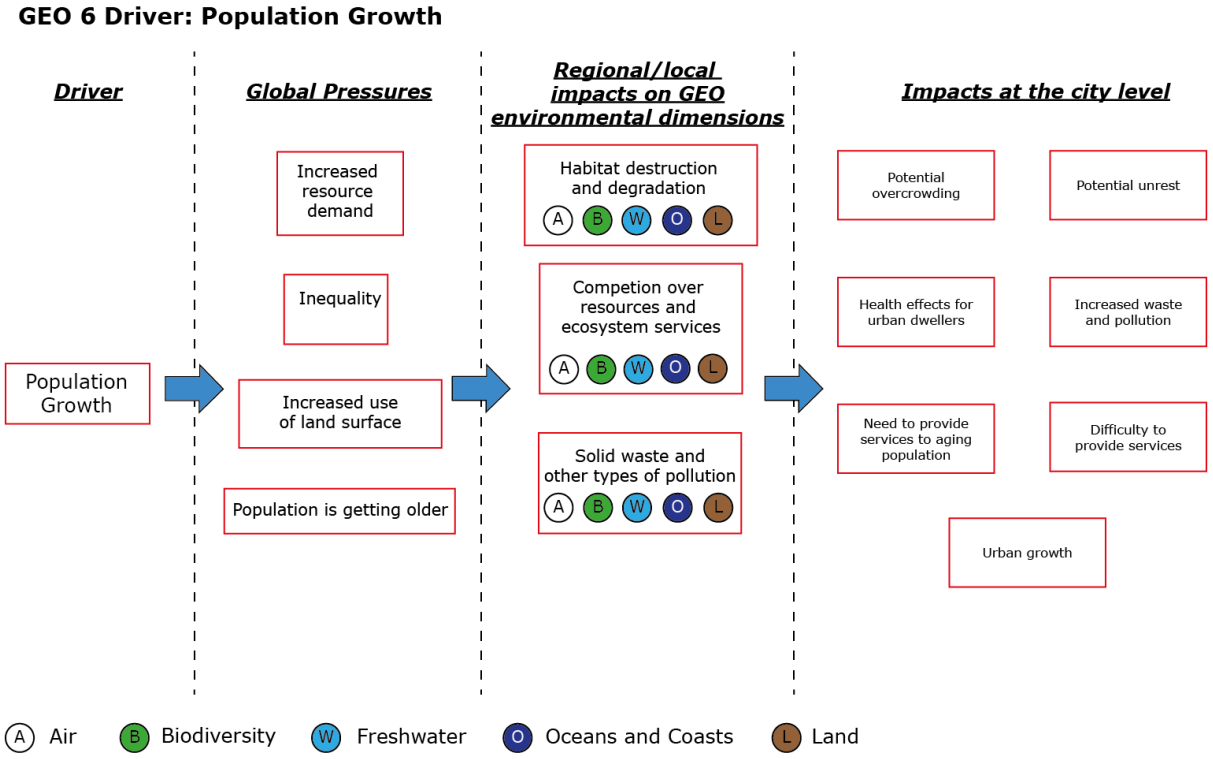
As discussed in chapter 2, cities of different sizes, institutional arrangements and income levels will have different capacities to cope with these challenges (Anguelovski, Chu and Carmin 2014; Reckien *et al.* 2015; Estrada, Botzen and Tol 2017, Paterson *et al.* 2017). Therefore, there is no single silver bullet for city planners and managers, as urban conditions are not globally homogenous (Brelsford *et al.* 2017). Unpacking the complexity of managing urban settlements is urgent, since urbanisation is forecasted to accelerate in all regions albeit at different paces (United Nations Department of Economic and Social Affairs [UN DESA] 2019). Cities need to adopt integrated, synergistic, resilient and adaptive strategies for urban environments to meet the goals established in Agenda 2030, the IPCC 1.5 C and the post-2020 biodiversity report (Bazaz *et al.* 2018; Organisation for Economic Co-operation and Development [OECD] 2020).

In this chapter, we try to present the most relevant issues of this urban-environment nexus. For organizational purposes, we adopt the five environmental dimensions of the Global Environment Outlook report (Air, Biodiversity, Land, Oceans and Coasts, Freshwater). However, we must acknowledge that, due to the interconnected nature of cities and the environment, their impacts in one dimension might also have effects in others. As a result, what appears to be repetitive in the text reflects the integrated nature of this nexus. The second section describes the most relevant impacts of environmental change on cities, while the third section emphasizes how cities contribute to environmental change, and how these interact with each other. The fourth section synthesizes the most important impacts at the city scale, provides possible global trends, and reflects on the data availability gaps. The fifth section explores how changes in the city and the environment affect health and well-being of urban residents. Finally, we highlight the urgent need

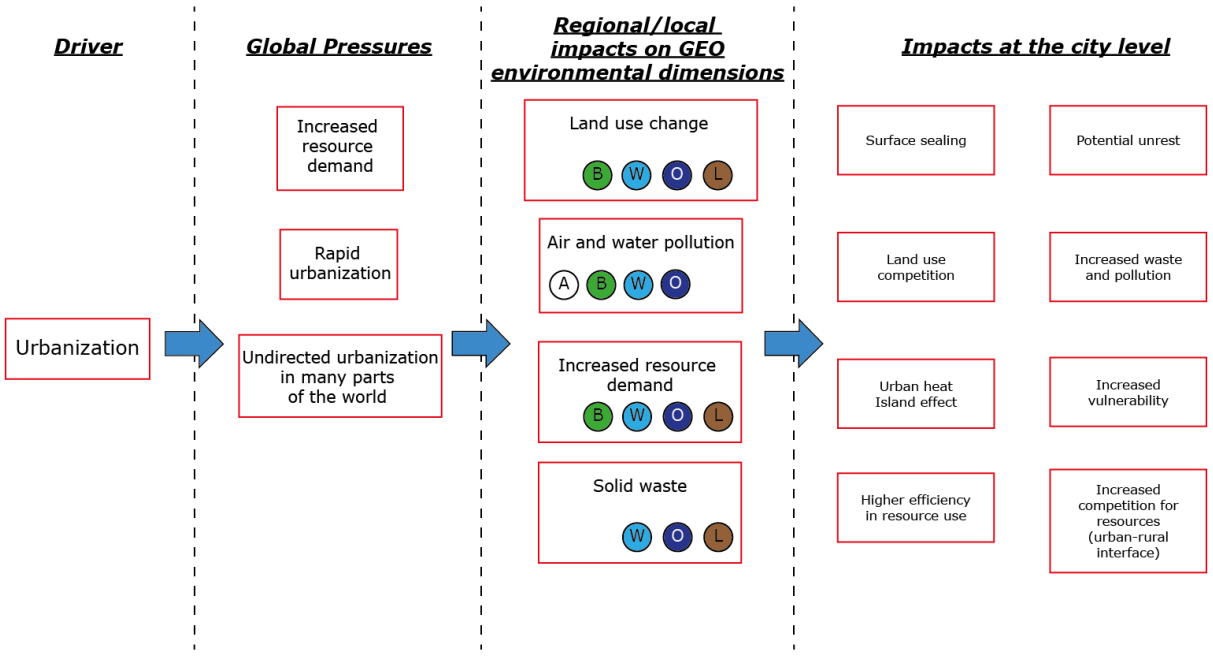
for more sustainable urban environments with more integrated and inclusive governance structures.

3.2 How are global environmental changes affecting cities?

As the global environment changes, some of the conditions in which cities have developed and functioned, transform. For example, many urban settlements located at higher altitudes in Africa and Latin America were free of the dengue virus as they benefited from a temperature threshold for the vectors of this disease. As global temperatures rise , some of these cities have become warm enough for the dengue fever vector *Aedes aegypti* to thrive (Lozano-Fuentes *et al.* 2012; Equihua *et al.* 2017) – demonstrating how a global change affects 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 illustrates how these drivers, through the DPSIR framework, impact cities, and highlights how regional/local impacts and city-level impacts can be the result of the interaction of several driving forces.

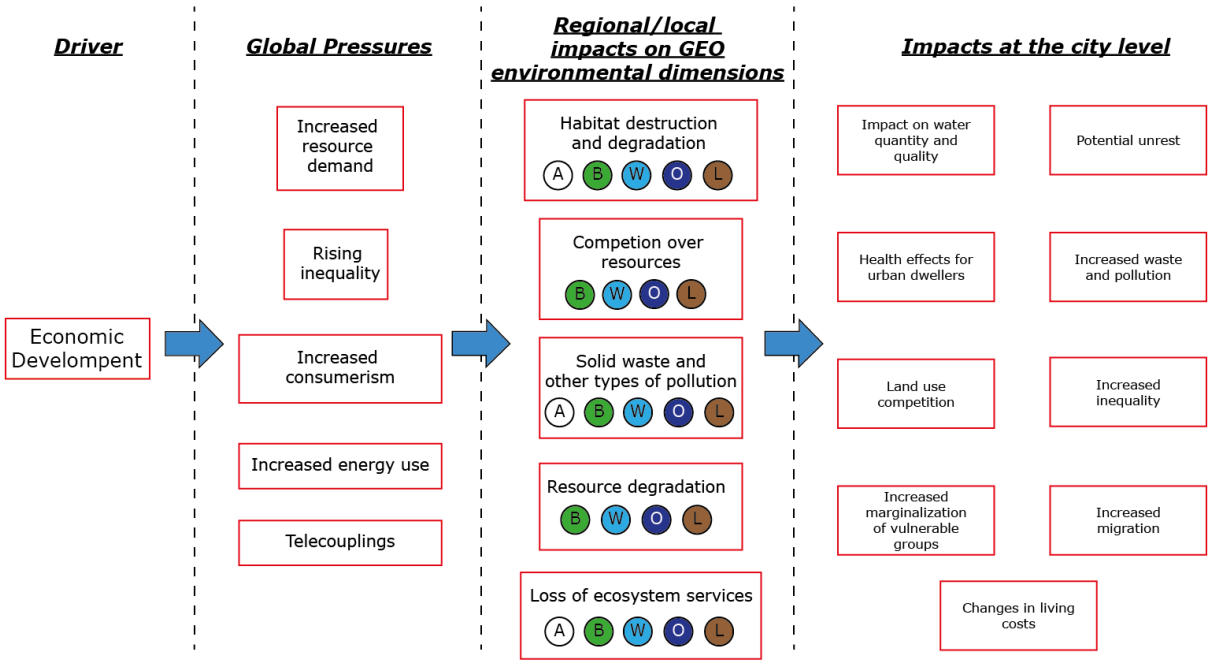


GEO 6 Driver: Urbanization

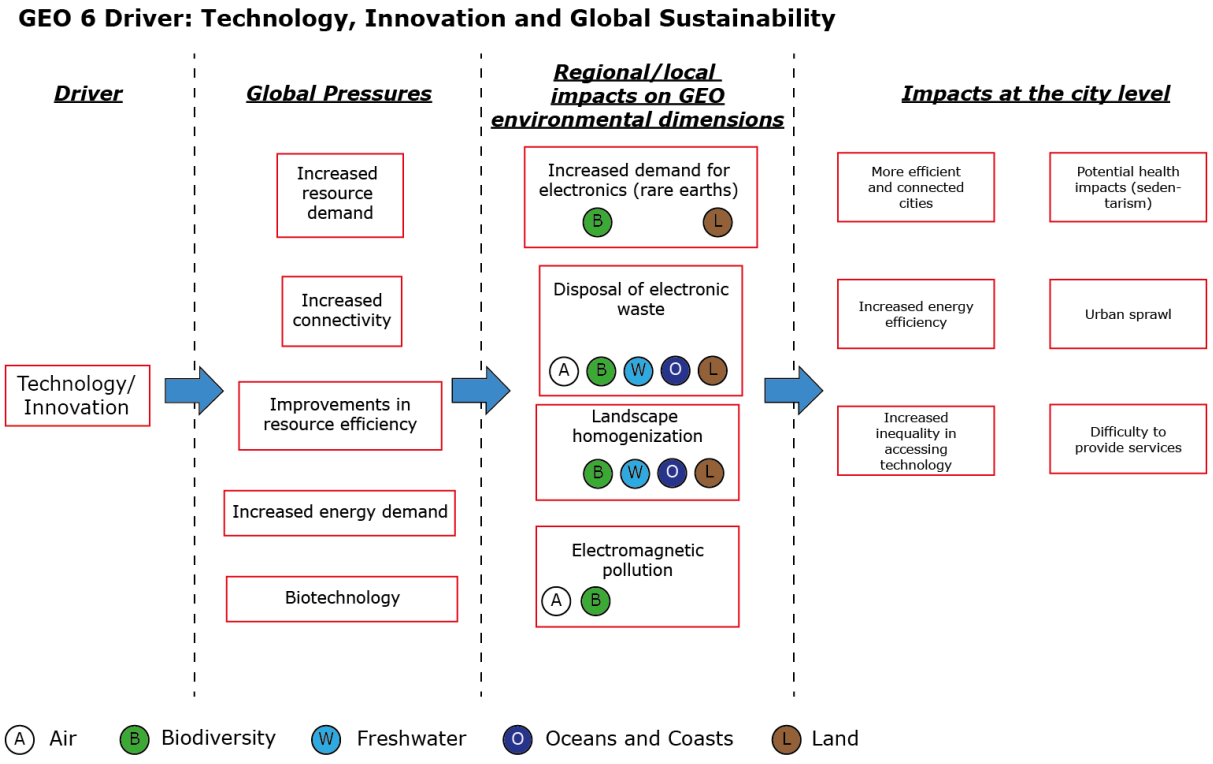


1378 A Air B Biodiversity W Freshwater O Oceans and Coasts L Land

GEO 6 Driver: Economic development



1379 A Air B Biodiversity W Freshwater O Oceans and Coasts L Land



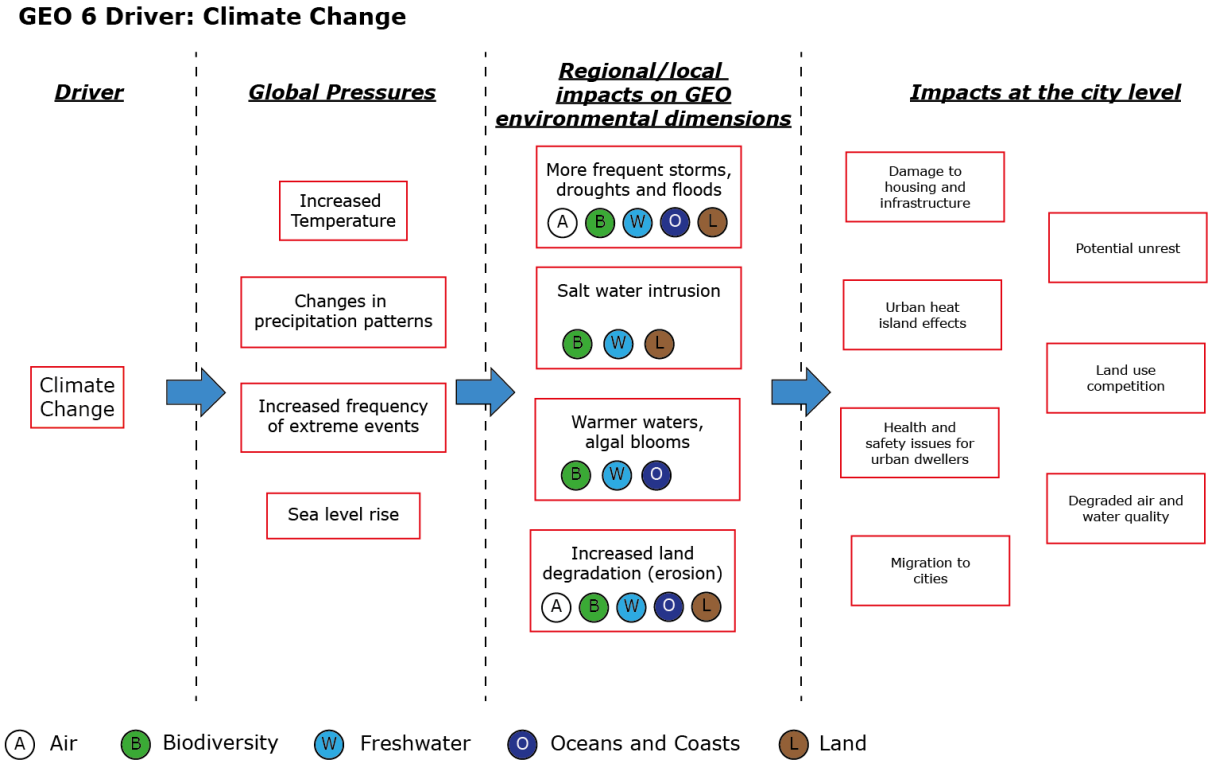


Figure 3.2 How different Global Environmental Outlook drivers (population growth; urbanization; economic development; technology; innovation and sustainability; and climate change) impact cities and human well-being

The remainder of this section examines in more detail how global environmental changes are affecting cities across the five environmental dimensions: air, freshwater, land, oceans and coasts, and biodiversity.

3.2.1 Air

The atmosphere has no boundaries and is the integrator of the Earth system due to its circulation patterns. Therefore, global environmental changes near and far impact the air quality and climate of cities. Emissions of greenhouse gases (GHGs) and short-lived climate pollutants (SLCPs) from human and natural sources warm the atmosphere resulting in significant impacts on cities (Intergovernmental Panel on Climate Change [IPCC] 2018). Emissions of carbon dioxide (CO2) into the atmosphere, in particular from the burning of fossil fuels, industry and land use change, is increasing annually at 0.6%, resulting in an atmospheric CO2 concentration of 407.4ppm and a global temperature increase of 1.0˚C as of 2018 (IPCC 2018; Friedlingstein *et al.* 2019; World Meteorological Organization [WMO] 2019a). The second most important human-influenced greenhouse gas is methane (CH_4). A recent study estimated 575 Tg CH_4 were emitted per a year from 2008-2017, with 60% of the emissions caused by direct human activity such as agriculture, waste management, and fossil fuel related activities (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 cyclonic storm frequency and intensity, and sea level rise (IPCC 2018). These climate pressures impact human health in cities through exposure to extreme temperatures, poor air quality, reduced food and water quality, 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 due to outdoor (ambient) and indoor (household) air pollution (World Health Organization [WHO] 2020a). Air pollutants know no boundaries and the air quality of cities can be significantly impacted by human and natural activities that occur outside their jurisdiction. This also presents an urban governance challenge for air quality mitigation strategies because cities cannot control emissions from outside their boundaries. There are only a few examples of efforts to improve air quality across jurisdiction such as the California Air Resources Board (https://ww2.arb.ca.gov) in the United States or the Convention on Long-range Transboundary Air Pollution that created a regional framework applicable to Europe, North America, and Russia and former East Bloc countries for reducing transboundary air pollution (United Nations Economic Commission for Europe [UNECE] 2019). More efforts are needed to establish air pollution control strategies across jurisdictions. It is important to note that air quality and climate change are linked from their sources to their impacts and should be addressed in a coordinated manner (Melamed, Schmale and von Schneidemesser 2016).

One example of global environmental changes impacting the climate and air quality in both urban and non-urban spaces is the Saharan dust storm in mid-June 2020. The largest dust storm in

decades, as the result of atmospheric circulation patterns, it transported dust from the Saharan Desert across the Atlantic Ocean, causing unhealthy air pollution across the Caribbean, Southeast United States, Mexico, and Central America (Çapraz and Deniz 2020; Farahani and Arhami 2020; Soleimani *et al.* 2020). In Puerto Rico, levels of particulate matter (PM10) soared above 400 µg m-3, two to three times the United States Environmental Protection Agency's 24-hour standard of 150 µg m-3 (Freedman, Cappucci and Samenow 2020). The impacts of the 2020 Saharan dust storm on human health, weather, and climate are currently being studied (NASA 2020).

Another case is the 2020 wildfire seasons in Australia and the United States which were extreme, fueled by record-breaking temperatures and severe droughts. The smoke from the wildfires temporarily resulted in the worst air quality in the world in Canberra, Australia (Fanner 2020) and San Francisco, California (Cabanatuan 2020). These wildfires are burning at the wildland-urban interface (WUI) destroying significant residential space, which is impacting the composition of "traditional" wildlife smoke. There is still a significant amount to learn about the emissions and chemical processes that occur during WUI fires and their impact on human health (National Academies 2020).

3.2.2 Biodiversity

Biodiversity[3] is directly linked to the quality of life of urban citizens, providing a multitude of benefits for humans from *ecosystem services* (Millennium Ecosystem Assessment 2003; The Economics of Ecosystems and Biodiversity [TEEB] 2011;International Union for the Conservation of Nature [IUCN] 2013; Convention on Biological Diversity [CBD] 2015; MacKinnon *et al.* 2019). Types of ecosystem services include provisioning (e.g. food), regulating (e.g. filtering for clean air and water), supporting (e.g. underlying and enabling the production of all other ecosystem services) and cultural (e.g. recreational and aesthetic enjoyment). Biodiversity comprises the biotic natural resource underpinnings that enable cities to persist. 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). Present rates of global species loss are estimated to be up to 1000 times greater than historical rate of extinction (Pimm *et al.* 2014), indicating the potential for a new sixth planetary extinction event within a few centuries (Barnosky *et al.* 2011). Cities are impacted by biodiversity loss through the resultant loss in ecosystem function and services. However, cities are not only places of biodiversity loss; they can be places of rich biodiversity (Elmqvist *et al.* 2013; Aronson *et al.* 2014; Ives *et al.* 2016)

[3] The variability among living organisms from all sources including terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are a part. This includes variation in genetic, phenotypic, phylogenetic, and functional attributes, as well as changes in abundance and distribution over time and space within and among species, biological communities and ecosystems, https://ipbes.net/sites/default/files/ipbes_global_assessment_glossary_unedited_31may.pdf

and cost savings to cities from maintaining biodiversity can be significant. Biodiversity is key for maintaining functional ecosystems, adapting to other environmental challenges such as climate change, and providing benefits to humans (See Chapter 4)(Millennium Ecosystem Assessment 2003; Millennium Ecosystem Assessment 2004; Haines-Young and Potschin 2010; Díaz *et al.* 2018; Díaz *et al.* 2019). For instance, the loss of insect species responsible for pollination of crops and other vegetation outside the city (a regulating ecosystem service) causes lower agricultural productivity that can lead to food insecurity in the city (Food and Agriculture Organization of the United Nations [FAO] 2015; Mbow *et al.* 2019). Urban trees provide substantial pollution reduction (a regulating ecosystem service); an estimate for the world's 10 megacities is $482 million per year in health cost savings for the reduction in pollutants (Endreny *et al.* 2017). The diversity of species supports ecological and functional redundancy[4] and resilience in the face of environmental shifts (Elmqvist *et al.* 2003; Mori, Furukawa and Sasaki 2013; Oliver 2015). For example, redundancy in urban coastal wetland species can help maintain its ecosystem services including water quality provision and protection against erosion, tidal currents, and flooding from storms. Hurricane Katrina (2005) caused massive damage, in part due to engineering practices that had disturbed wetland areas and preexisting patterns of flow in New Orleans.

Urban biodiversity in the form of spiders and dragonflies may also help to reduce the impact of infectious diseases. This effect occurs through organisms preying upon the disease vector or direct competition for resources between other organisms and the disease vector which prevents the further spread of the disease and also other organisms absorbing or "diluting" some of the burden of disease to humans by infecting other organisms (Epstein 1995; Chivian and Bernstein 2004; Campbell). Alternatively, biodiversity in cities can cause negative effects or *ecosystem disservices*. For example, urban form and some types of human behavior may contribute to the spread of some vectors like in subtropical and tropical cities, where urban characteristics are beneficial to *Aedes aegypti*, a vector of dengue and zika (Lindsay *et al.* 2017). Proximity between humans and animals in urban settings can also contribute to the spread of zoonotic disease, as in the case of the COVID-19 pandemic. Another ecosystem disservice example is invasive plant species, such as purple loosetrife *(Lythrum salicaria*), which can overwhelm waterways, with great cost for removal, and cause reduction in biomass of native plants and animals.

3.2.3 Freshwater

Cities and their sustainable development depend on access to sufficient and safe freshwater resources, and therefore they have historically developed near freshwater bodies. Prolonged

[4] The occurrence in the same ecosystem of species filling similar roles, which results in a sort of "insurance" in the ecosystem, with one species able to "replace" a similar species from the same functional niche, https://ipbes.net/sites/default/files/ipbes_global_assessment_glossary_unedited_31may.pdf

droughts, devastating floods and water mismanagement have led to the fall of multiple civilizations (van den Brandeler and Gupta 2020). Hydrological disasters have increased significantly over the past decades, as a result of climate change, and cities are particularly vulnerable to weather and climate extremes such as droughts, floods and resulting water quality problems (See Chapter 4) (Pahl-Wostl 2015). For instance, 79 large cities have suffered extensively from droughts since 2000 (Xiang *et al.* 2019). In 2018, Cape Town narrowly escaped "Day Zero", the day it would effectively run out of water, but endured severe water use restrictions (Rodina 2019); See Section 5.3 for how Cape Town built resilience to tackle this situation). Many cities are facing challenges adapting to more frequent water shortages as a result of rapid and unplanned urban growth and inadequate water management, as well as climate change, which leads to increased or decreased precipitation depending on the area (IPCC 2018). Sea level rise can lead to saltwater intrusion that threatens groundwater supplies of coastal cities and their surroundings (Safi *et al.* 2018). Deforestation and other land use changes in source watersheds are causing further stress to urban water supply (McDonald and Shemie 2014).

These pressures also lead to tensions between urban and rural water users (e.g. agriculture accounts on average for 70% of global freshwater withdrawals (FAO 2017)), as well as within cities between different (peri-)urban water users and social groups. Droughts also affect cities through impacts on ecosystem services, the health of urban dwellers and social stability (Xiang *et al.* 2019). Chronic water stress and extended droughts contribute to increased migration from rural to urban areas, often into informal settlements, as well as international migration that can fuel or aggravate refugee crises and conflicts (King 2015; Berchin *et al.* 2017). Meanwhile, urban land located in high-frequency flood zones is likely to increase from 30% in 2000 to 40% in 2030 (Güneralp, Güneralp and Liu 2015). Although land use and urban development factors 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 harbors and today 21 of the world's 33 megacities are located in low lying coastal areas (UN DESA 2018). It is estimated that more than 700 million people live in urban or quasi-urban areas that are 10 meters or less above sea level (Colenbrander *et al.* 2019). These coastal communities are increasingly vulnerable to the effects of human induced climate-change, with increases in mean sea level and extreme weather events predicted to continue this century and beyond (IPCC 2018). Models that assess the vulnerability of coastal populations indicate that, with the degree of sea level rise predicted under a low carbon emissions scenario, almost 200 million people are currently living in areas that, by the end of the century, will be flooded during high tide (Kulp and Strauss 2019). Rising sea levels

can result in damaging saltwater intrusion that can infiltrate groundwater, impede drainage and contribute to the contraction and disappearance of shoreline protecting coastal habitats.

Rising sea levels also increase the exposure of coastal cities to storm events. In addition to the destruction of 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 USD 4.6 billion in damage in the Bahamas, the USA and Canada. In Grand Bahama, the storm surge reached over 7 m (Le Page 2019). Similar levels of destruction are common across the tropics and modelling results suggest that by 2050 coastal cities in the tropics could experience a two-fold increase in these extreme weather events (Vitousek *et al.* 2017).

The impacts of higher tides due to sea level rise and increasing storms are exacerbated in some cities by significant land subsidence caused by ground water extraction and/or building on compactable coastal sediments. Residents of Jakarta, Venice, Bangkok and many other coastal cities and urban atoll islands are already directly or indirectly experiencing the negative effects of climate change (IPCC 2014) and the continued population growth in high risk coastal areas is likely to see more people suffer adverse physical, social, and economic consequences.

Wild catch fisheries are important financially and culturally to many coastal communities. Increasing ocean temperatures, nutrient runoff and acidification are already impacting fish catches and composition, 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 impacted by climate change impacts on fish stocks (Nong 2019).

3.2.5 Land

Cities, as hubs of human activities, require land resources such as food, fodder, fiber, and forest products. Additionally, land also involves dimensions such as shelter, property, and cultural identity, among others (UNCCD 2017). Many of these aspects are affected both directly and indirectly by environmental changes, and urban settlements are not an exception (See Table 3.1 State of the environment and trends at city scale). Indirect impacts, arising from telecoupling, are more common than direct impacts. Perhaps the most evident is related to the resources that the city requires most. Food and water predominately come from areas outside the city, and changes in those areas affect urban life (See Chapter 4: Circular city realm).

Land cover change in rural or wild areas has indirect impacts on cities. There are causal links between deforestation in the Brazilian Amazon with droughts in Southern Brazil, including cities

like Sao Paulo (Nobre 2014). This situation is present throughout the Amazon basin, and if deforestation continues, the rainforest's role as the source of rainfall for areas beyond the Amazon basin may be lost (Lovejoy and Nobre 2018), potentially reducing the availability of water in cities and rural areas. Land-resource degradation is associated with land-cover change, fragmentation, desertification and erosion that severely affect biodiversity and ecosystem services and nature's contributions to people (NCPs) (IPBES 2018), affecting well-being at the city level. These impacts affect areas that provide the necessary NCPs for maintaining urban function in cities.

Another example that illustrates the complex indirect impacts of land resource use and urbanization is land degradation. According to the United Nations Convention to Combat Desertification, land degradation is a process in which some or all of the following characteristics of land are reduced (UNCCD 2017): productivity, soil, vegetation, biomass and biodiversity, and ecosystem services. The estimated value from land degradation and land use change accounted for 10-17 per cent of 2015's global GDP (ELD Initiative 2015). The impacts on urban areas are many. For example, land degradation reduces agricultural productivity potentially leading to higher food prices, and farmers from degraded rural areas may try to find better opportunities by migrating into the city. Land degradation can contribute to the expansion of the agricultural frontier as more land is converted to agriculture to satisfy the resource needs of human population.

An example of direct impacts of global environmental change on land include coastal erosion that threatens urban infrastructure and increases the vulnerability of coastal dwellers. As mangroves, marshes and other ecosystems are transformed into urban areas, they become more susceptible to erosion, storm surge damage, and flooding. As urbanization continues, these direct and indirect impacts will likely increase unless changes in urban form and function, equity, transportation, and water and food footprints transform towards more sustainable cities (See chapter 4: 4.2) (UNCCD 2017).

3.3 How are cities affecting the environment locally and globally?

At the same time as cities are affected by global environment change, the process of urbanization and development of cities also affects local, regional and global environments. For example, sewage pollutes rivers, and through them, coastal areas. Urban air and land pollution affect the city and beyond. Air pollution may degrade ecosystems through acid rain, contributing to biodiversity loss and land cover change. At the same time, demand for certain products may affect and transform the land use and ecosystems through telecouplings. This section considers the most relevant impacts of urban areas on the environment.

3.3.1 Air

Emissions of GHGs and air pollutants from cities have impacts within the cities´ boundaries, regionally, and globally. As of 2015, cities cover roughly 0.5% of global land area (OECD and European Commission 2020) but are responsible for around 70% of the total anthropogenic GHG emissions (UN-Habitat 2016). Therefore, GHG emissions from cities greatly impact the entire planet via climate change.

Emissions of air pollutants from cities impact human health, climate, ecosystems, and food and water security at the local to regional level (WHO 2016c). Where data are available, 98 per cent of cities with populations over 100,000 in low- and middle-income countries exceed the WHO guidelines for PM2.5 or PM10, compared with the 56 per cent of cities in high-income countries with available data (WHO 2016c). While the density of urban areas offers benefits in terms of transport and energy efficiency, high population density and increased economic activity also lead to higher concentrations of emissions, from transport, heating and cooling, waste and construction. High population density also means more people are exposed to poor air quality. Air pollution from cities is transported outside cities boundaries. In India, ground level ozone pollution primarily from the emission of precursors in both Indian cities such as New Delhi and Lahore in Pakistan, is responsible for crop yield losses sufficient to feed about 94 million people in the country (Ghude *et al.* 2014).

Due to the concentration of GHG and air pollution emissions in cities, they can play a key role in mitigating climate change and improving the air we breathe. The unfortunate circumstances of the COVID-19 pandemic have resulted in GHG emission and air pollutant reductions in cities around the world (Forster *et al.* 2020). However, the reduced emissions do not necessarily correlate to improved air quality (Kroll *et al.* 2020; Le *et al.* 2020; Shi and Brasseur 2020) and their temporary reduction is unlikely to have an impact on long-term climate change (Forster *et al.* 2020; Le Quéré *et al.* 2020). The pandemic is providing a unique opportunity though for researchers to study how reduced emissions in cities will impact air quality and climate in the short- and long-term, which will likely provide insight in determining mitigation options to improve air quality and mitigate climate change in cities post-pandemic (Forster *et al.* 2020; Rosenbloom and Markard 2020). The research on the impacts of reduced emissions during the COVID-19 pandemic will likely 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, as well as indirectly through the production of food and other resources that are needed in urban areas (McDonald, Marcotullio and Güneralp 2013; McDonald *et al*. 2020). These impacts arise

from the destruction of natural habitats and landscape fragmentation, and also via changes in living conditions such as temperature increases, alterations in water availability and quality, soils, nutrients and biomass, and pollution (Pickett *et al.* 2001; Grimm *et al.* 2008). It is estimated that urban growth resulted in 190,000 km2 of habitat loss between 1992 and 2000, and a further 290,000 km2 is expected to be lost between 2000 and 2030 (The Nature Conservancy 2018; McDonald *et al.* 2020). The species composition of urban areas may also change through the introduction of non-native species (Müller *et al.* 2013).

Humans change the urban landscape through active selection of organisms through, for example, landscaping and pet breeding (Williams, N.S.G. *et al.* 2009; Kendal, Williams and Williams 2012; Aronson *et al.* 2016; Jenerette *et al.* 2016; Pearse *et al.* 2018). These changes may result in losses and gains in species. Though losses may occur, it is possible that a significant portion of native biodiversity may still be maintained in the city (Aronson *et al.* 2014). Aronson *et al*.'s (2014) demonstrates that, in 110 cities, a majority of urban bird and plant species are native within urban areas, but their density had decreased significantly when compared with a non-urban habitat. For the same cities, La Sorte *et al*. (2014) found that a median value of 52% of plant species were native. However, 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 of plant species than the 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, whereby the composition of species become more similar to each other across different urban areas (McKinney 2006; La Sorte, McKinney and Pyšek 2007; McKinney 2008), perhaps due to global plant exchange and nursery trade as well as sharing of aesthetic ideals and trends (Ignatieva and Stewart 2009), and introduction of potentially invasive alien species. The movement and exchange of organisms also includes microorganisms through waste disposal, tourism, food, and global transport (Zhu *et al.* 2017), which might spread certain diseases.

There are few studies of urban biodiversity conducted at the global scale (McDonnell, Hahs and Breuste 2009); most have focused on single type of organism across multiple locations, or patterns of multiple types of organisms 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 conservation of some species and ecosystems (Elmqvist *et al.* 2013; Aronson *et al.* 2014; Ives *et al.* 2016), thus, improving their ecosystem functioning and their articulation with the

surrounding landscape (See Chapter 4: 4.2). The extent of biodiversity within a city depends largely on how much greenspace is kept intact, its connectivity and size, both within and outside the city (Goddard, Dougill and Benton 2010; Beninde, Veith and Hochkirch 2015). Greenspaces include parks, conservation areas, abandoned lots, green roofs, private residential gardens, rivers and reservoirs. Most of these spaces also contribute to the well-being of citizens. For example, the Complete Streets initiative promotes street space not only as a transportation corridor, but also as social spaces that enhance the quality of urban space through leisure, culture and recreation activities, and greenery (Achuthan *et al.* 2019). This improved urban quality contributes to healthier people through noise and pollution reduction and provides opportunities for urban biodiversity. Examples of this initiative can be found globally in cities as diverse as New York, Paris, Bangalore, and Buenos Aires. Additionally, urban planning plays a critical role for improving biodiversity levels through urban ecosystem restoration, implementation of urban green and blue infrastructure, biodiversity corridors, and nature-based solutions (Connop *et al.* 2016; Raymond *et al.* 2017) (see 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 chapter 4 and Section 5.4.1).

3.3.3 Freshwater

Urbanization increases soil sealing (Ferreira, Walsh and Ferreira 2018), the covering of the ground by impermeable materials, which interferes with natural drainage patterns, increasing stormwater runoff 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 the groundwater, which may impact drinking water supply, infrastructure, and coastal alkalization (Kaushal *et al.* 2017). These effects are worse in sprawling cities (Lee *et al.* 2006; Chen, G. *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 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, D.S. *et al.* 2019) (See Chapter 4: 4.2) Domestic and industrial wastewater and other contaminants still frequently discharge untreated into water bodies and their in-stream habitats due to inadequate or absent wastewater infrastructure (McGrane 2016). This heavily impacts the quality of water in lakes, wetlands, rivers and aquifers and aquatic life both within

and outside the city (See Chapter 4: 4.2). It causes waterborne diseases, increased regional water stress and higher costs of water treatment. Emerging priority contaminants, such as pharmaceuticals and endocrine-disrupting chemicals, are under-regulated and their long-term consequences on human and ecological health remain unclear. Some Persistent Organic Pollutants (i.e. forever chemicals) cannot be removed by current drinking water treatment measures. Diffuse pollution within cities from solid waste and lawn fertilizer and from rural areas upstream largely due to agricultural fertilizers and pesticides is also difficult to regulate and can severely degrade water resources at local and regional scale. Solid waste also contributes to worsening hydrological hazards such as floods by blocking drainage infrastructure.

Between 1.6 and 2.4 billion people live in river basins that experience water scarcity, and potentially between 3.1 and 4.3 billion people will by 2050, equivalent to between 20 and 30% of the global population (Gosling and Arnell 2016). Urban water demand is projected to increase by 80% between 2018 and 2050 but total available freshwater remains more or less constant (Flörke, Schneider and McDonald 2018). Besides population growth, the economic development that often follows urbanization further increases per capita water use in cities (McDonald *et al.* 2014). The mode of urban water governance (e.g. conventional, integrated, adaptive) further shapes water demand and supply management approaches, including 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, many cities rely on inter-basin transfers for water supply, but these can cause water shortages for communities in supply basins and cause environmental degradation affecting aquatic species (McDonald *et al.* 2014; van den Brandeler 2020). For example, indigenous communities in rural hinterlands of Mexico City had the access to their local springs restricted as water was piped and transferred to the city (Delgado-Ramos 2015; Aragón-Durand 2019). Measures to increase urban water supply (e.g. inter-basin transfers, dams) may thus aggravate urban/rural as well as regional hydro-political tensions (Turton *et al.* 2006; Mgquba and Majozi 2020). Unregulated groundwater use in and around urban areas is depleting aquifers, increasing contamination, and causing land subsidence and subsequent damages to infrastructure below (e.g. pipes) and above 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 the way rainfall is generated due to their artificial thermal properties (i.e. urban heat island effect) and increased particulate matter which enhance 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 concentrated along the coast (Tibbetts 2002). This concentration of development has impacts on the marine and coastal environment at local, regional and global scales. Local impacts include loss and degradation of coastal habitats and ecosystems, and reduction in water quality (See Chapter 4: 4.2). Ports and harbors are sources of pollution and noise and are often sites of historical contamination that may pose an ongoing ecological threat. Impacts that extend beyond the local marine environment include those related to the movement of litter, nutrients and other contaminants (both from discharge and runoff and released into the atmosphere), and invasive alien species. Cities in general, as major sources of atmospheric CO2, drive global ocean warming and acidification (IPCC 2001; Licker *et al.* 2019)

Changes to coastal hydrodynamics as a result of shoreline and catchment modifications can have major impacts on sediment deposition and transport. Research indicates that coastal fortifications, put in place to protect coastal infrastructure from storms and sea level rise, increase coastal erosion in other areas (Gracia *et al.* 2018). Large scale engineering works, like land reclamation, can completely change the coastal environment. For example, Singapore has reportedly lost more than 65% 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 development. Urban population growth also exerts direct pressure on local fisheries around the world (through habitat loss and conversion) and indirect pressure, as seafood consumption continues to rise (Bange *et al.* 2017).

Many urban centers are struggling to manage the increasing volume of solid waste being produced. Up to 80% of litter entering the oceans is thought to be mismanaged urban waste (Li, Tse and Fok 2016), with estimates suggesting that the biggest contributors are dominated by middle income countries whose waste management systems have not kept pace with economic development (Jambeck *et al.* 2015). Litter can accumulate on shorelines, sink to the sea floor or remain in circulation where it can also act as a vector for invasive alien species. It poses a threat to marine organisms and birdlife through ingestion or entanglement (UNEP and GRID-Arendal 2016) and can contribute to GHG emissions (Royer *et al.* 2018).

Cities are also a major source of chemicals to the ocean. These chemicals can be components of discarded materials such as plastic or come from other land-based and marine sources such as storm water runoff, sewage discharge, airborne particulates, shipping and fishing. Microplastics, POPs, heavy metals such as mercury and pharmaceuticals are routinely found in fish and shellfish in higher concentrations nearby coastal urban centers (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 2016). Despite continued improvement in wastewater treatment globally, it is predicted that population growth will outpace progress, resulting in increasing in nutrient discharge into surface waters including estuaries and coasts (van Puijenbroek, Beusen and Bouwman 2019).

3.3.5 Land

Land is a scarce resource, and studies show that urban areas tend to use much less of it for their physical footprint, relative to other forms of human settlements (UNCCD 2017). Cities house over half of the world's population on less than 0.5% of its land (Ritchie and Roser 2013; OECD and European Commission 2020). This per capita 'efficiency' increases with progression in settlement class (from the village to the city) and proximity to the city centre (suburban areas have half as much efficiency as that of urban centres) (European Commission; Joint Research Centre [EC, JRC] 2019). However, consumption-based ecological footprint studies indicate that an average urban resident's indirect or teleconnected (Leisz *et al.* 2016) land-use (accounting for urban needs such as food) could be around 20 times their direct land-use (Zeng and Ramaswami 2020). Further, how this urban footprint gets used and transformed deepens environmental outcomes (See Chapter 4: 4.2).

Studies indicate that the use of urban land in terms of size, form, and quality of urban fabric have implications for local and regional climate (Morote and Hernández 2016; Hanif 2018; Artmann, Inostroza and Fan 2019). For instance, small, dispersed, and stretched cities could alleviate urban heat islands (UHI) (Zhou, Rybski and Kropp 2017), but these forms may result in higher fuel and energy consumption and increased pollution. Alternatively, planned green dense cities may be able to mitigate the UHI risk (Li, Y *et al.* 2020). While increased built-up densities might promote the per-capita land-use 'efficiency', if basic service provision is inadequate, it may increase risk of disease spread and reduce quality of life due to overcrowding.

Industrial land-uses lead to soil pollution with chemicals containing elements such as lead, arsenic, and cadmium (Sharley *et al.* 2017; Kubier, Wilkin and Pichler 2019). Port-cities and their surrounding areas often witness coastal erosion due to hard infrastructure engineering interventions (Sarma 2015; Airoldi, Ponti and Abbiati 2016). To abate such consequences and to promote ecosystem and human health, nature-based infrastructure solutions are gaining prominence (Tzoulas *et al.* 2007; Morris *et al.* 2018). As the built environment and materials contribute significantly to the GHG carbon inventory (Meng *et al.* 2017; Kayaçetin and Tanyer 2020), urban development and infrastructure investment choices made today will affect carbon lock-in for the future (Seto *et al.* 2016) (See chapter 4: circular cities realm).

One of the major telecouplings of urban areas is food production. Worldwide, about one-third of food grown gets wasted at source, on the way to markets, or by consumers (Lipinski *et al.* 2013). Since more than 55% of people live in urban areas, this food wastage may increase urban food prices and emissions as the wasted food decomposes. Indirectly, it contributes to habitat loss as more land is needed for food production, and fertilizers and other inputs are wasted. Many cities are promoting urban agriculture which could significantly reduce the urban ecological footprint, and increase food security (Corbould 2013), although, how this is adopted depends on the specific context of each city (Opitz *et al.* 2016; Clinton *et al.* 2018; Azunre *et al.* 2019; Edmondson *et al.* 2020) (See Chapter 5.2.2).

Land use and land cover (LULC) changes and other land transformations due to urban expansion (EC JRC 2018) and cities' resource needs are happening at the cost of fertile soils and forest cover, further stressing food security (Güneralp *et al.* 2020) and ecosystem services loss (e.g. regulation of water and air quality, habitat conservation, carbon storage) (Xie *et al.* 2018).

Many countries, especially in the Global South, are also experiencing unplanned urban expansion 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 lack of adequate waste management systems (UNEP 2015; UNEP 2019; Satterthwaite *et al.* 2020). These encroachments destroy and fragment critical habitats including those of surrounding wildlife which may cause human-wildlife conflict.

3.4 State and trends of the environment at the city scale

The previous sections highlight two critical aspects regarding urban settlements: how cities are affected by but also contribute to environmental change, and how impacts of environmental change are interconnected. Table 3.1 State of the environment and trends at city scale synthesizes the most important impacts at the city scale, and where possible, provides an indication of the global trend as well as if there are data availability gaps. The table serves to highlight some of the most pressing issues related to the urban environment. The importance of filling these data gaps for environmental management is paramount, as it provides valuable information about the interlinkages across the different environmental dimensions (air, biodiversity, freshwater, oceans and coasts, land) and between people and the environment (UNEP 2019) (See GEO-6: chapter 3)

1825 Table 3.1 State of the environment and trends at city scale

Environmental dimension	Current state and trends	Remaining gaps in knowledge
Air	While certain parts of the world are improving their air quality, it is deteriorating in many cities, exceeding the WHO guidelines for PM2.5 and NO2. Together with GHGs, non-climate air pollutants strongly impact the air quality in urban centers. CO2 emissions, particulate matter (PM2.5, PM10) and some toxic chemical pollutants are the leading environmental health risk factor. This has 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 CO2 and other GHG emissions and resulting in atmospheric concentration means hot temperature extremes, increased droughts and precipitation deficits alongside flooding and increased precipitation, and sea level rise for coastal cities (IPCC 2018). COVID-19 is providing a unique opportunity to study the impacts that reduced emissions have in the short- and long-term on air quality and climate change, which will likely influence mitigation strategies in the future.	Monitoring of air quality is limited in many low- and middle-income cities, as well as in some high-income cities, making proper air quality assessments difficult. In some cities, no monitoring data exists at all. Satellite monitoring data such as Copernicus Atmosphere Monitoring Service can help fill gaps. In addition to air quality monitoring, development of emissions inventories and air quality modeling in lower income countries are needed to get from the sources of emissions to impacts. Integrated Urban Hydrometeorological, Climate and Environmental Systems and Services (IUS) are needed (WMO 2019a). The full spectrum of urban hydro-meteorological and climate hazards need to be considered in a complex manner (WMO 2019a). The methodology for calculating air quality indicators such as an air quality index need to be standardized globally. Better air pollution epidemiology and attribution of specific pollutants to disease burden in the urban centers is needed so that decision makers can target reduction of specific air pollutants to reduce health impacts. Monitoring and emission inventories of common air pollutants on the priority chemicals such as toxic trace metals and cancerogenic and mutagenic Polycyclic Aromatic Hydrocarbons (PAHs).
Biodiversity	Biodiversity is declining globally on all the three main 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 IUCN red list species. These trends are projected to continue into the future (The Nature Conservancy 2018; McDonald et al. 2020). At some scales in cities, biodiversity in terms of species richness may be increasing, due to additions of non-native species (Sax and Gaines 2003; Müller *et al.* 2013) some of which become invasive.	Though biodiversity is decreasing globally, the rate, magnitude, and direction of change in biodiversity can differ according to spatial scale/focus in cities (Sax and Gaines 2003; The Nature Conservancy 2018) and there remain gaps in monitoring. Quantification of urban indirect impacts (e.g., food consumption, energy use, waste production) on biodiversity are less well studied than direct impacts (e.g., loss of habitat) (McDonald *et al.* 2020). Recent IPBES assessments do not analyze explicitly the biodiversity-urban-rural relationship (IPBES 2019). Urban biodiversity studies need a 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) and 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. SDG6 progress shows there are still huge gaps in provision, especially in low income countries. Larger cities increasingly rely on inter-basin transfers. Water shortages increase tensions and conflicts between	Impacts of hydrological disasters in terms of economic and infrastructural damage are difficult to assess due to a lack of reliable data. Flood impact assessment (pluvial, fluvial, coastal, sea-level rise) is challenging due to a lack of detailed topographic/gradient data at the city, neighborhood and even smaller scale. This creates a gap between global datasets and scenarios and targeted local (re)actions. Groundwater data is generally lacking which makes estimates for urban groundwater deficits difficult Irregular groundwater extraction in cities adds

Environmental dimension	Current state and trends	Remaining gaps in knowledge
	urban and rural water users, and between different users in (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, therefore especially sensitive to urban pollution from solid waste, sanitation and chemicals.	challenges to estimating groundwater budgets (Flörke, Schneider and McDonald 2018). Data is lacking on freshwater quality and quantity, and also on water quality of urban stormwater runoff. Impacts on human health and ecosystems from emerging contaminants such as microplastics are not yet clear.
Oceans and coasts	Coastal populations are increasing globally, with urban centers covering 10% of low- lying coastal land (within 10 meters of sea level) (Colenbrander *et al.* 2019). Coastal development is increasing in areas where the population is increasing, threatening coastal ecosystems such as coral reefs, mangroves, saltmarsh and seagrass (Inniss *et al.* 2017; Muñoz Sevilla *et al.* 2019; UNEP 2019). Rising sea levels increases the vulnerability of urban populations to flooding, salt water intrusion and coastal erosion (IPCC 2018; Masselink *et al.* 2020). Recent assessment of the impact of rising sea level (under high emission RCP 8.5) indicate 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 to 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 (number of visitors) and expanding (area) (Jarratt and Davies 2019), increasing pressure on services and the environment. Many large cities are port cities and marine traffic is increasing (Sardain, Sardain and Leung 2019).	Data is required to better predict the timing and extent of coastal change and its impact on urban areas (including human wellbeing and livelihoods and coastal and ecosystems). Monitoring of sea level rise is inadequate in many coastal centers, hampering effective coastal planning and sustainable development The economic cost of loss of services provided by coastal ecosystems is poorly understood (including food production and coastal protection) (Todd *et al.* 2019). There is a lack of data on the impact of climate change on the marine food web and food security (Blasiak *et al.* 2017).
Land	Urban areas are overall more 'efficient' in their land use as compared to other forms of human habitation (EC JRC 2019), but they expand, to accommodate the growing populations and their telecoupled needs, leading to conversions 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. In middle- and higher-income countries, there is greater sprawl (EC JRC 2018). Overall, the per capita built-up area is increasing globally but more in higher-income countries than in lower- and middle-income countries (Paresi *et al.* 2016) City centers are becoming greener (Paresi *et al.* 2016), but the poor are constantly pushed out. Land being a scarce resource, its unequal access is persistent. More people are now pushed to live in exposed spaces (Paresi *et al.* 2016), for example in high-frequency flood zones. The morphology and characteristics of urban green spaces and infrastructure have a clear impact on the quality of the	There are multiple definitions of 'urban', which affects comparative studies and the way data is aggregated to study land use patterns for different size-classes of urban areas. There is a need for a harmonized definition at the global level (EC JRC 2018). The emphasis on administrative land boundaries in the context of cities fails to capture their teleconnected impacts. There is a need for further studies across the administrative and ecological scales of influence to understand urban impact. For instance, more understanding is needed on how land conversion to urban areas is affecting food security in terms of soil and water quality degradation, restricted farmer access to land and the number of farms declining. Similarly, there is insufficient knowledge on the implications of global environmental changes like land degradation, desertification, and deforestation on urbanization processes via migration or reduction in resources required for sustainable habitation.

Environmental dimension	Current state and trends	Remaining gaps in knowledge
	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 also indicate that land degradation and contamination in urban environments will continue (UNEP 2015; Ferreira, Walsh and Ferreira 2018).	There is a lack of green infrastructure asset registers in most low- and middle-income countries (Schäffler and Swilling 2013). Therefore there is a gap in green infrastructure valuation.

3.5 Impacts on health and wellbeing in cities

This section considers the ways in which different populations groups, living in distinct parts of a city and with varying access to services and quality housing, will be affected by changes in air, land and coastal resources, freshwater, and biodiversity. Changes in the urban and environment nexus will have implications for the health and wellbeing of human populations and other species, with differential impacts based on levels of exposure and underlying vulnerabilities such as poverty and health conditions.

While urban areas display great disparities, urban residents may have access to better education, housing, and health care resulting in longer life expectancy (Vardoulakis and Kinney 2019). However, wealthier population groups 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 2016a). Socio-economically disadvantaged population groups are typically exposed to higher levels of air pollution, live in crowded places and sub-par urban services, and are more vulnerable to infectious disease outbreaks.

In particular, in lower- and middle-income countries, low-income urban populations and those living or operating in the informal sector face the highest levels of exposure to the negative consequences of environmental change. They will face bigger challenges due to their limited access to reliable and sufficient incomes, services (ranging from healthcare and education to financial services) and adequate housing and risk-reducing infrastructure (IPCC 2018) (see chapter 2). This has created a double burden of communicable and non-communicable diseases in these communities (Sverdlik 2011). Yet, protecting vulnerable population groups has positive health and wellbeing benefits for everyone in a city. Informal settlements are often located in marginal or poorly-connected areas of cities where land has less value, where residents are more exposed to hazards such as riverine or coastal flooding, landslides or subsidence, combined with the insecurity stemming from insecure land tenure and inability to access insurance (Dodman

and Satterthwaite 2008; Satterthwaite *et al.* 2020). Informal employment represents more than half the urban workforce in most countries of the Global South; especially in South Asia (82 percent in informal employment) and sub-Saharan Africa (over 66 percent) (Chen, M., Roever and Skinner 2016). This informality means they lack job security and access to social services, increasing their vulnerability to market crashes and other shocks such as COVID-19. Informal, migrant or refugee urban populations may be marginalised by urban governance and legal processes when they are not recognised as residents of the city through house registrations or voter registrations, so their voices may not be heard in planning decisions which will affect their lives and livelihood (Roy, A. 2009).

These underlying vulnerabilities may intersect with other factors: migrant populations (Chu and Michael 2019), refugees or internally-displaced persons, and those from ethnic or religious minorities (Pearson *et al.* 2017; Illingworth *et al.* 2018) may face barriers in accessing relevant information about climate change or other environmental stressors, and may lack the resources to take necessary coping or adapting measures. Women may face a disproportionate care burden (Chauhan and Kumar 2016) threatening their income-earning potential, while home-based workers may face a double impact if their homes and assets are damaged or destroyed by hazards (Alber, Cahoon and Röhr 2017). Where extreme events brought on by climatic change cause damage to assets and property, people lacking disaster insurance and tenure security are most vulnerable as they may be unable to recover their lost assets, which may 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 experienced in urban contexts such as water contamination and air pollution, will have disproportionate impacts on 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 2016). 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). Exposure to pollution in air, water, and soil is associated with increased cardiovascular and respiratory diseases, neurological damage and cancer incidence. Non-communicable diseases, including diabetes, cancers and cardiovascular diseases, linked to unhealthy diets, sedentary lifestyles and environmental pollution, are more prevalent (The Lancet 2012). Transmissibility of infectious diseases is higher in over-crowded

urban environments, challenging public health services and exacerbating existing socio-economic and health inequalities.

While loss of life from extreme flood events appears to be in decline due to improved standards of living and better disaster risk management (United Nations Office for Disaster Risk Reduction [UNDRR] 2019), the number of people exposed to extreme weather events has risen (Pahl-Wostl 2015). The global economic and infrastructure damage to cities from disasters is difficult to assess due to a lack of reliable data, however, 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 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. These include women and children working in the informal and care economies and home-based workers.

Let us consider the ways in which urban residents are affected by changes in each sector.

3.5.1 Air

Increased emissions of GHGs, other pollutants and anthropogenic heat to the atmosphere have implications for urban residents through higher temperatures, increased droughts and floods, and for coastal cities, sea level rise. The quality of dwellings and access to cooling systems will be a function of affordability, while population groups such as the elderly are particularly vulnerable to night-time exposure to elevated temperatures (Murage, Hajat and Kovats 2017). Exposure to air pollution both indoors and outdoors accounts for about 1 in 9 deaths (or over 7 million deaths in total) every year worldwide (WHO 2020a), with most of these deaths 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), while short-term exposure has been associated with increased daily mortality in cities (Liu, C. *et al.* 2019) and asthma exacerbations in children (Bouazza *et al.* 2018). Increased temperatures and changing weather patterns, especially stagnation events and a decrease in rainfall due to climate change, contribute to poor 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 dry and hot 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).

3.5.2 Biodiversity

Principally, biodiversity loss will affect urban residents through a reduction in many ecosystem services - provisioning services such as food, medicines, and fuel; regulating services such as clean water and air; and cultural services such as recreational enjoyment and spiritual fulfillment (TEEB 2011; Elmqvist et al. 2013; IPBES 2019). Low-income urban dwellers in developing cities remain heavily dependent on green and blue infrastructures and connected biodiversity for their contributions to well-being, but these are experiencing a reduction in quantity, quality and diversity as well as an increase in exposure to environmental risks, which will be exacerbated by climate change (Roy, M. *et al.* 2018). Almost half of the human population depends directly on natural resources and biodiversity for livelihoods, including many of the world's vulnerable people (CBD 2016). This has important environmental justice, gender and equity implications, as access to biological resources is currently uneven across different groups of people and the reduction in services may exacerbate this. The vulnerability of people and urban ecosystems are intertwined. For example, riverine ecosystems are vulnerable to changes in water flow as well as human mismanagement such as the release of raw sewage or dredging; this will create vulnerabilities for people who depend on the river for food, water or other services (Roy, M. *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, M. *et al.* 2018). Poorer populations may therefore be adversely affected by both development which destroys natural resources such as the infilling of ponds, or the converse, the designation of protected areas which limit access to those who use them to supplement their income or food supply (see Chapter 2).

Biodiversity can also have negative impacts on urban dwellers' health that must be prevented. One example is zoonotic diseases, illnesses that jump between animals and humans (e.g., Ebola, MERS, West Nile fever and COVID-19) (UNEP 2020). Urban development, environmental degradation, climate change, and increased demand for meat in diets are bringing humans and animals closer together in cities and facilitating the emergence of zoonotic diseases. Greater attention to integrated treatment of human, animal, and environmental health can help to prevent and reduce risk of zoonotic disease development and spread (UNEP 2020).

Urban biodiversity has also been shown to have direct positive impacts on physical and mental health and wellbeing (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 (those biological resources that are particularly culturally valued) (Maffi 2005; Maffi 2018) and the persistence of traditional ecological knowledge (Maffi 2005; Raymond *et al.* 2010) and social-ecological memory (Barthel, Folke and Colding 2010) where those losses occur. Further declines

in biodiversity would also result in urban dwellers having less contact with nature, a decrease in environmental literacy and an "extinction of experience" that can create negative impacts on health and wellbeing (Louv 2008; Soga and Gaston 2016). This may generate a need for reconnecting people 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).

3.5.3 Freshwater

Sustainable water management requires a balance between competing goals and trade-offs involved in ensuring sufficient and safe water for human well-being, food and energy, and for nature (i.e. 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 (i.e. less available water, deteriorated quality and increased costs). In rapidly developing and urbanizing nations that have not yet implemented comprehensive measures to control and treat pollution at the 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) though this is not a guarantee of water quality and reliability, and only 39% 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). Although access in urban areas is higher than in rural areas, 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 over-estimated in some cases as informal settlements are not always counted in the data and because of differences in the level 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 often of unknown quality, due to the absence of water delivery from a public supply network (UN-Water 2017; Mguni et al. 2020) . Inadequate sanitation leads to the pollution of waterways and coastlines, and affects urban dwellers' health (e.g. waterborne diseases) and well-being, especially of women and girls who depend on inadequate public sanitation facilities (UNEP 2019). The COVID-19 outbreak has highlighted that the difficulty to practice good handwashing hygiene in marginalized urban areas disproportionately exposes these groups to infectious diseases (WHO 2020b; Van Belle *et al.* 2020).

Meanwhile, shrinking cities in the Global North experience reduced water demand, leading to water stagnation and increasing the risk for bacterial growth and microbial contamination in pipes (Naumann and Bernt 2009). Water quality also deteriorates due to aging or inadequate

infrastructure (e.g. lead pipes), lack of regional planning (Morckel 2017) and a lack of regulatory compliance (Allaire, Wu and Lall 2018).

3.5.4 Oceans and Coasts

Sea level rise, coastal erosion, storm surges and coastal pollution have direct and indirect effects on the health and wellbeing of people living in coastal areas including those in coastal cities. For example, coastal flooding (the most common natural hazard), 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 ground water which can affect health.

Cities are major sources of pollution to the coastal zone. This can impact city residents as well as those outside the city. The economic and social costs of marine litter and chemical pollution on cities include indirect costs such as loss of amenity, disruption of tourism, and decline in 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 (however, 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).

3.5.5 Land

Land, although a critical requirement for human well-being, is still highly scarce and inequitably 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 the marginalized populations, most significantly the poor (UNEP 2016; UNEP 2019) (See Chapter 4: 4.2 and Chapter 2: 2.2).

Governance of common lands is highly contested and various actors take advantage of this to undertake construction activities that result in unwarranted environmental degradation such as biodiversity losses, the loss of access to certain resources by many city dwellers, and increased surface runoff, among others (Vencatesan *et al.* 2014; Jain *et al.* 2017; Steel, van Noorloos and Klaufus 2017). Evidence shows that clear recognition of traditional and de facto land rights and land ownership or tenure incentivize self-investments, leading to significant reduction in urban land degradation, improvements in waste management, and overall health and well-being of people and places (Ding *et al.* 2016; Amour *et al.* 2017*;* UNCCD 2017).

As urban consumption patterns remain unsustainable, solid waste management also remains an integral challenge in the waste-environment-public health nexus (see Chapter 4: Circular cities realm) (UNEP 2018b). Developing cities, in particular, are currently struggling with solid waste management crises which disproportionately affects the poor, especially informal recyclers exposed to these hazards and those living in informal settlements close to waste dumps (Tvedten and Candiracci 2018; Doherty and Brown 2019). Increasing populations, unsustainable consumption patterns, and increased demand for natural resources to sustain their needs (e.g. steel and concrete) are also resulting in unsustainable production practices such as excessive resource extraction through mining (See Chapter 4 : and Chapter 5). This may hinder the achievement of SDG 12.

Since urban growth is expected to vary across regions, it is likely to pose a severe sustainability concern, especially in Africa and Asia, reducing 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 poor governance systems in these regions, distributing the impacts disproportionately amongst their populations. Overall, how land is governed will have locked-in implications for the social and environmental equity outcomes for future generations.

3.6 Interacting impacts and urgency to act

This chapter has demonstrated how cities and their wider environments are intricately linked – and how human life and the environment in cities is affected by changes in the environment beyond cities, as well as activities within cities. The most relevant impacts of urbanization on air, biodiversity, freshwater, land and oceans and coasts have been outlined, and it is evident that the impacts are interlinked. The pressures further interact in synergistic ways that exacerbate environmental degradation and the deterioration of human well-being. Adapting to environmental change and the mitigation of these impacts is essential for achieving the SDGs not only in the urban environment.

Cities do however create the opportunity to act and mitigate these impacts on a large scale, by addressing environmental, economic and social sustainability, physical and community resilience, and inclusionary multi-species governance. These need to be addressed together at different administrative, spatial and temporal scales in order to address the environmental challenges faced by and caused by cities. A sectoral approach is insufficient, rather there is an urgent need for integrated approaches that consider the interlinkages of the urban-environment nexus, that incorporate nature-based solutions, that explicitly consider people and planetary health, leading us towards a better future for all. This will be considered in the forthcoming chapters.

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4 Urban Visions

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Key Points

Cities and metropolitan regions contribute to environmental and climate crises but also can be part of their solution. This chapter presents a broad, flexible *vision for future cities* that if realized, would allow cities to help avoid planetary points of no return. This vision arises from scientific evidence and case studies, and forward-looking ideas about how changes in policy, practice, and behavior could lead to their realization.

With this vision, we identify three areas of urban action – or '*urban realms*' – involving 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 behaviors, and multispecies interactions.

For each realm, *specific goals* for the future include energy and material efficiency and circularity; resilience and sustainability; and social inclusion and multispecies justice.

These goals are consistent with *global conventions and agreements* related to development, sustainability, disaster prevention, resilience, biodiversity conservation, and climate.

Diverse *transformation pathways* tailored to local-regional specificities, priorities and capacities (detailed in Chapter 5) set of *transitional actions*.

Much of our planet's economic, social, and political life plays out in diverse cities - urban and suburban places, dense urban cores and satellite cities, and expansive metropolitan regions (cf. Chapter 2). Cities account, directly and indirectly, for most of energy and material consumption, greenhouse gas (GHG) emissions, and waste generation worldwide (Seto *et al*., 2014; Bynes and Musando 2018; UNEP-IRP, 2018; Kaza *et al.*, 2018). Impacts of such resource consumption and waste/emission generation span the globe and have subsequent effects (cf. Chapter 3).

The scale of urban impacts depends on *how cities work*: how we produce goods and services; how we plan, design, and build; and how we live, feed, work, travel; and how –and who– governs the metropolis. Thus, if we hope to avert the environmental and climate crises of the Anthropocene, we

need to reimagine our urban futures by addressing how cities evolve and work, and who participates and benefits.

Cities offer the potential to radically change our current trajectory of accelerating climate change, environmental degradation, and social stress. To see how cities could become part of the solution to these collective challenges, we offer *one multi-dimensional, flexible, and comprehensive vision for an urban future* that addresses efficiency and economic organization, the built environment, and governance for urban planning. As part of this vision, we identify three areas of urban action – or '*urban realms*' which are not blueprints for urban change because priorities and implementation timescales may vary. Instead they focus on rethinking current structures, institutions, policies and behaviors, and move toward more sustainable, resilient and socially just futures in both, the Global North and the Global South, in order to disrupt entrenched ideas about cities and urban life.

Cities as Opportunities: Using Local Turning Points to Avoid Global Tipping Points

The global environment is in crisis, driven by the socio-economic and political organization, as well as cultural practices of contemporary human life. The crisis is localized in cities around the globe (or more generally urban regions; cf. Chapter 3), but patterns of urban life themselves also underlie the global crisis. In a rapidly urbanizing world, we must accept that cities have a major responsibility for ensuring a sustainable and inclusive planetary future.

Yet cities can also be *global turning points*, opportunities for moving to more sustainable, healthier, low carbon, resilient, inclusive and just ways of living.

Can cities take advantage of appropriate levels of responsibility and implement equitable transformative actions? The challenge is to confront (a) entrenched limitless growth ideologies manifest in powerful economic systems; (b) social inequalities across age, gender, class, race/ethnicity, caste, religion, ability and other forms of difference; and (c) accelerating environmental and climate change. Ingrained everyday practices –what and how much we consume, where and how often we travel, what we save or add to the waste stream– and widespread expectations of continually expanded consumption opportunities, profoundly influence the potential for success or failure. To prosper, pathways forward must grapple with the challenges of decoupling the material bases of life from economic dynamics, address planetary boundaries, respond to urban systems complexities, work across scales to design comprehensive solutions, and confront the politics and cultural practices involved.

But since cities and urban regions –and their institutions– are so diverse, there is no one-size-fits-all set of solutions (Prieur-Richard *et al.,* 2019; Bai *et al.*, 2018; see Chapter 2). Accordingly, co-production of knowledge and co-generation of potential solutions across a wide range of cities that support local capacity-building, participatory urban governance, and accountability, are vital (Prieur-Richard *et al.*, 2019; Solecki *et al*., 2020). Social learning maximizes potential co-benefits, integrates trade-offs, and handles undesirable outcomes of approaches implemented at different temporal and spatial scales. Lastly and crucially, cities need stable funding from global, national and state governments sufficient to meet challenges on the ground. The funding required will stretch fiscal capacities in even the wealthiest countries in the best of times, let alone middle- and low-income countries during economic downturns or crises, such as the crisis created by COVID-19 (although some crises may present opportunities to accelerate positive transformation as explored in the Cape Town Resilient Pathway case study in Chapter 5). Windows of opportunity that arise during crises may bolster business as usual practices if they are not profitable. In most of the COVID-19 economic recovery plans, as of May 2020, only 4% of the 7.3 trillion dollars in spending was for "green" productive investments with mid- to long-term returns (Hepburn *et al*., 2020). Accelerating such green investments, however, could promote sustainable and resilient urban change while reducing intra and intergenerational inequities if correctly designed (Hepburn *et al*., 2020; Solecki *et al*., 2020).

Cities are part of a continuum of a globalized but also site-specific built space. Cities thus need an articulated and coherent future vision to guide flexible agendas, plans, and coordination agreements. Such visions must recognize key aspects of cities: social diversity, spatial interlinkages; complex teleconnections; and capacity constraints on urban governments and civil societies to develop/implement policy. Moreover, institutions and urban residents must be willing to revisit prior decisions when circumstances change, and grapple with the fact that cities exist within larger organizational systems. Action plans need to be tailored to varying degrees of local autonomy and democracy, and to the extent possible, empower all types of residents as key actors. They must overcome the asymmetries between/within cities in terms of economic, political and social structures, cultures and institutions, patterns of injustice and exclusion, and everyday practices (UNEP 2019; Swinburn *et al.*, 2019; Biermann *et al*., 2016).

4.1 Future Cities: Envisioning Three Realms 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 diverse practices, pathways and practices need to emerge from an integrated approach in order to deliver the desirable impacts on climate, environment, human health and social life. To become solutions rather than problems, future cities must then address primary arenas of urban life and collective action –what we here call *realms of environmental, economic and social sustainability; physical and community resilience; and inclusionary multispecies governance.*

Cities are both blamed for and burdened by critical environmental challenges, some of which – chemical pollution and plastics - may persist for many decades to come (cf. Chapter 3). Moreover, while ongoing economic globalization may continue to drive economic and population growth and land expansion in some cities, other urban regions may be hollowed out as their economic base becomes obsolete or moves elsewhere and population shrinks, leaving a legacy of abandoned neighborhoods and stranded pollution hot-spots (cf. Chapter 2).

Therefore, cities must seize opportunities and catalyze transformative change while still burdened by environmental degradation, economic hardship, and social problems. Cities can catalyze transformative change through innovation, education, employment, economic diversity and economies of scale, entertainment and cultural interaction (Bai *et al.*, 2018; Vardoulakis and Kinney 2019; IPCC, 2018; Solecki *et al*., 2020). By using integrated approaches, cities can also account for the cross-cutting nature of urban dynamics in order to be forward-looking while also addressing a wide variety of legacy challenges. Using this as a basis to reimagine, redesign, remake and rebuild cities in ways that contribute, on one hand, to justice, equity and inclusion, and on the other, to sustainability, resilience, adaptive capacity, and climate change mitigation.

This is the vision we aim to describe here through the articulation of three primary urban realms that lie at the heart of how cities work and how we can reshape them if such realms are addressed as a whole while considering urban diversity:

- **Realm 1: Circular Cities:** achieving massive reductions in natural resource extraction, GHG, and other forms of pollution, and waste.
- **Realm 2: Resilient & Sustainable Cities:** protecting vulnerable urban places and populations from environmental degradation, climate change impacts, and extreme events – including associated disasters as well as everyday hazards.

- **Realm 3: Social Inclusion and Just Cities:** embracing the inclusion of all urban residents, urban nature and biodiversity, and desirable governance frameworks to do so.

To achieve the goals of these three realms, policy, regulation, funding and accountability at national as well as lower tier governmental units are fundamental. Such units may have access to critical policy levers and capacities to act, while the private sector, social movements from below and multiple individual actions may also propel changes that can lead to healthier and more livable cities, and certainly more inclusive and socially equitable societies.

The three urban realms, as said, are interdependent (Figure 4.2). A full urban transformation thus, requires a comprehensive approach of all three urban realms and the forces and dynamics that shape and reshape them. This includes multi-temporal and multi-scalar economic, financial, political, technological, social, and cultural dynamics and influences.

Urban Realm 1: Circular Cities: urban metabolism, efficient socio-technical systems and built environments

Despite urban dependencies on inflows and outflows of energy, materials, and information, cities can play a crucial role for advancing sustainability and resilience. Urban transformation can happen if use of inflows become dramatically more efficient from a systemic –not only sectoral– perspective along with substitution of renewable sources of energy even in the context of a globalized economy; Uzar, 2020; Zeren and Aklus, 2020) and behavioral and institutional changes (see Realm #3). Sustainable domestic material consumption in cities, for example, has been proposed at a range of 6-8 tons per capita as an indicative target, however, a business as usual scenario will take us to an average urban domestic consumption of up to 14 tons per capita (UNEP-IRP, 2018). Urban efficiencies in transport, buildings, heating and cooling can reduce such consumption estimations about 46 to 67 per cent (UNEP-IRP, 2018).

Because buildings constitute the physical fabric of cities and urban regions and are responsible for a large share of GHG emissions, Realm #1 looks closely at buildings and building operations from a resource efficiency perspective – particularly relevant since buildings are usually under direct local government control. Urban transportation is another major energy consumer and contributor of pollution, as already noted. Because transportation so powerfully shapes land use, access and mobility, however, we consider interventions in transportation within Realm #2, which deals with resilient and sustainable urban form.

In what follows we draw on the systems-based framework of urban metabolism, including ideas from industrial ecology and socio-ecological economics, to envision circular urban economy approaches (Friant *et al*., 2020) powered by efficient socio-technical infrastructures, which involve incorporating novel technologies into social behavior, everyday life and the structures and strategies of urban institutions.

What does Realm #1 look like?

First, imagine cities whose economies are designed for cradle-to-cradle material, energy and water flows (e.g., Mohan *et al.*, 2020; Maranghi *et al.*, 2020; John *et al.*, 2019; García-Guaita *et al*., 2018; Koutamanis *et al*., 2018; Ferrao and Fernández, 2013; Behhzad *et al.,* 2018). This means:

- Sourcing materials from discarded products to make new products 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 and household waste into new stocks of materials for manufacturing and utilization of manufacturing by-products by other industries that need such by-products (e.g., Xavier *et al.*, 2019; Arora *et al.*, 2020);
- Collecting, sorting and recycling electronic and electrical equipment waste into new stocks of materials for manufacturing;
- Reducing waste through secondhand markets or sharing platforms (Ghisolfi *et al*., 2017; Parajuly and Wenzel, 2017; Ardi and Leisten, 2016);
- Collecting, sorting, and sending edible food to those who need it, and composting all organic waste for urban/hinterland nutrient cycling (Lin *et al*., 2014) and agriculture (Edmondson *et al.*, 2020; Bahers and Giacchè, 2019; Wielemaker *et al.*, 2018).

Since not all materials will be locally available, imagine a regionalized cycle of production-consumption powered by clean electricity that mobilizes proximate resources in urban peripheries. This regionalized system stimulates the economy and provides jobs for a wide range of people in these exurban communities (Fratini *et al.*, 2019). For energy and materials sourced from further afield, a transparent and spatially explicit materials flows tracking system would monitor nodes along the supply chain and encourage collaboration on issues of health equity, worker justice, and environmental justice (John *et al*., 2019; Guibrunet *et al*., 2017; Cousins, 2017; Delgado and Guibrunet, 2017; Davis *et al*., 2016). Ideally, such monitoring systems would clearly reveal urban dependencies critical for urban resilience as well, and uneven urban development and dynamics. Such knowledge can empower both citizens and decision makers to implement actions for the long term.

Achieving circular urban production/consumption systems depends on a set of profound changes in the structure of the global economy as well as the local economies that both drive it and react to its dynamics. Most critically, the priorities of economic actors need to be reordered and a new value proposition embraced, to overcome deep seated structural barriers (cf. Chapter 2). Priorities must move away from the current emphasis on the 'financial economy' (stock markets, financial speculation and wealth generation) that primarily benefits its actors and institutions. Instead, healthy economies focus on the 'real economy' –production/consumption of goods and services– and the values it produces for workers and households, communities, society and life in general.

The guiding question for building such healthy economies is what we expect them to deliver, which in turn connects to our understanding of development and the importance we place on supporting human capacities for all on a finite planet. The material basis of human life is relevant for addressing poverty eradication and advancing social equity, yet such a basis must be built from a careful and collectively organized management of commons, including climate and biodiversity, if resilience and sustainability are to be equally addressed (IPSP, 2018). Priorities, some of which are aligned with the green economy paradigm, must therefore turn to responsible private sector production, jobs, and wages; public sector employment and collective consumption goods/services (such as social safety nets); and communities and households whose health and well-being are at the core of any economy's ability to persist and thrive over time (Ibid).

Second, imagine cities in which many buildings, both old and new, urban and suburban, are energy and material efficient, able to be their own power sources, and moreover, climate-ready for both, adaptation and mitigation; the later highly relevant for advancing decarbonization efforts. In this scenario, some key actions to consider are:

- Renewables such as roof-top solar (photovoltaics and solar concentrators); wind turbines or geothermal building energy; or renewable energy provided by solar farms and wind turbines in the urban hinterland (also generating resources and jobs for hinterland residents; Arabzadeh *et al.*, 2020; Bagheri *et al.*, 2018; Bracco *et al*., 2018)
- Distributed public-infrastructure and neighborhood-scale energy generation systems, as well as new building envelopes generate their own power (Sarralde *et al*., 2015; Bagheri *et al*., 2019; Mohajeri *et al*., 2019)
- Buildings and districts designed to be off-the-grid, rely on renewables that relieve pressure on the grid, or that through design, reduce energy consumption by using passive heating/cooling, daylighting, energy recovery ventilation, and even battery systems to store excess green energy for when it is needed (Dabaieh and Johansson, 2018; Sudhakar *et al.*, 2019)

If enough new buildings produce excess renewable energy, they can offset energy use by older buildings that, as needed, can be renovated gradually with more sustainable and climate-ready modifications (Dávi *et al*., 2016; Mokhtara *et al*., 2019; Moran *et al*., 2020; Kim *et al*., 2020). Supplying electricity to the vast numbers of buildings that currently lack access to formal provision can be accomplished via smart and climate-ready grids, and through projects that rely on collaborative governance schemes at local-regional and national levels (de Reuver t al., 2016; Winfield and Weiler, 2018). Buildings' energy and material footprints, either residential, commercial or offices, would need to be reduced through modifications, redesign and retrofitting. Yet footprints of substandard housing might increase, to improve dwellers quality of life and resilience. Where such homes are informal housing, improvements would be linked to a process for formalization of tenure (typically required for formal access to public utilities and services) that takes into account the complexity of informal settlements, their low metabolic dynamics, and the cultural and social contexts in which they are embedded (Smit *et al.*, 2017).

Think of buildings that collect and use rainwater on site. Greywater can be reused within buildings, by living walls and green roofs (with co-benefits such as cooling, air filtering and improved aesthetics; Pradhan *et al.*, 2019), and around the city, collected, treated, and reused at the most local level possible, limiting the need for water imports from elsewhere (Yoonus and Al-Ghamdi, 2020). Nature-based solutions such as bioswales can retain water on site to support landscape and habitat, and rainwater harvested on rooftops or through other small-scale systems can become a resource rather than a nuisance to be rapidly disposed of downstream (Khirfan *et al.*, 2020). Such 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. Using such small-scale systems decreases stress on stormwater infrastructure, and reduces the risk of stormwater overflow and floods, as demonstrated by strategies being implemented in Mexico City (Delgado *et al.,* 2020) and Wuhan (Dai *et al.*, 2018).

As fundamental changes in business, industry, and labor markets occur during the transition to a circular urban economy, picture how the development of new start-ups, factories, workshops, cooperatives, training centers, social and health care centers, and public programs could look if purposely crafted to address profound social and economic inequalities and disparities in health and well-being (rf Ch 2). Such efforts can provide training, meaningful livelihoods, better health and prosperity to those who live on the economic margins. This, in turn, can close gaps between haves and have-nots and transform cities from places of deep inequalities –informal settlements next to glittering skyscrapers– into places that welcome economic participants regardless of social

difference. Every neighborhood, however modest or informal, can be a healthy place of hope and opportunity created by a circular economy guided by principles of human prosperity, equity and justice (Schrôder *et al*., 2020).

The idea of Circular Cities does not imply that the introduction of novel technologies is free of impacts, neither that levels of consumption will need to decline across the board. 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. Thus, while we need absolute advances in aggregate efficiency of urban resource utilization, those advances should be distributed differentially. Some people and cities will need to radically reduce their consumption patterns, while others will need to consume more while avoiding waste through innovative, low-tech waste reduction, recycling and avoidance technologies.

How do we get from where we are now, to Circular Cities? Transformation pathways (Chapter 5) will be necessarily customized according to each city's circumstances, characteristics, and politics. There is no standardized solution as some efforts in cities such as Rotterdam and London, and a wide range of Chinese cities already demonstrate (Gemeente Rotterdam 2016; LWARB, 2017; Prendeville *et al.,* 2016; Wang *et al.,* 2018). Yet, many cities are moving aggressively toward what are often termed 'net zero' buildings, understood as those that minimize their operating energy demand through design, and meet their ongoing energy needs through renewables and district heating/cooling strategies (Lützkendorf and Balouktsi 2019). And a variety of studies indicate the possibility for major gains where cost effectiveness is enhanced through reorganization of utilities to better align incentives for conservation and maximally efficient production infrastructure (Pero *et al*., 2019; Laine, Heinonen and Junnila, 2020; Terés-Zubiaga *et al*., 2020).

In what follows, we highlight two major arenas where actions designed to move cities toward circularity are imperative: urban metabolism (arising from production and consumption patterns), and buildings.

1. **Urban metabolism**: By urban metabolism, we refer to how cities import resources, circulate them through production and consumption subsystems and generate waste as residuals. The resources imported 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, to food and building materials. Visions around urban metabolism call for a comprehensive approach

that furthers efficiencies for urban systems through adjustments in individual, socio-cultural, and managerial/operational business practices. Such adjustments in practices may accelerate with the introduction of novel technologies to achieve relative and absolute efficiencies within urban socio-technical infrastructures governing social processes, market structures, regulatory regimes and governance arrangements (UNEP-IRP, 2018). By coupling urban integrated planning and resource management, a metabolic shift can achieve aggregated results not possible through isolated interventions or BAU approaches. If following current trends, by 2050, the total urban consumption would be about 90 billion tons globally which is 50-60% more than total global urban and rural, energy and material consumption estimated for the year 2000 (UNEP-IRP, 2018).

Given the urban land use, density and form context, a combination of resource-efficient technologies and diversity of actions, from building designs and codes, energy generation, and transportation, to waste management should yield greater results. Despite uncertainties of estimating the potential scale of such combined interventions, a clear positive outcome is likely. Under a resource-efficient scenario, cities may expect a 5 to 20% decrease in land use, a 5 to 30% reduction in metal consumption, a 35 to 50% decrease in water consumption, and a reduction of 30 to 50% in GHG urban emissions (UNEP-IRP, 2018). Such achievements may be greater under a strategic densification scenario –where transportation plays a crucial role– with levels of 20 to 40% reduction in land use, 30 to 50% in metal consumption, 36 to 60% in water use and 40 to 60% in GHG emissions (UNEP-IRP, 2018).

Implementation of an urban metabolic approach requires multiple actions (see Figure 4.2), from measures related to urban inflows and measures to progressively reduce and close urban outflows. Actions also include improvements that urban form, urban densities and land use planning can enable, as discussed in Urban Realm #2. These include:

- 'End-of-life' regulations for consumer and industrial products, beginning with those with the largest impacts on urban metabolism, particularly energy flows
- Closed-loop consumer products that can be returned to producers for material mining; technology and infrastructure to create innovative industrial ecologies (both low and high tech), production methods and materials, and physical, financial and institutional infrastructure for recovery, recirculation, and sale of materials and for markets for recovered materials

- Formalization of waste and recyclables collection, partnering with or incorporating informal economy workers into recycling operations offering training, safe and healthy working conditions, and living wages (for European examples, see the Urban Waste project http://www.urban-waste.eu/)
- Improved, standardized models of material flow analysis (MFA) that assess, monitor, and identify needs for remediation in the spatialized urban circular economy footprint, and linked together, capture the non-linear and unbounded nature of these flows.

Transitional measures include *establishing material exchanges* and funding *best available technology recycling centers* offering jobs and training. Lisbon provides another example of transitional steps in their creation of *matrix models* of energy and water, (AEAL, 2015 and 2016). Developing *circular urban metabolism models and data collection protocols* can also contribute to the shift (Petit-Boix and Leipold 2018; Dijst *et al.,* 2018; Westin *et al.,* 2019; Lucertini and Musco 2020). In addition, construction materials and building design will need to promote durability while facilitating the reuse, recycling, and avoidance of build material waste. Many cities are already on this pathway and have made serious commitments under the auspices of C40's Zero Waste Declaration.

2. **Efficient buildings:** A wide mix of strategies is essential to achieve maximum building efficiency in terms of energy, water, and waste. Particularly relevant are two type of commitments:

    - National and/or local assessment standards ensure that all new construction and major retrofit projects and building operations minimize energy, water use, and waste production. For example with energy, such standards would require projects to put energy back into the grid or use energy offsets from green power where location, climate or building type preclude achieving operating energy self-sufficiency (Thomas *et al*., 2018). Standards can also set aggressive criteria for water use, municipal waste and building debris, especially in low-income peripheral neighborhoods and countries where such debris is now often dumped/shipped (Tauhid and Azwani, 2018; Duan *et al*., 2019; Ram *et al*., 2020; Lederer *et al*., 2020; Bao and Lu, 2020).
    - National and local commitments to retrofit cities to upgrade existing building stock (UNEP-IEA, 2020a and 2020b). The built environment is durable, and older building stock will be in use for decades if not centuries. Programs to make this existing stock more efficient are critical. Although there may be tension between historic preservation and sustainability-driven retrofits, it is also true that historic preservation itself is a fundamental sustainability strategy since it often avoids much of the carbon intensity of new construction (Foster, 2020).

These commitments could ensure that all dwellings –including those in informal settlements or refugee camps– are structurally safe, provide residents with efficient heating, cooling, sanitation, and good indoor air quality (free from chemical and microbial contamination). Standards would also empower residents to guide neighborhood evolution toward efficiency goals while respecting cultural values, practices, and patrimony, and make sure that construction and/or debris does not burden unfairly vulnerable communities.

In addition, transitional, context-sensitive measures are needed to reduce aggregate global energy demand, but also to correct inequities in energy consumption between cities in the Global North and South. These include:

- Best practice life-cycle analysis requirements for new construction or retrofitting of individual buildings and multi-building projects;
- Renewables for buildings, including solar, wind, geothermal, and micro-grids;
- Renewable energy facilities, building debris and municipal waste reduction and recycling programs, some of which may be located in regional hinterlands;
- Water quality, supply, and conservation programs, integrated into new building codes and procurement requirements (Bilal *et al*., 2020); and
- Water, nutrients and energy recovery from municipal wastewater streams to offset nutrient demand in agriculture, minimize eutrophication of urban water supplies, and recover embedded energy in wastewater (Qadir *et al*., 2020; Kakwani and Kalbar, 2020).

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

Circular Cities support public health by improving environmental quality; providing livelihoods, opportunities for active travel, enhanced and public transport infrastructure, and local-regional access to healthy food, and reducing adverse health risks and exposures. Achieving this will require sustained mobilization, supported by grassroots organizations and urban communities, national and subnational governments, organized labor, business, the academic sector, and industry. In particular, current administrative boundaries in many urban regions may require reconsideration or the establishment of state-level and/or regional governance structures with capacity to act (cf Ch 2). Jurisdictional fragmentation in metropolitan regions can distort industrial investment decisions while uniformity in building performance standards encourages widespread compliance. We could then look forward to cities whose economies are designed to connect the dots through cradle-to-

cradle material flows both within the city and to exurban or hinterland areas to maximize sustainability, building city-hinterland relations in a mutually beneficial, non-extractive way that supports both urban and adjacent rural economies and livelihoods.

A transition to Circular Cities will certainly face challenges and involve the pursuit of intelligent evolutionary transformational pathways (cf. Chapter 5). But this transition is also an opportunity to make important supplementary changes, including remaking the urban physical fabric with new opportunities for adaptive reuse and building urban resilience and sustainability (relating to Urban Realm #2). This would occur through built environment design/redesign, siting of circular economy facilities and activities in areas needing economic development/investment, and strengthening local networks with shorter communications and feedback loops that enhance resilience. Also, encouraging deliberative and participatory schemes can avoid over-reliance on technology fixes that counteract against vibrant and more sustainable local economies. The involvement of communities, through citizens assemblies formally incorporated in decision-making processes, as well as autonomous citizen-based coalitions and networks, can actively contribute to urban social equity, inclusion and health. Examples include Sustainable Seattle [http://www.sustainableseattle.org/], *Climate Assembly UK* [https://www.climateassembly.uk/], and a similar French initiative, the *Citizen Convention on Climate* [https://www.conventioncitoyennepourleclimat.fr/en/]. Other formally based initiatives are an expected outcome of the *Escazu Agreement* on Access to Information, Public Participation and Justice in Environmental Matters [https://www.cepal.org/en/escazuagreement].

Training and education programs related to the circular economy can enhance lives of marginalized groups, including women, people of color, people with disabilities, children and youth, religious minorities, indigenous people and immigrants, and others (hence supporting Urban Realm #3). As such, Urban Realm #1 can help to ensure a just and equitable shift from a fossil fuel economy to one based on renewables, improving 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 Realm can empower cities as hubs for just sustainability, but also its citizens by encouraging their proactive behavior and critical thinking (Ghisellini *et al.,* 2016).

Urban Realm #2: Resilient and Sustainable Cities: Nature, Urbanism and Social Fabric

Efficient circular cities will still utilize large energy flows due to the needs of people and freight to move from one part of the city to another. So, envision cities whose physical design promotes energy-efficient modes of transportation such as cycling and walking, since urban design does influence non-motorized mobility (see Sarkar *et al*., 2015; Zhao *et al*., 2018; Zhao and Wan, 2020). In these envisioned cities public transportation options are fast, ubiquitous, and both public transit and private vehicles are battery powered or all-electric, with electricity sourced by renewable energy (supporting Urban Realm #1; Majumder *et al.*, 2019; Helgeson and Peter, 2020). Through urban design and land use, access to everyday needs has priority, instead of requiring long-distance travel to meet routine needs. Where homes, work, school, shopping, and recreation are accessible, cities can be denser, more efficient and more equitable. Urban neighborhood and district designs can feature integrated energy, water, waste systems, and food security features, to create more sustainable urban form. And where the urban ground plane, the urban fabric that is typically so dominated by motor vehicles that it is thought of solely as 'street-level', instead, cities can be reclaimed and redesigned. The urban fabric of the ground plane could be characterized by clean, safe, and attractive places that support 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 vision counters current wasteful, unhealthy, and inequitable patterns developed on a building-by-building basis versus being based on systems and districts, where urban ground plane resources are captured by the parking, gas stations and related infrastructure associated with cars. Housing becomes healthier, as indoor air quality and sanitation infrastructure improves, and more affordable as expenditures on heating/cooling and private automobiles shrink. This can free up resources – including time– for small green business creation, green and public spaces, and family and community life; especially for poor people and neighborhoods (supporting Urban Realm #3; Dávalos *et al*, 2017).

The urban form envisioned here implies added densities in many cities that lack sufficient density to support mixed-use developments that increase access to everyday needs, walking and cycling opportunities, and public transit-rich urban environments. The COVID-19 pandemic, and more generally the prospect of future widespread contagions, raise the question of whether this urban form is desirable. Preliminary results of empirical analyses (Blanco, 2020) suggest that neither city size nor density are *per se* factors in the spread of COVID-19. Instead, residential crowding in low-

income communities seems to be what matters the most (Hamidi *et al*., 2020; Carozzi *et al*, 2020). In the case of COVID-19's spread in New York City, those communities are home to workers unable to work from home, including 'essential workers' who are disproportionately people of color, may also have contributed to swift increases in caseloads, hospitalizations, and mortality (NYU Furman Center, 2020). With respect to density, when public health measures are in place and followed, density actually supports urban populations during a pandemic –but the design of density matters. High-rise towers only accessible via elevators are not ideal, nor are closely spaced single-family housing neighborhoods that lack parks and open space. Rather, high-density, mid-rise such as multi-family 3-5 floor walk-up accessible via stairways as well as elevators, urban form seems ideal in terms of health and livability (Chow, 2002). Mixed-used, mid-rise residential buildings with internal courtyards and urban fabric featuring wider sidewalks, more bike lanes, etcetera, allow easy access to daily essential services, promote neighborhood cohesion, and reduce isolation of those working from home. Such dense urban design offers accessible open-air green spaces where residents can walk, exercise, play with children and companion animals, and assuming adherence to social distance requirements, permit socializing with friends and family (Honey-Roses *et al*., 2020). Lastly, the alterations in urban form proposed here remain crucial to avoid planetary risks posed by climate and environmental change.

Next, picture cities with clean air, soil and water, as pollutant emissions fall, and blue/green/grey infrastructure that helps people and places adapt to the effects of climate change and offers immediate protection from climate events (Matthews *et al.*, 2015; Li *et al.*, 2020). Sea walls, river barrages, and other traditional grey infrastructure may be required in some cities, without transfering risk to peri-urban or rural hinterland residents. Blue/green infrastructures such as floodable/floating buildings, parks and open space, green roofs and walls, and carefully designed and tended urban and peri-urban forests can reduce ambient temperatures, severity of heatwaves, and wildfire risk (Livesley *et al*., 2016). Tree-lined streets, bioswales, and windbreaks shelter and shade, providing habitat for wildlife while making walking, biking, and other types of physical activity a pleasure. Urban creeks and streams brought back to the surface, make cities more permeable and reduce flood risk. Restored estuaries and wetlands, using nature-based vector controls, provide flood protection and space for recreation, multispecies benefit, and ecosystem health (Walton, 2019). And through pro-poor planning, parks, open and public space, habitat, and green infrastructure can be fairly distributed, while limiting eco-gentrification driven by real estate strategies for place-branding and increased property values (supporting Urban Realm #3; Wolch *et al*., 2014; Ruth and Gulsrud, 2016; Wu *et al.*, 2019; Nesbitt *et al.*, 2019; Mulligan *et al.*, 2020; Tubridy, 2020).

Then, imagine cities that prioritize social as well as physical resilience, since social resilience in the face of environmental change depends on the capacity of residents and neighborhoods to act and mobilize public, private, and nonprofit resources (Satterthwaite *et al.*, 2020). Cities can rigorously assess risks to social as well as physical resilience related to buildings, infrastructure, and urban services, given proximity to industry and natural hazards. By explicitly recognizing the uneven social distribution of vulnerability and risk (across many spheres of difference), cities can take active measures to protect the most vulnerable through transformative or comprehensive community-led actions (Martin, 2015; Satterthwaite *et al.,* 2020). Urban places with thickly woven and well-resourced social fabric and participatory approaches can ensure that all neighborhoods, regardless of private wealth, have local organizations and facilities designed to 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 nonhumans) during extreme events (Steele *et al*., 2015; McEwen *et al*., 2018). Such a vision will require overcoming resilience resistance, in which governance systems develop barriers to change, flexibility and adaptability (Shamsuddin and Shatkin, 2019).

How do we get from where we are now, to Resilient Urban Forms and Social Fabrics? Locally tailored transformation pathways should have four major areas for action:

- **Sustainable urban form:** Building sustainable urban land use patterns and densities, including socially inclusive district building typologies and ecosystem services delivery, involves the following key strategies:

    - Urban/metro growth boundary policies and expansion criteria to protect agricultural land, forests, and wildlife habitat, ensuring urban watershed health and guide urban expansion.
    - Innovative regional transport systems (see #2 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 non-auto centric transportation systems to urban parks and open space, paths, trails, and natural habitat, including wildlife corridors.
    - Proactive regional planning by regional governance systems empowered with resources and robust regulatory/legislative mechanisms.
    - Participatory urban governance systems that provide a sound framework within which trajectories for change can develop (Hölscher *et al*., 2019), yet with sufficient openness

to foster social change movements and technological innovation that address informality, particularly in the Global South.

As transitional measures, mandate *urban general plan elements for urban trees and forests, parks and open space, biodiversity, food security, and watershed health.* Such measures not only enhance resilience but also protect public health (Guo *et al*., 2019; Mendonça and Szlafsztein, 2019; Gómez-Moreno *et al*., 2019; van Ryswyk *et al*., 2019). And, drawing on experiments in cities around the world, such as Chokwe, Mozambique's participatory urban resilience program (Rockefeller Foundation, 2019; UNHABITAT, 2017), promulgate *community governance and community development models* such as local capacity building programs, grassroots organizational development efforts, local and regional visioning, participatory land use planning community-based visioning and budgeting, and micro-finance programs designed to provide sustainable livelihoods and access to capital for informal businesses. Examples of such initiatives include the Climate Budget of Oslo (Municipality of Oslo, 2019), and REDE 9 URB-AL (no dated), the European Commission sponsored network for local finance and participatory budgeting in Latin American cities), and local participatory budgeting schemes such as those in New York and Buenos Aires (New York City Council, no date; Buenos Aires Ciudad, no dated). These examples confront 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).

- **Urban access/mobility:** this area of action involves urban sustainable and low carbon transport infrastructure, efficient public transit and freight handling, non-motorized mobility, and appropriate mix of land use patterns and densities, therefore evoking the following major policy thrusts:

  - Massive investment in clean public transit and freight handling, powered by electrification and/or battery systems that do not export power generation-produced pollution. Such investments would eliminate pollution hot spots associated with heavy traffic congestion; freight train terminals, seaports, and airports; and improve air quality and public health (Sclar *et al*., 2020; Khreis *et al*., 2019). Such transit would link job centers with housing, civic spaces, health facilities, schools, and retail districts, urban and suburban communities – and with superb service, comfort, and speed that makes it the preferred mode choice.
  - Urban transport infrastructure and land use planning for encouraging non-motorized forms of mobility (walking, bicycling). These strategies include walkable streets, dedicated bike lanes, safe routes to school programs (Poswayo *et al*., 2019), and secured

and attractive pedestrian trails and pathways promoting physical activity and health (Koszowski *et al*., 2019).

- Urban design investments for mixed land use patterns that increase access and connectivity between origins and destinations, and specifically transit-oriented development to support mass and active transportation (Knowles *et al*., 2020; Liang *et al*., 2020; Ibraeva *et al*., 2020), while preserving historical buildings and cultural heritage (Renne and Listokin, 2019). Moreover, if such investments are guided by universal design principles, cities become more accessible to those with disabilities and everyone (Inturri *et al*., 2017; Keblowski *et al*., 2019; Raman and Roy, 2019; Lah, ed., 2019).
- Measures that address affordable transportation access, for example subsidies for low-income commuters or fare free transit access (Shin, 2020).

Transitional measures are critical, particularly in cities that must undergo extensive redesign and retrofitting and/or massive new transit infrastructure to increase use of mass transit or non-motorized modes of travel. *Mandates for electric cars and motorcycle production*, powered by renewable energy, which is the case at the national level in the Netherlands and Norway. *Regulatory incentives/disincentives* such as automobile congestion pricing, access restrictions for polluting vehicles, fuel taxes, and fuel portfolio standards to reduce auto use could be utilized in the transition as well. Cities can also encourage use of alternative transportation, and car/truck drive fleet efficiencies (Jephcote *et al*., 2016; Gu *et al*., 2018; Steinsland *et al*., 2018; Yu *et al*., 2019; Tscharaktschiew and Evangelinos, 2019).

- **Resilient built environments:** These strategies primarily revolve around infrastructure.

  - Infrastructure reinvestment programs to repair and extend existing water, renewable energy, municipal waste, air quality management, and flood control infrastructure to all residents and communities regardless of socio-economic status or degree of informality (or legal status of tenancy/land occupation).
  - Smarter infrastructure monitoring and assessment technologies to alert risk managers, and disaster prediction and warning systems to alert vulnerable populations (ITU, 2020; Grimmond *et al*., 2014).
  - Green infrastructure investment in green roofs, bioswales, parks, rehabilitated streams, mangroves, wetlands and floodplains to build in redundancy with stormwater and flood controls, mitigate urban heat island effects and associated energy use (Sanchez and Reames, 2019; Delgado *et al*., 2020).
  - Biodiversity infrastructure to allow multiple species access to both terrestrial and aquatic physical spaces while simultaneously encouraging physical activity, sociality and community, and connection with nature. This also supports diverse organisms and bio-communities in the urban landscape (Connop *et al*., 2016; Frantzeskaki 2019; Hunter *et al*., 2019).

- Environmental justice in infrastructure distribution ensuring that benefits are shared equitably by urban residents (Nesbitt *et al*., 2019; Mulligan *et al*., 2020).
- Urban design innovation for either hotter or colder regions and increased extreme weather events, along with equitable long-term strategies and finance for urban retreat/resettlement as necessary.

As transition measures, identify *highest-risk urban zones* (waterfronts, low-lying communities, vulnerable building stock, etc.), and develop *interim multiscale infrastructure solutions* –based on existing technologies and nature-based solutions that can be incrementally funded– to reduce air pollution (Air Quality Expert group, 2018) and mitigate the urban heat island effect (Tan *et al*., 2016). Such solutions, ranging from regional levee systems to city seawalls, to neighborhood-scale bioswales, would need to be adjusted/redirected as new configurations of climate change risks emerge (see Copenhagen's Cloudburst Management Plan; Lerer *et al.*, 2017).

- **Resilient urban societies and communities:** Because social resilience is as important as the resilience of urban physical infrastructure, establish:

  - Social infrastructure investment programs to build neighborhood social capital, entrepreneurial and institutional capacity, expand participation in citywide infrastructure investment programs, and strengthen local organizations and networks.
  - Local climate adaptation, disaster and recovery plans, and local capacities to implement them, that create networks for mutual support in the face of extreme events (Saja *et al*., 2019; Fu, 2019; Davidson *et al*., 2019; ITU, 2020; Grimmon *et al*., 2014).
  - Targeted assistance programs, to support marginalized social groups and communities including women, ethnic/religious minorities, people with disabilities, children and youth, the elderly, and migrants and refugees, through building genuinely inclusive social resilience (Wijsman and Feagan, 2019).

As transitional measures, explicitly *identify the communities most vulnerable to risk*, and create facilities *neighborhood relief/recovery centers* 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). Also critical are *early warning systems* for floods, hurricanes, and other extreme events that allow some advance notice.

Resilient and Sustainable Cities will also require mobilization of both public and private financial resources to build the physical and social infrastructure needed to achieve it, as well as international collaboration and financing to assist cities in lower income countries (Delgado *et al*., 2020). Municipal, state, federal governments, including specialized agencies at multiple scales will need to make political and financial commitments, revise regulations and governance practices, and ensure

strong links between policy and practice. This in turn requires novel decision-making and collaborative schemes. These institutions will need to both address barriers and play an enabling role, offering financial incentives, supportive regulatory policy, transparency, inclusion in decision-making, and development of intra-stakeholder trust (C40, 2017).

Active involvement of social change organizations, urban communities, connected rural hinterlands, business and industry is critical (Grabowski, Klos and Monfreda, 2019), which in turn requires understanding 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). And because extensive retrofitting and planned urban retreat that threaten sites of patrimony, heritage, archeological resources, and deep cultural value may be inescapable, such interventions must tailor strategies to diverse contests, and be collaboratively planned and justly accomplished.

Urban Realm #2 actively contributes to Urban Realm #1, through its focus on low emission transportation systems linked to more efficient urban form. It also supports Urban Realm #3, by creating living wage employment opportunities, improving living conditions, ensuring multispecies health, and prioritizing social resilience through inclusive planning and governance. Moreover, interactions among these realms elevate transformative models for economies, markets and investments, highlighting enterprise as service, work as participation, investment as commitment, and money as a social good (Jackson 2016). This relates to Realm #3, since it requires such a reframed economy to deliver lasting prosperity, community well-being, robust social life, and the rights of nature. Such economic models will require a paradigm shift and will not be free of constraints and contradictions but "...prosperity today means little if it undermines prosperity tomorrow" (Jackson 2016, p.150; IPSP, 2018; Khmara and Kronenberg, 2020; Sandberg *et al*., 2019; Hanacek *et al*., 2020; Design *et al*., 2020).

Urban Realm #3: Social Inclusion and the Just City: cities, nature and people.

If cities envision and achieve a circular economy, and build sustainable and resilient urban forms and social fabric in ways that make best sense for their specific context, they should make strides toward reducing inequality, providing livelihood opportunities, and creating pathways toward upward mobility. But these strategies may still fall short without an explicit vision for social inclusion and justice. Thus, it is vital to imagine what characterizes an inclusive and just city within a finite planet.

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 *et al*.,2006; Albrechts, 2015; He, 2015; Meerow *et al*., 2016; IPSP, 2018; de Sá *et al*., 2019)

Besides the typically technocratic planning, decision-making, and power relations that define the (uneven) distribution of risks and resources we must consider all manner of residents, current and future. Refugee numbers in particular are sure to dramatically increase due to global political economy and geopolitical conflicts (e.g., massive migration from Central America to Mexico and USA; CRS, 2019; ECLAC-FAO, 2018), but also climate and global environmental change. Within each group of residents, there are also finer grained social differences and patterns of exclusion related to gender, age, class, race/ethnic heritage, caste, religion, sexual orientation, and many other intersectionalities. In addition, sociological and community level aspects of resilience matter, related to values; behavior patterns; knowledge; ability to adapt, transform, innovate; differential vulnerability and access to power, social networks and capital (Folke *et al*., 2016; Wilkinson, 2011; Patel *et al*., 2017). Nonetheless, all have 'rights to the city' (Lefebvre, 1968): This comprises the rights to data, information, participation and justice (cf. Rio Principle 10); the right to shape resilience plans, strategies, and projects (Friend and Moench, 2015); and more broadly, the concomitant right to co-create urban space and collective life. A more contested idea is that we plan not only for human residents but also for the countless other species that live in cities –either because they have always lived amongst people or because they are increasingly pushed into urbanized areas as climate and environmental change impact their habitats and homes ranges (Urbanik and Johnston 2017).

Since we seek to shake up conventional ways of seeing and catalyze new ideas –and because humanity's future is so closely bound to that of animals and wildlands that support biodiversity– we opt for a more inclusive vision: the multispecies city (Wolch, 1998; Houston *et al*., 2017; Parrish *et al.,* 2018; Shingne, 2020; Kirbis, 2020). This idea encompasses efforts to respect nature and protect/restore diversity of both animals and plants, and goes farther by recognizing the subjectivity of sentient animals, requiring moral consideration in discussions of inclusion. It also comprises issues of urban form and property as the latter may constrain urban greening and other multispecies urbanism interventions (Cooke *et al*., 2019). Animals are not only harmed by anthropocentric urban systems and lifestyles but are critical to healthy trophic structure, nutrient cycling, and soil health, and other ecosystem services critical to people –including the happiness and joy of seeing wild nature amidst the city or their so-called "amenity value". By extension, plant life is hugely important to cities as recognized by many global sustainability agendas.

For some this will constitute a challenging thought-experiment, since some nonhuman species can be disease vectors that threaten human health, and humans can likewise pose health threats to animals, and/or are otherwise troublesome to people. For those who believe we must plan for a multispecies urban world, however, the ideas that result are essential.

Start by considering a city whose human residents, regardless of any socio-spatial difference, enjoy *equitable access to sustenance and livelihoods*. Such cities ensure adequate nutrition, housing, education, health care and life-chances for all residents and their children and protect them (as well as flora, fauna and other forms of life) from disproportionate exposure to environmental hazards and harms. These cities also seek fair share access to natural resources needed to support human and non-human everyday lives. These resources include clean air, water, and soils, and 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.

Imagine also a city that practices *inclusive urban governance, taxation and spending programs* where all residents make use of their freedom and rights to engage and organize for institutional change to improve their lives and redress policies or practices they perceive as unjust. Such, inclusive governance and public finance may necessitate redrawing administrative or jurisdictional boundaries, and/or empowering regional governance bodies to set and enforce various targets. This could help to overcome fragmented metropolitan regions, characterized by stark divisions between rich and poor municipalities and 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 would be required to minimize counter-productive inter-metropolitan competition, legitimize and empower metropolitan authorities, and ensure that such entities have financial and regulatory capacities. Regional institutions themselves should be inclusive and transparent, helping build social learning networks, explicit empowerment strategies, and engage multi-level collaboration (Gómez-Álvarez *et al*., 2017).

Consider inclusive cities that recognize that the poor are typically at higher risk than the wealthy because of their residential location and/informal dwellings; housing precarity and need for affordable housing; and less affluent and/or powerful social networks and institutional access. They are less able to recover, improve their conditions, or reduce their vulnerability in the face of climate change (Satterthwaite *et al*., 2020). Such recognition paves the way for intersectional climate mitigation and adaptation plans that explicitly ensure that the most vulnerable residents –whether

because they are slum dwellers, women, elderly, children, disabled, etcetera– and collectively protected as a priority.

Lastly, picture a city that recognizes and values its multispecies character, the non-human world of the wild, feral, companion, or farmed, including many species offering crucial ecosystem services essential to people and nonhuman nature. And that "those who control and plan cities...consider the more-than-human" (Parrish *et al.,* 2018) and acknowledge the intrinsic value and demands our respect. By adopting a multi-species perspective, cities can thus play a major role in protecting planetary biodiversity, serving as refugia for wildlife (Lewis *et al.,* 2019; Goddard *et al*., 2009). Multispecies inclusion requires greater 'caring capacity' of residents, businesses, and institutions, and ways to 'hear' and recognize multi-species voices. It also prompts cities to develop multispecies plans as part of their regular urban planning and policymaking process, and to develop ways of giving overt consideration to the needs of animals and biodiversity along with people (Xie and Bulkeley, 2020; Apfellbeck *et al*., 2020).

Multispecies cities accept responsibilities to restore ecosystems (both near and far) damaged by its appropriation of energy, materials and natural resources, plans for potential added risk of zoonoses due to urbanization and biodiversity loss, and considers implications of environmental degradation and climate change for biodiversity and individual species currently resident or expected to arrive as climate migrants (Steele *et al*., 2015). Initial efforts include the Constitutions of Ecuador and Bolivia, which enshrine the rights of nature, and Mexico City's Constitution that respects rights of companion animals. Although such provisions remain primarily on paper rather than implemented in practice, they are laudable initial steps in a desirable direction.

How do we get from where we are now, to Social Inclusion and the Just City? The transformation pathway has 3 major areas for action:

- **Inclusive urban planning***.* Infrastructure improvements to protect everyone and planned relocations of specific neighborhoods, implemented via inclusive processes that empower and provide adequate resources to those who are the most vulnerable (Deakin, 2012; Bush and Doyon, 2019), contrary to recent relocation examples hurting 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, leaving many decisions to be framed by the

private sector and shaped by market and financialization dynamics (Shatkin, 2008, 2019). They should develop *pre-planning analyses* of climate vulnerability and urban biodiversity (including domestic, companion, and feral animals and plants, particularly those with conservation and cultural value), and inclusive planning and urban design processes, informed by data and resident science programs that gather situated knowledge, guided by *equity planning principles* and *environmental justice goals* drawing on users –including women and children. Inclusive planning process design recognizes that social learning is two-way and becomes embedded in permanent 'double loop' learning processes (Grönholm, 2020). For example, poor residents of informal settlements or refugee camps may need to learn about planning to be effective participants and may need legal support to hold developers accountable. But both planning practitioners and more affluent residents can learn from informal settlement dwellers and other marginalized residents about recycling, efficient use of material resources, and developing flexibility to adapt or serve precarious residential populations.

- **Just distribution of climate investments.** Just climate investment plans prioritize physical and social infrastructure that is built to protect low-income neighborhoods, including informal settlements. Retrofitting infrastructure (the majority of infrastructure spending in the US, for example; Kane and Tomer, 2019) to emphasize climate resilience could also ensure climate justice through revising the distribution of infrastructure benefits and using investments to correct long-standing injustices. For example, just infrastructure plans to address lack of access to adequate drinking water and sanitation services can reduce water pollution and waterborne diseases, while respecting the diverse neighborhood social fabric. Just social infrastructure distribution efforts may include risk alert programs, outreach, service delivery, and emergency rescue and support programs to the elderly, people with disabilities, health or mobility challenges.

At the same time, *anti-displacement programs* constrain unfettered land markets that may catalyze gentrification and displacement of poor people (especially those living in informal settlements). This may occur as insurance pricing begins to account for risk more accurately, making risker neighborhoods (such as low-lying areas) typically occupied by low-income people unaffordable, or as the riskiness of their neighborhoods wanes because of physical infrastructural improvements. This is particularly important with the addition of green infrastructure meant to be protective against (for example) flooding, but that makes urban neighborhoods and waterfronts more livable and hence may drive up property values.

Equitable distribution of high quality and diverse parks and open spaces can counter pressures for such 'green gentrification.'

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

- **Biodiversity conservation and multispecies strategies.** Based on sound science and local knowledge, it aims to advance in two key simultaneous tracks:

  - Urban biodiversity plans and habitat designs that enable to protect areas of high biodiversity from disruption and development, create single and multispecies habitat and landscape corridors, restore habitat wherever possible but also address novel ecosystems that will inevitably appear as ecotones 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 biodiversity (Parris *et al*., 2018). Planning and design would preserve and expand urban forests, bioreserves, and stepping stone habitats; maintain natural drainage lines, retain and use storm water, and develop grey/green/blue infrastructure projects such as urban river/stream restoration or green roofs and walls. Such infrastructure would enhance biodiversity, integrate plant conservation strategies, and utilize vacant, neglected, and newly available spaces to augment habitat (Parris *et al*., 2018).
  - Multispecies disaster preparedness plans that recognize the vital role that companion animals, domestic animals, and urban wildlife and the diverse plant life play in the quality of urban life. Double down on efficient metropolitan land use to minimize loss of wildlands. Move toward a circular economy that limits use of virgin materials such as forest products upon which animals depend, preventing damaging wastes (such as plastics or novel chemical pollutants) from entering the environment. Promote low-

carbon, high nutrition, plant-based diets to avoid, or at least reduce, GHG emissions from animal agriculture, save water, feed more people, and respect nonhuman lives.

As *transitional measures* explicitly identify the communities most vulnerable to risk, and create facilities to meet immediate needs. These are likely to include emergency alert systems and neighborhood relief and/or recovery centers that can be quickly set up in the advent of an extreme event such as a flood or fire. Such centers need to 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). Also, recognize *socio-cultural variation in attitudes toward animals and coexistence* (Rupprecht 2017; Nyhus 2016) and embark on *public education and discussion* programs through schools, community service organizations, etc. that expand understanding of non-human urban residents (their lifeways and urban geographies). This may require exploring ways to *provide non-humans a voice in governance* (Beatley and Bekoff 2013), and developing *regulatory strategies* to protect plants and animals, even by prohibiting harm to nonhumans. Lastly, *prepare people for new animals* that may appear in their cities as a result of climate change, including new and associated disease vectors, and *actively support existing/native biodiversity.* Do this by protecting existing habitat quality and creating landscape connections, such as Oslo's Bee Highway, the world's first of its kind, designed to provide pollinator pathways through the city for both wild and domestic bee populations via urban landscape design, dedicated private gardeners, 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; Figure 4.1). A more futuristic proposal, that builds on earlier landscape models such as Boston's Emerald Necklace, is Rutas Naturbanas in San Jose Costa Rica, a habitat corridor through the entire city, whose first kilometer has been funded by a private company (http://rutasnaturbanas.org/primerkm). Such large-scale landscape interventions may provide opportunities to design city-wildland buffers both to protect animals from human intrusion, and to protect people from dangers that wildlife may present (e.g., attacks, disease transmission).

Figure 4.1 Oslo's Bee Highway

This third urban realm has clear linkages to the earlier 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 (Urban Realm #1). With Urban Realm #2, it connects to urban design and resilience plans and investments as well as early warning systems and disaster recovery.

Urban Realm #3 is perhaps the most challenging of all to achieve. Cities the world over have struggled to create just and inclusive places, plans, and policies for diverse resident populations. Cities need to grapple with the fact that that plans and policies that work for one group may not work for another because of gender, race/ethnicity, migration status, age, class, caste, religion, ability, and more. The gaps between state policy goals and on-the-ground practice can be significant, and empowerment is challenging across all types of cities. This is especially true in places with weak rule of law and protections for individual rights, suffering high levels of insecurity, or lacking traditions of equity planning. Challenges to social participation and co-production are also magnified during wars, natural disasters, pandemic contagions, and other calamities. Yet resident mobilization around inclusion, institutional support for social learning, as well as explicit equity planning and participation policies, are crucial to further inclusion and justice (cf. Ch2).

The value of multispecies cities, characterized by consideration for the well-being of biodiversity and what it needs to persist if not thrive, is perhaps novel for some, but is increasingly embraced by more

scholars and planning practitioners; see Beatley (2020), Arof *et al* (2020), Russo and Cirello (2017). Multispecies urban planning is largely uncharted territory, and surely daunting, but is nonetheless compelling (Houston *et al.*, 2017). Humans do not live outside of nature, and our welfare is tied intimately to the fate of other species with whom we share the planet. This is why biodiversity loss is considered as one of the core planetary boundaries, along with climate change. It can lead us to a point of no return, further from Holocene conditions that support life as we know it and that we arguably have a duty to protect. Thus cities, national governments and global governance bodies have crucial visioning and enabling roles to play in protecting urban biodiversity and nature and creating multispecies future cities.

Each of these ambitious urban realms and related goals must be elaborated and constantly evolve over time in the face of changing context. The vision and goals for future cities and constituent strategies will face challenges repeatedly, and they will move toward goals achievement unevenly over time. Our capacity to imagine, innovate, collaborate, act, and persevere may limit their achievement but will also be the key to realizing these ambitions.

4.2 Working Across Urban Realms for Maximum Local and Global Impact

We have considered three "urban realms" as areas for critical intervention that cities can pursue. But as said, these realms are neither separate nor separable. Actions across realms increase the potential for cities to address systemic, cross-cutting issues and to contribute to global urban agendas. To illustrate:

- Circular cities can promote social inclusion by protecting air resources and water quality;
- Biodiversity conservation enhances public and ecosystem health; and
- Multispecies cities in which residents respect nonhuman lives, can support urban resilience by fostering plant-based diets enhancing public health, food security and food sovereignty, and mitigating climate change, air and water pollution, and waste.

The visions for these urban realms contribute to achieving critical global urban agendas that demand action.

Links Between Urban Realms

First, circular cities are a pathway toward 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; create new jobs, occupations and markets, and allow waste to become future material stocks for manufacturing and agriculture. Pollution and GHG emissions savings arise from circular production processes (Haines *et al.,* 2007). Compact walkable cities and

affordable and low-emission public transport improve air quality (Vardoulakis *et al.* 2018). Energy-efficient buildings and local renewable microgrids can reduce indoor emissions and toxic chemicals and increase thermal comfort (WHO, 2016). And water-efficiency measures can have ecosystem benefits and provide clean water for all (Delgado and Blanco, 2017).

Second, human and environmental health benefit from incorporating biodiversity conservation in planning inclusive and multispecies future cities. 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 inherent and instrumental value of all organisms and support local and endemic species. Granting spaces for people and nonhuman nature to thrive can also help to ensure a resilient, biodiverse urban ecosystem.

Lastly, food security and resilience can be supported by local-regional diets and food systems that also avoid food waste (Coulson and Sonnino, 2018; Reina-Usuga *et al.*, 2020). Regional food systems are particularly relevant for large cities where local and regional production, distribution and processing can work together using sustainable production practices (cf. https://soclaglobal.com/publishings). Particularly for the Global South, such region-local provision can support building a stronger social economy while moving forward a healthier and more affordable food system that respects and preserves diverse foodways and biocultural heritage (Buizer *et al.,* 2016; Vierikko *et al.,* 2015). Regional food systems can also increase urban resilience, reduce organic waste and support soil health and nourish green spaces including urban farms, backyard vegetable gardens, urban orchards and forests.

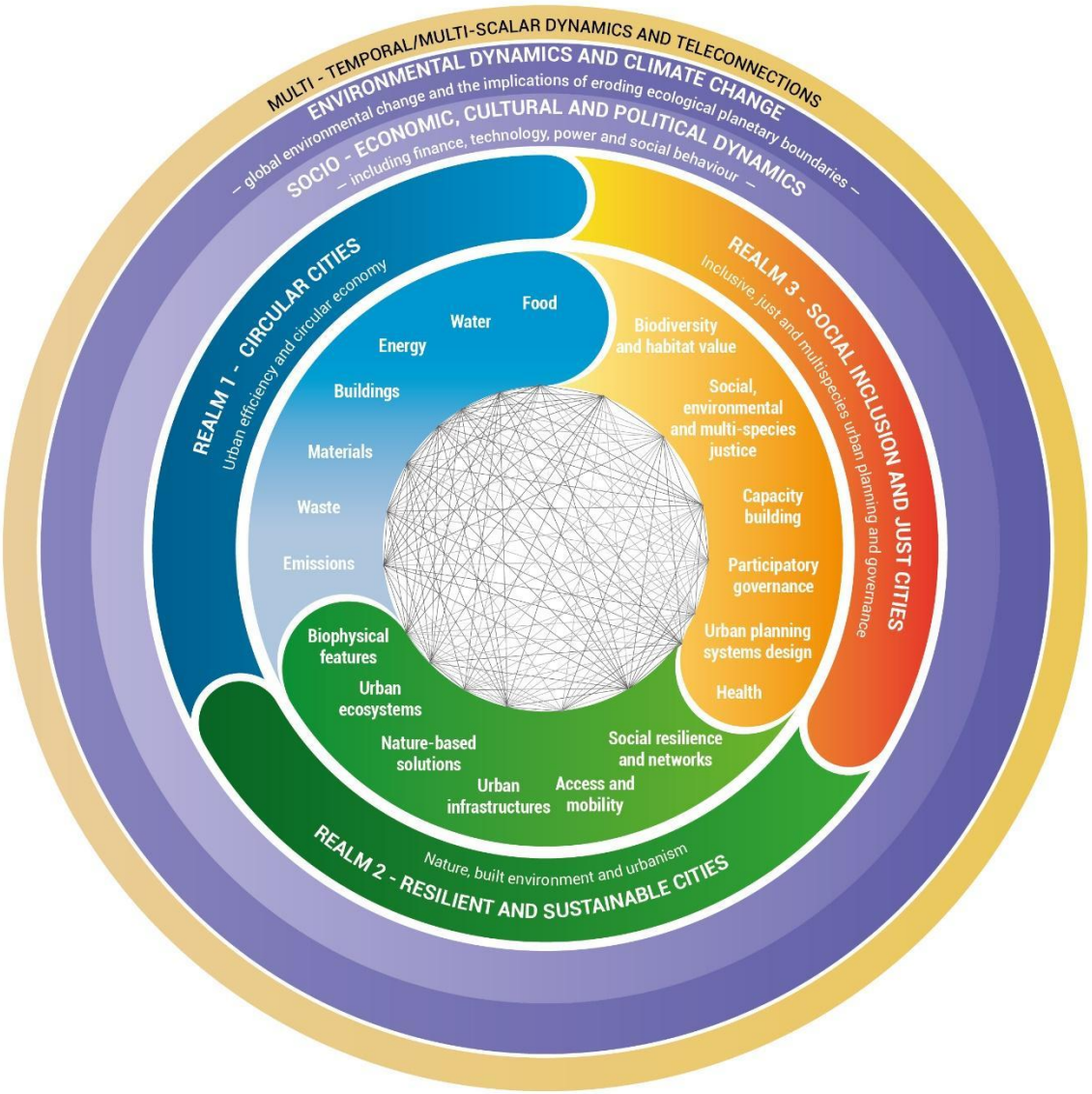
Realm components may thus generate synergies, positive or negative, within and among realms; for example:

- Infrastructure (green, blue, grey) and food systems strategies are vital to Realm #1 as well as Realm #2 because they have important benefits for circularity and climate, especially since resource efficiency can reduce latent stressors and hence enhance resilience (as noted in UN-HABITAT *New Urban Agenda*).
- Urban form and nature-based solutions are key to Realm #2 as well as Realm #1, since they can enhance and reduce vulnerability linked to inequalities.
- Drives for efficiency may generate trade-offs if redundancies of sociotechnical systems that are critical to urban resilience are not considered.
- Urban revegetation can generate positive but also negative impacts for example in relation to allergies propagation that affect public health.

- Progress on Realms #1 and #2 may be limited without proper changes in governance outlined in Realm #3, that build local capacities to act in bold ways that are also equitable, inclusive, and transparent, and recognize ties that bind cities and nature.

In order to accelerate urban transformation towards more livable 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 with all three realms, their components and interactions. But they will need to do so at the intensities and temporal and spatial scales that respond to their own priorities, needs, capacities, and governance reality. Advancing all urban realms as a whole transcends the aggregation of actions and their potential benefits, working with and within linkages in order to explore unique opportunities, either enhancing positive synergies or potential co-benefits, or avoiding negative outcomes.

To highlight the viability of the approaches outlined below, but also note the potential challenges ahead, we reference a range of current efforts or experiences. For many ideas presented here, however, useful examples do not yet exist, or at best only partial steps. The brief examples are only catalysts for new ideas, innovations, and initiatives. Greater detail on possible or concrete transformation pathways for each urban realm is offered in Chapter 5.



		R3. VI	R3. V	R3. IV	R3. III	R3. II	R3. I	R2. VI	R2. V	R2. IV	R2. III	R2. II	R2. I	R1. VII	R1. VI	R1. V	R1. IV	R1. III	R1. II	R1. I
R1. I	Food																			
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R1. VI	Waste																			
R1. VII	Emissions																			
R2. I	Biophysical features																			
R2. II	Urban ecosystems																			
R2. III	Nature-based solutions																			
R2. IV	Urban infrastructures																			
R2. V	Access and mobility																			
R2. VI	Social resilience and networks																			
R3. I	Health																			
R3. II	Urban planning systems desing																			
R3. III	Participatory governance																			
R3. IV	Capacity building																			
R3. V	Social, environmental and multi-species justice																			
R3. VI	Biodiversity and habitat value																			

Type of relationship for urban transformation	
Positive relationship	
Dual relationship (positve or negative)	
Neutral or non-significant relationship	
No data (no relationship)	

Figure 4.2 *Urban Realms and their Relationships through sub-areas*

Localizing Global Urban Agendas

A key challenge facing cities and urban regions around the world is to effectively localize –or adapt to their local context– key global and regional agreements and agendas that support the future urban vision proposed here (see Figure 4.3). The three urban realms here described are found to be consistent with the normative principles of sustainability, resilience and others included in the above-mentioned global agreements. Most of these global agreements explicitly or implicitly signal the role of city-level action, as such, they can guide cities in their efforts to avoid global tipping points.

Agenda 2030 for Sustainable Development is a useful entry point to integrate diverse international agendas including Agenda 2030, the Paris Agreement, the Sendai Framework or the New Urban Agenda, and the coming *New Deal for Natur*e that activates the Convention on Biological Diversity's Aichi Targets (McDonald *et al*., 2018; ICLEI, 2020). The task is to localize them and aggregate and coordinate forward-looking actions offered by governments, city networks, coalitions of mayors, international and regional development banks, academia, the private sector academia, and civil society.

These efforts reveal the interlinkages and potential synergies between different global agendas and the role of cities in goals achievement. Current reporting efforts detailing cities' climate action in the context of global agreements and agendas (such as the one implemented by C40 [https://www.c40.org/cities] or the Carbon*n* Center [https://carbonn.org]) are valuable too, for revealing the diverse realities of cities around the world. And cities themselves, such as New York, Copenhagen, Montreal, Rio de Janeiro, Paris, Sydney, Johannesburg or Seoul, among others, are already countering climate change impacts, mitigating GHG emissions and promoting adaptation (Delgado *et al*., 2020; Seto *et al*., 2014; ICLEI, 2018; C40/ARUP, no date).

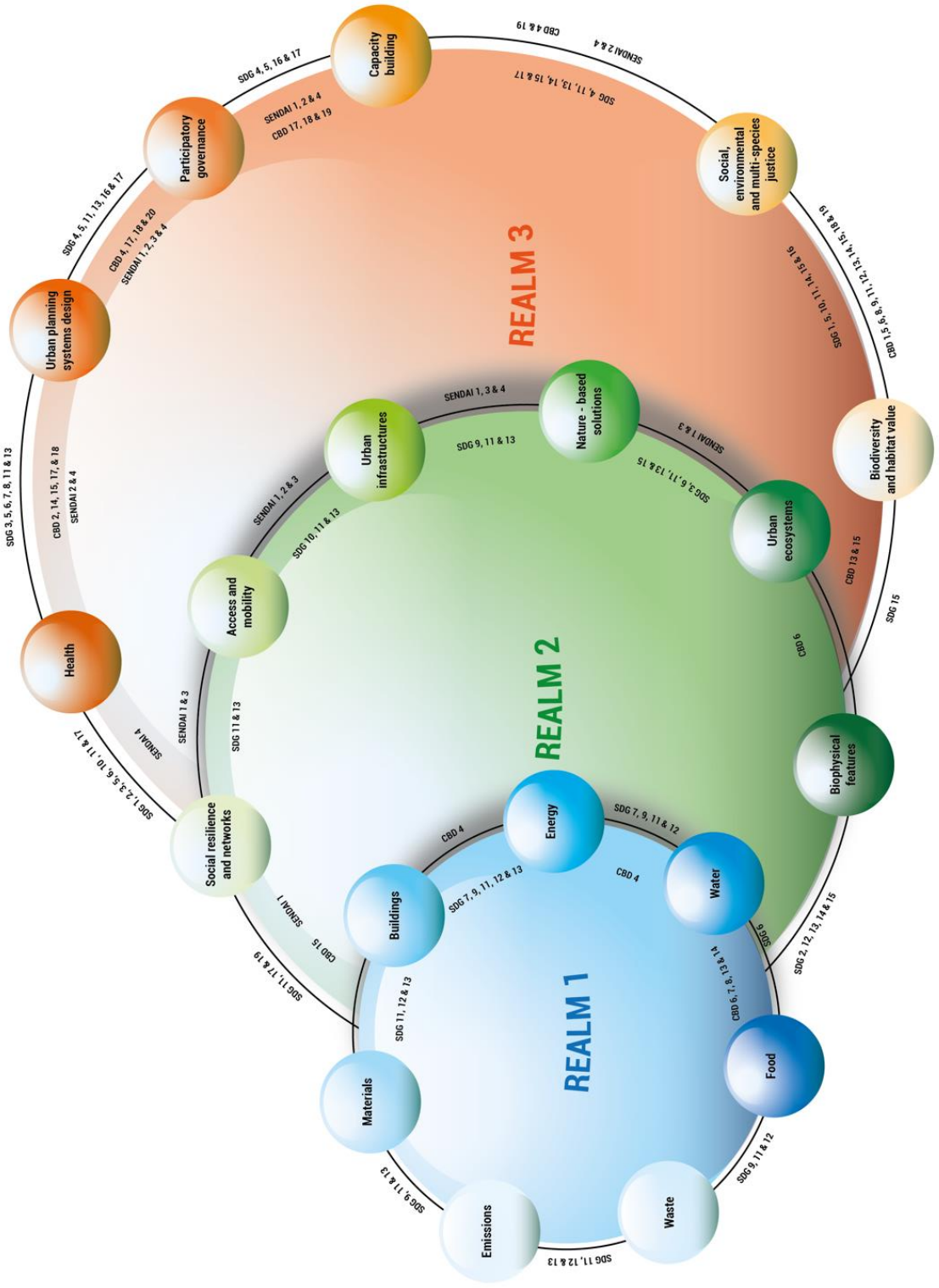

Figure 4.3 shows the interactions between the principles and related objectives, targets or priorities of the SDGs, Sendai Framework and CBD Aichi Biodiversity Targets, and the three non-mutually exclusive urban realms portrayed in this chapter.

4.3 From Future City Visions to Realities: Transformative Pathways to Change

It will be difficult to achieve the futures of cities that we have imagined here. Such futures set a general direction, even a paradigm shift, but indeed have to be grounded in practical and diverse realities. This effort requires us not only to identify potential challenges, but also to be creative in devising solutions at different timescales, work in solidarity across cities, develop lasting capacities and robust local governance systems, and incentivize urban residents to take up novel everyday practices that support the future cities we envision.

The extent of the challenge depends on how the goals will be set –will they be more or less ambitious and groundbreaking? A key issue is also what capacities cities and nations have to allocate towards goals achievement and implementation. Access to sufficient, high quality, and accessible data will also be helpful, not only to enable 'smart city' tools (where appropriate, equitable, and transparent), but also to promote open data access, evidence-based decision-making and citizen/resident science. Achieving sustainable, resilience and inclusive urban futures will entail less individualistic action and far more co-creation and co-production. Cities will need to enlist a wide variety of contributors: national governments, regional and international organizations, international cooperation agencies, non-governmental organizations and coalitions of mayors; the scientific community; various types of practitioners; city networks; communities and individuals. Also crucial will be those in the private sector willing to support urban transformation actions and enabling legislation that embraces the intersectoral nature of the challenge. That said, the variety of behavior changes that individual residents will need to embrace is enormous, requiring not only public messaging and education campaigns, but also powerful and consistent incentives and user-friendly innovations that can bend the curves on cultures of consumption, travel, diet, and more (Shahzalal and Hassan, 2019; Baum and Gross, 2017; Coskun *et al.*, 2015).

There is not just one route or pathway for a city to take. We have previously described how cities vary on a number of parameters. The pathways in Chapter 5 will depend heavily on the characteristics of each individual city, given their historical, geographic, and biophysical differences, as well as variability linked to culture, consumption patterns, population size/diversity, and political-economic structures and dynamics (Schröder *et al.*, 2018). Very significant is also the degree of embrace of, or resistance to, change (as described in Chapter 2). Therefore, cities will be taking different routes –or pathways– to realize the urban realms. These pathways will be shaped by the potential for groundbreaking change and the ability to actively accelerate a major urban

transformation over time. Pathways should be calibrated depending on a city's potential for radical change (high/low) and in a timeframe ranging from short to long term (e.g. 2030, 2050, 2100).

Figure 4.4 illustrates how the three urban realms might play out along transformational pathways. For each realm and its sub-areas (as shown in Figure 4.2), we provide two types of *action* or strategies key to the realization of that sub-area's goals. For example, under Realm #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 chart 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.

3730 Figure 4.4 . *Urban Realms, Subareas, and Types of Action: Urgency and Global Region Absorption Capacities*

The future cities envisioned here each have corresponding transformation pathways, transitions, and actions designed to achieve realization, all of which will provide short- and long-term co-benefits. If the transformations sought are sufficiently bold, trade-offs will be required, particularly in the face of a global pandemic (such as COVID-19), some of which will be politically and socially challenging. Moreover, in moving forward on one urban realm, care will be required to avoid undermining progress toward goals of the other two urban realms. Yet harnessed together, these urban realms and the vision behind them can propel cities forward towards robust and timely transformations of the world.

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5 Seeking urban transformation: From visions to pathways

*Graphics are still in development

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Key Points (Key Messages to be developed**)**

5.1 What do transformational pathways look like?

The fundamental changes required for the visions presented in Chapter 4 refer us to the notion of 'transformation' as a shared recognition and desire for deep, far-reaching, long term, radical and substantial changes to tackle interlocked environmental and development challenges. In recent years, there has been a convergence in this direction across different fields by urban practitioners, policymakers, local authorities, activists, think tanks and academics alike. As argued in Chapter 2, seeking transformation implies tackling deep-seated lock-in factors relating to the political economy of cities that perpetuate natural resource extraction and carbon intensive development, the results of which are described in Chapter 3, and worsen social inequalities.

This report recognizes that planning for such transformation presents a massive challenge for cities that are not accustomed to pursuing such goals and that policy change often occurs incrementally. Change typically begins with an inspiring project, a new policy, a new knowledge partnership, an impassioned individual or an active coalition of stakeholders. Over time, these important first steps may remain local, individual exemplary efforts towards sustainability, resilience or equality, or, under the right conditions, scale up and engender transformative changes at the city scale and beyond.

The main objective of this chapter is to take readers through an exploration of some of these impressive efforts that show how cities have initiated transformative processes to go from visions to results. The cases presented here are not meant to illustrate the best or only way to create transformative change, as no city has yet reached these ambitious goals. However, several cities offer us key principles of planning, (multi-level) governance, citizen participation, technological development and other key elements of transformative change that can help to achieve them.

Cities do not exist in a vacuum but instead are shaped by wider social, economic, cultural and environmental processes and their histories. Acknowledging this implies approaching transformational change as a multi-level process. This requires an engagement with the historical and contemporary drivers and outcomes of urban change. It also calls for a forward-thinking and critical approach to resist over-simplification of the current and potential role of cities. This chapter seeks to link the visions of the previous chapter to practical actions that break the inertia of the past and allow for new, more desirable pathways to be forged.

We call 'pathways' the different ways in which institutions and stakeholders build the conditions, policy and planning routes, and institutions that widen the possibilities for transformative courses of action. The establishment of a transformational pathway ofted begins from a single entry point: sometimes the process starts with the implementation of a new policy: sometimes they happen through the implementation of progressive policies, while in others they occur through changes in the organisational and governance structure of urban institutions. In some cases, pathways are led by the actions of citizens and civil society organisations; and in others, they are through the delivery of specific programmes and methodologies. The following pathways refer to a number of bold city actions that, over time, bring about the major environmental, resilience, equity and social justice changes described in Chapter 4. Moving towards these visions involves changes in economic, technological and political systems, as well as fundamental changes to culture and individual behaviour.

While real world examples of substantial urban transformations are not always easy to identify, the following sections examine how transformational pathways are being crafted in practice and why they matter. In doing so, the aim is neither 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 cases allow for inspiration and learning from current and ongoing approaches and initiatives, while casting a critical eye on both their potentials and shortcomings. Furthermore, our aim is to acknowledge the diverse factors that might converge in triggering such pathways, as well as the actual conditions that might enable cities to become transformative in different contexts in order to address the deeply entrenched and destructive trends, as those examined in Chapter 3.

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. However, without paying careful attention to the multiple dimensions that enable pathways to become systemic and transformational, opportunities to advance the goals described in Chapter 4 can be missed. Focusing on each of these realms, this chapter examines the entry points; opportunities and precedents that the pathways build upon; and the intended and unintended consequences. Several case studies are used to demonstrate how pathways are shaped. Each section includes a well-documented headline example for which a large amount of empirical evidence of success and trade-offs has been produced. Reference is also made to a wider set of experiences that illustrate the diverse conditions under which cities might catalyse transformation.

The final section invites readers to take stock of the key lessons emerging from a cross-reading of all pathways examined. Returning to the question of what makes pathways transformational, the concluding remarks aim to enhance the capacities of city-makers to embark on the journey of moving from ambitious visions to radical, aligned and sustained action at scale.

5.2 Circular cities pathway

The goal of circular cities transformation is to (re)design and (re)integrate urban resource systems such that as a city grows and improves quality of life, its demands for new resource inputs and supplies of solid, liquid and airborne wastes are driven towards 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 no net pollution. The concept of circularity first emerged in the industrial sector eco-efficiency practices of the 1990s and has more recently been applied to cities as a key sustainability strategy. The circular cities pathway aligns with Urban Realm 1: Circular Cities: urban metabolism, efficient socio-technical systems and built environments from Chapter 4.

The transition toward 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 (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. **Urban metabolism,** depicted in detail in Chapter 4, describes how these flows interact to shape the city, service the needs of its populace, and impact on the surrounding hinterland (Musango et al. 2017). With circular cities, the aim is to shift the urban metabolism from linear to circular, so that the amount of resources entering and exiting the city are minimised. A **circular economy** is one in which a continuous flow of technical and biological materials creates opportunities for economic value to be created in the process of shifting toward circularity. It is much more than recycling. The following diagram illustrates the multiple options available for circular economic value to be created, and serves as a useful framework for cities to understand the full range of possibilities for circular cities:

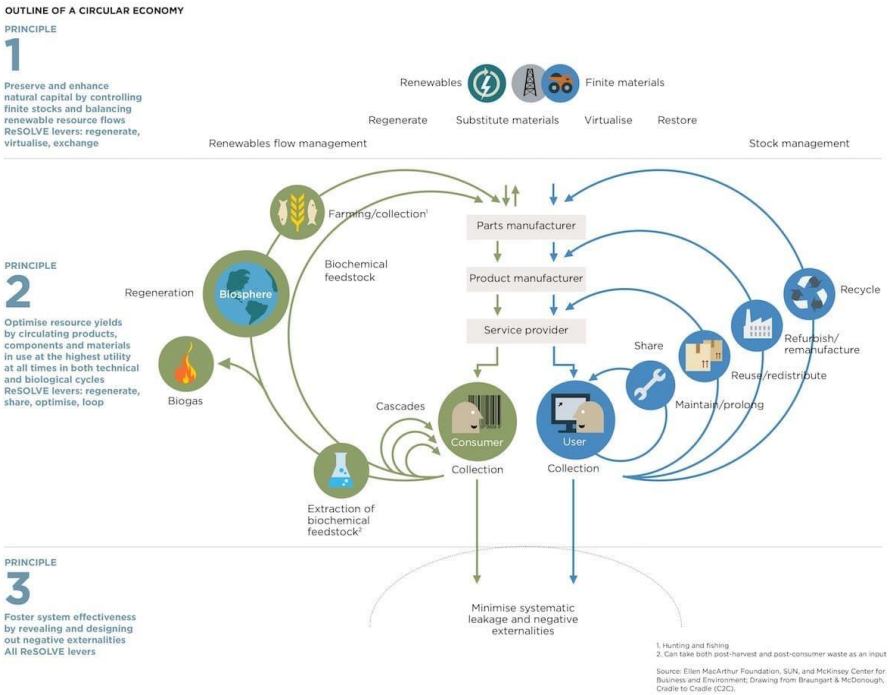

Figure 5.1 *Outline of a circular economy (Source: Ellen MacArthur Foundation, SUN and McKinsey Centre for Business and Environment; Drawing from Braungart & McDonough, Cradle to Cradle)*

While resource saving and waste minimisation inherently come with financial incentives, shifting beyond isolated private sector initiatives and pilot projects toward circular cities requires a systemic approach informed by a detailed understanding of a city's urban metabolism. Awareness of resource use plays a significant role in directing resource efficiency efforts, so urban metabolism needs to be understood and monitored to assist strategic planning by local governments (Musango et al. 2017; International Resources Panel[IRP] 2018). Measuring the efficiencies of current resources use and the production of waste across the urban system at each stage of processing and use enables the pinpointing of areas for systemic redesign and intervention, to both reduce resource consumption (i.e., eco-efficiency) and to process and direct erstwhile 'waste' resources for use in other resourcing processes.

Local governments around the world are coming together to pledge their commitment to the shift toward circular economy practices. In Europe, over twenty cities committed to this transition by signing the European Circular Cities Declaration (link)[5] in 2020. This followed the launch of the Green

[5] 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

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 experiences exchange and mutual learning (link).

Circular economy practices are increasingly being recognised as a means of achieving city level carbon neutrality targets. Estimates show that the emissions induced by consumption in cities are at least as high as the emissions directly linked to local production (C40 2018). On the road to the UN Framework Convention on Climate Change Conference of the Parties (COP26) due to take place in November 2021 in Glasgow, non-state actors such as ICLEI, C40, EMF, IUCN are convening local governments from all regions to assess which policies and local governments actions can best support the carbon neutral circular economy transition (UNFCCC). Front-running cities such as Turku in Finland are developing circular economy plans to support their carbon neutrality ambitions (ICLEI 2019).

While a narrow understanding of the circular economy might focus on environmental and economic issues alone, there is increasing recognition of the need to address societal issues too, some of those benefits are highlighted in the Chapter 4 description of Realm 1: Circular cities. An example of a related initiative currently underway is the collaboration between ICLEI, Circle Economy, the UN Environment Program in Bogor, Indonesia, which will estimate local circular economy jobs and develop a circular economy action plan for recovery in selected sectors after Covid-19.

The capacity to gather, analyse and interpret resource flow data rarely lies within local governments, and typically requires external assistance. Since 2015, Circle Economy has worked with over 20 cities to develop city-level strategies informed by material flow analysis. Their 'Circle City Scan' process consists of the following steps (Circle Economy 2020):

1) Use indicators to understand the socio-economic context and **identify priority sectors**

2) Use Material Flow Analyses (MFAs) to **understand how resources flow** through the priority sectors, and identify hotspots of resource misuse to be tackled

Sustainability, Circular Flanders, CSCP, ECERA, the European Investment Bank (EIB), Ellen McArthur Foundation (EMF), Eurocities, LWARB, UN Environment Programme and the WCYCLE Institute.

3) **Identify opportunities for intervention** to reduce resource requirements or better derive value from misused resources.

4) **Co-develop a roadmap for action** for a local circular economy with relevant government and non-government actors

This process includes a group of diverse local stakeholders from various government departments, the private sector, non-profit sector and civil society, who are taken on a shared learning journey via a series of workshops. To align these parties on common circular priorities, the city's material flow data is represented in simple, easy to understand diagrams (e.g. Sankey Diagrams) that help them to form a shared understanding of how their city uses and misuses resources. The result of the process is outlined below in the Amsterdam case study. Similar participatory action approaches to urban environmental accounting have been undertaken by other non-profit organisations, for example the work of Ecocity Builders in Cuzco and Medellin (Eberlein 2018).

Case Study: Transitioning toward full circularity with a circular strategy for Amsterdam, The Netherlands

Amsterdam has set the ambitious targets of halving its use of new raw materials by 2030 and becoming a fully circular city by 2050 and was the first city in the world to develop a city-level vision and roadmap for the circular economy. Starting the journey with a Circle City Scan, Amsterdam decided to focus on the 'Built environment ', and ' Food and organic wastes' and 'Consumer goods' value chains to render the circular economy concept tangible to local stakeholders. Next, the 'Learning by Doing' and 'Circular Innovation' programmes helped to boost the market, and in recent years the city has completed over 10 0 projects that contribute towards a circular economy. Evaluating the impact of these projects on jobs, emissions, economic value and raw material use has shown that the circular economy not only leads to environmental gains, but also has positive socio-economic effects. This has helped significantly to build support for the concept, and to align various actors toward shared goals. (REF)

With the approval of the Amsterdam Circular 2020-2025 Strategy in April 2020, Amsterdam is now focused on upscaling and accelerating its existing circular projects, employing all of its municipal instruments available and including businesses and residents in the process. On top of that, the municipality lobbies at the national and European level for fitting financial, fiscal and legal frameworks, making the city a champion of circular economy (REF).

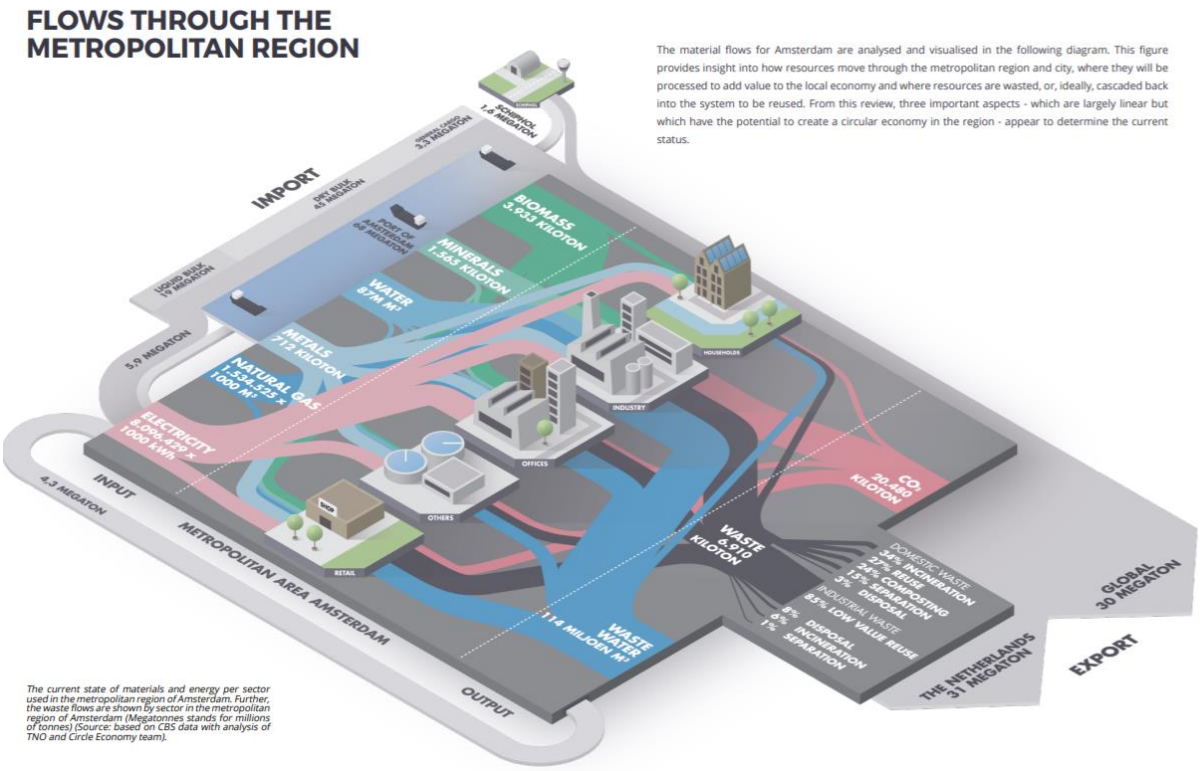

Figure 5.2 Example of a material flow diagram used to explain the urban metabolism of Amsterdam Metropolitan Region (Circle Economy 2016)

To illustrate in more detail how a circular city might manifest, the circulation of materials and nutrients will now be explored.

5.2.1 Materials Circulation

The urban metabolism and circular economy concepts are most typically applied to the flows of physical materials (e.g. water, fossil fuels, metals, biomass) used by cities. Although recycling has received a lot of attention in recent decades, it should not distract from opportunities for avoiding waste and creating value further up the value chain that would have a greater impact and be more financially viable.

The Alapuzzha, India case study offers lessons in fostering social justice through circular initiatives, while improving working conditions for urban waste workers.

Case Study: Encouraging the 3Rs through decentralised waste management in Alapuzzha, India

Alapuzzha, a city of approximately 174,000 people, in Kerala, India was one of the five cities recently recognized by UNEP for building an effective solid waste management system (UN Environment

2017). In a city where expensive formal systems for solid waste management 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.

In the initial stage, the program encouraged the 3R's - Reduce, Reuse and Recycle - and waste segregation at source. The local community was engaged through street plays, songs, marches and exhibitions. However, waste segregation at source proved difficult as the different wastes were often combined during collection (Venugopal). To tackle this problem, a pilot project that experimented with decentralized waste management was adopted in one of the wards.

Subsidized and supported by government agencies, individual households were encouraged to set up aerobic pipe compost or portable biogas units. These were complemented by innovations like Kitchen Bins (developed by the Kerala Agricultural University) capable of treating up to 2,000 kgs of organic waste and producing high quality compost in three months. In addition, 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, 2,800 composting units which together handle about 80% of the city's waste. The sale of biogas and manure fetches up to Rs. 6 million and Rs. 3 million (approximately USD 80,500 and USD 40,200), respectively. In addition to this, the decentralized system has done away with door-to-door waste collection, bringing down transport costs by nearly Rs. 5 million. The Alapuzzha case offers the following key lessons on the process of urban systems transformation:

- **Individual incentives attract participation and build long term commitment**: The program focused heavily on awareness of the benefits and building a culture of individual responsibility and participation in waste management. Empowering individuals to take responsibility for their own waste kept government costs low and promoted innovation and customisation. In schools, students were incentivised to participate in cleanliness and waste segregation programs. Ownership and control over biogas and composting units provided a strong incentive for household participation and promoted a long-term engagement and commitment to the project.
- **Strong political commitment and support aids the transition**: Kerala state government's desire to transform the waste management sector and encourage long-term, sustainable solutions was a key success factor. They worked to clearly identify problems, secured collaborations with different agencies, subsidized the campaign and actively promoted

decentralization. The government was motivated by the fact that household management of waste would reduce social disparities by freeing the class of 'waste workers' and encouraging a positive attitude towards waste collection.

Gaps in the circular waste management chain can be filled with multiple strategic partnerships. The pilot project was made possible due to localized and creative solutions developed by technical and research institutions. The Agency for Non-conventional Energy & Rurual Technology (ANERT) – the Nodal Agency for the Ministry of New and Renewable Energy Sources in Kerala - and IRTC- the Integrated Rural Technology Centre were instrumental in the setting up of household biogas and composting units. The Kerala Agricultural University produced innovations that addressed important gaps in consumer needs. The government also partnered with local contractors to collect plastic waste from households.

The case study of Alapuzzha demonstrates how city systems can achieve a long-lasting change that fundamentally shifts the way in which materials flow through a city. Instead of ending up polluting watercourses and releasing methane into the atmosphere, the biomass waste generated in day to day activities is now replacing fossil fuels, resulting in cleaner energy and environment for citizens.

5.2.2 Nutrient Circulation

One of the key dimensions of sustainable cities is the development of resilient, inclusive, equitable and sustainable urban food systems. Food is a strategic entry point to eradicate poverty, strengthen gender equality and reduce vulnerability in a multidimensional way (Van Veenhuizen and Danso 2007) and it relates to all three of the realms under the vision of Chapter 4. In order to address the social and environmental consequences of a food sector that is largely driven by the private sector, many cities across the global north and global south have implemented local/regional food strategies, food charters and other food system-related policies and initiatives to regionalize and close nutrient cycles.[6]

A key milestone in this regard was the 2015 Milan Urban Food Policy Pact, currently endorsed by over 200 local and regional governments worldwide. The pact marks their commitment to "develop sustainable food systems that are inclusive, resilient, safe and diverse, that provide healthy and

[6] For a comprehensive analysis of grassroots innovations to tackle food wastage in European cities, see Tartiu and Morone (2017).

affordable food to all people in a human rights-based framework that minimise waste and conserve biodiversity while adapting to and mitigating impacts of climate change."[7]

Further global initiatives on this front include the C40 food systems network, the ICLEI-RUAF CITYFOOD network and, at the national level, the Dutch 'Urban Agenda on Food' endorsed by 12 cities and three national ministries in 2017, among many others. Multiple similar initiatives have emerged across the world, marking the emergence of a wave of 'green municipalism' with urban and periurban agriculture (UPA)[8] as a key strategic pathway towards more sustainable, resilient, inclusive and equitable cities. Achieving these goals through urban food systems refers to all 17 UN-SDGs and their implementation in practice (Ilieva 2017).[9]

In addition to improving food security, providing livelihood opportunities and mitigating climate change impacts, urban agriculture is increasingly being pursued as a means of closing the nutrient loop (Allen and Frediani 2013). It is only in the last century that nutrients from human and animal waste have ceased to be returned to agricultural soils, replaced by fossil fuel-intensive synthetic fertilisers that destroy soil fertility in the long term. If food waste and current stocks of livestock manure and human waste were once again returned to soils through urban and peri-urban agriculture, 386 million tons of nitrogen, phosphorus, and potassium could be replenished per year, more than twice the world's current annual consumption (Dubbeling 2017). Diverting wasted nutrients to enrich the soils of the hinterlands then could significantly contribute to better outcomes for the dual challenges of rapidly declining soil quality and climate change, highlighted in Chapter 3.

While using surplus food and food waste to enrich agricultural soils is important, many of these resource streams have the potential to contribute much higher value to society as food instead of waste. It is estimated that at least one third of global food is wasted before consumption (Katz 2012), thus a key and growing challenge in creating more sustainable urban food systems is to cut food waste by ensuring that surplus edible food is diverted from disposal, and transported safely and timely to those in need. This is particularly important in cities with high levels of poverty, where inadequate nutrition has devastating implications for the development potential of low-income

[7] http://www.milanurbanfoodpolicypact.org/text/

[8] Here, as in the bulk of the literature reviewed, the terms 'UPA' and 'urban farming' refer to all forms of food production within and surrounding the boundaries of cities and includes crop and livestock agriculture, fisheries and forestry. It is worth noticing that often multiple farming and gardening systems exist in and near a single city.

[9] See also the Food in the Anthropocene: the EAT–Lancet Commission on healthy diets from sustainable food systems, by Williet et al (2019).

communities. Developing countries account for 44% of global food loss and waste (Lipinski et al. 2013), although the profile of food losses differs significantly between countries (FAO 2011).

Given the amount of water, energy, nutrients and other inputs that go into food production, reducing food waste has a significant role to play in addressing a city's ecological footprint. Food products and the nutrients they contain have many different uses according to their nature and condition. As shown by the Food Recovery Hierarchy in Figure 5.3 systems and institutions are required on multiple levels to optimise the societal value derived from surplus food, starting with reducing surplus food as early in the value chain as possible. Composting and incineration should only be considered once all other avenues have been pursued.

Figure 5.3 *The Food Recovery Hierarchy (Source: EPA Sustainable Management of Food. Available online at: https://www.epa.gov/sustainable-management-food/food-recovery-hierarchy)*

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

Urban food strategies are emerging as a means of integrating both the horizontal and vertical dimensions of urban food systems. Horizontally, a holistic food system aims to address multiple transversal policy domains and fields of action, such as health and wellbeing, gender equality, environmental impacts, economy and community development, social and cultural aspects, and

education. Working vertically, involves considering all different stages of the food system: food production, processing, storage, transport, retail, consumption and waste.

While this is challenging, there is a wide range of experiences that illustrate how cities are using their food systems as an entry point for addressing multiple sustainability issues:

- Toronto's Food Vulnerability Assessment undertook an in-depth diagnosis of the most significant risks climate change would pose to food distribution and access within the city. This pioneering study examined all food system sectors and interdependent infrastructure (Box 5.3) and highlighted the need to prevent the impact of disruptions to electricity, fuel and the transportation network on the food access of the most vulnerable. One of the actions identified was integrating food access into the city's emergency response planning (Zeuli et al. 2018a; 2018b).

- The city of Bristol built on the strong trajectory of civil society efforts to create a strong regional food culture, by creating the first Food Policy Council (FPC) in the UK. Bristol FPC brings together in a single platform key stakeholder across the city's food system, engaged in production, processing, distribution, retail, catering, consumption and waste disposal. The Council works as a high-level strategic decision-making body with the common objective of achieving a healthier, more sustainable and resilient food system. Bristol FPC's activities include mapping and publicising local food resources, creating shorter food miles, improving community gardens and organising farmers' markets (Carey 2013).[10]

- As part of a larger food security policy, Johannesburg developed a strategy for Urban Agriculture as Food Resilience. Led by the local government with the Johannesburg Inner City Partnership (JICP) and several local organizations as part of a larger food security policy, this climate-oriented strategy aims to increase resilience to urban-heat islands and provide relief from drought through its urban farming programme. The initiative has placed urban farms on rooftops, municipal buildings and public spaces throughout the city. During its first two years, the programme trained 60 people and supported 25 farms on rooftops. In the long

[10] Food policy councils are developing at a very fast pace across the world. In Canada and the USA there were only 20 active FPCs prior to 2000, but the number increased to 324 by 2016 (Sussman and Bassarab, 2016). In their initial phase, most food policy councils focus on healthy food access, economic development and food procurement, while some target planning and land use issues as high priorities. As these platforms mature over time, FPCs start to target their efforts beyond urban agriculture or food access, engaging with more challenging issues such as food waste and labour rights (Schiff, 2008; Scherb et al, 2011).

term, it aims to create 60 entrepreneurial businesses including farms and agri-processors (Naudé 2015).

- Malmö, Sweden developed a food strategy in 2010, and mainstreamed it through the city's Policy on Sustainable Development and Food. Making the most of its procurement power, the municipality took control of school meals as a means to reduce greenhouse gas emissions by up to 40% by 2020, through decreasing the amount of meat served and increasing organic ingredients.

Progress towards stronger – more inclusive, resilient and sustainable – urban food systems cannot be achieved overnight and requires long term commitment by local governments, and grounded and multi-scalar approaches. The AGRUPAR project illustrates the multiple gains that can be achieved over time when citizens participate in the planning of city-region food systems.

Case Study: Improving access to healthy and nutritious food in Quito, Ecuador

The Participatory Urban Agriculture Project (AGRUPAR) was started 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 are operating in over 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 (CRFS) project, building an agri-food policy for the city-region in a participatory way. Quito's key aspiration is to become a city where food is a right for all through a horizontal approach that seeks the realisation of improved health, sustainability, resilience, equity, education and economic development (Rodriguez Dueñas 2019).

In promoting and supporting urban food production, AGRUPAR has also helped to close nutrient cycles. It is estimated that each participating family composts 12.5 kg of kitchen scraps per week, on average, resulting in approximately 1,820 tonnes of organic wastes being recycled each year as a result of the project (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 cost, fossil fuel usage, air pollution and emissions.

Seeking transformative change through urban food systems requires moving beyond national-scale balance sheets of total food production and aggregate consumption, to the scale of individuals,

households and communities and cities. It is at these scales where many living in food deserts go hungry amidst the stacked supermarket shelves and bustling markets, and where multiple entry points can be pursued to build resilient, equitable, and 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 from Amsterdam – a large, capital city in Europe; Alapuzzha – a small city in India and Quito, a large capital city in Ecuador – demonstrate how initial actions and resultant pathways for circular economy – related to urban metabolism and resource flows can start and have effective impact in cities of different sizes and regions.

5.3 Decarbonization pathway

The preceding section explored how cities are developing circular economies by improving the way in which they manage materials and nutrients. This section focuses on the convergence of such circular economy efforts with the efforts of cities to address what is arguably the world's most pressing environmental challenge: global climate change due to the atmospheric accumulation of greenhouse gases (GHGs), largely arising from city-based production and consumption processes.

Since the late 1980s city governments worldwide have been preparing and implementing plans and investments to reduce their GHG emissions through energy retrofits, switching from coal to natural gas to low-carbon electricity, and other eco-efficiency measures in the buildings, utilities, transportation, and waste management sectors. For the most part, the wide range of measures have led to net local reductions in energy costs and net local increases in employment (European Parliament 2008; ILO 2020). Hundreds of cities have now committed to achieving 'net zero' carbon emissions targets for their buildings and districts. Bristol, United Kingdom, for instance, has set a target of becoming a net zero on a city-wide basis by 2030 (Dudd 2019) and. The European Commission's Strategic Energy Technology Plan is funding a support programme for 100 'Positive Energy Districts' across Europe that will advance the design, technology, and finance practices needed to transform city districts into net positive generators of their own low- or no-carbon energy supplies (Gollner et al. 2019). However, achieving full decarbonization will require further, systemic transformation of cities' resource metabolisms.

Decades of innovation and action across hundreds of cities demonstrates that achieving decarbonisation of a city involves systemic change in the following six areas related to energy supply, demand and efficiency of use:

- **Energy supply transition** from carbon-based fuels to de-carbonized grid electricity, including for electrified transportation systems.

- **Waste heat and bioenergy production** from organic wastes and wastewater solids, including the generation and use of biogas which also addresses the challenge of urban methane emissions.

- **Reduction in the energy supply** that produces the goods, materials, and food to meet the needs and wants of city dwellers in-line with a circular economy approach (described previouslu).

- **Reduction in the amount of energy needed** by urban residents for heat, light, transport, food etc giving particular attention to changing behaviours and social norms, such as broad-based adoption of low-carbon vegetarian diets.

- **Urban planning and development** regulations and models that establish energy efficient built forms, transit-oriented development patterns, and reduce goods and people mobility requirements.

- **Increases in the end-use efficiencies** of buildings, vehicles, power grids, and in the equipment of every kind of energy demanded device, from city water supply pumps to kitchen appliances.

Figure 5.4 illustrates the dual axes of a general decarbonisation pathway for cities. The verticals represent existing sectors and their legacy infrastructures, which have been organized and regulated as separate, unintegrated systems. The starting place towards decarbonisation involves the implementation of eco-efficiency measures and retrofits within the existing sectors. Such retrofits can include, among others, fuel switching, more efficient equipment and eco-building designs, demand side management and related regulatory reform, and economic incentives. For example, with the transportation sector, cities can start with expansion of public transit services and ridership, and on (re)building infrastructure for low-carbon transport modes such as cycling. More recently, cities have worked to reduce the carbon intensity of vehicles through development of the electrical charging station infrastructure to support personal electric vehicle ownership.

As cities pursue decarbonisation opportunities with both existing and new lower carbon systems, further gains generally require working in a new, integrated manner across sectors and systems to

achieve maximum system wide energy resource productivity. Achieving the greatest potential decarbonisation in a city requires maximum utilisation of each unit of energy input to deliver as many energy benefits as possible.

The horizontals in Figure 5.4 represent areas for innovation, integration, and the establishment of new resourcing and servicing systems that are optimized for decarbonisation purposes. The 'urban nexus' (BMZ/GIZ/ICLEI 2014), in which a city's energy, water, food, and waste systems are integrated into new systems for optimal efficiency and resilience focuses on this transition from separated legacy systems, as part of an overall urban metabolism and circular economy transformation. The horizontals in the figure provides examples of low carbon urban nexus systems and the following are demonstrations of cities implementing those examples.

Figure 5.3: Pathways for urban decarbonisation

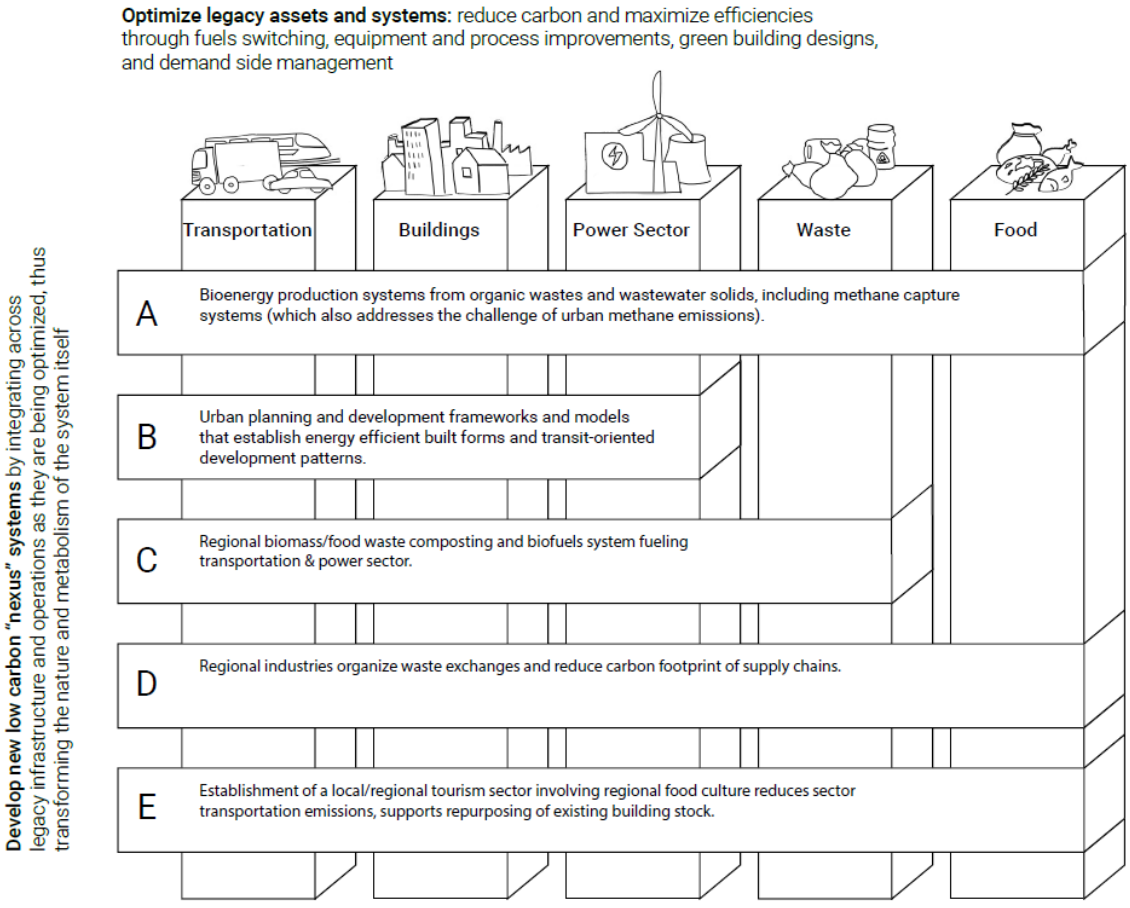

Figure 5.4 Pathways for urban decarbonisation

Linköping is harvesting biogas from multiple organic wastes and using it for transportation and other uses (A). Other cities are achieving GHG reductions through the design of buildings with power generation capacity to service the full energy needs of occupants, including their electric vehicles (B). Växjö, Sweden has developed a regional forestry and biomass management system that supports the city's 2020 target to have 50% of the city's new buildings built from renewable wood resources, replacing carbon intensive and non-renewable resources (C). In 2014 the Toronto Regional Conservation Authority established a business partnership, which includes Canada's largest international airport, to operate a regional materials exchange that by 2019 had cycled 18,500 tonnes of erstwhile waste materials between its members, thereby reducing further tonnes of GHGs (D).

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 niche innovations. For example, the introduction and scaling of rooftop solar power generation on residential and commercial buildings has required technology and business services innovations, such as solar and storage product offerings. But it critically also involves the deregulation of central power grids to permit feed-in from small generators, the establishment of special feed-in tariffs and economic incentives, the design and establishment of microgrids, retrofits in building power conversion systems, and training of households on the management and maintenance of their systems. Maximum system-wide reduction of carbon intensity in urban transportation systems eventually requires full integration of transportation planning and development with land use planning, development and building design, and transportation behaviours to fundamentally reduce demand for mobility.

Establishing new systems and creating enabling policy and regulatory environments for the eventual replacement of legacy systems often requires coordinated innovation and intervention at all scales of government and across the public and private sectors (Arup and C40 Cities 2017), as highlighted by the cases of Toronto, Canada and Beijing, China below.

Case Study: 30 Years of Decarbonisation Action in Toronto, Canada

At the 1988 World Conference of the Changing Atmosphere in Toronto, Canadian scientists and environmental activists proposed and gained conference adoption of the 'Toronto target,' a call to nations to reduce their GHG emissions by 20% from 1988 levels by 2005. In January 1990, the City of Toronto became one of the first governments to formally commit to the target, far exceeding the ambition of the subsequent 1996 Kyoto Protocol targets. With this, Toronto's city government became an early leader in pursuing a decarbonisation pathway.

To plan, administer and finance that pathway, the City established an Energy Efficiency Office in 1991, and then established the Toronto Atmospheric Fund (TAF) with CAD$25 million endowment in 1992. For 28 years, the TAF has served as an independent centre of innovation, seed finance, grant funding, and policy advocacy for achievement of Toronto's GHG reduction commitments. In 1991, Toronto also joined ICLEI's 14-city action research project that developed the first methodologies for municipal GHG baseline emission analysis and sector-by-sector emissions reductions (Harvey 1993).

The city initially failed to make significant progress in meeting the 20% target, and in 2007 deferred deep emissions reductions until 2020. Since 2007, Toronto emissions have been reduced markedly, as summarized in Table 5.1 Toronto's Decarbonisation Progress, by sector. Toronto's largest GHG reductions were achieved through the phase out of all coal-powered electricity generation stations by the Province of Ontario between 2001 and 2014. The other major source of reductions was in the solid waste sector, where the capture and reduction of methane gas has been the main investment (City of Toronto 2015).

Table 5.1 Toronto's Decarbonisation Progress, by sector

Source of GHG Emissions	Percentage Change in Toronto GHG Emissions from 1990 base year				
	2004	2008	2011	2012	2013
Electricity (under Provincial control)	+0.9%	-6.3%	-52.3%	-51.5%	-61.0%
Natural Gas (primarily use in buildings sector)	-5.9%	-4.1%	-9.1%	-18.9%	-11.1%
Transportation (not including rail, planes or boats)	-13.0%	-3.0%	0.0%	0.0%	0.0%
Waste (both City and private collections	-43.0%	-50.5%	-59.4%	-61.0%	-60.2%
Total Change from 1990	-7.3%	-8.8%	-21.5%	-25.1%	-23.9%
Total Change from 2004	-	-1.7%	-15.3%	-19.2%	-17.9%

In 2019, Toronto pledged to become net zero before 2050 but since 2014, the city's GHG emissions levels remained flat, leaving it a far distance from its target. Staving off the increasing emissions from transportation, and gaining further reductions from the buildings sector (56% of the city's total emissions), are continuing challenges (TAF 2019).

Toronto's central business district heating and cooling system contributed to GHG emission reductions and the steps involve give an indication of the coordinated interventions needed. Regulatory reform to permit a heat exchange loop within the city's potable water pumping station;

financing and establishment of a new business with a viable business model; city planning by-law amendments to require new buildings within the district to connect to the district system; and retraining of facilities management staff were all essential components.

Since committing to reducing emissions in 1988, Toronto has innovated in a number of areas that, if scaled, could secure further reductions. These include innovations in building owner financing for renewable energy installations; advanced green building codes and retrofits; district heating and cooling; the development of more integrated, multi-modal transportation options; and planning and development incentives intensify land use along transit corridors. The further introduction, acceptance and scaling of such innovations requires establishment of city-level transformation management capacity, cooperation between different levels of government, and ambitious private sector partnerships.

Urban decarbonisation pathways need to address the wider drivers of carbon intensity that extend beyond the direct powers and efforts of individual city governments, such as the sprawl of urban development beyond agreed boundaries, which increases transportation demand and vehicle traffic. As the Beijing case illustrates, the decarbonisation of urban regions also generally requires scaled, system-wide power system transformation that includes the region's development, including the decarbonisation of national and regional power grids; the reduction of the energy-intensity of the key metropolitan industry sectors; and significant innovation in the regional building industry.

Case Study: Integrating decarbonisation into the growth agenda of Beijing

The commitments and work of Beijing city government to reduce the capital region's GHG emissions further illustrate the importance of innovation, reform, investment, and coordinated governance across sectors and jurisdictions. Beijing's achievements are also notable for the way in which decarbonisation has been integrated into its regional growth strategy. Beijing government reports (Xinhua News Agency 2019) that it fully achieved the mitigation targets in its 12th Five-Year Plan (2010-2015), achieving an 8% reduction in carbon emissions while the city population and GDP grew 11% over the 5-year period. As a result, Beijing's carbon intensity in terms of GDP in 2018 was the lowest of all cities in China, while its per capita GDP is the highest.

Beijing's achievements—and further efforts within the context of the city's 13th Five-Year Plan (2015-2020)—focus on five areas:

1. Decarbonisation of the **energy fuel mix and end-use** 1) by managing the city's growth of energy end-use within an overall 10% limit between 2015-2020, 2) by shutting down all coal-fired power plants and continuing implementation of the "coal to clean energy" policy (The Municipal Government of Beijing 2017a) through initial conversion to natural gas or electricity in rural areas, and 3) by subsidizing the development of renewable energy sources for all sectors and by importing green power from other provinces and promoting establishment of a cross-province green power trading market.
2. For the **industrial sector,** Beijing is working to phase out traditional industries, by replacing these with lower carbon industry, or by reducing the carbon intensity of the traditional manufacturing sector. Focus industrial development areas include clean energy vehicles, cloud computing, big data, 5G, next-generation health care, and aviation and satellite applications.
3. In the **transportation sector** Beijing is working to reduce the region's traffic congestion (Municipal Government of Beijing 2020) through further development and promotion of public transportation, and is building a large network of electric vehicle charging infrastructure to reduce the average service radius to 5 kilometers (Municipal Government of Beijing 2017b) .
4. To reduce methane and carbon emissions in the **waste management sector**, Beijing has brought new mandatory waste sorting regulations into effect in 2020 (Standing Committee of Beijing Municipal People's Congress 2019), which will increase reuse and recycling of solid waste.
5. Finally, to **coordinate decarbonisation efforts** across the larger urbanized region, Beijing has joined with the neighboring city of Tianjin and Hebei Province.

Beijing and Toronto are both large, high-income and historically carbon-intensive cities that have made progress on existing sector reductions as well as working with a wider regional and metropolitan approach. There are other cities, primarily in the Global North, that have utilized the nexus and circular economy approach to reduce GHG emissions as cited above. The experience, ambition and learning from these cities can provide lessons on where and how other cities can start or intensify their decarbonization pathway.

5.4 Resilient cities pathway

The field of urban resilience emerged as urbanization became recognized as a key driver underlying the global increase of catastrophic events and losses since the 1980s (Tokyo Declaration on the International Decade for Natural Disaster Reduction 1989; Abramovitz 2001). Reflecting this trend, urban resilience practice 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 expanded to include climate resilience.

Urban resilience was further informed by the experiences of disaster risk reduction (DRR) practitioners as they confronted the unanticipated social and economic dimensions of climate-related urban crises and catastrophes. Events such as the Hurricane Katrina crisis in New Orleans in 2005 (Santos 2019) highlighted the extent to which, even in the wealthiest nations, chronic stresses of poverty and inequity, poorly designed transportation and telecommunications systems, and weak institutions and poor inter-governmental coordination, undermining a city's capacity to respond effectively, to recover, and advance the city's development goals.

These experiences gave credence to a developmental or 'evolutionary' concept of urban resilience (Davoudi 2012), which among other elements placed greater focus on the social and institutional dimensions of a city's resilience capacity, reflective of the Urban Realm 2: Resilient and Sustainable Cities in Chapter 4. This approach was first adopted by the Asian Cities Climate Change Resilience Network in 2008, and subsequently in 2013 by the 100 Resilient Cities (100RC) initiative, both of the Rockefeller Foundation (100 Resilient Cities 2019b; Martin et al. 2018).

The developmental approach to urban resilience addresses how chronic stress and vulnerability conditions in a city's population, communities, and institutions to the city's risks, in particular those most borne by the urban poor and other vulnerable groups such as the disabled, elderly, youth and women. The result is a view of urban resilience focused on the city's underlying capacity to adapt and 'bounce forward' to achieve and sustain their development ambitions instead of the earlier DRR focus on 'bouncing back' from a shock event to a city's original state. Urban planning, investments, and technical solutions needed to survive and adapt constitute part of the urban resilience focus along with fundamental changes in government institutions, functions, processes, and operations and their relationship with communities and social organizations (Collier et al. 2014, p. 80).

As such the establishment of city pathways to build urban resilience has been found to involve the development of two foundational capacities in city government and in the urban community broadly. These are:

1. **Resilience planning capacities** of government and city-building partners and community stakeholders and the **processes** related to policy, planning and institutional reforms required to prepare and implement a holistic, developmental strategy and agenda for society-wide resilience;
2. **Resilience-based design** in the context of specific urban investment projects, programs, and operations, regularly prioritized through the above resilience planning process.

5.4.1 Developing resilience planning capacities and processes

A city's exposures differ based on locations and economic sectors, and are related to specific urban forms and design, infrastructures and other built assets. A city's vulnerabilities are determined not only by the location and dependency of population groups and sectors related to exposed places and urban services systems, but also by their underlying condition independent of any hazard exposure or potential shock event. A city's overall resilience therefore is only as great as the strength and preparedness of all parts of a city together, including the most vulnerable, as an integrated urban system or place. In order to do so, city leaders and managers focus not only on how to improve and secure the performance of the distinct operations, infrastructures, places, and communities but on how to better enable the city to grow and thrive in both good and bad times.

Local governments pursuing a developmental resilience approach have generally developed two key planning processes and capacities, including improved collaboration between local government and service utilities, private sector and community stakeholders across all sectors, and other levels of government. These are:

i) Resilience assessment. Cities have institutionalized a range of comprehensive hazard and stress assessment processes to evaluate the cumulative risks arising from the interaction of shock events with local stress conditions under different scenarios. A resilience assessment typically considers longer-term (i.e., 30 year) hazard, exposure and vulnerability trends and scenarios that could undermine achievement of the city's strategic development goals. By their nature, resilience assessments cut across thematic and operational areas. They define the priority areas of exposure and risk that require system-wide resilience-building efforts, including actions to build the capacity of households, communities, and organisations to respond, adapt, and recover from shock events.

Establishing such a comprehensive view of conditions and interdependencies, between government, private, civic and community realities, has generally required broad based engagement of those 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 critical to enabling quality contribution to the process. Doing so can require the development of local political mandate and the evolution of more participatory and open governance cultures. For example, Accra's urban resilience strategy includes an entire section focused on embracing the contribution of the informal sector to resilience building (Accra Metropolitan Assembly 2017), developed in partnership with the local affiliates of Slum Dwellers International.

ii) Coordination, leadership & institutionalisation. The preparation and implementation of urban resilience plans has typically required the establishment of a distinct leadership approach and management capacity to coordinate the efforts across different jurisdictions and sectors, where this has not traditionally been done. Urban regions are generally divided into small and often uncoordinated, if not competing, local government jurisdictions. Within these jurisdictions city administrations and management are typically organized into separate sectors that do not coordinate their work on a regular basis, or even work at cross purposes. City plans and investments are typically executed, managed and owned by distinct entities separate and unintegrated infrastructures and services. Resilience building requires action across city processes such as spatial planning and development regulation, assessment, budgeting, and procurement, building codes and permitting, and local government asset management and service functions. The resulting need to coordinate resilience planning efforts across jurisdictions, operations, and sectors has instigated the evolution of new senior management functions and roles designed to provide such cross-cutting leadership. In Los Angeles, for example, this led the mayor to not only to establish a Chief Resilience Officer (CRO) within his Office, but also to mandate the establishment of standing CROs in all city departments (Los Angeles Mayor's Office 2018).

Case Study: Preparing a resilience transformation pathway in Cape Town, South Africa

The case of Cape Town, South Africa illustrates how cities are beginning to establish the above capacities and to institutionalize resilience planning in the face of extreme social, economic, and environmental stresses and major crisis events; and how those capacities are used to design a pathway for addressing both a city's acute risks and chronic vulnerabilities. In 2018, when Cape Town first established its resilience planning efforts, the city was confronted by a severe drought crisis. This crisis was followed 17 months later by the COVID-19 public health and economic crises.

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 inequity. In 1996, the South African government established Integrated Development Planning requirements for local governments (Parnell and Pieterse 1998). This developed capacities and imperatives within Cape Town to consider the inter-relationships between the city's spatial structure, its infrastructure and urban services systems, and its social and economic justice and environmental conditions . The integration-oriented approach, core to urban resilience, also developed organizations and partnerships that became central to Cape Town's resilience planning efforts in 2016-2019.[11]

The City has received advisory support in recent decades through participation in global city networks such as C40 and ICLEI. In 2017, the City appointed a Chief Resilience Officer and created a new resilience team, with support from 100RC. The team executed a comprehensive resilience assessment including interviews with over 11,000 civilians and 200 thematic experts from community-based organisations, non-governmental organisations, business, academia and government (City of Cape Town 2019a, p.2). The assessment considered the separate exposures and risks of the distinct areas of city services and operations, of the economy, and of different aspects of social well-being and vulnerability to those exposures (e.g. health, security). It also focused on how risks in each area interacted with those of other areas, which helped to refine cross-cutting priorities for action. The result of this process was an official city government commitment, in partnership with participating 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 pathway for resilience transformation:

1. Compassionate, holistically healthy city
2. Connected, climate-adapted city
3. Capable, job-creating city
4. Collectively, shock-ready city
5. Collaborative, forward-looking city

[11] These organisations are cited in the Cape Town Resilience Strategy as the African Centre for Cities, University of Cape Town; GreenCape; the Cape Investor Centre; the Western Cape Economic; Development Partnership; and Slum Dwellers International. (City of Cape Town 2019, p.2).

During Cape Town's resilience planning process, an acute water supply crisis emerged, demanding immediate and intensive deployment of its new resilience planning and partnership capacities. Cape Town has faced increasing water stress since the 1980s, and the city government was already instituting demand management measures in the 1990s. In that decade, the city achieved a decoupling of water consumption from population growth. Predictions of severe water crises in the early 21st century (Parks et al. 2019, p.1) materialized in the 2015-2018 period, and by early 2018 the City was preparing for 'Day Zero' when the city's potable water sources would be exhausted.[12]

Efforts to forestall Day Zero were substantially coordinated by the City's new resilience team and related network of external support organizations. The Day Zero communication campaign reduced city-wide water use by 40% from 2015 levels through successful execution of regulatory, technical, and voluntary measures, and related economic incentives. To support society-wide mobilization, the campaign built on constructive relationships between the City, civil society organisations, and the business community. It encouraged citizen responsibility via a wide range of voluntary measures including the collection of grey water for toilet flushing, installation of rainwater tanks and water-saving devices and re-landscaping of lawns. Some businesses took themselves off the municipal water system, and new businesses emerged to meet 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 long-term water strategy, further applying the 'bounce forward' developmental resilience approach whilst drafting the City's broader resilience strategy (City of Cape Town 2019b). The Cape Town Water Strategy was developed with reference to 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 is based on a comprehensive system-of-systems approach, addressing all aspects of water supply, management, consumption, and equity

[12] The City and its strained water utility had to address the crisis within the context of unique policy, jurisdictional, and socio-economic 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/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. Then the shock event—the drought—occurred.

4863 across the entire regional watershed, including the restoration and further development of natural
4864 systems.

4865 The City launched its final comprehensive Resilience Strategy in August 2019. Following a year of
4866 public comment and review, the final Cape Town Water Strategy was released shortly thereafter in
4867 February 2020. In March 2020, Cape Town identified its first cases of Covid-19 - the start of an
4868 equally severe shock event. The Cape Town CRO and resilience team immediately assumed city-wide
4869 coordination and response planning capacity on behalf of the City, applying approaches and
4870 coordination mechanisms developed in the preceding resilience strategy planning efforts.

4871 5.4.2 Resilience-based design

4872 Ultimately, the implementation of an urban resilience pathway involves the design and management
4873 of resilience within each of the basic building blocks of a city: within each of its infrastructures,
4874 streets, districts and neighborhoods, facilities and buildings, utilities and services, businesses,
4875 livelihoods, and households. To achieve such comprehensive implementation, new design capacities
4876 and guidelines may need to be developed within each area, working with the relevant stakeholders.

4877 Figure 5.4D indicates four aspects of resilience performance for any project, asset, service, or activity
4878 that support its contribution to city-wide resilience. This design framework was applied, for instance,
4879 in the development of a detailed set of design and operational recommendations for school
4880 infrastructure resilience in Cali, Colombia, linked to the City's plan to replace 69% of the existing city
4881 school buildings (Alcaldía de Santiago de Cali and 100RC 2019). Reflecting each of indicated four
4882 quadrants in Figure 5.4D, the City has been applying the retrofit funds not only to reduce risks from
4883 earthquakes, but also to improve the use of schools for a range of community functions such as health
4884 clinics and community centers and to better address community socioeconomic challenges through
4885 school curricula.

4886 Figure 5.4D (to be designed with this information)

4887 **A. Organize and manage for routine performance.** Consider how to design and manage the asset,
4888 service, or activity so that it can reliably achieve high quality performance, contributing to targeted
4889 development objectives *under routine conditions*. Although such basic performance would seem to
4890 be the least common denominator of responsible design, many cities and stakeholders require
4891 greater support to achieve established general performance standards.

4892 **B. Ensure robustness, safe failure, and prevent cascading impacts from shock events.** Consider
4893 how to 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, so that in the instance of failure, potential cascading impacts are minimized. This requires comprehensive assessment of risks and of interconnectedness between assets, services, etc. 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 response, and the incorporation of special features for example, redundant power or water supply.

C. Leverage the greatest co-benefits from city resources. A developmental resilience approach emphasizes securing the maximum possible societal benefit from any particular investment or service, with a particular view towards vulnerable groups and places. Specifically, resilience design seeks to generate co-benefits that contribute to the reduction and mitigation of the city's main chronic stress conditions, which reduce the capacity of people, businesses, and institutions to withstand shock events. The identification and development of co-benefits generally requires collaboration between stakeholders, and across departments, functions, and disciplines, and co-design with vulnerable communities.

D. Build adaptive capacity. Finally, a resilience design process seeks to develop the awareness and capacity of engaged institutions, businesses, communities and households to anticipate changing circumstances, and to adapt. In the context of any project, service, or enterprise, a resilience approach leverages opportunities to not only deliver a more reliable, quality asset or service, but also to build know-how, skills, and to facilitate access to relevant information in the instance of an extraordinary event.

The concept of urban resilience has evolved over time to incorporate climate resilience and to advance a wide range of development aims. As a result, resilience work builds governance systems and processes that are more integrated and inclusive. The Cape Town case demonstrates how the process of building transformative urban resilience can be targeted to acute shocks, which is especially relevant as cities continually deal with the COVID-19 crisis and its fallout.

5.5 Socially inclusive and just cities pathway

The need to articulate justice in the pursuit of urban sustainability and resilience has been long acknowledged,[13] yet equity considerations are often absent from sustainable urban development

[13] See for instance: Fraser (1996); Schlosberg (2003); Agyeman (2005); Fainstein (2010); Heynen (2014) and UN Habitat (2015).

efforts.[14] As discussed in Chapter 2, the persistence of colonial and patriarchal relationships, the increasing commodification of urban life, the inadequacy of planning systems, as well as the misrecognition of 'informal' city-making processes are some of the underlying processes that impede the transition toward socially inclusive and just cities.

As argued in Chapter 4, a 'just' city can be defined as one where all residents have equal opportunity to thrive and prosper, and where health outcomes and environmental benefits are shared equitably, regardless of people's class, gender, age, ethnicity, religion and ability. Working towards socially and environmentally just urban development requires attention to both equitable processes and outcomes. However, planning practice is still characterized by a number of significant oversights in this regard, such as the reluctance to confront the historical trajectories that produce and reproduce injustice, both in terms of how 'problems' and 'solutions' are framed. For example, when addressing equitable access to food across US cities, there is a need to take into account the differentiated impact of policies and planning in marginalized black communities. (Raja, Morgan and Hall 2017). While the 'poor diets' and individual behavior of African-Americans have become the target of many US urban policies, hardly any attention goes to addressing the steady decline of their control over food production and the extent to which this has been the outcome of public policy.

While fair distribution is a key component of justice, a focus solely on distribution is not enough. For instance, many cities have engaged in enhancing urban mobility by making transport more accessible geographically or in economic terms through reduced fares. However, a single focus on transport infrastructure and services is likely to ignore the diverse travel needs and choices of different urban dwellers – women, children, or people with health conditions or impairments, among others (Levy 2019; UNECE 2020). This is because transport systems are usually planned to cater for the needs of 'average' users, a practice that is deeply biased towards some urban residents while rendering invisible the experiences of others who rarely have a voice in their design. Thus, pursuing just urban development demands tackling processes of mal-distribution and misrecognition in cities, while seeking parity of participation in decision-making, particularly for those typically marginalised from such processes.

[14] 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 equitable access to low carbon services through accountable mechanisms of production and distribution (Horne 2017, Bulkeley, Edwards and Fuller 2014).

In short, urban transformation requires bridging actions towards justice, sustainability and resilience through everyday planning and political practices, while casting a critical eye on historical trajectories and the factors that make them unjust. Typical past responses have looked at environmental education and pricing mechanisms to change urbanites' behaviour towards more sustainable consumption and indirectly production patterns. However, when people are locked into urban trajectories that are characterized, for instance, by inadequate access to water and sanitation services or the lack of alternatives to commuting via private vehicle, such mechanisms alone are unlikely to achieve significant change. This applies not just to most fast-growing cities across the Global South, but also to Global North cities, where infrastructural deficits and poverty might be less widespread but where spatial and socio-economic inequality still prevails.

The above emphasizes the value of approaching cities as complex and self-organising 'adaptive systems' structured through multiple interactions across different scales and levels of organisation (Olazabal 2017). Understanding cities as complex adaptive systems implies that change towards more desirable trajectories is the product of multiple interfaces and interactions within any given system, based for instance on food availability, mobility options, or perceived safety - rather than through individual behaviors or top down approaches.

To avoid locking urban development into socio-environmentally negative trajectories, urban areas need to be more self-reliant in terms of food, power, and water; create multiple options for recycling, reuse, and remanufacturing of materials; and enhance car-free mobility, which connects back to the Circular Cities pathway (section 5.2). These substantial changes are not easy, particularly within the timeframe in which assertive action is required. What is clear, is that transformational action towards just urban development relies upon the collective capacity and agency of ordinary citizens vis a vis the responsibility of the state to lay the foundations for equitable processes and outcomes. Multiple initiatives and processes enabled to mature over time allow room for reflexive learning along the way. Pursuing inclusiveness and justice requires attention to the unintended consequences of green interventions, for example by triggering green gentrification and displacement. Building upon these considerations, this section explores four distinctive approaches through which pathways to just and equitable urban development are built in practice:

1. **Re-naturing the city** or 'planning with nature', by applying landscape ecology principles to enhance health and well-being of all citizens, urban biodiversity, the provision of ecosystem services and resilience to climate change shocks.

2. **Injecting equity considerations** –such as racial justice-into the pursuit of environmental justice.
3. **Securing the right to the city** by transforming and grounding urban governance processes and adopting a wider political perspective.
4. **Building justice beyond the city**, tackling the impacts that cities impose upon distant 'elsewheres' and typically marginalized social groups in and outside of the city.

These approaches are often initiated with the explicit intention to tackle the inequitable impact of chronic urban environmental stresses and deprivations, whether in relation to ill-health outcomes or inequitable access to urban services, public amenities or ecosystem services.

5.5.1 Re-naturing the city with equity

The notion that cities should be designed with and not against nature is not new, but it has re-emerged in recent years (McHarg 1969; Steiner et al. 2019).[15] Under the wide umbrella of 'urban greening', 'biophilic cities' and the 're-naturing' of cities, there is a growing call for collective action to protect biodiversity in and around cities to prevent irreversible loss and damage to the natural systems we depend on. This broad movement acknowledges that nature provides diverse life-supporting and life-enhancing contributions to people in cities, but also that a just city should also include justice to nature.

In this context, nature-based solutions are rapidly proliferating across different urban systems and ecosystems as with coastal cities where urban landscapes and seascapes meet and where human behaviour and urban development have profound impacts on both terrestrial and marine ecosystems (UNESCAP 2019). Furthermore, the field has evolved over the last few years from its original emphasis on economic and instrumental values, as well as technocratic solutions, to encompass a more critical and holistic perspective on questions of justice and equity (Randrup et al. 2020). Race and gender equality considerations have played a key role in expanding the scope of current debates and practice. For instance, the work of the Gender CC – Women for Climate Justice is an example of emerging global networks seeking to overcome gender-blindness across the world. Gender CC is a

[15] Since 2008, the Convention on Biological Diversity (CBD) has included a focus on cities and subnational governments. The 2009 adopted Plan of Action on Subnational Governments, Cities and Other Local Authorities for Biodiversity (2011-2020) has helped cities coordinate local and national biodiversity strategies and action plans. The Post-2020 Global Biodiversity Framework (GBF) 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 IUCN, with support from CBD – offers an international platform for cities to enhance urban nature and work towards greater sustainability.

broad coalition operating across the global north and south working to ensure that gender responsive approaches are implemented in urban adaptation, mitigation and low-carbon development.[16]

Over the last decade, we have also witnessed a growing wave of responses to calls for re-naturing cities. These include the experience of Milan, as well as Barcelona's Green Infrastructure and Biodiversity Plan 2020; Melbourne's Vision to enhance the city's biodiversity and human wellbeing by restoring native vegetation through nature-based solutions; and Shanghai's ambition to become a 'sponge city' for flood prevention.[17] Meanwhile, some cities are engaging in participatory processes to guide green regeneration in targeted derelict areas, a trend observed across many USA cities, which have transformed disused rail corridors for public greenways under the Rails-to-Trails initiative, also providing havens for wildlife (Scherrer et al. 2020). A similar approach has been adopted in Berlin, where citizens engagement has led the transformation of the inoperable Tempelhof airport into one of the city's most popular parks, managed by 100% Tempelhofer Field Group, who act as environmental stewards to conserve the biodiversity of the park and prevent its development.

Case Study: Greening Milan, Italy

Milan is among other 'urban greening' champions facing contradictory outcomes. In 2013, the local administration devised an environmental plan to expand urban greenery to cool the city - an action badly needed considering that over 60 percent of the soil is sealed (one of the highest levels in Italy). Since then, the number of regional parks in the city has increased by almost 40 percent (Mariani et al. 2016). Heat mapping has enabled the city to focus extensive tree planting on sidewalks, streets and exposed pavements in the hottest neighbourhoods. The local administration has committed to plant three million trees - more than twice Milan's current population - by 2030. Milan's green cooling is part of a wider metropolitan strategy that includes the creation of a green system connecting green spaces and parks throughout the metropolitan area (Green Rays and Green Belt). These schemes include reserved public rights to purchase land, though there is little information to establish if this has prevented green gentrification. Furthermore, the collective versus individual

[16] For more information about Gender CC work visit: https://www.gendercc.net/home.html

[17] This programme includes a battery of measures, including the replacement of concrete sidewalks with permeable pavements, street rain gardens and rooftop gardens.

positive impacts on citizens attributable to Milan's greening are still to be assessed (Blessi, Grossi and Pieretti 2015).

The experience of 'Isola', a central neighbourhood situated between railroad tracks and canals, puts the equitability of Milan's greening strategies into question. Back in 2001, a collective of local residents and activists established the Isola Art Center to work against gentrification by linking art and greening projects locally produced as counter proposals to the municipal plans for the area. In 2007, the city council evicted the craftspeople and the associations and demolished the building. Two years later, Isola became one Milan's new eco-districts, with plans to build underground parking lots, luxury dwellings and two tree-covered towers called 'vertical forest' in place of an existing park. Nowadays, Isola is described as one of the 'coolest' areas of the city, blooming out of a former working-class district to a vibrant hipster area.

The case of Milan highlights that counteracting the processes that threaten the equitable flow of benefits from greening strategies remains a challenge. Greening initiatives often lead to increases in land prices, while reduced access to affordable urban land tends to displace poor populations away from working areas, which in turn reduces their resilience and wellbeing. 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 the poor and the fragmentation of ecosystems (Raja, Morgan and Hall 2017). This calls for a deeper simultaneous engagement with the recognition of nature and social diversity, and the prevention of green gentrification processes (Anguelovski et al. 2018).

Retaining and increasing social housing plays a key role in preventing green achievements from being made at the expense of lower income groups. Looking into the establishment of new parks in historically disinvested neighbourhoods in 10 US cities, Rigolon and Nemeth (2019) found that the creation of small green areas and nearby affordable housing is not enough to prevent green gentrification because new greenway parks and active transportation improvements, as well as new downtown parks appear to trigger gentrification.

A critical factor across most city-greening experiences is to plan for gentrification effects before displacement happens. A "just green enough" approach uncouples environmental regeneration and cleanup from high-end residential and commercial development (Curren and Hamilton 2017). The experience of Brooklyn's Sunset Park neighborhood illustrates how this looks in practice. Greening strategies are anchored and driven by the neighborhood's oldest Latino community-based organization, and built on the experience and expertise of its largely working-class immigrant

residents. Combining racial justice activism with climate resilience planning, the group advocates for investment and training for existing small businesses (often Latino-owned) to activate a sustainable and circular local economy. Similar initiatives in the North Brooklyn industrial area are working to ensure that 'Superfund'[18] cleanup and other remediation measures do not rely on displacing workers and residents in manufacturing areas. 'Greening' cannot just be conceived as a feature of post-industrial cities, it requires crafting new grounded actions through an equity lens.

As demonstrated in Buenos Aires, where to mitigate flooding, they are undergoing an extensive program to update and improve its river basins to better handle flood events and protect low-income communities most at risk, while also extending access to drinking water (C40 2019).

5.5.2. Building equity into environmental justice & the right to the city

As cities focus on environmental issues and balancing this with the needs of their residents, there are several approaches that they can take to improve the well-being of residents and address broader injustices. For example, in Cape Town many residents of poorly insulated homes are susceptible to tuberculosis and other illnesses. By focusing on retrofitting ceilings in low-income communities, the city can reduce energy demand whilst improving health.

In Barcelona which published its new Climate Plan in 2018, there is a strategic focus on environmental justice and citizen co-production in order to focus on inclusive climate actions that address climate challenges and socio-economic inequality simultaneously, benefitting all Barcelona residents (C40 2019).

Case Study: Seattle and the Duwamish Valley Program (DVP), USA

The city of Seattle has long been at the vanguard of tackling social and environmental injustices simultaneously. Seattle's municipal electric utility was the first large utility in the United States to achieve carbon neutrality, the city is making good progress towards the goal of ensuring that 30 percent of all new vehicles are electric by 2030, and recycling rates are amongst the highest in the country. Nevertheless, the city's administration has also acknowledged that Seattle's environmental performance is not enough, if structural inequalities are not tackled. The local administration defines a 'sustainable city', as "one where all residents have equal opportunity to thrive and prosper, where health outcomes are consistent across all community, racial, and ethnic groups, and environmental benefits are shared equally by everyone" (Coven 2018).

[18] The term 'Superfund' designates polluted locations in the United States requiring a long-term response to clean up hazardous material contaminations. In the USA and other contexts like the UK, there are now institutionalized mandates to remediate industrial lands for repurposing.

In 2015, Seattle launched the Equity & Environment Initiative (EEI), with the explicit aim of tackling structural and institutional environmental racism, acknowledging "that communities of colour and others most affected by environmental inequities must be at the table to build solutions" (Local and Regional Government Alliance on Race and Equity 2016). To this aim, the EEI created an Environmental Justice Committee, which includes leaders representing African-Americans, low-income residents, immigrants, refugees, and those with limited English proficiency. Recognising gender and age biases in local leadership, the emphasis went to engaging women and the youth from all these communities. Constructing new spaces for participatory democracy was essential to enable discriminated communities to shape the actions and resources required to support an urban environmental agenda centered on racial equity and identify where municipal action and resources were most required. This led in 2016 to the launch of the Duwamish Valley Program (DVP), a multi-departmental effort to advance environmental justice and equitable development in a site where local dwellers have experienced well-documented injustices for years.

Home to approximately 5,600 people and numerous businesses and industries, Duwamish Valley is not only a 'Superfund' site requiring a long-term response to clean up hazardous material contaminations, but also an area where local communities face many other stressors and have received significantly less investment than other parts of Seattle over the years. Here, 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 is frequently subject to flooding. The DVP started with an 18-month process that engaged residents, workers and businesses to capture their priorities, values and aspirations. This led to a co-designed Action Plan to expand livelihood and housing opportunities, improve environmental and health outcomes, and increase investments in the Duwamish Valley.

To ensure that these objectives are tackled in an articulated manner, the DVP relies on the Healthy Living Assessment, an ongoing community-led diagnosis to understand how racial inequality and health disparities correlate, where, with what consequences and for whom. This georeferenced system allows the identification of key interconnections between social and built-environment health determinants, and to orient specific measures and investments in health-promoting infrastructure and opportunities where they are most needed. For instance, the diagnosis revealed that life expectancy in predominantly African-American low-income areas is 13 years lower than in white upper-income neighborhoods. Similarly, about 24 percent of women and men living in disadvantaged areas lack any form of health insurance – almost twice the citywide average. Lack of mobility options,

high incidence of diabetes and food insecurity also show higher prevalence in these areas. The DVP includes plans to adopt equity indicators to track differential impacts and housing displacement according to race, ethnicity, and income, as well as demographic information to understand who is benefiting from local authority investments (Coven 2018).

The DVP has nurtured spaces to enhance political participation in local decision-making beyond male dominated leadership. For instance, a Latino Women Coalition are leading local efforts to pursue affordable housing and anti-displacement strategies, bringing to the fore the reality of low-income renters in the Duwamish Valley. Actions to prevent displacement city-wide have been greatly aided by the adoption of the Displacement Risk Index, a living map that shows where displacement of marginalized populations is more likely to occur. Putting in place accessible georeferenced information tools that show how key correlations change dynamically over time and project trends is essential for forward planning.

Figure 5.5 shows how the programme is evolving 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 locally meaningful and to anticipate and tackle real estate trends that could lead to green gentrification and displacement.

Figure 5.5 Duwamish Valley Action Plan

Source: Coven (2018).

Despite the aforementioned achievements, Seattle, among other cities on the west coast of the US and Canada known for being "green" are still largely dependent on imported wealth, which highlights the

importance of addressing their dependency on tourism and consequent high energy intensive impacts.

5.5.2 Crafting a rights-based approach to equitable and sustainable development

Case Study: Equitable approaches to urban development in Rosario, Argentina

Fostered over 20 years of continuous commitment to decentralization, transparency, accountability and participation, the city of Rosario offers an inspiring example, where a broad vision towards equity and sustainability and a democratically grounded process drive the city's strategic planning for the whole metropolitan area.

Since 1989, successive mayors have built upon the core principles of progressive municipalism. Over the years, the democratisation of municipal governance has involved the decentralisation of resources and decision-making capacities to the district level. With just over one million inhabitants living in six districts, each district undertakes a robust and grounded participatory process not only in the definition of urban projects and allocation of municipal resources, but also in the development of the strategic plan for the whole of Rosario (PER) and its update after 10 years (PERM+10) (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. Box X outlines the key pillars in Rosario' strategy.

An essential component of the ancillary of Rosario's long-term approach to equitable urban development has been the Integrated Programme for the Rehabilitation of Informal Settlements. Created in 2001, the programme focused 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 difficulties faced in relation to land regularization, the programme set an important precedent, showing that upgrading instead of relocation is a viable strategy at city-scale. The Rosario Hábitat Programme ended in 2012, having invested during its first phase almost US$ 72 million – 60 percent financed by a loan from the InterAmerican Development Bank and the rest from municipal finances. Since then, informal settlements rehabilitation continued under Promeba[19], a national programme that works across other municipalities (Almansi 2009).

[19] *Programa de Mejoramiento de Barrios*.

A second key component in Rosario's strategy has been its Urban Agriculture Programme (PAU)[20]. Launched in 2002, to supplement the city's food donations to the poor, over time, PAU became aligned with the national program Pro Huerta, and its scope expanded to integrate urban agriculture into land-use planning. This included the systematic identification of vacant land, and the recognition of farming practiced through peaceful usurpation of vacant plots, a practice that emerged in Rosario during periods of economic crisis, but is also frequent across other cities in the global south even outside crises. The granting of temporary use rights for urban agriculture, gave urban farmers certainty to invest, while the PAU became responsible for monitoring and controlling the use of vacant land for farming throughout the city. Furthermore, farmers are encouraged to work on plots of land alongside roads, railroads, and streams, where they can farm indefinitely while greening interstices within the city. Enhanced access to land also led to the creation of communal gardens in a nearby natural reserve and supporting measures to ensure access to water through new wells and water pumps installed by the municipality (Rosenstein 2008). The Programme has a strong gender focus, benefiting disadvantaged women through the creation of new livelihoods along the full food chain (Guénette 2010).

The third backbone anchoring Rosario's strategy is its Participatory Budgeting (PB). Introduced in 2003, over time, PB has become a key redistributive mechanism, a rights-based governance instrument, a communication tool, as well as a vehicle for citizenship capacity building (Lerner and Schugurensky 2007). Between 2003 and 2011, the PB budget amounted to roughly 9 million dollars per year, representing approximately 22 % of municipal budget for investment but only 1.5 % of the overall municipal budget (Cabannes and Lipietz 2015). PB promotes gender equality through: parity in political participation; prevention of domestic violence against women and children, awareness raising on sexual rights and the strengthening of women networks, among other mechanisms. Since 2004, Rosario's PB also earmarks part of the budget available to initiatives supporting the youth. In 2013, the city introduced a voting system in Braille and translated the PB manual in one indigenous language, becoming the first city in Argentina with a multicultural approach to planning, spearheaded by PB (Corbetta and Rosas 2017).

In a comprehensive study that looks at the performance of PB in 10 cities across the world, Cabannes and Lipietz (2015) argue that one of the deepest achievements of PB lies on its contribution to 'reversing' previously established municipal priorities and long-term disinvestment on the urban poor. The notion of 'reversion' or 'inversion' originates from PB experiments in Brazil and it implies

[20] *Programa de Agricultura Urbana.*

shifting priorities "both in political terms (i.e. those who previously never exercised power can now make decisions concerning the budget) and in territorial terms (i.e. historically investments did not reach poor neighbourhoods and adjacent rural areas and now they do) (Cabannes 2014 p. 27).

Adopting a rights-based approach, Rosario has indeed engaged with a full-reinvention of planning mechanisms. In addition to the ones aforementioned, the city has a strong and clear set of rules and obligations to guide public and private urban development. These include reserved land for public and community spaces; the preservation of historical and natural heritage, density controls and land value capture mechanisms. Under the latter agreements signed with big private landowners or real estate developers have to dedicate part of the land for the development of public spaces and for social housing. Although this and similar redistribution mechanisms are not exempted from challenges, the fact that they remain operational across the city and over the years is remarkable.

5.5.3 Seeking equity beyond the city

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 large ecological footprints (Allen 2014). If this trend remains unabated, the impact of cities on inter-regional and intergenerational justice will continue to be unchallenged. In many parts of the world, urbanisation goes hand-in-hand with growing reliance on food transfers from rural to urban areas and remittance flows from urban to rural areas (Frayne 2005; Allen et al. 2015). Strengthening reciprocal rural-urban linkages means that the flows and interactions that link different locations together are increasingly important. In this regard, encouraging and facilitating the engagement of transdisciplinary approaches that examine the dynamics of social-ecological-technical systems (SETS) is key (McPherson et al. 2016).

Seeking urban justice inevitably means to take into account how material flows, transformations and effects work in the face of regional and global change. Because of the insurmountable difficulties for a city to work on its own to close material loops, shift to renewable energy sources, increase reuse and recycling or lower the CO2 footprint of economic activities, it is not surprising that most initiatives on this front are highly networked.[21] Box X examines how the Transition Towns (TT) network works to proliferate nihes of radical innovation changes across the word.

[21] Examples include the C40 network, a worldwide coalition of 94 cities committed to reducing their greenhouse gas emissions. By 2019, about 30 cities within C40 are reported to have curbed emissions by 22 percent on average. While London, Berlin and Madrid lowered their emissions by 30 percent, Copenhagen reached a dramatic

Case Study: The Transition Towns Network

Founded in the United Kingdom in 2006 as Transition Town Totnes, the Transition Network – also known as Transition Towns (TT) movement – emerged one year later to rapidly expand grassroots-led innovation across other cities in Europe, North America, Australia and Brazil. The aim of TT is to promote self-sufficiency to reduce the effects of peak oil, climate change and economic stability. By 2010, the network recorded more than 130 active transition towns in Britain, and another 250 worldwide. By September 2013, the network was supporting over 1,000 initiatives in 43 countries.

The working principles of TT are ambitious but highly context-specific in the implemented actions. For instance, since 2007, Transition Town Brixton – one of London's most socially and ethnically diverse boroughs - has nurtured grounded efforts towards radical transformative change, building along the process close working relations between local communities and the local authority. Examples include the coining of a local currency – the Brixton Pound - aimed at promoting a solidarity economy, local trade and production; the Remade in Brixton initiative promoting action to make better use of resources locally, focusing on efficient use, repair, reuse and recycling to cut carbon and build local resilience. And the Brixton Food and Growing initiative that propagates permaculture practices in urban agriculture, as well as the Food for Schools initiative endorsed by the local authority to tackle deep inequalities in access to healthy and nutritious food across the Borough.

TT's transformational potential lies in its capacity to proliferate niches of grassroots-led innovation to diffuse new ideas and practices into wider society, as well as to translate these changes into wider socio-technical regimes. Looking at the performance of TT in the UK, Seyfang and Haxeltine (2012) found significant achievements in the areas of innovation, niche formation and diffusion. Translation however is more difficult, particularly, given the movement's countercultural and radical approach to unsustainable regimes. Nevertheless, some key messages closely aligned with the vision of Net Zero Circular Cities - such as reskilling, localising food production, and thrift – are becoming mainstream.[22] While it is difficult to attribute these changes solely or directly to the TT movement, its emphasis on the public communication of radical but achievable practices has played a role in

61 percent, though in relative terms its pick emission levels were historically significantly lower than those of other cities in the coalition (Poon 2019).

[22] Examples include the UK's National Trust shift to turn stately home gardens into allotments, although wider access to them remains a challenge, partly addressed by making some of these spaces available for community gardens and for schools. A similar orientation to expand opportunities for healthy living can be seen in the UK government's promotion of skills for growing and cooking healthy food.

crafting new discussions and imaginaries on what cities and citizens can do to move towards substantial transformation.

While the TT movement encompasses elements of a social shift towards increasingly fashionable 'make, do and mend' cultural practices – at least across certain sectors of urban societies - tackling consumerism remains a key challenge where bold city-actions are badly needed. This requires concerted efforts to understand and change urban consumerist behaviour, whether in relation to car use or diet and nutrition. Action-oriented 'tactical urbanism' or DIY urbanism (Silva 2016) might offer an alternative to address the shortcomings of formal spatial planning tools. This approach encompasses community-led urban interventions deployed to promote deep change in attitudes and behavior. Examples include the work of City Repair[23] in the Portland Metro Area, DePave[24] and BetterBlocks[25] across various Canadian and US cities.

The above examples represent networked efforts that operate at two extremes of the urban action spectrum, each of which faces its own challenges to put in motion the changes required to activate true radical transformation from the local scale. While it is too early to assess their impact in translating ideas and practices from innovation niches into wider regimes, these experiences indicate that relying on social rather than technical change can open opportunities for equity considerations to be closely aligned with substantial environmental aims.

As argued throughout the experiences reviewed, to produce equitable outcomes requires activating not just 'change' in the city but rather simultaneous processes of interlinked changes, as well as accountable governance systems to ensure that social and environmental benefits flow across diverse social groups over space and time (Andersson et al. 2019). Unless these complex urban dynamics are explicitly acknowledged and tackled, the root drivers of socio-environmental injustice will continue to self-reproduce across space and time.

5.6 Navigating urban transformations: key lessons

The pathways examined throughout this chapter are necessarily complex, and they must be so in order to solve complex, inter-linked problems. However, as we have shown through cases, cities, city networks, local actors and national governments have been successful in achieving at least some of the goals of transformation. An overarching lesson is that it is unrealistic to expect any one actor to

[23] https://cityrepair.org/blog
[24] https://depave.org/learn/resources/
[25] https://www.betterblock.org/

play a transformational role alone–many cities around the world do not have funds, capacities and agency to act, and at the same time national governments often do not fully understand and respond to city-scale challenges and inequities. Single national-level policies, incentives for a limited set of actors (such as behavioural change measures or inducing competition among cities), and better technology are unlikely to achieve transformative change in isolation. Further, many existing programmes and policies are geared towards promoting technocratic transitions that do not recognise the role that citizens can play in driving forward the transformations required. A cross reading of efforts towards transformational change offers a number of important considerations:

- **Take a critical approach to establish meaningful agendas:** The travelling 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 fast carbonising, and instead climate change adaptation needs to be prioritised. Most cities face a combination of challenges that need to be identified and tackled in light of their own development trajectories, instead of recipes externally prescribed.

- **Leverage stresses and shocks for long term visioning:** While many actions might begin as responses to chronic stresses or specific shocks, this can be converted to long-term and strategic responses. Allow time for a system to evolve from discreet actions to wider-impact and long-term strategies and space for reflexive learning.

- **Incorporate expert insights from data and science into decision making processes:** Many of the insights required to guide transformational pathways require specialist expertise that often does not sit within local governments. Expert guidance is required to gather, process and interpret the data required for material flow analyses, GHG baselines and resilience assessments, amongst others. Participatory processes of engagement are required to develop strategies from these reports, ensuring that they 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 on which local or international content specialists have the necessary experience, and in some cases can help to connect cities with funding to conduct these studies.

- **Take advantage of existing knowledge-based institutions and networks, and form early partnerships with political parity in decision-making:** They are crucial for guiding priorities, developing locally appropriate technologies, testing and piloting new ideas,

monitoring and evaluation, and long-term local knowledge and capacity enhancement. Crucially, grassroots organisations and educational institutions are well-placed to source and analyse data on urban inequality and informality, filling in important gaps in key processes of governance and policy formulation. .

- **Make the search for equity and justice central to local environmental action and programming:** Equity and justice are not just sectoral considerations to be addressed as an afterthought, and require strategies to shift the multiple structural drivers of inequity commonly found in our cities. For example in the case of informality, the everyday practices of ordinary women and men need to be recognised and supported, rather than viewing informality as an environmental risk that needs to be reduced.

- **Expand the political space for decision-making to those typically excluded:** Ensure that, in the process of relieving vulnerable communities and social groups of environmental burdens, they are fully involved in decision-making processes in meaningful ways that make them more visible. For this to happen they should not just be approached as 'intended beneficiaries' but as rightful agents of change, as seen in the case of Alapuzzha's approach to waste management.

- **Drive gender empowerment and equality:** Gender inequality in cities arises from a combination of low-income, inadequate and expensive accommodation, limited access to basic infrastructure and services, exposure to environmental hazards, high rates of crime and violence and a whole range of deeply rooted 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 crise s like COVID19 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 address 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 women can play in finding solutions that meet the specific and changing needs and aspirations among women and men, girls and boys in and around cities.

- **Invest in instruments for cross-sectoral collaboration, governance and implementation:** While transformative action requires cross-sectoral integration, current

governance arrangements largely operate in departmental/sectoral silos. Attempts to pursue broad cross-sectoral goals cannot succeed unless supported by investments that increase convergence across sectors (Candel and Biesbroek 2016). Such resources can include explicit convergence across existing government programs, interdepartmental working groups (for example, the City of Cape Town's resilience team), and legislative orders, among others. Beyond coordination, long-term institutional capacity can also ensure transformational change from changing political priorities.

- **Foster inter-city exchange and co-learning:** Even if urban agendas need to talk to their own context, geographies and histories, there is enormous value in engaging in networked learning from the experiences of other cities. This might enable some cities to think more critically about future challenges that are not a priority today, or others to identify the historical processes and trajectories that are impeding their efforts towards a more sustainable and equitable future. In recent decades, city networks and national and international associations of local governments have played an important catalytic and intermediary role in sharing ideas between cities, building partnerships between the 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 in recent years to support cities in transforming their urban systems and metabolisms.

- Pursue **coordinated collaborations for transformative impact: Urban transitions require supportive policies and coordinated efforts at all levels of government, and between government and the private sector (Coalition for Urban Transitions 2019).** Multi-level governance structures that coordinate and accept the diversity of actors involved are powerful mechanisms for transformation if used effectively to mitigate risks associated with pilots and enable upscaling. Mechanisms such as grants/subsidies, incentives to trigger performance improvements, favourable legislation and effective decentralisation at the levels of local government create much-needed structural conditions for multiple complimentary actions aligned toward transformational goals. It is well-known that local governments in developing countries are often unable to address all needs with their own resources. There is a need for national (and sometimes international) support, particularly for addressing global issues like decarbonisation. However, beyond government institutions, the private sector and civil society are also important partners in development. Creating well-

functioning and fair markets in which the private sector can contribute toward sustainability goals, and innovative financing options for urban infrastructure are also important methods for overcoming limited public sector capacity and attracting funding to cities (UNFCCC 2019)[26]. Collaborating with civil society can help to fill communication and implementation gaps, and support the collective visions and governance frameworks that are critical to transformation. Finally, enhancing opportunities for citizen coproduction can open up new avenues for improving governance capacity.

- **Decouple urban infrastructures from unsustainable production and consumption:** Because urban infrastructures are long lasting, they can shape resource needs for decades to come. Thus, they can also play a key role in decoupling urban development from unsustainable production and consumption patterns. However, decisions about infrastructural investments and the protection of environmental resources and ecosystems tend to be at odds with each other and often exclude issues of equity or justice . Cities need to balance the protection of vital ecosystem services and ensuring the rights of the poor and those straddling between rural and urban areas to access infrastructure from 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 to develop interventions with reciprocal benefits. These include the two-way movement of people, capital, information, nutrients, ecosystem services and more. Ecosystem services between urban and rural areas can be strengthened by maintaining or rehabilitating 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 also important to prevent the flow of hazardous urban waste and pollutants from degraded ecosystems and natural resources, to the detriment of the health and livelihoods of the poor in peri-urban and rural areas. Adopting planning perspectives that transcend the rural-urban divide and engage critically with the governance systems that can ultimately determine how, where and what type of flows work and for whom.

[26] https://unfccc.int/sites/default/files/resource/SCF%20Forum%202019%20report_final.pdf

- **Foresee and plan to prevent undesirable impacts and unintended consequences:** Many of the experiences reviewed throughout this chapter reveal that more often than not, efforts to enable transformational change in one area might trigger negative impacts and unintended consequences. This is clearly illustrated in the experiences of many cities embarking in greening initiatives, which in turn led to eco-gentrification and displacement. Such consequences cannot be addressed as an afterthought, instead planning needs to encompass the adoption of proactive, preventative mechanisms, for instance through the adoption of land value capture instruments and protection of social housing and mixed uses.

- **Distill actionable knowledge from real world actions to facilitate learning and replication.** This requires refining the way in which we capture what amounts to transformational change, contributes or undermines substantial change. Four key assessment criteria emerge from the previous discussion:

    a) Assess the reach of impact of concrete actions, plans and programmes: do they have city-wide impacts? Do they go beyond?

    b) Scrutinize their impact sensitivity: are actions and interventions responsive to the diversity of socio-cultural needs, experiences and aspirations of women and men, girls and boys? Do they protect and enhance biodiversity and nature's rights within and beyond cities?

    c) Appraise their empowering capacity to build parity of political participation in the governance of transformational change: do they open political spaces and coalitions beyond the realm of mainstream institutions and powerful actors? If so, are these properly resourced to play a substantial role? Are their knowledge and capacities fully recognized and strengthened?

    d) Examine their catalytic capacity to ignite change beyond the remit of specific interventions and goals: do these interventions and practices trigger further transformative actions in other spheres? Do they have the capacity to nurture and

propagate innovation niches and to become viral enough to gradually bring about substantial change to unsustainable and inequitable socio-technical regimes?[27]

As argued 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 required, as demonstrated through the chapter and beyond. Collectively, we must identify what works, and derive general principles for governance from these existing cases. Doing so will allow us to consolidate a common knowledge and practice base on how cities, citizens, local authorities and their networks are co-producing pathways around progressive and forward-looking urban agendas, and inspire others to do so too.

[27] Emergent discussions offer precise frameworks for questions on capacity by delineating analytical, managerial and political capacity across multiple levels of governance. See for instance: Wu et al (2015).

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Glossary

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.

Agroecology
An ecological approach to agriculture that views agricultural areas as ecosystems and is concerned with the ecological impact of agricultural practices.

Alkalinity
The accumulation of sodium ions on exchange surfaces of soils, resulting in high pH values and often collapse of soil structure due to dispersion of clays.

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.

Arable land
Land under temporary crops (double-cropped areas are counted only once), temporary meadows for mowing or pasture, land under market and kitchen gardens, and land temporarily fallow (less than five years). The abandoned land resulting from shifting cultivation is not included in this category.

Billion
109 (1 000 000 000).

Biocapacity
The capacity of ecosystems to produce useful biological materials and to absorb waste materials generated by humans, using current management schemes and extraction technologies. The biocapacity of an area is calculated by multiplying the actual physical area by the yield factor and the appropriate equivalence factor. Biocapacity is usually expressed in units of global hectares.

Bioenergy
Renewable energy produced by living organisms.; Energy derived from any form of biomass such as recently living organisms or their metabolic by- products.

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.

Black carbon
Operationally defined aerosol based on measurement of light absorption and chemical reactivity and/or thermal stability. Black carbon is formed through the incomplete combustion of fossil fuels, biofuel and biomass, and is emitted as part of anthropogenic and naturally occurring soot. It consists of pure carbon in several linked forms. Black carbon warms the Earth by absorbing sunlight and re-emitting heat to the atmosphere and by reducing albedo (the ability to reflect sunlight) when deposited on snow and ice.; The substance formed through the incomplete combustion of fossil fuels, biofuels, and biomass, which is emitted in both anthropogenic and naturally occurring soot. It consists of pure carbon in several linked forms. Black carbon warms the Earth by absorbing heat in the atmosphere and by reducing albedo – the ability to reflect sunlight – when deposited on snow and ice.

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

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 CO2 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.

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."

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
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.

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.

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.

Disaggregation
To separate into component parts.

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.

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.

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.

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 management
An approach to maintaining or restoring the composition, structure, function and delivery of services of natural and modified ecosystems for the goal of achieving sustainability. It is based on an adaptive, collaboratively developed vision of desired future conditions that integrates ecological, socio- economic, and institutional perspectives, applied within a geographic framework, and defined primarily by natural ecological boundaries.

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

Effluent
In issues of water quality, refers to liquid waste (treated or untreated) discharged to the environment from sources such as industrial process and sewage treatment plants.

Electrification
The action or process of charging something with electricity.

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

Environmental assessment
The entire process of undertaking an objective evaluation and analysis of information designed to support environmental decision making. It applies the judgement of experts to existing knowledge to provide scientifically credible answers to policy -relevant questions, quantifying where possible the level of confidence. It reduces complexity but adds value by summarizing, synthesizing and building scenarios, and identifies consensus by sorting out what is known and widely accepted from what is not known or not agreed. It sensitizes the scientific community to policy needs and the policy community to the scientific basis for action.

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 governance
Environmental Governance is the means by which society determines and acts on goals and priorities related to the management of natural resources. This includes the rules, both formal and informal, that govern human behavior in decision-making processes as well as the decisions

themselves. Appropriate legal frameworks on the global, regional, national and local level are a prerequisite for good environmental governance.

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 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.

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.

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.

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 gap

The term gender gap refers to any disparity between women and men's condition or position in society. It is often used to refer to a difference in average earnings between women and men, e.g. "gender pay gap." However, gender gaps can be found in many areas, such as economic participation and opportunity, educational attainment, health and survival and political empowerment.

Genetic diversity

The variety of genes within a particular species, variety or breed.

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."

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 (H2O), carbon dioxide (CO2), nitrous oxide (N2O), methane (CH4) and ozone (O3) 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 CO2, N2O and CH4, the Kyoto Protocol deals with sulphur hexafluoride (SF6), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and nitrogen trifluoride (NF3).; The atmospheric gases responsible for causing global warming and climatic change. The major greenhouse gases are carbon dioxide (CO2), methane (CH4) and nitrous oxide (N2O). Less prevalent, but very powerful, GHGs are hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF6).

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.

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.

Kyoto Protocol
A protocol to the 1992 United Nations Framework Convention on Climate Change (UNFCCC) adopted at the Third Session of the Conference of the Parties to the UNFCCC in 1997 in Kyoto, Japan. It contains legally binding commitments in addition to those included in the UNFCCC. Countries included in Annex B of the protocol (most OECD countries and countries with economies in transition) agreed to control their national anthropogenic emissions of greenhouse gases (CO2, CH4, N2O, HFCs, PFCs, SF6 and NF3) so that the total emissions from these countries would be at least 5 per cent below 1990 levels in the commitment period, 2008 to 2012.

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 grabbing
Large-scale land grabbing is defined as “acquisitions or concessions that are one or more of the following: (i) in violation of human rights, particularly the equal rights of women; (ii) not based on free, prior and informed consent of affected land-users; (iii) not based on a thorough assessment, or in disregard of social, economic and environmental impacts including the way those impacts are gendered; (iv) not based on transparent contracts that specify clear and binding commitments about activities, employment and benefits sharing; and (v) not based on effective democratic planning, independent oversight and meaningful participation.”

Land tenure
The relationship, whether legally or customarily defined, among people, as individuals or groups, with respect to land. (For convenience, “land” is used here to include other natural resources such as water and trees.) Land tenure is an institution, i.e., rules invented by societies to regulate behaviour. Rules of tenure define how property rights to land are to be allocated within societies. They define how access is granted to rights to use, control, and transfer land, as

well as associated responsibilities and restraints. In simple terms, land tenure systems determine who can use what resources for how long, and under what conditions.

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.

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).

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

Lockdown
A state of isolation or restricted access instituted as a security measure.

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.

Marginalization
Treatment of a person, group, or concept as insignificant or peripheral.

Megacities
Urban areas with more than 10 million inhabitants.

Merit goods
Goods or services (such as education and vaccination) provided free for the benefit of the entire society by a government, because they would be under-provided if left to the market forces or private enterprise.

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 CO2 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.

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 infrastructure
Strategically planned and managed network of natural lands, such as forests and wetlands, working landscapes, and other open spaces that conserves or enhances ecosystem values and functions and provides associated benefits to human populations.

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

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.

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.

Pathogen
A bacterium, virus, or other microorganism that can cause disease; 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.

Peri-urban
(Especially in Africa) 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.

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.

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.

Prediction
The act of attempting to produce a description of the expected future, or the description itself, such as "it will be 30°C tomorrow, so we will go to the beach".

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.

Remote Sensing
Collection of data about an object from a distance. In the environmental field, it normally refers to aerial or satellite data for meteorology, oceanography or land cover assessment.

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.

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

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".

Secondary pollutant
Not directly emitted as such, but forms when other pollutants (primary pollutants) react in the atmosphere.

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.

Severe Acute Respiratory Syndrome (SARS)
A viral respiratory illness caused by a coronavirus, SARS- associated coronavirus (SARS-CoV). First reported in Asia in 2003, the illness spread to more than two dozen countries in North America, South America, Europe and Asia before the SARS global outbreak of 2003 was contained. Since 2004, no known cases of SARS have reported anywhere in the world.

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.

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.

Species richness
The number of species within a given sample, community or area.

Spillover effect
The trickle down of growth from one region to another.

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 agriculture
Sustainable Agriculture puts the emphasis on methods and processes that improve soil productivity while minimising harmful effects on the climate, soil, water, air, biodiversity and human health. It aims to minimise the use of inputs from nonrenewable sources and petroleum-based products and replace them with those from renewable resources. It Focuses on local people and their needs, knowledge, skills, socio-cultural values and institutional structures. It ensures that the basic nutritional requirements of current and future generations are met in both quantity and quality terms. It provides long-term employment, an adequate income and dignified and equal working and living conditions for everybody involved in agricultural value

chains. It educes the agricultural sector's vulnerability to adverse natural conditions (e.g. climate), socioeconomic factors (e.g. strong price fluctuations) and other risks.

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.

Taxonomy
A system of nested categories (taxa) reflecting evolutionary relationships or morphological similarities.

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.

Theory of change
A theory of change is a method that explains how a given intervention, or set of interventions, is expected to lead to specific development change, drawing on a causal analysis based on available evidence.

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
1012 (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 agglomeration
The population contained within the contours of a contiguous territory inhabited at urban density levels without regard to administrative boundaries". In other words, it integrates the 'City Proper' plus suburban areas that are part of what can be considered as city boundaries; a term that in itself is controversial.

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.

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 m3 per person.

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.